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Developing deep-water fisheries: data for their assessment and for understanding their interaction with and impact on a fragile environment

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National Centre for Marine Research, Greece.

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TASK 1
Sub-task 1.2: To describe the deep-water fisheries of Greece.

TASK 2
Sub-task 2.4: To collate and analyse data relating to Greek surveys of deep-water species.

TASK 3
Sub-task 3.3: Discard studies in Greek waters.

TASK 4
Sub-task 4.2: To sample the landings at Greek ports.

TASK 5
Sub-task 5.6: Biological parameters of the deep-water resources of Greek waters

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Sub-task 5.6: Biological parameters of the deep-water resources of Greek waters

By

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The biology of the shrimps (*Aristeus antennatus*, *Aristaeomorpha foliacea* and *Parapenaeus . longirostris*) and of *Galeus melastomus* was studied by K. Kapiris, the biology of the macrourids species (*Nezumia sclerorhynchus* and *Coelorhynchus coelorhynchus*) and the estimation of the diversity indices by Dr. M. Labropoulou, the biology of *H. mediterraneus* by Dr. V. Vassilopoulou and G. Petrakis, the biology of *Helicolenus dactylopterus* by Dr. C. Papaconstantinou, G. Petrakis and A. Chilari, the biology of *Chlorophthalmus agassizi* by A. Anastasopoulou and the study of other shrimps species and decapods fauna was undertaken by Dr. C.-Y. Politou.

Introduction

The proposed program by the NCMR in this subtask had the following objectives:

1. Biological parameters of target species
2. Biological parameters of non-target species

As target species we define the species with commercial value, which are or will be subject of a fishery. As non-target species we define the species without commercial value, which are considered to be key species for the ecosystem because of their abundance.

The initial plan involved three bottom trawl sampling cruises during the project. The first cruise took place in August 1996. The results of this cruise have been presented in the first interim report. Since the findings of the first trip were very promising, mainly because of the presence of the two deep water red shrimps *Aristeus antennatus* and *Aristaemorpha foliacea*, we modified the sampling design and we decided to make 12 monthly cruises.

In order to study the biology of the shrimps and of other fish species we collected monthly samples. Some results from the cruises that took place from December 1996 to November 1997 have been presented in the second interim report. In the final report all the results of the monthly sampling cruises are presented in order to give a complete picture of the situation in the deep waters of the Ionian Sea.

Knowledge on the deep-water ecosystem is very limited; a broad range of unpublished raw data exists, concerning mostly deep water fish species of the north east Atlantic and the Mediterranean (Connolly *et al*., 1995). New records on deep water species are constantly being reported (Kotlyar and Pakhorukov, 1992; Trunov, 1991). Pressure on inshore fish stocks has led to the exploitation of demersal fish in the European deep waters (400-1500 m). Some of the deep water species currently exploited are relatively long lived, slow to mature and have low fecundities. These characteristics make them especially vulnerable to overfishing and have given rise to serious concerns within the scientific community (Connolly and Kelly, 1996). Therefore, new information on fish biological parameters such as age, growth and reproduction is required, in order to formulate an effective management policy about deep water resources and subsequently regulate their exploitation in a sustainable way.

During the last years a growing interest exists in Europe about deep water fish, hence a developing deep water fishery would inevitably take pressure off the shallow water species. In present days, the development of new fishing techniques and improved gear designs have made fishing units ever more efficient and adaptable (Galbraith and Stewart, 1995). There is a great necessity for good management and regulation techniques to meet different fishing conditions and socio-economic requirements.

The west coasts of Greece (Ionian Sea) have a very limited continental shelf and the commercial bottom trawl fishery is mainly carried out in the North West where there is a restricted area with depths less than 500 m. The objective of the sampling in deep waters in the Ionian Sea was to provide data on the deep water fish community, which will form the basis for comparisons with future investigations, enabling the estimation of the stability of this particular ecosystem in time, as well as comparisons with other, exploited deep sea areas in the Mediterranean. Furthermore, to collect the data that are needed in order to study the biology of the species.

Although this area has not been commercially exploited until now, the results so far appear to be very promising for future exploitation. The presence of two deep water shrimps (*Aristaeomorpha foliacea* and *Aristeus antennatus*) of great economical value, in significant quantities (up to 40 Kg/hour of fishing), leads to the conclusion that a new fishery, aiming at these species, is going to be developed.

Materials and Methods

Sampling took place in the South Ionian Sea on monthly basis from December 1996 to November 1997 (Table 1, Fig. 1). The sampling took place only during day-light. In total 90 valid hauls were carried out. The duration of the tows ranged from 30 to 100 minutes according to depth and substrate. In 72% of the tows the duration was 60 minutes, in 14% was less than 60 minutes and in 14% was more than 60 minutes. The depth ranged from 303 to 823 m but valid hauls took place in depths down to 750 m. The majority of the stations were located between 450-600 m (Table 2, Fig. 2). The length of the ropes (from the doors to the net) was constant (220 m), whereas the length of the warps was changing accordingly to depth (Fig. 3). In tows with depths <400 m the ratio wire-length ranged from 3.8 to 3.2. In the middle depths (400-600 m) the ratio ranged from 3.5 to 2.2 and in the deeper tows (>600 m) it ranged from 2.9 to 2.3.

All the surveys were performed by means of a hired commercial bottom trawl fishery vessel named “Panagia Faneromeni”. For each haul, the following characteristics where recorded:

- Initial and final position
- Initial and final depth
- Beginning of haul
- Duration of haul
- Speed of the vessel
- Length of the ropes and warps used during the haul

The gear used in this project was a common bottom trawl used by the fishermen in Greek waters. The mesh size in the cod-end was 14 mm (bar length). In each station the catch was sorted to species level, the number and the weight of the specimens per species were recorded and the lengths of all the specimens were measured. Shrimps other than *A. foliacea*, *A. antennatus*, and *P. longirostris* were weighted on board all species together and were preserved for further analysis in the laboratory. Biological data (such as sex and maturity stage) and otoliths were collected for the target species. The sex and the maturity stages were examined macroscopically on board for the species *Merluccius merluccius* (hake), *Lophius budegassa* (angle fish), *Micromesistius poutassou* (blue whiting) and *Phycis blennoides*. Otoliths were extracted, weight was weighted, sex and maturity were determined for the species *Hoplostethus mediterraneus*, *Helicolenus dactylopterus*, *Coelorhynchus coelorhynchus*, *Nezumia sclerorhynchus* and C*hlorophthalmus agassizi*. Both sagittae were removed, dried and stored for further examination. Furthermore, samples of shrimps were collected in order to analyse them in the laboratory.

Specimens were measured whilst fresh or defrosted. The pre-anal length (PAL) of *N. sclerorhynchus*, *C. coelorhynchus* and *C. monstrosa* was recorded to the nearest millimeter and they were weighted to the nearest 0.1 g. The total length to the nearest mm of the other fish species and the carapace length to the nearest 0.01 mm of the crustacean species were measured.

Since the duration of the tows was not the same at every station, the number and the weight of the species were standardised to one hour of fishing, allowing comparative results. In order to determine possible vertical movements, two depth zones were defined: The first one from 300 to 500 m and the second one from 500 to 750 m.

The CPUE was calculated as Kg/Hour of fishing as follows:

The total weight or the weight of the species was standardised to one hour of towing:

$Wi = wi*60/t$ (where Wi = standardised weight, wi = actual weight, t = duration of the tow)

The CPUE was estimated as the mean of the standardised weight in the depth zone:

$CPUE = SWi/N$ (where N = number of hauls in the depth zone).

The Spearman Rank Correlation test was used in order to examine the correlation between the mean length and the depth. The ranked values were used because they are less sensitive to outliers. The Mann-Whitney W test was used in order to examine the difference in the CPUE between the 300-500 m and 500-750 m depth zones at 95% confidence level.

Since the distribution of the abundance and biomass was very skewed, the data of each haul were log-transformed, to compare by means of one-way ANOVAs the mean values between depth zones (Zar, 1984). Correlation between fish length and weight, otolith length, otolith diameter and otolith weight were calculated from the equations: $y = a + bx$ and $y = a*x^b$. The allometric index (b) values were compared with a Student's t test, whereas analyses of covariance (ANCOVA) were used to detect any significant differences on the linear relationships. All statistical inferences were based on 0.05 significance level.

The maximum lengths of the otoliths were measured to the nearest 0.1 mm and they were weighted to the nearest 0.001 g. All but the very small otoliths (right sagittae) were polished with a grinder-polisher until the nucleus was reached. Then they were placed in a black dish, immersed in glycerol and examined under reflected light, using a binocular microscope fitted with a video camera, linked to a high definition monitor and the rings were manually marked through image processing. Readings were undertaken twice. When the two readings of the same otolith resulted in different age estimates, it was considered to be unreadable. The timing of growth check formation was determined by noting the visual appearance of the otolith margin and expressing it as a percentage of the monthly sample.

Length at age was described by the three-parameter von Bertalanffy growth model of the form

$$L_t = L_\infty\left(1 - e^{-k(t-t_0)}\right)$$

where: L_t = Length or PAL at age t, L_∞ = asymptotic length, K = growth coefficient, t_0 = theoretical age at zero length.

Mean monthly data were used in order to assign equal weight to all observations. Only mean values from samples of greater than five fish were used. As there is no birth-date data on these species, the number of rings was considered as the age. Growth parameters were estimated iteratively using the Simplex minimization algorithm (Wilkinson, 1988). The measure of goodness-of-fit was the coefficient of determination (r^2). The von Bertalanffy growth parameters K and L_∞ are inversely correlated, so to compare growth rates, the growth performance index Φ (Munro and Pauly, 1983) was employed.

The growth of the shrimps was studied using the Von Bertalanffy equation. In general, the Von Bertalanffy equation has been found to describe adequately the average deterministic growth of penaeid shrimps, especially if a term to allow a seasonal oscillation has been included (Dall *et al*., 1990). The parameters of the Von Bertalanffy growth equation L_∞, K and t_0 were estimated for each species and sex by running the program LFSA suite (Length-based Fish Stock Assessment; Sparre, 1987) on the overall size distribution. This program estimates these parameters by using a non-linear least squares procedure.

The estimation of the age structure and the growth parameters in crustaceans is difficult due to the absence of permanent hard parts. In such cases, length frequency analysis has often been used to estimate mean lengths-at-age and growth parameters (Hillis, 1979). Many approaches exist for the separation of groups in a length distribution. In the present study the Bhattacharya's (1967) method have been used, which is useful in estimating mean lengths of the groups present in length distributions of the deep water shrimps (Ragonese *et al*., 1994b; Ragonese and Bianchini, 1992; Mura *et al.*, 1997). Castro (1990) maintained that Bhattacharya is easier than other modern methods and could be applied in a more objective way than other graphical methods. Consequently, with the advantages offered nowadays by computer programs, this method could be considered as objective, quick, easily applied and adequate for length-based analysis. The selection of the best results was based on the following criteria: (a) the values of separation index (S.I.) (Gayanilo *et al.*, 1988) for the different age groups, (b) the number of the identified age groups and (c) the standard deviation (S.D.).

Results

General description of the area

Decapods fauna in the area

A review of the information available until then about the systematic and distribution of decapods in the Greek waters is given by Koukouras *et al*. (1992). Some more recent information is presented by Politou *et al*. (1996), Mytilineou and Politou (1997), Koukouras *et al*. (1997a) and Koukouras *et al*. (1997b). However, all these works concern the Aegean Sea. The literature on the decapod fauna of the Greek waters in the Ionian Sea is very limited. Recently, information on the composition, distribution and abundance of decapods in that region, obtained in the framework of the project MEDITS, is given by Politou *et al*. (1998). Even though the sampling of that project extended in depths from 10 to 800 m, the density of hauls was low in that region and particularly in the deeper strata. Furthermore, the performance of the gear used was not so satisfactory in high depths and especially for crustaceans. Finally, it must be underlined that the sampling of the MEDITS project is conducted only one season (late spring-summer) per year. For these reasons the information given by Politou *et al*. (1998) for the decapods of the Ionian Sea can be considered only as indicative.

An important result coming from the latter work was that the most abundant category of decapods found on the slope (200-800 m) was Natantia with Macrura Reptantia (mainly *Nephrops norvegicus*) following. Anomura were also found mainly on the slope, but in low quantities, whereas Brachyura were caught mainly on the shelf (10-200 m) and scarcely on the slope. This trend was also observed in the framework of the Deep Water Fisheries project, even though Anomura were not studied (Table 3).

Concerning Natantia, 18 species, most demersal, were found in the present research program. The most remarkable result was the high quantities of *Aristaeomorpha foliacea* and *Aristeus antennatus* caught in this area, for which only small or accidental catches were reported for the Greek waters earlier (Koukouras *et al*., 1997b; Mytilineou and Politou, 1997; Politou *et al*., 1998). From the rest of the shrimps caught in the present program, *Ligur ensiferus* was for the first time reported for the Greek waters. Furthermore, *Plesionika acanthonotus, P. antigai* and *P. gigliolii* are Pandalids, which, according to the Fiches FAO (1987), are not present in the Greek waters. However, *P. acanthonotus* was reported for the Aegean Sea by Koukouras *et al*. (1992), whereas all the three species were found by Politou *et al*. (1998) in the region of Argosaronikos (Aegean Sea). Furthermore, concerning the Ionian Sea, only *P. gigliolii* was reported for that region by Politou *et al*. (1998), whereas *P. acanthonotus* and *P. antigai* were found for the first time in that Sea.

Fish fauna in the area

It has been pointed out by many authors that the ichthyofauna of the Eastern Mediterranean still remains poorly known (Tortonese, 1978; 1985a; 1985b). For the Greek seas and the Mediterranean in general, it could be assumed that deep-dwelling species are mainly rare bathyal, mesopelagic or bathypelagic fishes which have a wide distribution along the Greek continental shelf. The boundary between the above distribution is not always accurately expressed. The results of the Danish oceanographic expeditions conducted by the ships «THOR» between 1908-1910 and «DANA» between 1928-1930 provided most of the available information on the mesopelagic and bathypelagic fish fauna of the Greek seas. In recent years, several fish species have been recorded for the first time or have been found in new localities, often situated far away from those previously cited.

Information on the distribution of mesopelagic fishes in Greek seas during the last two decades that have appeared in various publications have been based on the results of research cruises, aiming mainly, at the study of the state of demersal fish populations (Papaconstantinou, 1988; 1990). This information is extremely limited because of inappropriate sampling gear employed and entirely different orientation of the research, taking into account that: (a) the depth of sampling rarely extends farther than 500 m, (b) the mesh size used was 28 mm, resulting in a significant loss of relatively smaller individuals and/or species, and (c) mesopelagic fish are caught occasionally, while the net is on its way up and consequence, the depth, where they occur is not known.

The Ionian Sea is characterized by a narrow continental shelf and high depth, with salinity and temperature levels between those of the west and east Mediterranean. It offers also, an interesting opportunity for taxonomic and zoogeographical studies on fishes because of its various types of substrates and depths varying from shallow to 4000 m. This topographic feature results in a broad sense of factors such as depth, sediment and coastal and sea bed morphology (Kaspiris, 1973). However, future planning demands a more detailed study of the relationship between the fish population and the ecological parameters and of the over-fishing area of the Ionian Sea. For a complete faunistic study of the area, it is necessary to examine the wider area of the Ionian Sea and to evaluate the data of the Italian (Brunelli and Bini, 1934a; 1934b, Parenzan, 1960; Galloti, 1973) and Albanian coasts (Rakaj, 1995).

The ichthyofauna of the area, consisted mainly of Atlantic-Mediterranean and cosmopolitan taxa, has not been studied satisfactory. For a good number of species a definite answer about their presence in the Ionian Sea cannot be offered at present and any knowledge on their distribution is still incomplete. Several species, such as those of the genere *Chlorophthalmus, Maurolicus, Micromesistius, Trachyrhynchus, Hoplostethus, Gadiculus* etc, formerly regarded as rare, proved to be abundant, at least locally, when intensive fishing with modern trawlers was applied in deep waters, thus representing an important part of the commercial catches in the area (Papaconstantinou, 1988). Even in recent bibliography no accurate data are available on the occurrence and the distribution of certain common species in the Ionian Sea, e.g. *Micromesistius poutassou*, *Gadiculus argenteus argenteus*, *Lepidotrigla dieuzeidei* etc (Whitehead *et al*., 1984-1986). The only available information is given by Kaspiris (1973) and Papaconstantinou (1986a; 1986b; 1986c). Scarce reference on the presence of some taxa can be found in Panagiotopoulos (1916a; 1916b; 1916c), Taaning (1918), Belloc (1948), Ontrias (1971) and Economidis, (1973). Almost nothing is known about the fish fauna in depths more than 500 m in the area.

Seventy three fish taxa, most bathypelagic, representing 60 genera and 44 families were collected during the present research program. Sixty three fish taxa were caught in depths between 300 and 500 m, and fifty three in depths between 500 and 750 m (Table 4). Almost all of these species have been reported in the Greek fish fauna, but no information exist concerning their abundance in depths greater than 500 m. The information provided in Table 4 has been divided into two depth zones, 350-500 m and 500-750 m. In depths from 500 to 750 m have been caught exclusively the following species: *N. bonapartei, B. apoda, C. niger, D.*

rafinesqei, G. mystax, H. griseus, O. centrina, P. acarne, P. coregonoides, R. pretiosus, Symphodus sp. and *S. acanthias*. The most common species in the 500-750 m depth zone, which extent their presence and in the shallower one are the following: *A. hemigymnus, C. sloani, C. monstrosa, D. metopoclampus, H. dactylopterus, H. mediterraneus, N. melanurum, N. sclerorhynchus, P. blennoides, S. boa, S. nigrescens, L. crocodilus, M. dipterygia macrophthalma.*

The most characteristic residents in the 300-500 m depth zone of the area are species belonging to the families Macrouridae and Myctophidae. Concerning the depth distribution of the first family in the area, *N. sclerorhynchus* extends in higher depths presenting a peak of its abundance in 500-750 m, while the other two species, *C. coelorhynchus* and *H. italicus*, even though are fished in both depth zones, seem to present higher abundance in depths 300-500 m. All species belonging to the family Myctophidae were fished in higher numbers in stations between 500-750 m. Most common was *D. metopoclampus*, followed by *L. crocodilus and D. rafinesquei*. Thirty five not identified specimens were caught during our research. Some information concerning the bathymetrical distribution of the various myctophid species in the Aegean Sea, are reported by Papaconstantinou *et al*. (1997).

<u>Catch composition</u>

The composition of the catch by weight was examined separately for the crustaceans and the fish species. Since the number of tows per month was low, in order to obtain more reasonable results the catch composition was examined seasonally. The proportion of the nine most abundant species was estimated separately and the proportion of all the other species was summed under the category “others”.

In the crustacean catch, *A. foliacea* was the dominant species during all seasons in both depth zones (Fig. 4). At the 500-750 m depth zone *A. foliacea* always consisted more than 50% of the catch (winter 65%, spring 59%, summer 59% and autumn 72%). In the 300-500 m depth zone the species consisted lower proportion (winter 51%, spring 43%, summer 41% and autumn 33%).

Unidentified shrimps (*shrimps sp.*) followed *A. foliacea*, and in the 300-500 m depth zone consisted about 30% of the crustacean catch (winter 29%, spring 26%, summer 31% and autumn 36%) (Fig. 4). The contribution of the unidentified shrimps in the crustacean catch in the 500-750 m depth zone was lower (winter 15%, spring 15%, summer 21% and autumn 9%).

A. antennatus contributed more to the catch of the 500-750 m depth zone (winter 12%, spring 22%, summer 11% and autumn 13%) than of the 300-500 m depth zone, where during summer and autumn no specimens were caught (winter 8%, spring 9%, summer 0% and autumn 0%) (Fig. 4).

The contribution of *P. longirostris* was higher during summer and autumn in both depth zones (15%, 22% in the 300-500 m depth zone and 6%, 4% in the 500-750 m depth zone, respectively) (Fig. 4). The presence of *N. norvegicus* was higher in the 300-500 m depth zone during all seasons (winter 7%, spring 10%, summer 14% and autumn 9%) than in the 500-750 m depth zone, where the proportion of the species in the crustacean catch was low (winter 3%, spring 2%, summer 2.7% and autumn 1.2%).

In the fish catch, *C. agassizi* was the dominant species in the 300-500 m depth zone (winter 43%, spring 33%, summer 27% and autumn 29%) (Fig. 5). The contribution of the species to the fish catch in the 500-750 m depth zone was lower (winter 10%, spring 10%, summer 16% and autumn 17%).

S. blainvillei and *A. sphyraena* followed the same pattern. Both species contributed more to the fish catch of the 300-500 m depth zone during all seasons (spring 11%, 11%, summer 16%, 17%, autumn 13%, 11%, respectively) than to the catch of the 500-750 m depth zone, where the contribution of the species was very low (less than 2.5%) (Fig. 5). During winter *A. sphyraena* consisted 3% of the catch.

The proportion of *L. piscatorius* was higher than the other species in the catch of the 500-750 m depth zone during winter and autumn (15% and 26%, respectively), whereas during spring and summer was 4% and 6%, respectively. In the 300-500 m depth zone the species was among the nine most abundant species only during spring, contributing by 3%.

L. budegassa was among the nine most abundant species in the 500-750 m depth zone during all seasons except in autumn (winter 10%, spring 7% and summer 7%) (Fig. 5). In the 300-500 m depth zone during autumn contributed by 3% and during the other seasons by less than 2%.

H. dactylopterus was more abundant in the catch of the 500-750 m depth zone during all seasons (winter 13%, spring 18%, summer 14% and autumn 11%) (Fig. 5). During spring in this depth zone it was the most abundant species. In the shallow depth zone (300-500 m) the contribution of the species was generally low (winter 4%, spring 3%, summer 4% and autumn 3%).

H. mediterraneus contributed more to the catch of the 500-750 m depth zone (winter 11%, spring 10%, summer 14% and autumn 7%), than to the catch of the 300-500 m depth zone (winter 3%, spring 5%, summer 3% and autumn 7%).

The proportion of *G. melastomus* was higher in the fish catch of the 500-750 m depth zone than in the 300-500 m depth zone during all seasons (winter 7%, 7%, spring 7%, 4%, summer 8%, 7% and autumn 7%, 3%, respectively) (Fig. 5).

M. merluccius, M. poutassou and *P. blennoides* contributed with small proportions to the catch of both depth zones during all seasons (Fig. 5).

Catch Per Unit of Effort fluctuations of the total catch

In the 300-500 m depth zone the CPUE of the fish was higher than the CPUE of crustaceans and cephalopods during the twelve months of sampling (Fig. 6). Its minimum value was observed in February (37.8 Kg/hour) and the maximum in March (146.7 Kg/hour). During April to September the CPUE was quite constant (about 80 Kg/hour). The CPUE of the crustaceans was lower and ranged from 0.1 Kg/hour (July) to 16 Kg/hour (February). The CPUE of the cephalopods was low (less than 2.9 Kg/hour).

In the deeper depth zone (500-750 m), the CPUE of the fish and of the crustaceans during December 1996 to May 1997 and during October to November 1997 was almost the same but during June to September 1997 the CPUE of the fish was higher (Fig. 7). The CPUE of the fish in the 500-750 m depth zone was lower than in the shallow depth zone, ranging from 7.2 Kg/hour to 51.5 Kg/hour, whereas the CPUE of the crustaceans was higher in the deeper depth zone and ranged from 8.1 Kg/hour to 33.6 Kg/hour. The CPUE of the cephalopods was very low (less than 1.2 Kg/hour).

<u>Depth patterns in species diversity</u>

Four different depth zones were defined (<300 m, 300-400 m, 400-500 m and >500 m) in order to investigate how species richness, diversity, evenness and dominance changed with the water depth in the study area. The following measures were applied to the species abundance matrix:

1. The Shannon-Wiener diversity index (H´)
2. Species richness (Margalef's index)
3. The evenness index (J´)
4. Dominance (Simpson's index)

The depth-gradient characteristics of species diversity are given in Table 5. Overall species richness, evenness and diversity get their lowest values at depths < 300 m where dominance is the highest, due to the dominance of *Chlorophthalmus agassizi* in the catches at these depths.

The highest values of species richness, evenness and diversity were found at depths between 300 to 400 m and significantly decrease at depths below 400 m. On the contrary, dominance is getting the lowest values at depths 300-400 m where species diversity was found to be comparatively high. Although species richness do not change considerably with depth, species dominance significantly decreases with depth below 500 m, while diversity slightly increases from the depth zone of 400-500 m to depths greater than 500 m.

ANOVA tests revealed that the effect of both season and depth on species diversity measurements was always significant ($P< 0.000$). In general, the seasonal trends observed are rather similar with those described for the overall diversity characteristics of the community in the study area.

Biology of the most abundant non commercial species

<u>Argentina sphyraena</u>

The analysis of the length frequency distribution showed that this species was mainly caught in the 300-500 m depth zone (Fig. 8). The number of the specimens in the 500-750 m depth zone was very low but the fish were larger. The lengths of the specimens ranged from 40 to 190 mm. The bulk of the population in the 300-500 m depth zone during winter was at 140 mm and during the other seasons at 120 mm. In the 500-750 m depth zone the bulk was at 150 mm. Young fish with lengths 40-80 mm appeared in the catch mainly during autumn and winter in the 300-500 m depth zone.

A. sphyraena was caught in abundance in the 300-500 m depth zone in April and during July to October (Fig. 9a). Higher values of the CPUE were observed in April and in July (39 and 30.8 Kg/hour, respectively). In the 500-750 m depth zone the species was not abundant. Higher value of the CPUE in this depth zone was observed in May (0.3 Kg/hour). The Mann Whitney W test showed that the CPUE in the 300-500 m depth zone was significantly higher than in the 500-750 m depth zone ($p=0.000$).

The mean length of the species showed an increase with the depth (Fig. 9b). In depths down to 425 m the maximum mean length was 139 mm, whereas in the deeper stations was larger than 140 mm (except in two stations). Spearman rank correlation test showed a significant non-zero correlation between depth and mean length ($p=0.004$, correlation=0.616).

The bathymetrical distribution of the species in the study area extended from 300 to 600 m (Fig. 9c, 9d). Higher aggregations, in terms of number and weight, were observed in depths between 300 and 410 m.

Chimaera monstrosa

In total 153 males and 189 females were caught during the sampling period and the length distribution is not presented seasonally. The PAL of the males ranged from 40 to 340 mm and of the females from 40 to 260 mm (Fig. 10). In the 500-750 m depth zone two modal lengths were observed for both sexes. The first at PAL 40 mm for the males and 40-60 mm for the females and the second one at PAL 180-200 mm for the males and 160 mm for the females. In the 300-500 m depth zone the modal length of the males was observed at 120 mm and of the females between 60-140 mm. The fish with PAL 80-160 mm segregated more in the 300-500 m than in the deeper depth zone.

Generally the species was more abundant in the deeper depth zone (Fig. 11a). From December to February, it was caught mainly in the shallower zone (maximum 2.5 Kg/hour in February). The rest of the months it was caught in higher quantities in the deeper zone, with the highest values taken in April (2.3 Kg/hour). The difference in the CPUE between the two depth zones was found not significant (Mann Whitney W, test p=0.165)

There was not a clear relationship between the mean length and the depth for both sexes (Fig. 11b). Even though, in depths less than 550 m the mean length ranged from 60 to 200 mm and in depths deeper than 550 m the mean length ranged from 120 to 200 mm. The correlation between depth and mean length was found not significant for both sexes (Spearman rank correlation, p=0.656 and p=0.361 for females and males, respectivelly).

The bathymetrical distribution of the species in the Ionian Sea ranged from 350 to 740 m (Fig. 11c, 11d). Almost all individuals were caught at the 440-600 m depth zone, while very few individuals appeared in depths >600 m.

Gadiculus argenteus argenteus

The species was mainly caught in the 300-500 m depth zone (Fig. 12). According to Sostoa (1990) the species aggregates in big schools. Some specimens were caught in the 500-750 m depth zone mainly during winter. The length distribution ranged from 60 to 120 mm and the bulk of the catch had lengths between 60 and 90 mm. A reduction was observed in the modal length of the distribution from winter to autumn. Thus, the modal length was 80 mm during winter, 75 mm during spring, 65 mm during summer and 60 mm during autumn. The absence of the species in the deeper depth zone excludes the possibility that larger specimens migrated to deeper waters.

The CPUE of the species in the 300-500 m depth zone showed great fluctuations, whereas in the deeper depth zone was always very low (less than 0.15 Kg/hour) (Fig. 13a). The Mann-Whitney W test showed significant difference (p=0.000). Thus, in the 300-500 m depth zone, for six months (during February, April, July, August, September and November) ranged from 0-0.2 Kg/hour, whereas during the other months ranged from 2.3 to 8 Kg/hour. These differences in the CPUE of the species could be explained by the opportunistic capture of the species because of the shoaling behaviour.

The mean length increased with the depth (Fig. 13b). The minimum mean length was observed in 360 m depth (55 mm) and the maximum in 500 m depth (87 mm). The Spearman rank correlation between depth and mean length was found significant (p=0.026).

The bathymetrical distribution of the species ranged from 350 to 600 m but it was mainly caught at the 350-400 m depth interval (Fig. 13c, 13d). The highest catch took place at 382 m (4208 fish/hour and 14.3 Kg/hour).

Hymenocephalus italicus

The PAL of *H. italicus* in the 300-500 m depth zone ranged from 10 to 52 mm and in the deeper one ranged from 12 to 54 mm (Fig. 14). During winter and spring, more individuals were caught in the 300-500 m depth zone, whereas during summer and autumn more individuals were caught in the 500-750 m depth zone. During winter the modal length was at 24-26 mm. During spring a difference was observed in the modal length between the two depth zones. In the shallower one it was at 22 mm, whereas in the deeper one at 34 mm. During summer and autumn it was at 30 mm. During spring the recruitment of young fish (PAL 10-20 mm) took place in the shallower depth zone.

Higher catches were obtained in the shallower zone (except in July and August) (Fig. 15a). Massuti *et al*. (1995) reported that the abundance and the biomass of the species decrease below 500-600 m. The Mann-Whitney W test showed that the median in the 300-500 m depth zone was significantly higher than the median in the 500-750 m depth zone (p=0.044). In the shallower depth zone the highest values of the CPUE were observed in May (1.41 Kg/hour) and in January (1.4 Kg/hour), whereas in the deeper zone in July (0.71 Kg/hour). During the other months, the catch never exceeded 0.9 Kg/hour for both zones.

The mean PAL of the species was generally larger than 24 mm, except in four stations (Fig. 15b). The largest mean PAL in stations shallower than 450 m was 27 mm. In the deeper stations the mean PAL was always larger than 24 mm (except in one station). No correlatioin was found between depth and mean length (Spearman rank correlation, p=0.814).

The bathymetrical distribution of the species extended from 350 to 730 m (Fig. 15c, 15d). It was mostly found over the zone 350-400 m and decreased progressively with depth. Highest catches occurred at 350 to 400 m depth. The same distribution pattern was observed in the northwestern Mediterranean (Massuti *et al.*, 1995).

Molva dipterygia macrophthalma

A total of 113 individuals were caught in the area during the sampling period (Fig. 16). The lengths ranged from 300 to 900 mm. The bulk of the population was between 450 and 650 mm. More specimens were caught in the 500-750 m depth zone.

The CPUE of the species in the 300-500 m was 0 during five months (Fig. 17a). The highest value was observed during September (0.7 Kg/hour). In the deeper zone, during January and February the catches were almost null. During the other months the CPUE was higher than 0.5 Kg/hour. The highest value was observed in April (1.2 Kg/hour). The Mann-Whitney test showed that the CPUE in the 500-750 m depth zone was significantly higher than in the 300-500 m depth zone (p=0.002).

There was no relationship between the mean length of the species and the depth (Fig. 17b). The bathymetrical distribution of the species covered all the range of the depths where sampling took place. However, higher catches, both in terms of numbers and of weight were obtained in depths between 550 and 600 m (Fig. 17c, 17d).

Peristedion cataphractum

There were no significant differences between the two depth zones in the length frequency distribution (Fig. 18). The length of the fish ranged from 40 to 310 mm in the shallower depth zone and from 80 to 290 mm in deeper waters. Seasonal differences in the modal length were not observed in both depth zones. The modal length ranged between 150 and 170 mm. Small fish with lengths between 40 and 120 mm appeared in the catch in the 300-500 m depth zone during all seasons but they were more evident during winter and autumn.

The CPUE of the species was higher in the shallower depth zone during all months, except in August (Fig. 19a). The Mann-Whitney W test showed that the difference was significant (p-0.001). In the 300-500 m depth zone higher values (about 3.3 Kg/hour) were observed during winter and March (except in February when the CPUE was 0.69 Kg/hour). During summer and autumn the CPUE in this depth zone was quite constant (1.42-2.16 Kg/hour). In the deeper depth zone during August the CPUE was 3.33 Kg/hour, whereas during the other months ranged between 0.08 Kg/hour (in February) and 1.25 Kg/hour (in June).

No relationship was found between the mean length and the depth (Spearman rank correlation, p=0.60) (Fig. 19b). The larger mean length (271 mm) was observed in 627 m depth. In the other stations the mean length ranged from 115 to 216 mm.

The species was fished in the Ionian Sea at a depth range from 300 to 700 m (Fig. 19c, 19d). The species was found quite abundant in all the stations with depth less than 450 m. In the deeper stations it was not always present and the number and the weight per station showed high variation.

Scyliorhinus canicula

The length of the males *S. canicula* ranged from 200 to 580 mm and the length of the females ranged from 220 to 580 mm (Fig. 20). Both sexes were caught mainly in the 300-500 m depth zone. The bulk of the males were between 300 and 440 mm and of the females between 320 and 420 mm.

The species was more abundant in the shallower depth zone during all months (Mann-Whitney W test, p=0.000) (Fig. 21a). Higher values in this depth zone were observed during summer and autumn. From July to November the CPUE was higher than 2 Kg/hour, whereas from December to June was lower than 1.5 Kg/hour.

The mean length of the males ranged from 296 to 490 mm and of the females from 293 to 460 mm (Fig. 21b). The correlation between depth and mean length has been found not significant for the females (p=0.080) and significant for the males (p=0.038).

The species was caught between 300 and 600 m (Fig. 21c, 21d). The greatest abundance was found in the upper depth (300-400 m).

Biology of the most abundant commercial species

Lepidorhombus boscii

The length of the species ranged from 40 to 420 mm (Fig. 22). During winter, two modal lengths were observed in both depth zones. The first one at length 60 mm and the second one at length 180 mm. During spring and summer the bulk was at 140-200 mm in both zones. In autumn the length frequency distribution was different between the two depth zones. The length classes from 100-120 mm were well represented in the 500-750 m depth zone and were almost absent in the 300-500 m depth zone. The bulk in the 300-500 m depth zone was at 200-260 mm. From the seasonal length frequency distribution of the species a migration of the juveniles from the shallower to deeper waters is indicated.

The CPUE was higher in the shallower depth zone (Mann-Whitney W test, p=0.005) (Fig. 23a). Higher values in this depth zone were observed in January (1.83 Kg/hour) and in September (2.01 Kg/hour). In the 500-750 m depth zone better catches were obtained during summer (highest value of the CPUE in July, 1.10 Kg/hour).

No relation has been found between the mean length and the depth (Spearman rank correlation, p=0.804) (Fig. 23b). The bathymetrical distribution of the species extended almost in all the depths where sampling took place (300-700 m) (Fig. 23c, 23d). It was fished in higher abundance in depths around 380 m (206 fish/hour and 5.05 Kg/hour).

Lepidorhombus whiffiagonis

The species was found in low quantities during the whole study period. The length ranged from 40 to 450 mm (Fig. 24). It was more abundant in the 300-500 m depth zone where two modes were observed. The first one at length 50-100 mm and the second one at length 300 mm.

The CPUE of the species was higher in the 300-500 m depth zone than in the 500-750 m during all months except in July (Mann-Whitney W test, p=0.008) (Fig. 25a). The highest values were observed in the shallower depth zone during September (0.93 Kg/hour) and in the deeper depth zone during July (0.34 Kg/hour).

The mean length of the species ranged from 150 to 368 mm (Fig. 25b). Smaller mean lengths were observed in shallower waters, whereas the largest mean length was observed in 500 m depth. The correlation between depth and mean length was found not significant (p=0.392).

The species was caught almost in all the depths where sampling took place (Fig. 25c, 25d). Higher catches in terms of number were observed at 380 m and in terms of weight at 450 m.

Lophius budegassa

The length of *L. budegassa* ranged from 150 to 750 mm (Fig. 26). In both depth zones the modal length was at ~300 mm. There were no differences in the length distribution between the two depth zones.

The CPUE in the 300-500 m depth zone ranged from 0.33 Kg/hour in August to 5.31 Kg/hour in October, whereas in the 500-750 m depth zone ranged from 0 Kg/hour in January to 3.32 Kg/hour in August (Fig. 27a). The difference in the CPUE between the two depth zones was found not significant (Mann-Whitney W test, p=0.665). During summer the CPUE was higher in the deeper depth zone. A migration of the species in deeper waters during summer could be possible.

The mean length ranged from 270 to 610 mm (Fig. 27b). The relationship between depth and mean length was found not significant (Spearman rank correlation, p=0.392). In the shallower stations (depth <425 m) the mean length was smaller than 350 mm, whereas the maximum mean length was observed in depth 590 m and the minimum in depth 500 m.

The species showed a very wide depth distribution and it was present in all the depths where sampling took place (Fig. 27c, 27d). Thus, the bathymetrical distribution of the species ranged from 300-750 m depth. Higher numbers were observed in depths between 500-600 m.

A relatively low number of monk fish (N=198) was sexed due to the low abundance of the species during the study period. The total length of the examined males ranged from 150 to 570 mm, whereas the females were generally larger (200-700 mm) (Fig. 28a). There was a statistically significant difference between the two length distributions (male and female) at the 95% confidence level (Kolmogorov-Smirnov test, p=0.000). The number of the males examined was higher than of the females (151 and 47, respectively). Overall there were just 2 mature females and they were found in December. The mature males were not abundant and the majority were found in February (8 individuals) and in April (5 individuals) (Fig. 28b).

Merluccius merluccius

The length of *M. merluccius* ranged from 70 to 655 mm (Fig. 29). The number of individuals caught in the deeper depth zone was much lower but the specimens were larger. The modal length in the 300-500 m depth zone in winter was at 130 mm, in spring at 160 mm, in summer at 190 mm and in autumn at 220 mm. A second mode was observed in autumn at 110 mm. The modal length in the 500-750 depth zone in winter was at 160 mm, in spring at 190-200 mm, in summer at 220 mm and in autumn at 280 mm. During all seasons the modal length in the deeper depth zone was larger than in the shallower depth zone. In the 300-500 m depth zone during winter and spring about 85% of the specimens were smaller than 200 mm, whereas during summer and autumn the proportion was 0.43% and 0.27%, respectively. In the 500-750 m depth zone the proportion of the fish with lengths smaller than 200 mm was much lower (54% in winter, 49% in spring, 26% in summer and 0.5% in autumn).

The CPUE of the species was higher in the 300-500 m depth zone during eight out of twelve months (Fig. 30a). However the difference was found not significant (Mann-Whitney W test, p=0.087). In the 300-500 m depth zone higher values were observed during March and September (7.7 and 6.4 Kg/hour, respectively). In the 500-750 m depth zone higher values were observed during summer (2.2 to 3.7 Kg/hour). A possible migration to deeper waters is indicated. The distribution of length frequency in relation to depth of hake in Saronikos and Thermaikos gulfs indicated a tendency of hakes to migrate in deeper waters (Tsimenidis *et al.*, 1978).

The mean length of the species was increasing with the depth (Spearman rank correlation, p=0.027) (Fig. 30b). Larger mean lengths were observed in depths between 500-550 m. In stations deeper than 450 m the mean length was always larger than 175 mm.

M. merluccius in the study area had a wide depth distribution and was fished between 300 and 700 m (Fig. 30c, 30d). The main bulk of the population was caught in depths <450 m.

During the sampling period the majority of the hake caught were small (less than 20 cm TL) therefore, they were discarded for sexual maturity examination. The lengths of the hake examined ranged from 150 to 600 mm and from 150 to 700 mm TL for the males and females, respectively (Fig. 31a). There was a statistically significant difference between the two length distributions (male and female) at the 95% confidence level (Kolmogorov-Smirnov test, p=0.019). The number of the examined females was higher than of the males (174 and 77, respectively). The majority of the specimens examined were caught during September (39 females and 25 males). Almost no mature individuals of both sexes were found (Fig. 31b).

Micromesistius poutassou poutassou

The species was more abundant in the shallower depth zone during all seasons except in summer (Fig. 32). The lengths of the specimens ranged from 110 to 420 mm. Larger specimens were caught in the deeper depth zone. Thus, in the 300-500 m depth zone, the bulk of the population during winter was at 200-270 mm, during spring at 200-220 mm, during summer at 260-310 mm and during autumn at 290-320 mm. In the 500-750 depth zone the bulk of the population during winter was at 270-310 mm, during spring at 300-340 mm, during summer at 310-330 mm and during autumn at 300-310 mm.

The monthly fluctuation of its catches was quite similar to that of *M. merluccius* (Fig. 33a). The CPUE was generally higher in the 300-500 depth zone, but it was higher in the 500-750 m depth zone during July to September. The difference between the two depth zones was found not significant (Mann-Whitney W test, p=0.052). The highest catches in the 300-500 m depth zone were obtained in January (5.4 Kg/hour) and in March (10.8 Kg/hour), whereas in the deeper depth zone in August (2.5 Kg/hour) and in September (2.4 Kg/hour).

The mean length of *M. poutassou* was increasing with the depth (Fig. 33b). The Spearman rank correlation was found significant (p=0.000). Smaller mean lengths were observed at depth 350 m (215 mm) and larger at depth 650 m (370 mm).

The species was fished in the Ionian Sea at depths ranging between 350 and 720 m (Fig. 33c, 33d). It was mainly caught at depths <400 m, being the most abundant catch at 382 m (486 fish/hour and 39.77 Kg/hour).

The length of the sexed blue whiting females ranged between 220 and 430 mm TL, but almost all specimens had lengths ranging from 300 to 400 mm (Fig. 34a). On the other hand, males were smaller than females, having lengths from 200 to 410 mm TL, while the bulk was at 250-350 mm. The difference on the males and females length distribution was significant at the 95% confidence level (Kolmogorov-Smirnov test, p=0.000). In total 294 female and 246 male fish were examined. Mature specimens of both sexes were found during December, January and November (Fig. 34b).

Phycis blennoides

No particular difference was displayed in the length distribution and in the abundance of the species between the two depth zones (Fig. 35). The length ranged in both zones from 50 to 550 mm. The majority of the fish had lengths from 100 to 200 mm. The bulk of the population had larger lengths in the 300-500 m depth zone than in the 500-750 m during all seasons. This is not in accordance with the distribution of this species in the Northwestern Mediterranean slope, where there was found a distinct bathymetrical distribution of the small and large sized specimens, specifically an increase of mean size with depth (Massuti *et al.*, 1996). The recruitment of the species took place mainly in the 500-750 m depth zone. Thus, juveniles with length 50-75 mm appeared in the catch in both depth zones during spring but in the following seasons the presence of the juveniles is more significant in the catch of the 500-750 m depth zone.

The CPUE was higher in the 300-500 m depth zone during winter and autumn and in the 500-750 m depth zone during spring and summer (Fig. 36a). The difference in the CPUE between the two depth zones was found not significant (p=0.563). In the 300-500 m depth zone higher values were observed in February (2.5 Kg/hour) and in April (2.4 Kg/hour), whereas in the 500-750 m depth zone in April (4.4 Kg/hour) and in August (2.2 Kg/hour).

Even though small mean lengths were observed in the shallower stations and large in the deeper stations, the relationship between depth and mean length was found not significant (Spearman rank correlation, p=0.083) (Fig. 36b). The smallest mean length was observed in depth 570 m (100 mm) and the largest in depth 640 m (322 mm).

The species showed a broad bathymetrical distribution and it was present in all the stations except in four stations between 350-380 m and one station in depth 575 m (Fig. 36c, 36d). The bathymetrical distribution of the species extended from 300 to 725 m, but the main bulk of the population was located at the 350-600 m depth interval. The highest abundance in terms of number was observed at the depth of 600 m (43 fish/hour) and in terms of weight at 500 m (6.15 Kg/hour).

The length of the sexed *P. blennoides* females ranged from 140 to 560 mm TL with a peak at 270 mm (Fig. 37a). The male individuals were smaller ranging from 150 to 490 mm TL. There was a statistically significant difference between the two length distributions (male and female) at the 95% confidence level (Kolmogorov-Smirnov test, p=0.007). Overall, the number of females examined was higher than the number of males (171 and 43 specimens, respectively). The number of mature males and females was almost null (1 mature female was found in April and 1 mature male was found in September) (Fig. 37b).

Squalus blainvillei

The species was caught in low abundance in the 300-500 m depth zone. (Fig. 38). In the deeper depth zone only some males were caught. The length of the males ranged from 200 to 900 mm and of the females from 200 to 850 mm. The bulk of the males were at 500-600 mm, whereas two modes were observed for the females. The first one at 500-600 mm and the second one at 650-700 mm.

The CPUE of the species was higher in the 300-500 m depth zone during all months (Fig. 39a). The Mann-Whitney W test showed significant difference between the two depth zones (p=0.000). The CPUE was quite high in comparison with the other species. Higher values were observed in July (22 Kg/hour) and in October (23.9 Kg/hour).

The correlation between mean length and depth was found not significant for both sexes (Spearman rank correlation, p=0.634 for the females and p=0.166 for the males) (Fig. 39b).

Eventhough the bathymetrical distribution of the species was broad, the majority of the fish were caught in depths less than 450 m (Fig. 39c, 39d). The species was present in a depth range from 300 to 715 m.

Trigla lyra

A small number of specimens was caught and almost all of them at the 300-500 m depth zone (Fig. 40). The bulk of the population was at 200-260 mm.

The CPUE was significant higher in the 300-500 m depth zone (Mann-Whitney W test, p=0.000) (Fig. 41a). Higher catches were obtained in May and in August (1.3 Kg/hour).

The correlation between mean length and depth was found not significant (Spearman rank correlation, p=0.614) (Fig. 41b). The bathymetrical distribution ranged between 300-600 m (Fig. 41c, 41d). The species was caught in highest abundance at depth 300-400 m.

<u>Nephrops norvegicus</u>

The length frequency distribution of the males and the females *N. norvegicus* is presented in Figure 42. The lengths of the males ranged from 8 to 70 mm CL. There was not clear difference between the two depth zones except in autumn when more large specimens were caught in the 300-500 m depth zone. Young males (8-17 mm CL) appeared in the catch during spring. Generally, smaller individuals were caught in both depth zones during autumn. In the 300-500 m depth zone the mode of the distribution during winter and spring was at 46 mm CL, during summer at 44 mm CL and during autumn at 32 mm CL. In the 500-750 m depth zone the mode of the distribution during winter was at 58 mm CL, during spring at 50 mm CL, during summer at 42 mm CL and during autumn at 28 mm CL.

The females were smaller than the males. Their lengths ranged from 5 to 55 mm CL. During winter the small specimens (17-37 mm CL) were caught almost in the 500-750 m depth zone. Young females (5-11 mm CL) appeared in the catch during spring. In the 300-500 m depth zone the mode of the distribution during winter was at 41 mm CL, during spring at 39 mm CL, during summer at 37 mm CL and during autumn at 41 mm CL. In the 500-750 m depth zone the mode of the distribution during winter was at 39 mm CL, during spring at 43 mm CL, during summer at 41 mm CL and during autumn at 39 mm CL.

The CPUE of *N. norvegicus* was higher in the 300-500 m depth zone during all months except in December and July (Fig. 43a). The difference was found significant (Mann-Whitney W test, p=0.011). Higher values in the 300-500 m depth zone were observed from February to June (0.8-1.5 Kg/hour). In the deeper zone, it was less abundant. The highest value was observed in April (0.8 Kg/hour).

The correlation between depth and mean length were found not significant for both sexes (Spearman rank correlation, p=0.983 for the males and p=0.262 for the females) (Fig. 43b). Generally, the mean length of the males was larger than the mean length of the females.

N. norvegicus showed a broad bathymetrical distribution (Fig. 43c, 43d). It was found in depths from 350 to 700 m but almost all individuals were present in the 450-550 m depth interval. The species was caught in highest abundance at 486 m (67 specimens/hour and 3 Kg/hour). In the Gulf of Gadiz is reported that the largest individuals were usually found at greatest depths (Fernadez and Farina, 1984).

Biology of *Aristeus antennatus*

<u>Introduction</u>

The blue-red shrimp *A. antennatus* (Risso, 1827), is a decapod crustacean belonging to the family Aristeidae. The spatial distribution of this species is quite complex (Sarda *et al*., 1993), but normally the species shoals in deep waters of the upper and middle slope (400-800 m) and is caught by trawling on muddy bottoms, near to submarine trenches and canyons. The blue-red shrimp is mainly distributed in the central-western Mediterranean Sea, in the Eastern Atlantic Ocean from Portugal to Cape Verde islands and Azores, in South Africa, Mozambique, Zanzibar, Madagascar, Malvide islands (Farfante and Kensley, 1997).

<u>Catch per unit of effort fluctuations (CPUE)</u>

The species was present in the 300-500 m depth zone only from January to March (Fig. 44). The maximum value in this depth zone was observed in February (2.42 Kg/hour). In the 500-750 m depth zone the species was caught all the year and the CPUE was increasing from December (0.8 Kg/hour) to May (7.69 Kg/hour). During the following months the CPUE was lower and ranged from 0.5 Kg/hour (June) to 3.7 Kg/hour (July). The difference in CPUE between the two depth zones was found significant (Mann-Whitney test, p=0.000).

A. antennatus is a species that shows high fluctuations in the abundance in the whole Mediterranean basin (Sarda, 1993; Sarda *et al*., 1993). Generally this fluctuation is correlated with seasonal migrations of this species (Maynou *et al.*, 1996). Similar results as in the East Ionian Sea have been observed in the West Ionian Sea (SE Italy). During 1990 higher quantities were landed in March and April. The availability of the species showed an increase in late winter until early spring (Vacchi *et al*., 1994). In Catalan Sea this increase has been correlated to the beginning of the period of the gonadal ripening and fertilisation (Sarda and Demestre, 1987).

During spring 1985 in the Gulf of Taranto (Italian Ionian Sea) the CPUE was 5.5 Kg/hour, while in September of the same year was decreased at 1.3 Kg/hour (Tursi *et al*., 1993a). In Calabria, the average daily yield of *A. antennatus* was maximum in March 1990 (13.34 Kg/hour). Generally, the catch of the species in this area has not changed dramatically during the decade 1980-1990 (Vacchi *et al.*, 1994). In the SE Tyrrhenian Sea the catch during 1990-1993, showed a grand mean of 2.2 Kg/hour, and a maximum of 12 Kg/hour in spring 1992 (Greco *et al*., 1994). In the South coast of Portugal, the abundance of the blue-red shrimp ranged from 1 to 10 Kg/hour in all seasons in depths between 500-600 m (Ribeiro-Cascalho, 1987). In Spain (region of Murcia) maximum quantities were landed in summer and minimum in winter (Martinez-Banos, 1994), while in Majorca island the daily catch of the commercial bottom trawler in 1991 usually varied between 4 and 25 Kg/hour (Carbonell, 1994).

Length frequency distribution

A total of 8551 individuals of *A. antennatus* were caught during the sampling period. The majority of the catch was consisted of females (87.1%). Monthly length frequency distributions of males and females are presented in Figure 45 and Figure 46, respectively. The shrimps were measured using a pair of callipers (precision 1 mm), recording the oblique length of the carapace (CL).

A total of 1302 males were caught during the sampling period (335 in winter, 844 in spring, 33 in summer and 90 in autumn). Males ranged in lengths between 9 and 42 mm, but the bulk of them occurred between 23 and 29 mm. This was the dominant size group in almost all the months. Young individuals (9-15 mm) were present mainly in January.

During winter, the carapace lengths of the male specimens ranged from 9 to 42 mm but the bulk of them were between 23 and 29 mm (Fig. 45). The smallest individual was caught in January, while the largest one in December. In spring, their lengths ranged from 18 to 35 mm but most of them were between 22-32 mm. In summer, the lengths ranged between 21 and 36 mm. Most of them occurred in a length range from 27 to 32 mm. In autumn, the males had a length range from 20 to 34 mm and the bulk of them were between 23 and 30 mm.

A total of 7249 females were sampled (1083 in winter, 3469 in spring, 1120 in summer and 1577 in autumn). Females ranged in lengths between 11 and 62 mm, but the bulk of them occurred between 27 and 45 mm. Young-of-the-year (11-13 mm) appeared as recruits in the trawl fishery in January and March.

During winter, the female specimens ranged in lengths from 11 to 57 mm CL and the bulk of them were found in the range of 27 to 43 mm (Fig. 46). The smallest specimen was caught in January and March while the largest one in May. In spring, their lengths ranged from 11 to 61 mm and the bulk were found to be between 25 and 51 mm. In summer, the lengths ranged between 23 and 59 mm and most of them occurred between 33 and 51 mm. In autumn, females ranged in lengths from 19 to 57 mm and most of them lied between 29 and 49 mm CL.

The largest individuals were caught in spring and summer, when the spawning season takes place. In addition, the highest number of individuals in both sexes was found in spring.

A Kolmogorov-Smirnov test was performed per sex in order to detect significant differences at the 95% confidence level in the length frequency between seasons. For the males, significant differences were observed in all the examined pairs, except the following two: spring-summer and summer-autumn. For the females, all the examined pairs of length distributions were significantly different.

In the Strait of Sicily, the carapace length of females ranged between 22 and 66 mm, while the average length of males was 29.7 mm (Ragonese and Bianchini, 1996). In Portuguese waters the length of males ranged from 21 to 39 mm and of females from 18 to 66 mm (Arrobas and Cascalho, 1984). In the Italian Ionian Sea, the mean carapace length of females was larger in autumn than in spring samples (44±11 and 40±5 mm CL, respectively). However, males caught in spring, presented higher dimensions than those sampled in autumn (27±1 and 26±5 mm CL, respectively) (Tursi *et al*., 1993a). Recruitment, in the same area, takes place in various months (July, August and September). In the Catalan Sea, recruitment takes place in July-August for males (20-22 mm) and in May-June for females (18-25 mm) (Sarda and Demestre, 1987).

Mean length distributions in relation to depth

The mean length in each station was plotted for each sex against the depth in Figure 47. However, the relationship between mean length and depth was examined seasonally.

The relationship between mean carapace length and depth was not clear for both sexes. The Spearman rank correlation between mean length and depth was not statistically significant for both sexes (p=0.371 for the females and p=0.978 for the males). The smallest mean length of the males (16 mm CL) was observed in depth 564 m and the largest (32 mm CL) in depth 590 m. Except the minimum and the maximum values, the range of the mean lengths of the males *A. antennatus* was restricted (23-29 mm CL). Larger mean lengths of the females were observed in depths between 520-600 m. The smallest mean length (28 mm) was observed in depth 690 m and the largest (45 mm) in depth 525 m. The range of the mean length values of the females was more wide than of the males (28-45).

The larger mean lengths of the males in winter were observed in depths 510-600 m, in spring, in depths 520-590 m, in summer in depths 530-590 m and in autumn in depths 560-640 m.

The mean length of the females during winter was quite constant in all the stations and ranged between 30-36 mm CL, whereas during the other seasons the range was wider. Higher values in spring were observed between 520-590 m, in summer between 520-630 m and in autumn between 580-640 m.

A decreasing trend of the mean length with the depth has been indicated for the species in the Catalan Sea (Sarda and Cartes, 1993). In the same area the percentage of smaller individuals tended to increase with depth. On the contrary, the mean length of both sexes was increasing in the deeper samples, according to Carbonell *et al*., (1998) in the area between Gibraltar strait and Cape Creus (Spain).

<u>Carapace length-weight relationships</u>

The carapace length-weight relationships were based on the regression $W = aL^b$, where W = weight, L = carapace length and a, b = constants. The relationship was estimated for both sexes separately seasonally(Table 6).

Differences in slopes and intercepts between the sexes were tested seasonally using analysis of covariance (ANCOVA). The slopes differ significantly between the two sexes (ANCOVA, $P<0.01$) all the seasons.

The slope of the regressions indicated an allometric growth for this species, since the coefficient b is about 2 (less than 3). Females were heavier than males in all seasons except in autumn. In summer the weight of the females increased confirming a late spring-summer spawning season. The estimated parameters are in agreement with other studies (Table 7).

<u>Depth distribution by number and by weight</u>

In order to examine the relationship between the abundance of *A. antennatus* and the depth, the logarithms of the total weight+1 and the total number+1 of the individuals in each station were plotted against depth for each sex (Fig. 48). This relationship has been also examined for each sex seasonally.

There were no differences in the range of the bathymetrical distribution of the two sexes (Fig. 48). Thus, both sexes were presented in depths from 450 to 730 m. Higher abundance for both sexes were observed in spring at depths between 500-600 m. The highest catch of the males in terms of number was 210 ind./hour and in terms of weight 19.37 Kg/hour and was obtained in depth 590 m, whereas of the females in terms of number 949 ind./hour and in terms of weight 28.9 Kg/hour and was obtained in depth 564 m.

Differences were observed in the seasonal depth distribution of the males and the females *A. antennatus*. During winter and summer both sexes were distributed from 480-730 m and were more abundant between 480-580 m. In spring and autumn the distribution was narrower and the majority of the individuals were caught between 550-600 m. Concluding, the abundance of the species seemed to be increasing with depth from spring to autumn.

According to Demestre (1994), *A. antennatus* is distributed over muddy grounds in depths from 350 m to below 800 m. Specimens were caught in the Catalan Sea between Barcelona and the Balearic Islands at depth 600-2200 m, where the abundance was decreasing with the depth (Sarda and Cartes, 1994). In the Italian Ionian Sea the species was fished always at depths greater than 400 m (Matarrese *et al*., 1994). In the same area the two sexes have not showed significant differences in the bathymetrical distribution.

<u>Reproduction</u>

Overall, 3926 individuals of *A. antennatus* were sexed. The males consisted 14.69% (577 individuals) and the females consisted 85.31% (3349 individuals). The sex ratio per month is presented in Figure 49. The females were more abundant than the males in all the cruises. The proportion of the males was higher in December (40.7%), while it was lower in June and July (~1%). Therefore, the highest proportion of the females was found in June and July (~99%).

Similar results have been reported in other areas of the Mediterranean Sea. In the Catalan Sea, the sex ratio (M/F) of *A. antennatus* in spring was 1/2.5, in autumn 1/1.8, in winter 1/2.1 and in summer 1/92.7 (Sarda *et al.*, 1997; Sarda and Demestre, 1987). In the Ligurian Sea the sex ratio was 1/12 (M/F) (Relini-Orsi and Pestarino, 1980). In the Tyrrhenian Sea, the females showed a clear dominance, as in summer 1993 the ratio was 1/4 and in autumn 1/8 (Spedicato *et al.*, 1995). In the South Portuguese coasts, the females consisted 77-84% of the catch in the quadrennial 1981-1984. In this region females were more abundant at the beginning of maturation period (April-May), while males in September-October (Arrobas and Ribeiro-Cascalho, 1987).

The proportion of the females bearing spermatophores (mated females) is illustrated in Figure 49. The absence of spermatophores indicated either a virgin or a spent specimen. Females of all the maturation stages were found carrying spermatophores. It is possible that they play a role in inducing ovarian maturation rather than simply being passive sperm containers.

Spermatophores were found during all seasons on the thelycum. The proportion of the females with spermatophores in winter was 17.90%, in spring 79%, in summer 75.08% and in autumn 78.49%. In December no specimens bearing spermatophores were found, while in August almost all the females were mated (98.57 %). In general, the proportion of the females bearing spermatophores was higher from April to September (breeding season) (Fig. 49). The minimum length of mated female was caught in March (19.16 mm CL) in 540 m depth, while the maximum one in May (62.38 mm CL) in 564 m depth.

Almost all the females were found to bear spermatophores in the South Portuguese coasts, during April to August, (reproduction period). During the rest of the year, only a few females maintained spermatophores with the resting ovaries in the spent stage (Arrobas and Ribeiro-Cascalho, 1984). Same observations has been done in the Ligurian Sea (Relini-Orsi and Pestarino, 1980; Relini-Orsi and Relini, 1979). In the Catalan Sea, the highest proportion of the mated females was obtained consistently between May and September (80 to 100%), when all the females displayed ripe ovaries (Demestre, 1995). In the Northern Tyrrhenian Sea the 64% of the females *A. antennatus* had spermatophores in the thelycum. During spring the proportion of the mated females was 60% and during summer was 87% (Righini and Abella, 1994).

The maturity stages of the ovaries were determined of fresh specimens, according to the scale proposed by Relini-Orsi and Relini (1979) for *A. antennatus.* As "immature" were considered the females of the stages I and II, while as "mature" these of the stages III and IV. The maturity of the males was related to the degree of fusion of the petasma, the presence of spermatic masses in the terminal ampulla (Tunesi, 1987; Relini-Orsi and Relini, 1979) and the presence of the appendix masculina (Demestre and Fortuno, 1992). The percentages of mature and immature females during the study period are presented in Figure 49.

Mature females were observed first in May when they consisted the 43% of the examined females. In June their proportion was 37%, in July the proportion was the highest (97%) in August 85% and in September 32%. During the other months no mature females have been observed. Generally, the percentage of the mature females was 73.46% during summer. The smallest mature female was 29.95 mm CL and was caught in July (570 m depth), while the largest one was 60.60 mm CL and was caught the same month in the same depth. An overlap was observed in the carapace length per maturation stage. According to our observation the reproductive period of *A. antennatus* in the East Ionian Sea extended between May and September.

All the males were found mature. The smallest mature male (determined by the presence of sperma in the terminal ampulla) was 20.97 mm CL and was caught in April (720 m depth).

The examination of the gonads and the presence of the spermatophores showed that the period of mating was more extended than the period of reproduction. Thus, the period of mating extended from January to September and the period of reproduction extended from May to September. Eventhough the higher proportions of mated and of mature females were observed in the same period (summer).

In the Catalan Sea the spawning period occurred between June and August and at least three spawnings were possible within the same reproductive period (Demestre, 1995). In the S. Portuguese coast, the development of the gonads began in April-May attaining its maximum in June-July (Arrobas and Ribeiro-Cascalho, 1984). The smallest female with ripe ovary was 27 mm. In the Sardinian Channel the maturation of the gonads of this species begins the second half of June till the first half of October. The highest proportion of the ripe ovaries has been observed at the end of July (Mura *et al*., 1992). In the Ligurian Sea, the spawning of *A. antennatus* takes place in summer and autumn and the smallest ripe male was 20 mm CL while the female 31 mm (Relini-Orsi and Relini, 1985). In the gulf of Genoa, during July to October, the females with ripe ovaries represented 20-50% while the smallest observed ripe female was 31 mm CL (Relini-Orsi, 1982).

Mature males throughout the year, has been also reported in other areas. In the S. Portuguese coast, Arrobas and Ribeiro-Cascalho (1984) referred that although males were mature all the year, they were sexually active only from April to August. In the Catalan Sea, males were also mature during all the year (Sarda and Demestre, 1987).

Age determination

Bhattacharya's method implemented in the package FiSAT, has been used in order to identify the different normally distributed size groups in the polymodal distribution of the males and the females *A. antennatus*. All the age groups were derived from at least three consecutive points. The identified age groups from the length frequency analysis per month, are presented for each sex, in Tables 8 and 9.

The carapace length of each group, using combined data, of the males was 17.32, 23.92, 28.36 and 34.28 mm and of the females was 20.34, 29.67, 40.73 and 50.17.

Comparing the two sexes, fewer age groups were identified for the males. Since the number of males during some months was very low, it was not possible to determine the age groups of the available data. Four age groups were defined using the monthly samples of the males and five age groups using the monthly samples of the females. However, five age groups for the females have been determined only in January. The general pattern shows that the female longevity (around 4-5 years) was greater than this of the males (around 2-4 years). The normal components, corresponding to these age groups, showed high separation index (S.I.) and low standard deviation (S.D.) for both sexes.

The same method (Bhattacharya) has been used in Majorca island waters (Carbonell, 1994). Five normally distributed size groups have been identified in females, around 22, 30, 40, 48 and 59 mm CL. In males, four normally distributed size classes have been detected around 18, 22, 27 and 32 mm CL. The same number of age groups has been determined in the region of Murcia (SE Spain) for both sexes (Martinez-Banos, 1994), in the Catalan Sea (Demestre, 1994; Demestre and Lleonard, 1993), in the French Mediterranean (Campillo, 1994). In the Strait of Sicily two clear modes have been observed (Ragonese and Bianchini, 1996).

Growth

The growth parameters for each sex are presented in Table 10. The infinity length of the males is smaller than that of the females. The values of K denote that metabolic rates of males are higher than those of females. A certain coincidence derived from a comparison of our results to those of other authors (Table 11).

Biology of *Aristaeomorpha foliacea*

Introduction

The giant red shrimp *A. foliacea* (Risso, 1827) is a decapod crustacean belonging to the family Aristeidae. This species was found in the Mediterranean Sea, Eastern Atlantic (off Morocco and south-western Sahara and Portugal), South Africa, Northern-Western Atlantic (from Venezuela and the Gulf of Mexico to North Carolina), Indian Ocean and Western Pacific-Japan, Australia, New Zealand (Holthuis, 1980).

Catch per unit of effort fluctuations (CPUE)

The CPUE of *Aristaeomorpha foliacea* was higher in the 500-750 m depth zone (Mann-Whitney test, p=0.000). In the 300-500 m depth zone was maximum in January (8.1 Kg/hour), during the following months showed a reduction until May when the CPUE reached the minimum value (0.5 Kg/hour) (Fig.50). On the other hand, in the deeper depth zone (500-750 m) the CPUE was increasing until April (20.12 Kg/hour), during May and June it was decreasing and during the following months the CPUE was quite constant (9.1 Kg/hour to 14.8 Kg/hour).

In the South coast of the Portugal *A. foliacea* was caught in small quantities in the depth zone between 500-600 m (1-5 Kg/hour) (Ribeiro-Cascalho, 1987). In the Italian waters (Ionian Sea) the average catch was much lower (0.2 Kg/hour in spring and 0.1 Kg/hour in autumn). The species was present only in the 500-600 m depth zone (Tursi *et al.*, 1993a). Higher catches were observed in the Central Tyrrhenian Sea (up to 5 Kg/hour in depth more than 500 m) (Mori, 1994). In experimental surveys in the Sicilian Channel the catch was around 3 Kg/hour, with peaks at 9 Kg/hour (Ragonese *et al.*, 1994a). A decreasing trend was observed in this area, from 25 Kg/hour in the early '60s to 8 Kg/hour in 1972 and 5 Kg/hour in 1988. In the Australian waters the catch rates were usually between 25 and 50 Kg/hour (Wadley, 1994). Higher catches in spring have been also referred in the Italian Ionian Sea (Matarrese *et al.*, 1994), while smallest catches during winter have been also observed in the Sardinian waters (Murenu *et al.*, 1994).

Length frequency distribution

A total of 37227 individuals of *A. foliacea* were caught during the sampling period. Males formed 54% of the total catch. The length frequency distribution of males and females per month, are presented in Figure 51 and Figure 52, respectively.

A total of 20092 males were caught during the sampling period (4061 in winter, 6496 in spring, 4383 in summer and 5152 in autumn). The male specimens ranged in lengths between 18 and 44 mm, but the bulk of them occurred between 29 and 38 mm. There is no clear seasonal length variation in this species. The peak of the distribution ranged between 32-34 mm CL. Young individuals (18-24 mm) are present mainly in winter and spring.

During winter, the carapace length of the male specimens ranged from 18 to 44 mm, but the bulk of the sample was from 30 to 36 mm. The smallest specimen of the catch (18 mm) was fished in January. Relatively bigger individuals were caught during spring and summer. In spring, their length ranged between 21 and 41 mm, but the bulk of the sample was between 30 and 36 mm. In summer, the caught specimens extended in a length interval of 25-40 mm, but most of them occurred in a length range from 31 to 37 mm. In autumn, males had a length range between 24 and 41 mm, while the bulk of them lied between 31 and 37 mm CL.

A total of 17135 females were sampled (3044 in winter, 6157 in spring, 3915 in summer and 4019 in autumn). The carapace length of the female specimens ranged between 16 and 62 mm, but the bulk of the individuals ranged between 36 and 50 mm. In both sexes, the highest number of individuals was fished during spring. The appearance of juveniles (~16 mm) was observed in February and March, but the recruitment (20-26 mm) was more evident in June and July.

During winter, the length of the females ranged from 16 to 60 mm CL and the bulk of them lied between 36 and 48 mm. In spring, their length ranged from 16 to 60 mm and the bulk of the sample occurred between 36 and 50 mm. In summer, the length ranged from 20 to 56 mm. Most of them occurred in a length range from 38 to 50 mm. In autumn, females had a length range from 24 to 54 mm and most of them lied between 38 and 50 mm CL.

A Kolmogorov-Smirnov test was performed on pairs per sex between seasons, in order to detect differences in the length frequency. The P-value was less than 0.05 in all pairs, so there was a statistically significant difference between the two distributions.

In the Northern Tyrrhenian Sea the smallest female specimen of the species was 25 mm CL and the largest one 57 mm CL, while the smallest male was 31 mm CL and the largest one 39 mm CL (Righini and Abella, 1994). In the Northern Ionian Sea the minimum and maximum length of females was 16 and 72 mm, respectively, while the periods of recruitment were restricted (D' Onghia *et al*., 1994). In the Eastern Sicily coast, Pipitone and Andaloro (1994) reported a length range of 28 to 45 mm CL for males and 16 to 65 mm CL for females. The recruitment (~25 mm CL) in the Sicilian Channel was also limited at the spring and summer months (Ragonese *et al*., 1994a).

<u>Mean length distributions in relation to depth</u>

The mean length in each station was plotted for each sex against the depth (Fig. 53). The mean carapace length for both sexes of *A. foliacea* tends to increase with depth. The correlation was found significant for both sexes. (Spearman rank correlation, p=0.000 for the males and p=0.009 for the females). Minimum mean length of the males (28 mm) was observed in depth 500 m and maximum (36 mm) in depth 730 m while minimum mean length of the females (35 mm) in depth 610 m and maximum (49 mm) in depth 660 m.

The increase was more obvious in winter and spring, while no clear relationship seems to exist during summer and autumn for both sexes.

In the Southern Tyrrhenian Sea the mean carapace length of *A. foliacea* was increasing according to depth. At 200-450 m it ranged from 29.8 to 33.9 mm CL and at 450-700 m from 38.2 to 42.7 mm CL. (Spedicato *et al*., 1994). The same positive correlation between carapace length and depth has been observed in the Sicilian Channel.

Carapace length-weight relationships

The carapace length-weight relationship was estimated seasonally per sex seasonally (Table 12).

Differences in slopes and intercepts between the CL-W regressions of the two sexes were tested using analysis of covariance (ANCOVA). The slope differed significantly between the two sexes (ANCOVA, $P<0.01$).

The slope of the regression indicated an allometric growth. Females were heavier than males in all seasons. In Table 13 the parameters of the length–weight relationship of the species in other areas of the Mediterranean are presented.

Depth distribution by number and by weight

In order to examine the relationship between the abundance of *A. foliacea* and the depth, the logarithm of the total weight+1 and the total number+1 in each station were plotted against depth for each sex (Fig. 54). This relationship has been also examined for each sex seasonally.

Both sexes showed a wide depth distribution and extended from 350-730 m but the higher catches were obtained between 450-600 m. The highest abundance of the males were observed in depths 500-550 m and of the females in depths 450-550 m.

The highest abundance of the males in terms of number was 1297 ind./h and in terms of weight 21.97 Kg/hour and of the females was 988 ind./h and 26.94 Kg/hour in terms of numbers and weight, respectively. The maximum abundance has been found in spring for both sexes. The same predominance of males has been also referred in the Strait of Sicily (Bianchini *et al*., in press).

The vertical distribution of *A. foliacea* ranged between 430-650 m in the Southern Tuscany archipelago (Mori *et al*., 1994), from 450 to 700 m in the South Eastern Tyrrhenian Sea (Greco *et al*., 1994), from 375 to 550 m depth in NW slope of Australia (Wadley, 1994).

Reproduction

The sex ratio was estimated from 8798 individuals (4704 males and 4094 females) (Fig. 55). Even though the sex ratio remained close to 1:1 in almost all the months, males seemed to present a slight predominance. The only extreme values were observed in April (the sex ratio was 1/1.57 in favour of females), in October (1/1.8 in favour of males) and in November (1/1.7 in favour of males).

The sex ratio of the species, in the Sardinian Channel (Mura *et al*., 1997) does not differ significantly from 1:1, while in the Sicilian Channel females were more abundant than males during spring 1985 to winter 1987 (Ragonese and Bianchini, 1995). In the North Tyrrhenian Sea females were always more abundant than males (Righini and Abella, 1994), while in the Latium coast the proportion was 1.06:1 in favour of males (Leonardi and Ardizzone, 1994).

The mating season of *A. foliacea* is longer than this of *A. antennatus*. Almost all the females carried spermatophores during the year and the percentages by season were: 86.94% for winter, 93.77% for spring, 95.05% for summer and 94.1% for autumn. The percentage of the non-mated females ranged from 0.69% (August) to 16.75% (January). The minimum length of female with spermatophores was measured in January (17.87 mm CL, at 637 m depth), while the maximum one in March (61.49 mm CL, at 573 m depth) (Fig. 55).

In the Sardinian Channel, the lowest percentage of females with spermatophores has been observed between October and January and this percentage was never less than 38% (Mura *et al*., 1992). In the same area females showed a longer mating period than *A. antennatus*. Females with the spermatophores on the thelycum in the Central Tyrrhenian Sea were observed throughout the year, with the highest presence in March (93.7%) and April (84.6%) and the lowest in November (10.4%) (Mori *et al.*, 1994).

The maturity stages of the ovaries were recorded on fresh specimens, according to the scales proposed by Levi and Vacchi (1988) for *A. foliacea.* As "immature" are considered females of the stages I and II, while as "mature" these of the stages III and IV. The male maturity was determined by using the same criteria as for *A. Antennatus*. The percentages of mature and immature females are presented in Figure 55.

The mature females were abundant almost exclusively during summer. In winter, all the females were found immature. In spring, only few mature individuals have been observed (4.37%), while in summer they consisted 70.76%. From June to August, the percentage of the mature females ranged from 55% to 79.16%. In autumn, mature females consisted 15.15%. During October and November no mature females were found. The smallest mature female was 36.91 mm CL and was caught in July at 571 m depth, while the largest one was 55.05 mm and was caught the same month, in the same depth.

All the males were found mature. The smallest mature male was 26.69 mm CL and was caught in September at 564 m depth.

The reproductive period of *A. antennatus* starts earlier than *A. foliacea*. Follesa *et al*. (1998) suggested a greater gametogenetic intensity and consequently a greater fertility of the first species. The reproduction of *A. foliacea* starts in spring and peaks in summer (Ragonese and Bianchini, 1995; Mura *et al*., 1992; Levi and Vacchi, 1988). In the Central Tyrrhenian Sea the reproduction of *A. foliacea* took place during a long spawning season between the end of April and the second half of September (Mori *et al.*, 1994).

The smallest mature individual in the Italian Ionian Sea had a length of 35 mm CL (D' Onghia *et al.*, 1994). In the Australian waters the ovaries were generally full developed in females of 40 mm CL and in males of 29 to 31 mm CL (Wadley, 1994). In the Ligurian Sea the corresponding carapace lengths were 35 and 30-32.5 mm, respectively (Relini-Orsi and Relini, 1985).

Age determination

Bhattacharya's method implemented in the package FiSAT, has been used in order to identify the different normally distributed size groups in the polymodal distribution of the males and the females *A. antennatus*. All the age groups were derived from at least three consecutive points. The identified age groups from the length frequency analysis per month are presented for each sex, in Tables 14 and 15.

The general pattern showed that the longevity of both sexes rises to 2-4 years. Using combined data the carapace length for each age group of the females was 26.72, 40.74, 49.28 and 56.96 and of the males 23.06, 33.37 and 38.83.

Three age groups with corresponding mean carapace length for each group 33, 42 and 49 mm were found for the females except in December and May when four age groups were found (the mean length of the forth group was 54 mm).

The mean carapace length for the age groups of the males was 30, 35 and 38 mm. Only in November and December were found four age groups (the mean carapace length of the fourth was 41 mm). The normal components, corresponding to these age groups, showed high S.I. and low S.D. for both sexes.

In the Sicilian Channel, two modal pulses were discriminated for the juvenile females *A. foliacea* and two to three "years" were visible for the adults. Similar results were found for the males but the model was less well defined and valid (Ragonese *et al*., 1994b). In the Central Tyrrhenian Sea the life span of the females has been estimated to three years, while of the males to two years (Leonardi and Ardizzone, 1994). In the upper part of the Ionian Sea, no more than two modes were exhibited in the size composition of the males (D' Onghia *et al*., 1994). Using MIX analysis to analyse the normal components of the size distribution of *A. foliacea* caught in Australia, Wadley (1994) found three year-classes for the females and only a single mode for the males. The mean carapace lengths of the females were 26.2, 43.3 and 51.8 mm and of the males was 38.8 mm.

Growth

The growth parameters of *A. foliacea* for each sex are presented in Table 16. The infinity length of the males estimated is smaller than of the females. The values of K denote that metabolic rates of males are higher than those of females. A certain coincidence derived from a comparison of our results to those of other authors (Table 17).

Biology of *P. longirostris*

Introduction

The pink shrimp *P. longirostris* (Lucas, 1846) is one of the most important commercial shrimps. It is a decapod crustacean belonging to family Penaeidae. This species can be found on muddy or muddy-sandy bottoms, mainly in depths of 150-400 m. In the Mediterranean Sea is very widespread. It is also found in the western and eastern northern Atlantic Ocean (Maurin, 1968).

Catch per unit of effort fluctuations (CPUE)

In contrast to the other two shrimp species, *P. longirostris* was more abundant in the shallower depth zone (300-500 m) than in the deeper one (500-750 m) (Fig. 56). The Mann-Whitney test showed that the difference between the two depth zones was significant (p=0.046). The highest value (2.35 Kg/hour) in the swallow depth zone was observed in September, while in the deeper depth zone in August (1.21 Kg/hour).

Length frequency distribution

A total of 7336 individuals of *P. longirostris* were caught during the sampling period. Males formed 66.3% of the total catch. Monthly length frequency distributions are presented in Figure 57 and Figure 58 for the males and the females, respectively.

A total of 4865 males were caught during the sampling period (951 in winter, 1195 in spring, 1226 in summer and 1493 in autumn). The length of the males ranged between 15 and 36 mm, but the bulk of them occurred between 23 and 27 mm. Young individuals (15-20 mm) were caught in December, January and July.

During winter, the carapace length of the males ranged from 15 to 36 mm CL and the bulk of the sample was between 23 to 27 mm. In spring, their length ranged from 19 to 31 mm, but the bulk of the sample occurred between 24 and 27 mm. In summer, the caught specimens extended in a length interval of 16-32 mm, but most of them occurred in a length range from 24 to 27 mm. In autumn, males ranged between 19 and 31 mm of length, while the bulk of them lied between 23 and 27 mm CL.

A total of 2471 female individuals were sampled (624 in winter, 581 in spring, 645 in summer and 621 in autumn). Females ranged in lengths between 12 and 36 mm, but the bulk of the sample was between 25 and 31 mm. The appearance of the juveniles (15-18 mm) was observed in January, March and July.

During winter, females ranged in lengths between 15 and 36 mm CL, while the bulk of them was between 26 and 31 mm. In spring, their length ranged from 12 to 35 mm and the bulk of the sample occurred between 23-31 mm. The smallest specimens (12 mm) of all the surveys, were fished during March, while the biggest ones (36 mm) in December. In summer, the caught specimens ranged in lengths between 16 and 34 mm, but most of them occurred in a length range from 26 to 31 mm. In autumn, females had a length range from 19 to 34 mm, while the bulk of them lied between 27 and 31 mm CL. The peak of the distribution of the females was at greater lengths than the peak of the distribution of the males.

Kolmogorov-Smirnov test was used in order to examine differences in the length distribution between season in each sex. The P-value was less than 0.05 in all pairs, so the difference was statistically significant at the 95% confidence level.

In Sicily, the maximum observed size was 40 mm CL (Froglia, 1982). In the Tyrrhenian Sea, the mean carapace lengths of females ranged from 20.9 to 36.8 mm and these of males between 16.4 and 30.8 mm. The highest values have been observed in summer (Spedicato *et al.*, 1996). In Portuguese waters the carapace length of males ranged from 8 to 36 mm and of females from 8 to 41 mm (Ribeiro-Cascalho and Arrobas, 1987). In the Central Mediterranean Sea (Latium, Italy), recruitment was observed during summer (Ardizzone *et al*., 1990). However in Portugal, two recruitment periods were observed: one in summer and another one in winter (Ribeiro-Cascalho and Arrobas, 1987).

<u>Mean length distributions in relation to depth</u>

The mean length of the males was not increasing with the depth, whereas the mean length of the females showed an increasing trend with the depth (Fig. 59). The correlation between mean length and depth was found not significant for the males and significant for the females (Spearman rank correlation, p=0.133 for the males and p=0.006 for the females). The mean length of the males ranged from 18 to 27 mm CL and of the females from 20.5 to 31 mm CL. Eventhough, for both sexes minimum length was observed in depth 560 m, smaller mean lengths were observed in the shallower stations.

The same relation between carapace length and depth has been observed in the Tyrrhenian Sea (Spedicato *et al*., 1996), in the Central Mediterranean Sea (Italy) (Ardizzone *et al.*, 1990; Mori *et al*., 1986) and off west Africa (Crosnier *et al.*, 1970). In Sicilian waters no specimens smaller than 20 mm CL has been found deeper than 450 m (Froglia, 1982). However, Burukovsky (1969) found that in samples from Morocco to the Congo River, the smallest specimens occurred in shallow waters and the size increased down to 200 m of depth, but the distribution of the largest (longer than 90 mm) specimens cannot be correlated with depth.

Carapace length-weight relationships

The carapace length-weight relationship has been estimated for both sexes of *P. longirostris* (Table 18). Differences in slopes and intercepts between the CL-W regressions of the two sexes were tested using analysis of covariance (ANCOVA). The slopes differ significantly between the two sexes (ANCOVA, $P<0.01$).

The slope of the regression indicated an allometric growth. By contrast with the other two shrimp species, males of *P. longirostris* were heavier than females in almost all seasons except in summer.

The parameters of the length–weight relationship of the species in the European waters are reported in Table 19.

Depth distribution by number and by weight

The abundance of the species was decreasing with the depth for both sexes (Fig. 60). Higher abundance for both sexes was observed in depth from 450 to 550 m. The bathymetrical distribution extended from 380 to 700 m. The highest catch of the males was 410 ind./hour or 2.77 Kg/hour and of the females 198 ind./hour or 1.99 Kg/hour.

In the Tyrrhenian Sea the depth distribution of *P. longirostris* ranged from 80 to 500 m (Mori *et al.*, 1986), while the maximum density of this shrimp in the Central Mediterranean Sea (Latium, Italy) has been observed between 150 and 300 m (Ardizzone *et al*., 1990). *P. longirostris* is the most important species of the crustacean fishery of the south Portuguese coast, representing a high percentage of the whole crustacean catch (50%) (Ribeiro-Cascalho and Arrobas, 1987). In the Italian Ionian Sea, the highest value of the catch has been reported in spring (5.4-7 Kg/hour) (Tursi *et al*., 1993a).

Reproduction

The sex ratio was calculated from 5324 individuals. The proportion of the two sexes in each month is presented in Figure 61. The sex ratio remained close to 1:1 in almost all the months. Females predominated on males in September (1/2.6), while the opposite has been observed in May (1/1.7), in October (1/2.3) and in November (1/2.9).

The sex ratio of *P. longirostris* in the Tyrrhenian Sea varied between 0.91 and 2 (females/males) during spring and summer (Mori *et al.*, 1986). In the Central Tyrrhenian Sea (Spedicato *et al.*, 1996) and the Central Mediterranean Sea (Ardizzone *et al*., 1990) the sex ratio did not differ significantly from 1:1 in all seasons. A slight predominance of females has also been observed in the south Portuguese coast during 1981-1982, except in August and March (Arrobas and Ribeiro-Cascalho, 1982).

Age determination

The identified age groups from the carapace length frequency analysis of *P. longirostris* for both sexes are presented in Tables 20 and 21. The general pattern showed that females live 2 to 4 years, while males 1 to 3 years.

Two age groups of females were defined in 8 out of 12 months (mean length of each group 24 and 28 mm). In December, February and May three age groups were defined (the third had mean length 31 mm), whereas in January the young specimens formed a forth age group (17.5 mm mean length).

Two age groups of males were defined in 9 out of 12 months (23 and 27 mm mean carapace length). In March and September one age group and in December three age groups were determined.

The life span of each generation of *P. longirostris* in the Central Mediterranean Sea is two years, with a few individuals entering a third year. Froglia (1982) has reported similar results for the Southern Tyrrhenian Sea and the Sicily Channel and Ribeiro-Cascalho and Arrobas (1987) for the Southern Portuguese coast.

Growth

The parameters of growth for each sex are presented in Table 22. The infinity length of males is smaller than that of females. The values of K denote that metabolic rates of males are higher than those of females. A certain coincidence derived from a comparison of our results to those of other authors (Table 23).

Biology of *N. sclerorhynchus*

Introduction

Macrourids are generally benthopelagic species occurring at considerable depths on the continental slopes and the abyssal planes. The family is rich in species and representatives are found in most oceans. Sagittae and scales of macrourids contain growth zones apparently homologous with those on the same structures of shallow-living fishes (Rannou, 1973; 1976; Rannou and Thiriot-Quievreux, 1975; Relini-Orsi and Wutz, 1979; Wilson, 1988; Jørgensen, 1996). The growth rates of various macrourids in the Catalan Sea were relatively high (Massuti *et al*., 1995), but no information exists on the growth of the macrourids in other parts of the Mediterranean Sea. The purpose of the present study was to investigate the bathymetric distribution, the size composition and the growth of two macrourids, *Coelorhynchus coelorhynchus* and *Nezumia sclerorhynchus* that co-exist in relatively high abundance in the Ionian Sea. The hypothesis of whether the values of otolith size and otolith weight might be directly related to fish age is also considered, attempting to provide strictly objective measurements that could be used to determine age.

Catch per unit of effort fluctuations (CPUE)

CPUE (Kg/hour) was estimated on a monthly basis for two different depth zones: 300-500 m and 500-750 m (Fig. 62a). It appears that CPUE is generally higher at depths between 500-750 m, with the exception of January, February and October when the highest value was found at 300-500 m. CPUE ranged from 0.04 to 1.45 Kg/hour in the shallower depths, while in the deeper zone the CPUE values were 0.49-2.92 Kg/hour. The highest value of the CPUE was recorded in April (2.92 Kg/hour), while the lowest in December (0.04 Kg/hour).

Bathymetrical distribution

N. sclerorhynchus was found to occur at depths between 350 to 750 m. The maximum abundance (116 individuals/hour) and biomass (1378 g/hour) for *N. sclerorhynchus* were reached in 500 to 550 m depths. Abundance and biomass showed significant variation with depth (ANOVA tests, $p<0.05$), with a tendency to decrease towards depths greater than 550 m (Fig. 62b, 62c).

From Figure 63 it appears that the majority of the specimens were found at depths from 500 to 600 m during all months. Thus no clear effect of month on the distribution patterns of this species has been found during this study.

Size composition

Sizes ranged from 8 to 60 mm PAL for *N. sclerorhynchus* (Fig. 64a). The average specimen size increased progressively from 350 to 600 m depth, after which it slightly decreased (Fig. 64b).

Size composition of the catches per month revealed that the majority of the specimens caught were between 30 and 40 mm PAL, whereas smaller specimens appeared in the catches mainly during April, May and June. Specimens larger than 40 mm were found almost during all months, except November, but their relative abundance in the catches was low (Fig. 65).

Morphometric relationships

Morphometric relationships between length and weight, otolith length, otolith diameter and otolith weight for *N. sclerorhynchus* are summarized in Table 24. In most cases the highest correlations between morphometric variables were obtained using exponential regression. A Student's *t*-test revealed significant differences ($p<0.05$) between the regression coefficients (b) obtained and those expected if growth were isometric, with each case showing negative allometric growth in the weight in relation to length. However, otolith length and fish length were linearly related.

Growth

The otoliths from 267 specimens of *N. sclerorhynchus* were examined, of which 67 (25.1%) were considered unreadable. The incidence of opaque and hyaline material at the margin of the otolith through an annual period suggests some degree of periodicity in the ring formation for this species. In the otoliths examined the opaque rings were always broader, suggesting that they equate with the fast growth or summer rings of shallow-water species. The first hyaline zone, surrounding the opaque central nucleus was always distinct and was interpreted as "transitional zone", indicative of a change of habitat from a pelagic post-larval phase to the demersal juvenile phase. In specimens older than 5 years the otolith growth increments decreased in width and thin distinct evenly-spaced rings were laid down. The proportion of otoliths depositing hyaline material was found to be highest in January and lowest in August (Fig. 66).

On the assumption that the rings were laid down annually, age estimates ranged from 2 to 10 years for *N. sclerorhynchus.* The von Bertalanffy growth parameters and the growth performance index (Φ) are presented in Table 25.

A great range in lengths within each age group was observed as it is seen for several other slow growing deep water species (Table 26). The majority of the population sampled in the present study was comprised of 3, 4 and 5 years old specimens (Fig. 67).

Since the length range for each age class was wide and the length overlap between age classes increased with age, the otolith mass growth rate (mg/year) was computed by regressing otolith weight against age. The relationship for *N. sclerorhynchus* was linear:

W_o=-0.0081+0.0065*Age.

The otolith mass growth rate, equivalent to the slope of the regression was found to be 6.5 ($\pm$ 0.3) mg year^{-1}. The regression of otolith length against age did not indicate any significant relationship for the species examined.

Biology of *C. coelorhynchus*

Catch per unit of effort fluctuations (CPUE)

CPUE (Kg/hour) was estimated on a monthly basis for two different depth zones: 300-500 m and 500-750 m (Fig. 68a). It appears that CPUE is generally higher at depths between 300 and 500 m, with the exception of July when the highest value was found at 500-750 m. CPUE ranged from 0.01 to 4.1 Kg/hour in the shallower depths, while in the deeper zone the CPUE values were between 0.21 and 1.18 Kg/hour. The highest value of the CPUE was recorded in February (4.1 Kg/hour), while the lowest in July (0.01 Kg/hour).

Bathymetrical distribution

C. coelorhynchus was found to occur at depths between 350 and 750 m. The maximum abundance and biomass for *C. coelorhynchus* was reached in 450-500 m (149 individuals/hour and 2733 g/hour, respectively). Abundance and biomass showed significant variation with depth (ANOVA tests, $p<0.05$), with a tendency to decrease towards depths greater than 500 m (Fig. 68b, 68c).

From Figure 69 it appears that the majority of the specimens were found at depths between 450 and 500 m during all months. Hence the results did not show any effect of month on the distribution patterns of the species during this study.

Size composition

Sizes ranged from 8 to 104 mm PAL for *C. coelorhynchus* (Fig. 70a). The average specimen size increased progressively from 350 to 600 m depth, after which it slightly decreased (Fig. 70b).

Size composition of the catches per month revealed that the majority of the specimens caught were between 40 to 60 mm PAL, whereas smaller specimens appeared in the catches mainly during March, April and May. Specimens larger than 60 mm were found during all months but their relative abundance in the catches was low (Fig. 71).

Morphometric relationships

Morphometric relationships between length and weight, otolith length, otolith diameter and otolith weight for *C. coelorhynchus* are summarized in Table 27. In most cases the highest correlations between morphometric variables were obtained using exponential regression. A Student's *t*-test revealed significant differences ($p<0.05$) between the regression coefficients (b) obtained and those expected if growth were isometric, with each case showing negative allometric growth in the weight in relation to length. However, otolith length and fish length were linearly related.

Growth

The otoliths from 298 specimens of *C. coelorhynchus* were examined, of which 54 (18.1%) were considered unreadable. The incidence of opaque and hyaline material at the margin of the otolith through an annual period suggests some degree of periodicity in the ring formation for this species. In the otoliths examined the opaque rings were always broader, suggesting that they equate with the fast growth or summer rings of shallow-water species. The first hyaline zone, surrounding the opaque central nucleus was always distinct and was interpreted as "transitional zone", indicative of a change of habitat from a pelagic post-larval phase to the demersal juvenile phase. In specimens older than 5 years the otolith growth increments decreased in width and thin distinct evenly spaced rings were laid down. The proportion of otoliths depositing hyaline material was found to be highest in January and lowest in August (Fig. 72).

On the assumption that the rings were laid down annually, age estimates ranged from 3 to 11 years for *C. coelorhynchus.* The von Bertalanffy growth parameters and the growth performance index (Φ) are presented in Table 28.

A great range in lengths within each age group was observed as it is seen for several other slow growing deep water species (Table 29). The majority of the population sampled in the present study was comprised of 5, 6 and 7 years old specimens (Fig. 73).

Since the length range for each age class was wide and the length overlap between age classes increased with age, the otolith mass growth rate (mg/year) was computed by regressing otolith weight against age. The relationship for *C. coelorhynchus* was linear:

$W_o = -0.1515 + 0.0342 * Age.$

The otolith mass growth rate, equivalent to the slope of the regression was found to be 34.2 (± 1.4) mg/year. The regression of otolith length against age did not indicate any significant relationship for the species examined.

Biology of *H. mediterraneus*

<u>Introduction</u>

The silver roughy *H. mediterraneus* is a bathypelagic fish species, that dwells in relatively deep waters, down to 800 m. It displays a rather wide distribution, being present in the Mediterranean, as well as in the Atlantic, both in the eastern and in the north-western part (Bauchot, 1987).

Few aspects on the biology-ecology of the species come from studies in the eastern Atlantic (Maurin, 1968; Golovan, 1978; Marshall and Merrett, 1977; Merrett and Marshall, 1981; Mauchline and Gordon, 1984; Gordon and Duncan, 1985; 1987), while its growth pattern in the continental slope of Ireland is provided by Kotlyar (1980). In the Mediterranean, certain biological data, mainly on the reproduction of the species, are derived through Cau and Deiana (1982), while a thorough analysis of the life history traits of the silver roughy is given by D'Onghia *et al*. (1998).

The present study makes an effort to present the size distribution, age, growth and mortality of the silver roughy in the South Ionian Sea (Greece), aiming at gathering the appropriate data, that will contribute to the knowledge of the species' biology in that area.

<u>Catch per unit of effort fluctuations (CPUE)</u>

The CPUE of the species was generally higher in the 300-500 m depth zone except from May to August when it appeared to be higher in the 500-750 m depth zone (Fig. 74). Highest values were observed in the 300-500 m depth zone in April, (8.7 Kg/hour) and in the 500-750 m depth zone in June (7.3 Kg/hour). The Mann-Whitney W test showed that the difference in the CPUE between the two depth zones was not significant (p=0.435)

Length distribution

The smallest specimen collected in the study area was 46 mm TL and the largest measured 236 mm TL. Specimens smaller than 90 mm were mainly collected in December and March (Fig. 75). It should be pointed out, however, that relatively few fish measuring less than 60 mm were caught in the study area, in comparison at least with D' Onghia *et al*. (1998) in the North Ionian Sea. In fact, size intervals 20-40 mm were absent from the length frequency distribution of the present work. Thus, a definite remark on the exact time of the young-of-the-year recruitment cannot be made. It appears though from the limited relevant data, taking also into account the observations of D'Onghia *et al*. (1998) regarding the species in the north Ionian, that recruitment should take place sometime in the period of winter-early spring. The bulk of the silver roughy stock consisted of fish 120-160 mm TL. This was the dominant size group in all samplings. The rather small growth rate of the species did not allow the explicit observation of modal increment of the specimens on a monthly basis.

One-way analysis of variance applied to the sexed length data revealed significant differences ($F=17.3$, $P<0.001$). The mode of the female length frequency distribution was slightly shifted to larger specimens (140-170 mm), while that of males was constituted of specimens 130-160 mm (Fig. 76). Females were encountered more frequently among fish larger than 160 mm. Beyond 200 mm no males were collected.

Bathymetrical distribution

The species was collected in waters from 300 to 750 m. The regression correlating abundance (N) of specimens and depth (d), $\ln(N+1)=-6.363+0.046d-0.000048d^2$,($r^2=0.68$), suggested that the theoretical maximum abundance of the silver roughy stock in the Ionian Sea appeared in the depth of 479.2 m.

A trend of larger specimens to prefer deeper areas was displayed (ANOVA $F=71.5$, $P<0.001$). This observation was also made by D'Onghia *et al*. (1998). In the 300-450 m depth zone, the mean length of specimens was 126.9 mm. In the 450-600 m zone the mean length was 144.5 mm and in deeper waters it was 149.4 mm.

From Figure 77 it is obvious that in almost all samplings the majority of specimens was collected in the 450-600 m depth zone. Fish larger than 200 mm were mainly found in the deep zone. D'Onghia *et al.* (1998) stated that silver roughy in the North Ionian Sea was caught almost exclusively at depths greater than 500 m. In sites shallower than 450 m a great amount of specimens had sizes smaller than 130 mm. The existence of smaller specimens (<100 mm) in relatively shallower areas, medium size specimens (100-170 mm) in 450-600 m and larger specimens (>170 mm) in deeper areas is more obvious when observing Figure 78.

Age and growth

Age determination of the silver roughy was based on otolith readings. Two distinct types of rings were observed: opaque rings appeared white and translucent rings appeared dark. Translucent rings continuing around the entire circumference of the otolith were considered annual growth zones (annuli). Specimens were classified to 11 age classes (0 to 10). The bulk of the collected stock was comprised of two and three years old specimens (Fig. 79). Fish ageing one and four years displayed limited abundance. 0-group silver roughy and those older than four years were rarely encountered.

The age length-key for the silver roughy in the Ionian Sea is presented in Table 30. An overlap of two to three years appears to exist in each length class, which is expected in slow growing deep water fish. According to the age-length key of the silver roughy in the North Ionian Sea

(D'Onghia *et al*. 1998) it appears that only 0+ specimens were collected in the present study. Smaller fish of 20 to 50 mm, reported by D'Onghia *et al*. (1998) as 0-group ones, were absent from our catches, with the sole exception of a 46 mm fish. In general, our results are in accordance with those presented in the work of D'Onghia *et al.* (1998). In the latter study one more age class was determined (11 years), which could be attributed to the fact that larger specimens (>240 mm TL) were collected in the North Ionian Sea as compared to the southern part.

Total length (TL)-otolith radius (R) regression, estimated for all specimens, was TL=15.57+2.15*R, (r^2=0.88). Analysis of covariance applied to the data revealed that no difference existed in the growth in length between the two sexes (F=0.049, P>0.5), which was also confirmed by the findings of D'Onghia *et al*. (1998).

Parameters of the TL - R regression were used for back-calculating silver roughy lengths-at-age. The results appear in Table 31. During the first year of their life fish reach the 40% of their total mean back calculated size at age 10. Then, annual growth increment declined steadily reaching a low of 5.5 mm at age 10. The small number of specimens in ages older than six years, however, does not allow the extraction of reliable conclusions for the growth of large fish. Observed lengths-at-age were greater than back calculated lengths-at-age, since the majority of the specimens used in the age study was collected outside the period of annulus formation.

The von Bertalanffy growth equation was fitted to the mean weighted back-calculated lengths-at-age using a non-linear regression program available in FISHPARM (Saila *et al*., 1988). The maximum back-calculated asymptotic length of the silver roughy in the Ionian Sea was estimated to be L_∞=239.1 mm and K was found to be 0.237. The 95% confidence interval for L_∞ was from 233.2 to 245.0 and that for K was from 0.215 to 0.259. According to the results provided by D'Onghia *et al*. (1998) the confidence intervals for L_∞ and K of the species in the north and south Ionian Sea overlap, suggesting no significant differences in the growth of the silver roughy stocks in the two areas. Kotlyar (1980) in the slope of Ireland, mentioned that ages of specimens 137 to 198 mm ranged from 4 to 9 years; these observations, however, based on the study of 13 fish are not considered to be representative of the growth pattern of the Atlantic stock.

Growth in weight

Analysis of covariance revealed that the slopes of the total length (TL) - total weight (TW) regressions differed significantly between sexes (F=4.13, P<0.05). TL - W regressions of males, females and both sexes combined of the silver roughy stock in the Ionian Sea appear below:

males : $W = 0.0000036\ TL^{3.265}$, (c.i.$_b$±0.0497), r^2 = 0.96, N = 746
females : $W = 0.0000027\ TL^{3.327}$, (c.i.$_b$±0.0645), r^2 = 0.94, N = 617
all fish : $W = 0.0000020\ TL^{3.380}$, (c.i.$_b$±0.0398), r^2 = 0.96, N = 1541

The 95% confidence intervals of the parameter b of the TL - W regressions revealed an allometric growth in weight of the silver roughy specimens in the south Ionian Sea, yielding fish heavier for their length.

Mortality

Total mortality (Z) of the silver roughy in the Ionian Sea was estimated using the catch curve method (Pauly, 1983), applied to our data by the LFSA computer software (Sparre *et al*., 1989). Using the catch curve method and according to the regression ln(N/dt)=6.853-0.824t (r=0.99), Z being the slope of this regression, suggests that Z=0.824. Natural mortality (M) of the Ionian silver roughy was estimated using the Pauly (1980) regression:

$$LogM = -0.0066 - 0.279LogL_{\infty} + 0.65431LogK + 0.46341LogT,$$

where L_{∞} and K are the parameters derived from the von Bertalanffy growth equation and T is the mean annual temperature value of the bottom layer in the Ionian Sea. Hence, according to the Pauly (1980) method M = 0.48. From the above, the fishing mortality was F = 0.34 and the exploitation ratio was E = 0.41 implying that the silver roughy stock in the study area is rather at an under exploited status.

Reproduction

In all 845 females and 972 males were examined in order to study the reproductive cycle of the species (Fig. 80a). The length of the examined females ranged from 70 to 230 mm, whereas of the males ranged from 70 to 200 mm. The maturity stages were determined according to Nicolsky's scale (1976). In Figures 80b, 80c the proportion of the mature, premature and immature specimens of each sex per month is illustrated. Mature were considered those fish whose gonads were in maturity stage IV and V, premature the fish with gonads in stage III and immature the virgin or with resting gonads fish (stages I and II). The reproductive activity of the species in the East Ionian Sea lasted all year round with a peak from February to April, when more than 50% of the examined specimens of both sexes were mature. A smaller proportion of mature fish was found during the rest of the year. In November 40% of the females and 20% of the males were premature.

All the female *H. mediterraneus* that were smaller than 9 cm were found to be immature (Fig. 81a). About 7% of the females with lengths 9-11 were premature. The smallest mature females had length of 12 cm. As size increased the proportion of mature specimens also increased. More than 50% of the females that were larger than 13 cm were mature (except for the 22 cm length class which was due to the small sample). The males with lengths 6-9 cm were immature (Fig. 81b). The smallest mature males had a length of 10 cm. About 40% of the specimens with lengths larger than 13 cm were mature. Generally, the proportion of premature males was higher than that of the premature females fact possibly influenced mainly by the less clear separation of the stages in the male gonads compared to females. An under-estimation of the maturity stage of the males was possible. Thus, some of the males that were characterised as premature could have pass to the mature stage.

The sex ratio (females/males) was estimated for each month (Fig. 81c). Males were more abundant in the sample than females except in August. The ratio ranged from 1:0.6 to 1:1.9. The sex ratio was found to differ significantly from the expected ratio 1:1 (X^2 test, p=0.003).

Biology of *H. dactylopterus*

Introduction

Rock fish, *H. dactylopterus,* exists from Norway to Morocco, the Azores, Madeira and the Canaries in the Atlantic Ocean, and in all the Mediterranean, except the Black Sea (Whitehead *et al.*, 1984-1986). This demersal scorpaenid is distributed on the slope of the continental shelf between 200 and 1000 m, and is more abundant from 350 to 550 m. In the Mediterranean Sea, rock fish support major commercial fisheries in the western part and along the Italian coasts of the Ionian Sea.

Although various aspects of rock fish life history such as bathymetrical distribution, age, growth, mortality etc, have been documented from the Western and Central Mediterranean (Ragonese, 1989; Ragonese and Reale 1992; 1995; D'Onghia et al., 1992; Ungaro and Marano 1995; D'Onghia *et al*., 1996), almost nothing has been reported for the biology of the species in the Eastern Mediterranean and the Greek seas.

The present study provides information on the size structure, growth, abundance, bathymetrical distribution, reproduction and mortality data of the rock fish in the Greek Ionian Sea, which can be compared with the same parameters of the species in the Western and Central Mediterranean Sea.

Catch Per Unit Effort fluctuations (CPUE)

The CPUE of the species in the 300-500 m depth zone ranged from 0.3 Kg/hour in July to 4.6 Kg/hour in April, whereas in the 500-750 m depth zone ranged from 1 Kg/hour in January to 6.4 Kg/hour in March (Fig. 83). The Mann-Whitney W test showed that the difference between the depth zones was not significant (p=0.312). During summer the CPUE of the species was higher in the 500-750 m depth zone, whereas during the other seasons was similar in the two depth zones. Thus a migration to deeper waters during summer was possible. In surveys carried out in the coast of Portugal in a depth range 100-700 m the indices of abundance of rock fish were higher at 200-500 m than in the other depth ranges (Cardador and Pestana, 1995).

Length frequency distribution

Monthly length frequency distributions of 3166 rock fish, caught along the coast of Greek Ionian Sea from December 1996 to November 1997, for both sex combined, are presented in Figure 84. Fork lengths ranged from 40 to 360 mm. During some months the number of the fish was small and the modes in the length frequency distribution were not clear.

Generally the modes in the 300-500 m depth zone were between 120-220 mm and in the 500-750 m depth zone between 130-170 mm. There was not a clear pattern in the modes between the two depth zones. During six months the mode in the 500-750 m was at larger length than in the 300-500 m, during two months was approximately at the same length, during one month was at smaller length and during three months the sample was small, so the definition of the modes was impossible.

Recruits (individuals with lengths smaller than 100 m) were observed in both depth zones but they were concentrated more in the 300-500 m depth zone. Thus, in January, February, April and August young fish were caught only in the 300-500 m depth zone and in March, May, June and September the number of the young fish in the 300-500 m depth zone was higher than in the 500-750 depth zone. Only in December and July more young fish were caught in the deeper depth zone. According to Ragonese and Reale (1995), in the Strait of Sicily the juveniles were recruited continuously but not uniformly, mainly at the edge of the continental shelf.

Larger fish were segregated more in the deeper depth zone and in the length distributions of eight months this was clear. The lengths in the 300-500 m depth zone ranged from 40 to 310 mm and in the 500-750 m depth zone ranged from 70 to 360 mm.

Bathymetrical distribution

The species showed a wide bathymetrical distribution (Fig. 85). It was caught in all stations where sampling took place in a depth range from 300-750 m. More abundant was in depth 580 m (157 fish/hour, 16 Kg/hour). In the Strait of Sicily the species was caught between 120 and 730 m, with an average depth of capture between 270 and 460 m (Ragonese and Reale, 1995), whereas in Portuguese coasts in depths 100-750 m (Cardador and Pestana, 1995).

Depth-mean length relationship

The mean length of the species was increasing with the depth (Fig. 86). The Spearman rank correlation showed a significant positive correlation between depth and mean length (p=0.000). Smaller mean length was observed in depth of 370 m (66 mm) and larger in depth 728 m (267 mm). Mean lengths estimations in Portuguese coasts by depth and zone have indicated that rock fish was bigger at 500-750 m depth (23.4 cm) (Cardador and Pestana, 1995).

Length-Age key

Ten age group (0-9 years) were determined by otolith reading of fish measuring from 50 to 250 mm (Table 32). The evaluation of the length-age key revealed age variation of one to four years within a single length group. The greater size interval (60 mm) appeared in fish of age group IV. The number of fish with ages older than 6 was small in the sample.

Back-calculated growth

The relationship between otolith radius and fish length was determined by least squares regression with both linear and power fits. The best fit between length in mm (L) and otolith radius (R) was linear:

$$L = -6.66 + 30.03 * R \ (r^2 = 0.95, n = 203)$$

The lengths at the time of annulus formation were back-calculated by a direct proportion method. No significant difference was calculated between the two sexes (P<0.01), so the total number of individuals was combined (Table 33).

Growth was fast in the first year and the mean back calculated length at age I was 87 mm. A sharp decline in growth was observed during the successive years. There was not any indication of the Rosa Lee’s phenomenon (smaller estimated size for fish of younger ages when the size is calculated from otoliths of older fish). Back-calculated fish lengths agreed reasonably with length at capture of corresponding age groups. Differences were attributed to growth following formation of the annulus.

The back calculated size-at-ages of the present study were a little larger than those estimated in the Western Ionian Sea (D’Onghia *et al.,* 1996). The aging of the *H. dactylopterus* in the present study was based on otoliths collected during August 1995. The formation of the annual rings is taking place during winter and spring. The differences in the estimated size between Eastern and Western Ionian Sea could be attributed to the growth during the period from the formation of the annual ring to the time of collecting the sample.

von Bertalanffy’s equation

A von Bertalanffy theoretical growth curve was fitted to mean back-calculated lengths using the FISPARM package (Prager *et al*., 1987). The calculated model was:

$$L = 311.709 * \{1-\exp [-0.1172*(t-(-2.10))]\},$$

The estimated L_∞ was smaller than the maximum observed length (360 mm) due to the fact that the larger aged fish was 260 mm. The fitted lengths at age were 95.0 mm at age I, 119.0

mm at age II, 140.3 mm at age III, 159.3 mm at age IV, 176.2 mm at age V, 191.2 mm at age VI, 204.5 mm at age VII, 216.4 mm at age VIII and 226.9 mm at age IX.

Age distribution

The age distribution was estimated using the age-length keys. Since aging has been done in fish with length less than 260 mm, in the age distribution fish with length larger than 260 mm were not included. More abundant were the fish at age 3 and 4 (Fig. 86). Their proportion was 17.8% and 18.6%, respectively. The small proportion of the fish at ages 0-2, partly could be attributed to the selectivity of the sampling gear, especially for fish 0 years old or to the distribution of the young fish to shallower waters or in different substrates.

Growth in weight

The length-weight relationship was estimated using the equation $W = a*L^b$ rer sex and per season.

Males

	a	b	N	R^2	SE(b)
Winter	0.000006	3.164	168	0.985	0.029
Spring	0.000006	3.176	272	0.987	0.021
Summer	0.000005	3.204	98	0.991	0.029
Autumn	0.000008	3.114	130	0.989	0.029
yearly	0.000006	3.165	668	0.988	0.013

Females

	a	b	N	R^2	SE(b)
Winter	0.000005	3.207	188	0.983	0.030
Spring	0.000008	3.125	269	0.988	0.020
Summer	0.000006	3.157	106	0.987	0.034
Autumn	0.000008	3.122	113	0.978	0.043
yearly	0.000007	3.149	676	0.986	0.014

Reproduction

In all 676 females and 668 males were examined in order to study the reproductive cycle of the species (Fig. 87a). The length of the examined females ranged from 80 to 320 mm, whereas of the males ranged from 60 to 340 mm. The maturity stages were determined according to Nicolsky's scale (1976). In Figures 87b, 87c the proportion of the mature, premature and immature specimens of each sex per month is illustrated. Mature were considered those fish whose gonads were in maturity stage IV and V, premature the fish with gonads in stage III and immature the virgin or with resting gonads fish (stages I and II).

Mature males were caught all year round but during some months no mature females were caught. The reproductive activity of the species seemed to last all year round with a peak from January to March when the proportion of the mature specimens was higher.

The female *H. mediterraneus* started to mature from 17 mm and the males from 16 mm (Fig. 88a, 88b). All the females smaller than 13 cm and all the males smaller than 12 cm were found to be immature. More than 50% of the males with lengths larger than 22 cm were found to be mature. The females larger than 23 mm were more than 50% mature but this proportion was lower in the 25 mm and 27 mm length class.

The sex ratio (females/males) was estimated for each month (Fig. 88c). Males were more abundant in the sample than females except in August. The ratio ranged from 1:0.6 to 1:1.3. The difference in the sex ratio was not found significant from the expected 1:1 (X^2 test, p=0.113).

Mortality

Natural mortality (M) was calculated according to the Pauly (1983) relationship, taking into account the mean annual temperature in the study area. The mean temperature in the Ionian Sea, at depth 450 m is ~12^{o}C, and the value of M was found to be 0.28. As L_∞ was used the length of 40.0 cm, which is a little greater than the maximum fished length in the area. Using the catch curve method (Pauly, 1983) total mortality (Z) was calculated to be equal to 0.50, thus the fishing mortality (F = Z-M) was 0.22. The exploitation rate (E = F/Z) was estimated 0.44 and the rock fish stock in the study area is considered not to be overfished.

Biology of *C. agassizi*

Introduction

The shortnose greeney *C. agassizi* (Bonaparte, 1840), is a demersal fish species which lives on the continental shelf and upper slope, over muddy and clay bottoms. Its geographical distribution in the eastern Atlantic ranges from Spain to Senegal, while in the western Atlantic it is known to exist from Cape Cod to Suriname. The species is very abundant in the Central Basin of the Mediterranean (Whitehead *et al*., 1984). It is also very abundant in the Greek seas, as reported by Taaning (1918), Kaspiris (1973), Economidis and Bauchot (1976), Papaconstantinou *et al*., (1979). The species is of no commercial value, which might be the main reason for the fact that its biology is almost unknown. There is little information, concerning only its feeding habits (Mead, 1966).

The objective of the present study is to provide information on the length composition, age and growth, length-weight relationship, mortality and reproduction of shortnose greeney.

Catch per unit of effort fluctuations (CPUE)

The species was present in the 500-750 m depth zone from April to October (Fig. 89), and its catches peaked there in August (17.22 Kg/hour). In the 300-500 m depth zone the species was caught during all year round and its CPUE values presented a rather wide fluctuation, being 63.43 Kg/hour in October and 5.22 Kg/hour in August. A shift of specimens towards deeper waters could possibly take place during summer times (Fig. 89). Man Whitney W test showed that the CPUE of the species was significantly higher in the 300-500 m depth zone (p=0.000).

Length frequency distribution

A length frequency diagram was constructed from length data of 118093 shortnose greeney, collected monthly between December 1996 and November 1997 (Fig. 90). Lengths ranged from 45 to 200 mm, with a dominant mode between 85-130 mm. The abundance of the species was rather high during all the sampling periods: 17801 individuals were fished in winter, 48976 in spring, 17290 in summer and 34025 in autumn.

Although the sampling gear used in this study did not provide a complete picture of the population biology of shortnose greeney, one can nevertheless obtain a reasonable idea of certain aspects of population structure and associated population parameters. Young shortnose greeney, belonging to 0-age group, are pelagic, living in the upper layers of the water column. Taaning (1918) caught juvenile specimens, about 44 to 46 mm, close to the surface, together with larvae. There is, however, a well-known tendency for the older age groups of the species to be found closer to the bottom (Sulak, 1984). The absence of specimens <45mm from the present samples corroborates possibly Taanings (1918) findings. Thus, the population structure as portrayed by the bottom-trawl samples is likely to be skewed in favour of the older year classes.

The mode of the length distribution in the 300-500 m depth zone varied between the surveys and ranged from 70 mm in July to 160 mm in February. From December to April and in June the bulk of the population was between 90-150 mm. In May two modes were observed. The first one, consisted of young fish with lengths between 60-75 mm and the second one, consisted of fish with lengths between 90-140 mm. In June only the second mode was present, whereas the following months the sample was consisted mainly of the young fish. They can be followed from July to November when they reached a length of 75-95 mm. The increment of these fish during seven months was 15-20 mm reflecting a rather slow growth of the species.

New recruits to the trawl fishery, with lengths ranging from 45 to 54 mm, first appeared during winter months (December-January). Between March and September 1997, the youngest specimens, 55-75 mm (Fig.90), were quite abundant, contributing significantly, during some months, to the total population.

According to the bibliography, Tortonese (1975) reported that the maximum size of the species in the Italian seas measured about 20 cm, and Sulak (1984) mentioned that the common size of the species is about 11 cm, the maximum reaching at 20 cm.

<u>Bathymetrical distribution</u>

In order to examine the relationship between the abundance of shortnose greeney and the depth the logarithms of the total weight+1 and the total number+1 of the individuals in each station were plotted against depth (Fig. 91). Higher aggregations, in terms of number and weight, were observed at depths between 350 and 400 m. The fact that increased weight values of the species in relation to number of specimens appeared in relatively deeper areas suggests that larger (heavier) specimens preferred deeper waters (Fig. 91). The above is corroborated by the study of the length frequency distribution with depth and the bathymetrical distribution of the mean size of the specimens.

<u>Depth-mean length relationship</u>

The mean length in each station was plotted against the depth in Figure 92. The mean length of the species increased with the depth (Spearman rank correlation, $p=0.000$). The mean length of the species in stations deeper than 450 m was always greater than 110 mm (except in one station)

<u>Length -Age key</u>

Thirteen age groups were determined from otolith reading of the collected fish (Table 34). Only the first four 5 mm length intervals contained fish from one age group. The length distribution of fish within a single age group was rather broad covering 3 to 12 size intervals. The evaluation of the length-age key for the species revealed age variation of two to seven years within a single length group.

<u>Back calculated growth</u>

The growth rate of shortnose greeney was estimated by aging the otoliths of 2327 samples, caught between December 1996 and November 1997. Various equations (power function, first and second degree polynomial) were used in order to choose the one that best fitted the data of the body length-otolith radius. The power function was chosen according to the above mentioned criteria. Thus, back-calculation was made using the following equation:

$$TL = 0.39 * R^{1.47}$$

The total lengths at the various annuli were back-calculated and the growth history was constructed for each year class, along with growth increments for each age group. The oldest specimens were 13 years old. The most rapid growth occurred in the first four years of life, and calculated for the 46% of the total growth at the maximum back calculated size. The average calculated annual growth increment was greatest during the first year of life and decreased steadily until the thirteenth year (Table 35). There were clear indications of the Rosa Lee's phenomenon - a smaller estimated size for fish of younger ages, when calculated from otoliths of older fish.

In conclusion, the shortnose greeney of the Greek Ionian Sea is a slow-growing fish with moderate longevity, taking also into account the longevity of other mesopelagic fishes. There is a difference between the observed and calculated length at age due to the different seasons of sample collection. Especially in the first and second year of life this difference is attributed to the Rosa Lee's phenomenon.

<u>von Bertalanffy's equation</u>

On the basis of observed length-at-age, the parameters of the von Bertalanffy equation were estimated using FISPARM package (Prager *et al.*, 1987). These parameters were: L_∞=227.9 mm, K=0.127 and t_0=1.343.

<u>Age distribution</u>

More abundant were fish 4 years old (Fig. 93). The proportion of the 4 years old fish was 25.8%. A sharp reduction was observed in the proportion of the following year classes. Fish 0 years old were almost absent. The selectivity of the sampling gear and the behaviour of the species were the reasons that the 1-3 years old fish were represented with smaller proportion in the sample.

<u>Growth in weight</u>

The length weight relationship was based on the regression $W = aL^b$. Since statistically differences in length-weight relationship was found between the different seasons (Analysis of variance, P>0.001), all data were treated separately for each season.

	A	b	r^2	N
Winter	0,0000012	3,34	0,95	1077
Spring	0,0000001	3,37	0,98	1222
Summer	0,0000050	3,09	0,99	618
Autumn	0,0000049	3,04	0,98	1286

<u>Reproduction</u>

The maturity stages were described according to the Nikolsky (1976) scale. Immature fish were considered those whose gonads were at stages I and II, premature those at stage III and mature those at stages IV, V and VI. In Figures 94, 95, the proportion of each maturity stage per length class are shown. All the individuals with lengths smaller than 130 mm were immature (except some fish with length 110-120 mm). During winter only some specimens were found to be mature, whereas in spring individuals with lengths 130-180 mm were found to be mature and the highest proportion was at the 185 mm length class (about 40%). The peak of the reproductive activity was observed during summer (Fig. 96) when more than 50% of the fish larger than 155 mm were mature and all the fish larger than 180 mm were mature. During autumn the reproduction activity showed a reduction but it was more intense than in spring. Concluding, the spawning period of the species in the Ionian Sea extended from spring to autumn with a peak in summer.

Mortality

Pauly (1983) demonstrated that natural mortality (M) of fish is correlated with the mean environmental temperature in which the stock lives. The annual mean temperature in the Ionian Sea at depth of 450 m is about 12^{o}C. Thus, M was estimated to be 0.31. Using the catch curve method (Pauly 1983) to calculate the total mortality the value of Z was equal to 0.50, thus the fishing mortality (F) was F = Z-M = 0.2.

Biology of *G. melastomus*

Introduction

The blackmouth catshark *G. melastomus* (Rafinesque, 1810) is a common or locally abundant chodrichthys species, cosmopolitan through all basins of the Mediterranean including the Adriatic (mostly southern-central regions) and the Aegean Sea. The species is also reported in the North-Eastern Atlantic Ocean, from Scandinavia to Senegal (Compagno, 1984). It is found at depths of several hundred meters (Blacker, 1962; Gordon and Duncan, 1985), but it can be found in shallower waters occasionally (Mattson, 1981).

Blackmouth catshark in the Ionian Sea was caught almost exclusively in the meso-bathyal zone. The distribution of young individuals in the epibathyal zone confirms what has been documented in the literature (Capape and Zaouali, 1977; Relini-Orsi and Wurtz, 1977). Very little information exists concerning the biology of this species in the Ionian Sea (Tursi *et al*., 1990).

The aim of this work is to present some data on the biology of the species, concerning mainly the length frequency distribution and the growth, in the Eastern Mediterranean Sea.

Catch per unit of effort fluctuations (CPUE)

The species was more abundant in the 300-500 m depth zone (Fig. 97) and the difference was found to be significant (Mann-Whitney W test, p=0.049). The highest value was observed in December (9.2 Kg/hour) and the lowest in July (0.71 Kg/hour). In the 500-750 m depth zone the CPUE was the highest in June (4.1 Kg/hour) and the lowest in November (0.2 Kg/hour).

Length frequency distribution

The total length of males ranged between 100 and 535 mm, while of females from 50 to 635 mm (Fig. 98, Fig. 99). The bulk of the males in winter were between 190-300 mm, in spring between 170-320 mm, in summer between 200-340 mm and in winter between 160-370 mm. The bulk of the females in winter and spring were between 140-320 mm, in summer between 180-320 mm and in autumn between 150-340 mm. More large males (larger than 370 mm) were caught during summer and autumn while the young males (100-130 mm) appeared in the sample during winter. The sex ratio (M:F) was almost 1:1 in all seasons, except in spring, where females were more abundant than males. The same was observed in the Western Ionian sea (Tursi *et al*, 1993b).

The population of the species in the Eastern Ionian Sea was consisted of larger specimens than in the Western Ionian Sea where the majority of the males had lengths between 180 and 320 mm and of the females between 185 and 318 mm. (Tursi *et al*., 1993b). The maximum blackmouth catsharks caught in Tunisia measured 550 mm (Capape and Zaouali, 1976). In Portugal the bulk of the population was between 210 and 650 mm (Figueiredo *et al*., 1995). Young-of-the-year recruited in the Italian Ionian Sea all year round, except in February (Tursi *et al*., 1993b).

Depth-abundance relationship

Both sexes showed a wide depth distribution (Fig. 100). The depth range was between 350 - 730 m. Generally, the number of individuals decreased with depth. Higher abundance for both sexes was observed in a depth range from 350-450 m.

Differences have been reported in the bathymetrical distribution of *G. melastomus* in the Mediterranean and in the Atlantic Ocean. The species according to Compagno (1984) in the Atlantic occurs between 55 and 1000 m preferably at the 200 to 500 m. In the Mediterranean sea, Bauchot (1987) and Fredj and Maurin (1987) reported the same range, whereas Golani (1986/87) reported the capture of 2 individuals at 1440 m off the coast of Israel. In the North Ionian Sea, was present from 200 down to 650 m which was the maximum explored depth. In the same region, more specimens were caught in the depth zone 400-650 m than in the shallower one (Tursi *et al*., 1993b).

Depth-mean length relationship

An increase in the mean length with the depth was observed for both sexes (Fig. 101). The mean length of the males and the females in stations with depth less than 450 m was smaller than 300 mm, whereas in stations deeper than 625 m was always larger than 300 mm. The Spearman rank correlation was found to be significant for both sexes (p=0.000 for the males and p=0.000 for the females).

In Portugal a similar relationship of the size of fish with depth was observed (Figueiredo *et al*., 1995). In the North Ionian Sea the larger specimens tended also to be distributed at greater depths (Tursi *et al*., 1993b).

Determination of age

Bhattacharya's (1967) method implemented in the package FISAT (FAO, 1994), was used in order to estimate the mean lengths of the age groups present in the length distributions of the species (Tables 36, 37). Castro (1990) suggested that Bhattacharya is easier than other modern methods and could be applied in a more objective way than other graphical methods.

For both sexes 4-5 age groups were defined. Concerning the males three age groups were defined in spring, five age groups in summer and four age groups in winter and autumn. Five age groups were defined for the females except in summer. The normal components, corresponding to these age groups, showed high separation index (S.I.) and low standard deviation (S.D.) for both sexes.

Generally, the best results were obtained from the analysis of the summer data for the males and the spring data for the females when more age groups, lower standard deviation (S.D.) of the mean lengths at age and higher values of the separation index (S.I.) were observed. The results from age classification of these seasons were used in order to fit the von Bertalanffy growth model.

The parameters of the von Bertalanffy growth equation L_∞, K, and t_0 were estimated for each species and sex using the LFSA (Length-based Fish Stock Assessment; Sparre, 1987) package (Table 38).

In Portugal, an increase in length of about 5 cm from summer to winter has been observed (Figueiredo *et al.*,1995). Such increase would, however, denote a fast growth rather unusual among the squalids. In the North Ionian Sea, the estimated monthly growth rate was lower (1 cm) (Tursi *et al.*, 1993b).

Composition and distribution of other shrimps

As other shrimps were classified on board shrimps species other than *A. foliacea*, *A. antennatus* and *P. longirostris*. Samples of these shrimps were analysed in the laboratory. The results are presented bellow.

Catch per unit of effort fluctuations (CPUE)

The CPUE of the shrimps in the 500-750 m depth zone ranged from 1.02 Kg/hour in November to 5.41 Kg/hour in May, whereas in the 300-500 m depth zone it ranged from 0.06 Kg/hour in July to 3.89 Kg/hour in February (Fig. 102). During spring and summer the CPUE was higher in the deeper zone. The difference was found to be not significant (Mann - Whitney W test, p=0.976).

Species composition

A total of 15 species was found and their list per season and per depth zone is given in Table 39. *Plesionika martia* was found in both depth zones during all seasons, and it was always dominant both in numbers and weight (Fig. 103, Fig. 104). Its percentage by weight ranged between 77.8% in the shallower zone during winter and 98% in the deeper zone during spring. In terms of numbers it composed from 59.7% in the deeper zone during winter to 97.8% in the same zone during spring. Another species found constantly was *Plesionika edwardsii*. The percentage by weight of this species ranged from 1.3% in the deeper zone in autumn to 11.1% in the shallower zone in spring, whereas its percentage by numbers ranged from 0.6% in the deeper zone in autumn to 3.4% in the shallower zone in spring. Finally, *Plesionika heterocarpus* was always present in the catches, except in the deeper zone during spring and winter, with a lower contribution by weight (maximum 12.9% in the shallower zone in winter) and a higher one by numbers (maximum 21.6% in the shallower zone in spring). The rest of the shrimp species were found in lower quantities or occasionally.

Length composition

The length composition was analysed for the three most important species.

Plesionika martia: In winter, its carapace length ranged from 9 to 22 mm in the shallower zone with most specimens having a CL between 17 and 18 mm (Fig 105). In the deeper zone, no specimens smaller than 14 mm CL were found, whereas the larger ones had a CL of 24 mm. However, the main bulk had a CL between 17 and 18 mm also in this zone. In spring, the CL ranged from 11 to 21 mm in the shallower zone and from 13 to 23 in the deeper one with a peak between 17 and 19 mm in the first one and between 17 and 20 mm in the second one. In summer the CL was between 15 and 22 mm with a peak in 18 mm in the shallower zone and between 13 and 22 mm with a peak between 18 and 19 mm in the deeper zone. Finally, in autumn, the specimens of the shallower zone had a CL from 11 to 21 mm with a peak between 17 and 20 mm, whereas the specimens of the deeper zone had a CL from 10 to 22 mm with a peak between 16 and 20 mm.

Plesionika edwardsii: During winter in the shallower zone, the CL ranged from 20 to 26 mm with a peak in 24 mm (Fig. 106). In the deeper zone few specimens were caught with CL between 20 and 24 mm. In spring, the CL ranged from 19 to 27 mm in the shallower zone with the highest peak in 21 mm, whereas in the deeper zone it ranged from 18 to 26 mm with a main peak in 24 mm. During summer, this species was found in low quantities and only in the deeper zone with CL ranging from 20 to 26 mm. Finally, in autumn, *P. edwardsii* was caught mostly in the shallower zone with CL ranging from 21 to 26 mm with a main peak in 24 mm.

Plesionika heterocarpus: In winter, this species was found in high quantities in the shallower zone with CL ranging from 9 to 16 mm with a peak in 14 mm (Fig. 107). In the deeper zone, its CL was between 14 and 16 mm. In spring, high quantities of small specimens (9 mm CL) were found in the shallower zone, whereas the species was absent in the deeper zone. In summer few specimens of CL 14 mm were found in the shallower zone, whereas in the deeper zone its CL ranged from 12 to 15 mm with a main peak in 14 mm. In autumn, in the shallower zone, the CL ranged from 10 to 16 mm with a high peak in 15 mm and a secondary in 10 mm. In the deeper zone, a low quantity of this species was caught with CL ranging between 13 and 15 mm.

Discussion

The results of the surveys which were carried out in Ionian Sea indicate that there are significant quantities of fish and crustaceans in waters deeper than 300 m. The catch of crustaceans was consisted mainly of commercial species and the quantity was enough to support a commercial fishery. During these experimental surveys in the depth zone 300-500 m the crustaceans catch ranged from 0.06 Kg/hour to 15.98 Kg/hour (average 8.34 Kg/hour). In the deeper depth zone (500-800 m) the catch ranged from 8.06 Kg/hour to 33.67 Kg/hour (average 19.47 Kg/hour). The most important crustacean species was *A. foliacea* (average catch 3.54 Kg/hour and 12.40 Kg/hour, in the 300-500 m and 500-750 m depth zone respectively). Shrimps belonging mainly to the *Plesionika* genus, were abundant in both depth zones, (average catch 2.62 Kg/hour and 2.85 Kg/hour, in the 300-500 m and 500-750 m depth zone respectively) and *A. antennatus* was abundant in the 500-750 m depth zone (average catch 3.09 Kg/hour). *N. norvegicus* and *P. longirostris* contributed to the crustacean catch with about 1 Kg/hour in both depth zones.

The catch of fish was higher. In the depth zone 300-500 m ranged from 37.83 Kg/hour to 146.67 Kg/hour (average 87.69 Kg/hour) and was consisted mainly of non commercial species. In the depth zone 500-800 m the catch ranged from 7.19 to 51.51 Kg/hour (average 29.07 Kg/hour). The contribution of the commercial species in this depth zone was higher.

The average catch per hour of the commercial crustacean species (the *Plesionika* species were not included) was 10.5 Kg/hour in the 300-500 m depth zone and 26.8 Kg/hour in the 500-750 m depth zone. However, in some tows the catch was more than 60 Kg/hour. The average catch of the commercial fish species was 43.5 Kg/hour in the 300-500 m depth zone and 25.3 Kg/hour in the 500-750 depth zone. Thus, the average commercial catch was more than 50 Kg/hour in both depth zones.

The above average catches were estimated from experimental surveys targeting not to maximise the catch but to explore the area and using a bottom trawl not adapted for this fishery. In professional fishery conditions these values will be increased. The fishermen will be more experienced on the behaviour of the species, the duration of the tows will be longer, the tows will take place in selected fishing grounds and more adapted gears will be developed.

It should be noticed than more tows per month and per depth zone are needed in order to extract more accurate conclusions about the abundance of the species in the two depth zones (300-500 m and 500-750 m). The CPUE fluctuations that have been observed, in one degree reflect changes in the abundance of the species but they also could be attributed to the sampling procedure (gear performance, aggregation of the fish, etc.).

During 1990-1992 seasonal bottom trawl surveys took place in Aegean Sea in depths down to 500 m (Papaconstantinou et al. 1993). Comparing the CPUE results of the *N. norvegicus* in the Aegean Sea at 200-500 m depth zone with the results obtained in the Ionian Sea surveys, it can be seen that *N. norvegicus* was more abundant in the Aegean Sea. The CPUE in the west part of the Aegean Sea ranged from 1.5 to 7 Kg/hour where as in the east part of the Aegean Sea ranged from 3 to 14 Kg/hour. The CPUE of *L. budegassa* in Ionian Sea during 1996-1997 was similar to the CPUE in the Aegean sea in the 200-500 m depth zone during 1990-1992 (0.5 to 5 Kg/hour). The abundance distribution of *L. budegassa* is low but it appears in a wide range of depths. The CPUE of *A. sphyraena* in the Aegean Sea during 1990-1992 ranged from 1-8 Kg/hour and it was lower than the CPUE in the Ionian Sea. This difference could be due to the higher abundance of the species in the Ionian Sea but could also be result of the vessel and/or a depth effect since the sampling in Ionian Sea took place in deeper zones than in the Aegean Sea. There are no available data on the CPUE of the other species in the Aegean Sea.

The situation was different in the Italian coasts where in surveys which took place in similar depths *A. antennatus* and *P. longirostris* were more abundant species (Anon. 1997). Concerning the fish catch in the Greek coasts *H. dactylopterus* was more abundant than *H. mediterraneus* whereas in the Italian coasts the number of *H. mediterraneus* was more than 10 times the number of *H. dactylopterus.*

These differences between the east and west coast of the Ionian Sea could be attributed to the exploitation status of the two areas. In the west coast there is a fishery operating for many years whereas the east coast is almost unexploited. Therefor a managing design is needed in order to exploit the east coast of the Ionian Sea which would avoid as much as possible the impact of the fishing on the ecosystem.

The reduction of the catches in the depth zone 300-500 m and the increase of the catches in the depth zone 500-800 that has been observed during summer months possible indicates a migration of these species to deeper water during summer. To justify this hypothesis more work is needed since the number of stations per month was low and the results could be considered as indicative. Furthermore to understand the reasons of this migration a better knowledge on the biology and the behavior of the species is necessary.

The length frequency distribution study shows that the majority of the samples from middle waters were composed of smaller specimens than those form deeper waters**.** The progressive increment of larger specimens to deeper waters corroborates the idea that young shift from shallow waters to deeper waters. The mean length of *A. sphyraena, G. argenteus, S. canicula, M. merluccius, M. poutassou, A. foliacea,* females *P. longirostris, H. dactylopterus, C. agassizi* and *G. melastomus* was positive correlated with the depth.

The movement of individuals to deeper waters as they grow is common among demersal fish (Machpherson and Duarte, 1991). The underlying factors which determine this migration are uncertain: Bathymetrical changes in food availability and avoidance of predators may explain differences in demersal fish biomass, but not size structure (Machpherson and Duarte, 1991).

Temperature is a major factor in fish metabolism (Fry 1971) and behavioral responses (Brett 1979, Garside 1970, Kinne 1970). Large fish show greater preference for colder waters than small fish of the same species (Jobling 1981). Accordingly, early life stages live in warmer waters, where food supply and growth rates are often greater (Machpherson and Duarte, 1991) and older fish live in colder waters,

It may be that size-depth relationship observed represents and evolutionary rather than physiological response of the fish, independent of the depth changes in habitat conditions in the particular location inhabited by the fish. Many Mediterranean fish species experience a general ontogenic change of the nervous system, which increases the light and sound threshold of the fish, such changes allows adult fish to exploit deeper waters than those suitable for smaller individuals (Macpherson and Duarte 19912).

The reproduction cycle of the commercial demersal fish species has been studied extensively in shallower waters of Greece (e.g Papaconstantinou *et al*. 1989; 1993; 1995). Generally, in Greek waters the spawning period of many species starts early in the spring and finish late in the summer. In most cases the duration of the reproductive activity does not extend a period of 6 months. Reproductive activity around all the year has been referred for hake (Papaconstantinou and Stergiou, 1995) and a long reproductive period (nine months) was referred for *Trisopterus minutus capelanus* (poor cod) (Papaconstantinou *et al.* 1989).

The spawning period of *C. agassizi* lasted from spring to Autumn, whereas *H. dactylopterus* and *H. mediterraneus* showed reproductive activities during all the sampling period. The peak took place during December to March for blue mouth and during January to April for *H. mediterraneus*. *P. cataphractum*, which has been caught in abundance in the same area showed the same reproductive behavior (Terrats, unpublished data). Mature individuals of *P. cataphractum* were caught during all the sampling period but higher proportion of mature individuals was found during August to October.

Generally, the number of mature female monk fish, which have been caught during bottom trawl surveys in Greece is very low and therefore the spawning period and area of the species can not be defined. The same was observed during the sampling in the Ionian sea where only 2 mature females and 18 mature males have been caught. Hake is showing reproductive activity around all year in Greek waters. The number of mature hake, which have been caught in deep waters in the Ionian Sea is very low. The length at first maturity (L_{50}) of hake occurs at 18-35 cm for male and 18-41 cm for females (Papaconstantinou and Stergiou, 1995). In the Ionian Sea, the majority of the examined fish were larger than 25 cm but they were immature. A possible explanation for the lack of mature specimens could be that the species is using the deep waters ecosystem mainly as a feeding ground and not as a spawning ground.

The spawning period of blue whiting in Euboikos gulf (Greece) was found to extent from late winter to spring (Papaconstantinou et al., 1989). Mature females and males have been caught during the same months in the Ionian Sea. The number of the examined fish was low and therefore it is difficult to give safe conclusions about the intensity of the spawning activity of the species in this ecosystem.

No mature individuals of *P. blennoides* were caught during the surveys in the Ionian Sea and generally during all the surveys in other Greek areas where the species was quite abundant. Since large specimens have been caught during all the cruises and all the individuals were immature, the species could spawn in deeper waters or in bottoms which are inappropriate for bottom trawl fishery.

The reproduction period of *A. antennatus* extended from Nay to September whereas of *A. foliacea* from June to August. The female of *A. antennatus* was found more abundant than the male. The sex ratio of *A. foliacea* was about 1:1. The same results were observed in other areas of the Mediterranean Sea.

The results from the present study indicate that both macrourids are fairly abundant fish in the Ionian Sea, inhabiting deeper parts of the shelf and adjacent areas on the continental slope. The distribution patterns observed were general similar to those presented by Massuti et al. (1995), in the Catalan Sea, for *N. aequalis* and *C. coelorhynchus*. The mean size of both species increased with depth up to 600 m, but after that there is a significant decrease in fish mean size. Therefore their bathymetric trends did not particular indicate a size related depth distribution pattern, known as the "bigger-deeper" phenomenon (MacPherson and Duarte, 1991).

The results of the morphometric relationships were similar to those obtained for many other teleost fish species. Generally, the size of the sagitta in relation to fish growth shows a negative allometry. This observation has been made in macrourids (Wilson, 1985, Massuti et al., 1995) and it has been reported that this negative allometry is more pronounced in species found at greater depths. However, it should be noted here that although otolith length and fish length were linearly related for both species, the regression slopes and intercepts differ significantly between the two species (ANCOVA, $F=57.5$, $p<0.001$).

Growth ring formation has been reported for many deep-water fish, but the underlying mechanisms causing the formation of marks on the otoliths are not well-known. However, the presence of many age classes seems to be a common feature of all deep-sea fish populations (Rannou, 1976; Lombarte and Morales-Nin, 1989; Bergstad, 1995; Massuti *et al*., 1995). In the present study the pattern of monthly variation of otolith opaque and hyaline edges suggested the formation of one ring per year. Although hyaline rings were found all year round, a clear peak occurred during January indicating seasonal growth for these fish. Although the deep Mediterranean environmental conditions are considered to be aseasonal, at least with respect to temperature (Tyler, 1988), other mechanisms such as seasonal variation in feeding rhythms, food availability and activity patterns could be the main factors resulting in ring formation.

There are very few studies on age and growth of *C. coelorhynchus* and *N. sclerorhynchus* (Rannou, 1973; Rannou, 1976), and no information is given on the growth rates of the species. Therefore the predictions obtained in the present study could not be compared. Age estimations could be validated by comparison among different methods. Modal length progression is commonly used in estimating growth of fish (Ricker, 1975). However, for the species examined the progression of cohorts over time was difficult to distinguish in the length frequencies, because the size mode was situated in the 30-40 mm L_{PA} interval. This might be due to continuous breeding (D’Onghia et al., 1996) that gives rise to a succession of larval cohorts. For this reason age estimations could not be validated by comparison among different models for these species.

Considering the otolith rings as annual, the age composition (maximum 11 years for *C. coelorhynchus* and 10 years for *N. sclerorhynchus*) and growth rates indicated that for both species growth was low. Other macrourids are known to have far greater longevity and it is possible that the older specimens are distributed below the depths examined in the present study. However, *C. coelorhynchus* grow comparatively fast and attain greater asymptotic sizes than *N. sclerorhynchus*. Since *N. sclerorhynchus* tends to be found in relatively high abundance in deeper waters than *C. coelorhynchus*, it could be argued that this lower growth rate agrees with the general pattern suggesting that when comparisons of closely related species are possible, those found at greater depths exhibit the slowest growth rates (Gage and Tyler, 1991, Massuti et al., 1995).

The results indicated that the relationship between otolith weight and fish age is linear. This observation is in agreement with the findings of other studies and it seems that the weights of the otoliths of several fish having the same total body length were ranked in the same order as the ages determined for the fish by examination of the structure of the otoliths. It appears that for two identically-sized fish of different ages the older, and therefore slower-growing individual, will have a heavier otolith possibly because the deposition of otolith material has continued for a longer time. In addition, for any age class, the smaller, slow growing fish will have heavy otoliths relative to their body length, whereas the otoliths of bigger, faster-growing fish will be relatively light. Furthermore, the otolith mass growth rate equivalent to the slope of the regression verifies that *C. coelorhynchus* grows faster than *N. sclerorhynchus,* confirming the results from ageing.

Dissemination

Kapiris, K., Thessalou-Legaki, M., Petrakis, G., Moraitou-Apostolopoulou, M. and Papaconstantinou, C. 1998. Population characteristics and comparison of feeding parameters of *Aristeus antennatus* and *Aristaeomorpha foliacea* (Decapoda: Aristeids,) from the Ionian Sea (Eastern Mediterranean). (Accepted for publication in *Crustacean Issues*).

Kapiris, K., Thessalou-Legaki, M., Petrakis, G., Moraitou-Apostolopoulou, M. and Papaconstantinou, C. 1998. Comparison of feeding parameters of two sympatric aristeids from the Ionian Sea, Greece. 4th International Crustacean Congress, Amsterdam, 20-24/8/98

Labropoulou, M., Petrakis, G. and Papaconstantinou, C. 1998. Comparison of otolith growth and somatic growth in two macrourid fishes. Second International symposium on fish otolith research and application, Bergen, Norway, 20-25/8/98.

Labropoulou, and Papaconstantinou, C. 1998. Comparison of otolith growth and somatic growth in two macrourid fishes. (submitted for publication *Fisheries Research).*

Mytilineou, Ch., Petrakis, G., Fourtouni, A., 1998. Composition of the discarded catches from experimental bottom trawl surveys in Greek waters. Poster, *Book of abstracts of the 1998 ICES Annual Science Conference. 16-19/9/1998, Cascais, Portugal*, CM 1998/ O:38

Papaconstantinou, C., Boutsioulis, C. and Petrakis, G., 1998. Biological aspects of black-bellied angler (*Lophius butegassa,* Spinola, 1807) in the Aegean Sea. *Book of abstracts of the 1998 ICES Annual Science Conference. 16-19/9/1998, Cascais, Portugal*, CM 1998/O:85.

Petrakis, G., 1998. Catch Per Unit of Effort fluctuations in deep waters in West Coast of Greece (Ionian Sea). *Book of abstracts of the 1998 ICES Annual Science Conference. 16-19/9/1998, Cascais, Portugal*, CM 1998/O:50

Petrakis, G., Terrats, A., Plastiras, A. and Papaconstantinou, C., 1998. Some aspects on the reproduction of six deep water fish species in West Coast of Greece (Ionian Sea). *Book of abstracts of the 1998 ICES Annual Science Conference. 16-19/9/1998, Cascais, Portugal,* CM 1998/O:45

Petrakis, G. and Papaconstantinou, C. 1997. First results of bottom trawl ssurveys in deep waters of the Ionian Sea. 8th Hellenic Symposium of Icthyologists, Thessaloniki, 26-27 September.

In the framework of the project two PhDs are running:

1. 'Biology, reproduction and feeding of the deep water shrimps *A. antennatus*, and *A. foliacea* in the Ionian Sea' by K. Kapiris, University of Athens, supervisor, Dr. M. Thessalou-Legaki.
2. 'Biology of *Chlorophthalmus agassizi* in the Ionian Sea' by A. Anastasopoulou, University of Athens, supervisor, Dr. K. Yiannopoulos.

Data collected during the 'Deep water fisheries' project are using in the following TMR projects which are running now in NCMR. Two PhD thesis are carring out in the framework of the TMR projects.

1. 'Feeding strategies and energy requirements of deep-sea demersal fish in Eastern Mediterranean' FAIR GT 97-1376, grant holder T. Madurell, University of Balearic Islands, supervisor, B. Morales-Nin.
2. 'Evaluation of the reproductive strategy of the deep water fish species in west coast of Greece' FAIR GT 97-2374, grant holder A. Terrats, University of Thessaloniki, supervisor K.I Stergiou.

Conclusion

The results of the surveys in the Greek waters indicated that the answer in the question if there are catches able to support a commercial fishery in the deep waters is positive. The quantity and the quality of the catches were found to be enough to ensure a profitable fishery at least in the Ionian Sea where the surveys took place. On the other hand, the depth zone 400-800 m is about 30% of the Greek seas. Thus, it would be interesting to investigate the situation in other areas too.

However, more questions are rising. It is known that the regeneration rate of the deep water stocks is low, their growth is slow and their maturation is late. Consequently, will this fishery be sustainable? What is the size of the commercial stocks? How vulnerable are they in the bottom trawl fishery? Is the mesh size of the cod-end used in Greek bottom trawl fishery the appropriate one? Is the bottom trawl the most appropriate gear? What management design should be followed?

More research is needed to investigate the situation in these depths in other areas, to assess the stocks, to study the biology and the dynamic of the populations and the interactions between them in order to purpose management measures for a rational exploitation of the deep water ecosystem.

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Table 1. Sampling cruises in the Ionian Sea from December 1996 to November 1997.

Month	Date	Days at sea	Number of stations
December 96	10-15	6	12
January 97	23-26	2	6
February 97	12-15	2	5
March 97	13-20	6	12
April 97	9-11	2	6
May 97	11-14	2	6
June 97	20-25	4	9
July 97	21-25	3	7
August 97	19-22	2	5
September 97	15-21	5	12
October 97	22-25	2	6
November 97	20-23	2	4

Table 2. Fishing stations per cruise from December 1996 to November 1997.

Cruise	Station	Duration	Depth	Warp length
2	D201	60	490	1523
2	D202	60	525	1313
2	D203	90	350	1138
2	D204	60	429	1138
2	D205	60	578	1313
2	D206	60	569	1488
2	D207	60	700	1663
2	D208	90	665	1663
2	D210	60	490	1488
2	D211	60	578	1575
2	D212	60	376	1400
2	D213	60	490	1488
3	D301	75	464	1488
3	D302	100	469	1488
3	D303	90	613	1488
3	D304	80	481	1488
3	D305	60	368	1400
3	D306	60	543	1488
4	D401	55	502	1488
4	D402	65	478	1488
4	D403	60	473	1488
4	D406	60	530	1488
4	D407	60	480	1488
5	D501	60	497	1575
5	D502	60	453	1575
5	D503	60	539	1575
5	D504	30	429	1138
5	D505	60	569	1750
5	D506	90	688	1925
5	D507	30	368	1225
5	D508	60	481	1575
5	D509	60	569	1838
5	D510	60	473	1400
5	D511	60	823	2013
5	D512	30	341	1225
5	D513	60	560	1750
5	D514	30	744	1925
5	D515	60	438	1488
6	D601	60	534	1575
6	D602	45	303	1138
6	D603	60	560	1575
6	D604	60	504	1488
6	D605	60	481	1400
6	D606	45	481	1138
7	D701	60	504	1750
7	D702	60	429	1313

7	D703	60	543	1750
7	D704	60	394	1313

Table 2. Continued

Cruise	Station	Duration	Depth	Warp length
7	D705	60	569	1663
7	D706	90	630	1838
8	D801	60	508	1575
8	D802	60	473	1488
8	D803	60	534	1400
8	D804	30	431	1488
8	D806	60	574	1575
8	D807	60	537	1575
8	D808	60	362	1225
8	D809	60	438	1488
8	D810	60	604	1575
9	D901	60	506	1488
9	D902	60	487	1488
9	D903	60	560	1663
9	D904	60	373	1400
9	D905	60	560	1663
9	D906	90	516	1575
9	D907	90	569	1575
10	D1001	60	499	1575
10	D1002	60	450	1400
10	D1004	30	364	1400
10	D1005	60	553	1575
10	D1006	60	551	1575
11	D1101	60	518	1575
11	D1102	60	491	1400
11	D1103	60	564	1575
11	D1104	30	369	1138
11	D1105	30	447	1400
11	D1106	60	564	1575
11	D1107	60	589	1575
11	D1108	20	576	1575
11	D1109	60	637	1663
11	D1110	90	578	1575
11	D1111	60	691	1663
11	D1112	60	582	1575
12	D1201	60	518	1575
12	D1202	60	491	1400
12	D1203	60	573	1663
12	D1204	30	369	1313
12	D1205	60	606	1663
12	D1206	60	587	1663
13	D1301	60	482	1400
13	D1302	60	522	1575
13	D1303	60	582	1575

13	D1304	30	360	1313

Table 3. Total actual number and weight of the crustacean species caught per depth zone from December 1996 to November 1997.

	Number		Weight (Kg)	
Species	300-500 m	500-750 m	300-500 m	500-750 m
Aristaeomorpha foliacea	7507	30892	151.88	666.56
Aristeus antennatus	1067	7671	16.76	167.70
Shrimps sp.			100.19	162.17
Parapenaeus longirostris	3542	3628	34.33	40.27
Nephrops norvegicus	566	435	31.29	23.84
Brachyura	2	7	0.82	0.62
Polychelidae	8	25	0.12	0.41

Table 4. Total actual number and weight of the fish species caught per depth zone from December 1996 to November 1997.

Species	Number		Weight (Kg)	
	300-500 m	500-750 m	300-500 m	500-750 m
Argentina sphyraena	22316	262	235.99	3.77
Argyropelecus hemigymnus	18	38	0.04	0.05
Arnoglossus rueppelli	101	1	0.40	0.00
Aspitrigla cuculus	38	1	3.18	0.22
Bellottia apoda		3		0.01
Boops boops	26		1.53	
Callionymus maculatus	1		0.00	
Capros aper	539	7	10.59	0.09
Centracanthus cirrus	7		0.19	
Centrolophus niger		2		3.46
Chauliodus sloani	2	37	0.05	0.30
Chimaera monstrosa	130	261	25.29	61.81
Chlorophthalmus agassizi	75302	10421	874.89	240.71
Coelorhynchus coelorhynchus	3505	1757	61.64	35.21
Conger conger	34	62	7.48	13.67
Dalatias licha	11	12	16.25	14.62
Diaphus metopoclampus	9	143	0.08	1.12
Diaphus rafinesqei		2		0.02
Epigonus denticulatus	13		0.21	
Epigonus telescopus	147	46	3.79	1.10
Etmopterus spinax	948	780	34.91	44.84
Gadella maraldi	4	5	0.01	0.02
Gadiculus a. argenteus	20336	156	74.85	1.43
Gaidropsarus sp	2	1	0.03	0.00
Galeus melastomus	2976	1031	148.60	129.29
Gnathophis mystax		2		0.04
Gobiidae	1	13	0.06	0.01
Helicolenus dactylopterus	1381	1821	113.77	236.37
Heptranchias perlo	1	2	2.05	4.92
Hexanchus griseus		1		
Hoplostethus mediterraneus	3280	4075	149.61	182.88
Hymenocephalus italicus	7162	4433	23.64	16.30
Lampanyctus crocodilus	8	67	0.12	0.98
Lepidopus caudatus	12	1	3.40	0.31
Lepidorhombus boscii	605	413	36.36	29.43
Lepidorhombus whiffiagonis	78	34	12.48	5.52
Lepidotrigla cavillone	281	3	6.06	0.07
Lepidotrigla dieuzeide	45		1.39	
Lophius budegassa	98	139	66.95	111.54
Lophius piscatorius	3	16	44.00	169.57
Merluccius merluccius	1437	297	91.84	66.82
Micromesistius p. poutassou	880	258	103.38	69.95
Molva d. macrophthalma	20	93	7.73	39.45
Mora moro	2	3	0.02	2.09

Mullus surmuletus	31		2.95	
Myctophidae	17	35	0.10	0.25

Table 4. Continued

Species	Number		Weight (Kg)	
	300-500 m	500-750 m	300-500 m	500-750 m
Nettastoma melanurum	36	131	1.10	3.23
Nezumia sclerorhynchus	2333	5456	24.83	57.53
Notocanthus bonapartei		14		0.30
Oxynotus centrina		1		0.71
Pagellus acarne		1		0.04
Pagellus bogaraveo	67	69	11.53	12.22
Paralepis coregonoides		1		0.00
Peristedion cataphractum	2702	1439	63.51	36.55
Phycis blennoides	400	536	45.10	77.35
Phycis phycis	1		0.02	
Raja clavata	48	12	30.99	12.77
Raja oxyrinchus	83	12	58.79	4.54
Raja sp.	2		2.00	
Ruvettus pretiosus		1		1.69
Scorpaena notata	2	1	0.64	0.40
Scorpaena scrofa	4		2.02	
Scyliorhinus canicula	193	25	36.48	7.43
Squalus acanthias		1		2.65
Squalus blainvillei	175	9	219.29	18.86
Stomias boa	31	57	0.15	0.46
Symphodus sp.		2		0.01
Symphurus nigrescens	19	54	0.06	0.19
Synchiropus phaeton	223	78	0.63	0.33
Torpedo marmorata	1		0.15	
Trachurus trachurus	2		0.31	
Trigla lyra	93	12	10.39	1.13
Zeus faber	2		0.28	

Table 5. Diversity indices for each depth zone and season.

		Richness			Evenness		
Season	Depth Zones	mean	min	max	mean	min	max
Winter	<300 m	3.817	2.976	4.657	0.476	0.324	0.627
	300-400 m	3.84	3.245	4.434	0.633	0.526	0.74
	400-500 m	3.703	3.217	4.188	0.542	0.454	0.629
	>500 m	3.2875	2.4085	4.166	0.6835	0.5245	0.8415
Spring	<300 m	2.419	1.578	3.259	0.251	0.1	0.403
	300-400 m	3.565	2.914	4.216	0.571	0.453	0.688
	400-500 m	3.558	3.169	3.947	0.521	0.45	0.591
	>500 m	3.165	2.135	4.195	0.524	0.339	0.709
Summer	<300 m	1.775	0.934	2.615	0.341	0.19	0.493
	300-400 m	3.083	2.355	3.811	0.613	0.481	0.744
	400-500 m	3.207	2.803	3.61	0.532	0.459	0.605
	>500 m	3.518	2.062	4.973	0.532	0.269	0.794
Autumn	<300 m	1.842	1.001	2.682	0.311	0.159	0.462
	300-400 m	3.138	2.41	3.866	0.713	0.582	0.844
	400-500 m	2.788	2.368	3.208	0.409	0.333	0.485
	>500 m	3.26	2.419	4.1	0.603	0.452	0.755
Total	<300 m	2.46	1.99	2.93	0.34	0.293	0.387
	300-400 m	3.41	3.23	3.59	0.63	0.6	0.66
	400-500 m	3.31	3.1	3.52	0.5	0.47	0.53
	>500 m	3.31	3.24	3.38	0.58	0.55	0.61

		Simpson			Shannon		
Season	Depth Zones	mean	min	max	mean	min	max
Winter	<300 m	0.293	0.111	0.474	1.7	1.199	2.201
	300-400 m	0.257	0.129	0.385	2.11	1.756	2.464
	400-500 m	0.291	0.186	0.395	1.792	1.503	2.081
	>500 m	0.2525	0.063	0.442	1.8575	1.3335	2.381
Spring	<300 m	0.663	0.481	0.844	0.8	0.299	1.301
	300-400 m	0.235	0.0944	0.375	1.919	1.531	2.307
	400-500 m	0.304	0.22	0.388	1.729	1.497	1.961
	>500 m	0.331	0.108	0.553	1.54	0.926	2.153
Summer	<300 m	0.438	0.256	0.619	0.967	0.466	1.463
	300-400 m	0.264	0.107	0.421	1.926	1.492	2.36
	400-500 m	0.315	0.228	0.402	1.696	1.456	1.937
	>500 m	0.333	0.018	0.647	1.711	0.843	2.578
Autumn	<300 m	0.573	0.392	0.755	0.894	0.393	1.395
	300-400 m	0.148	0.018	0.287	2.265	1.831	2.699
	400-500 m	0.476	0.385	0.566	1.214	0.963	1.464
	>500 m	0.244	0.062	0.425	1.856	1.355	2.357
Total	<300 m	0.49	0.409	0.571	1.09	0.88	1.3
	300-400 m	0.226	0.196	0.256	2.055	1.975	2.135
	400-500 m	0.35	0.31	0.39	1.61	1.48	1.74
	>500 m	0.29	0.27	0.31	1.74	1.66	1.82

Table 6. Estimated values of the parameters of the length-weight relationship of *A. antennatus* in the Ionian Sea.

Males				
	a	b	r^2	N
Winter	0.006887	2.190955	0.94	58
Spring	0.012127	2.018307	0.93	319
Summer	0.011134	2.016714	0.98	14
Autumn	0.002805	2.458472	0.92	29
Females				
	a	b	r^2	N
Winter	0.003798	2.361449	0.97	125
Spring	0.007749	2.168716	0.96	1018
Summer	0.003773	2.350012	0.98	562
Autumn	0.004532	2.297544	0.97	675

Table 7. Parameters of the carapace length-weight relationship of *A. antennatus* in the European waters.

Sex	a	b	r^2	Region	Reference
Males	0.00227	2.481	0.98	S. coast of Portugal	Ribeiro-Cascalho & Arrobas, 1984
Females	0.00228	2.493	0.99		
Males	0.00402	2.317	0.97	Catalan coast	Demestre, 1993
Females	0.00264	2.466	0.98		
Males	0.00299	2.413	0.94	Majorca island	Carbonell & Alvarez, 1995
Females	0.00511	2.147	0.90		
Combined	0.00262	2.436	0.96	French Mediterranean	Campillo, 1994
Females	0.0030	2.455	0.98	Tyrrhenian Sea	Righini & Abella, 1994

Table 8. Identified age groups from the CL-frequency analysis of *A. antennatus*, (males) during the twelve monthly sampling cruises using Bhattacharya's method. S.D.: standard deviation; S.I.: separation index; C.L.: carapace length (mm); N: number of individuals.

	Mean C.L.	S.D.	N	S.I.
December	22.79	1.01	9	
	28.82	1.91	47	4.12
	35.06	0.88	3.81	4.46
	38.5	2.43	1.83	2.06
January	14.08	1.76	16	
	18.96	1.12	13.5	3.38
	24.03	1.11	11.99	4.53
	28.28	0.68	6.91	4.63
February	24.63	1.05	38	
	26.9	0.97	94.26	2.43
March	19.73	1.16	25	
	26.74	1.77	329	4.78
	30.68	0.85	68.79	2.99
April	23.1	0.816	116	
May	24.67	0.54	26	
	29.97	1.32	37	5.67
	24.65	0.817	16	

September	26.5	0.925	16.87	2.119
	30.14	0.366	22.6	5.64
October	28.25	0.73	15	

Table 9. Identified age groups from the CL-frequency analysis of *A. antennatus*, (females) during the twelve monthly sampling cruises using Bhattacharya's method. S.D.: standard deviation; S.I.: separation index; C.L.: carapace length (mm); N: number of individuals.

	Mean C.L.	S.D.	N	S.I.
January	13.27	1.25	8	
	23.49	2.14	21	6.00
	32.69	2.36	76.98	4.08
	41.71	3.48	36.02	3.08
	47.92	1.02	10.55	2.75
	25.22	1.99	82	
February	35.52	2.14	134.98	4.97
	41.7	1.71	175.64	3.20
	48.58	2.31	108.18	3.42
March	14	2.23	13	
	27.52	2.73	788.82	5.45
	34.58	1.96	260.61	3.00
	43.49	5.39	462.67	2.42
April	28.47	6.14	285	
	35.25	1.07	107.66	1.87
	40.7	1.82	242.18	3.76
	46.46	2.85	89.28	2.46
May	29.92	3.13	87	
	39.11	2.47	226.75	3.27
	48.89	2.22	259.47	4.16
June	31.62	3.89	15	
	41.24	2.70	58.35	2.91
	48.23	1.32	14.37	3.47
July	30.99	3.47	190	
	40.99	3.87	332.03	2.72
	46.66	1.89	120.08	1.96
	52.28	2.37	69.58	2.63
August	32.21	2.51	59	
	39.07	1.75	52.09	3.21
	49.4	2.18	21	5.24
September	34.69	3.50	656	
	43.24	2.54	264.31	2.82
	48.9	2.89	156.61	2.07
October	33.03	4.12	85	
	41.17	2.33	87.35	2.52
	46.49	1.40	40.9	2.84
November	25.58	1.58	14	
	31.08	1.44	21.25	3.62
	36.91	2.03	37.69	3.34
	44	1.27	5.28	4.27
December	24	2.79	13	
	33.1	1.69	93.73	4.05
	39.19	1.71	66.61	3.57
	44.19	2.44	17.05	2.40

Table 10. Growth parameters of *A. antennatus* in the Ionian Sea.

Sex	L_∞ (mm)	K	t_o
Males	57.547	0.434	-0.464
Females	65.985	0.392	0.384

Table 11. Growth parameters of *A. antennatus* in the European waters.

Sex	L_∞ (mm)	K	t_o	Region	Reference
Females	65.1	0.36	0.046	Algeria	Yahiaoui *et al.*, 1985
Males	44-54	0.25-0.29	0.5-0.8	Catalan Sea	Sarda & Demestre, 1987; Demestre, 1993
Females	68-76	0.20-0.30	0.7-1.1		
Females	86.7	0.25		Strait of Sicily	Arculeo *et al.*, 1992
Females	67.7	0.59		Strait of Sicily	Ragonese & Bianchini, 1996
Females	66.81	0.558	-0.23	Tyrrhenian Sea	Spedicato *et al.*, 1995
Males	54.6	0.99		Ionian Sea	Matarrese *et al.*, 1992
Females	66.2	0.93			
Males	46	0.47	0.13	Majorca Island	Carbonell & Alvarez, 1995
Females	74	0.38	0.07		

Table 12. Estimated values of the parameters of the length-weight relationship of *A. foliacea* in the Ionian Sea.

Males				
	a	b	r^2	N
Winter	0.004381	2.313622	0.86	626
Spring	0.011279	2.036105	0.69	1121
Summer	0.005495	2.234109	0.78	762
Autumn	0.010369	2.064108	0.72	1020
Females				
	a	b	r^2	N
Winter	0.002496	2.46186	0.93	884
Spring	0.002178	2.488708	0.92	1174
Summer	0.001964	2.508176	0.91	708
Autumn	0.002875	2.414195	0.91	649

Table 13. Parameters of the carapace length-weight relationship of *Aristaeomorpha foliacea* in the Mediterranean waters.

Sex	a	b	r^2	Region	Reference
Males	0.0006	2.873		Sicily Strait	Bianchini *et al.*, in Press
Females	0.0013	2.642			
Females	0.0011	2.63		Centr. Tyrrhenian	Ardizzone *et al.*, 1988
Males	0.00053	2.948	0.91	Northern	Righini & Abella,

Females	0.00317	2.437	0.98	Tyrrhenian	1994
Females	0.00137	2.610	0.93	S. Tyrrhenian (autumn)	Spedicato *et al.*, 1994
Females	0.00088	2.742	0.99	S. Tyrrhenian (spring)	
Females	0.00096	2.723	0.99	S. Tyrrhenian (summer)	

Table 14. Identified age groups from the CL-frequency analysis of *A. foliacea*, (males) during the twelve monthly sampling cruises using Bhattacharya's method. S.D.: standard deviation; S.I.: separation index; C.L.: carapace length (mm); N: number of individuals.

	Mean C.L.	S.D.	N	S.I.
January	21.84	1.04	25	
	33.46	1.65	749	8.60
	37.9	0.98	117.45	3.36
February	32.84	1.55	1020	
	37.75	0.63	78.79	4.48
March	32.27	1.92	1707	
	36.32	1.02	193.14	2.75
	40.13	0.38	39.7	5.42
April	33.68	1.23	1623	
	35.5	0.52	62.93	2.06
May	32.83	1.88	2003	
	37.65	0.60	7.41	3.86
June	32.74	1.34	844	
	37.12	1.02	104.56	3.69
July	32.69	1.11	1006	
	35.33	1.22	396.32	2.26
	38.5	1.67	26.73	2.18
August	28.68	1.24	153	
	33.09	1.34	914.67	3.40
September	28.01	1.349	26	
	33.94	1.647	2720.78	3.95
	39.03	1.101	54.69	3.70
October	34.08	1.68	1225	
	39.34	0.44	13.14	4.92
November	27.65	2.06	35	
	32.99	1.67	958.31	2.86
	37.54	0.77	30.5	3.72
	39.5	1.43	7.87	1.77
December	27.14	0.91	201	
	33.17	1.46	1100	5.08
	37.17	1.03	90.69	3.21
	42.83	2.61	16.83	3.10

Table 15. Identified age groups from the CL-frequency analysis of *A. foliacea*. (females) during the twelve monthly sampling cruises using Bhattacharya's method. S.D.: standard deviation; S.I.: separation index; C.L.: carapace length (mm); N: number of individuals.

	Mean C.L.	S.D.	N	S.I.
January	35.19	2.90	366	
	44.64	2.11	431.78	3.76
	50.6	2.16	69.37	3.08
February	29	3.26	27	
	37.25	2.58	152.88	2.81
	45.55	2.80	550.93	3.08
March	37.22	3.16	1794	
	48.04	2.36	1071.92	3.91
	55.51	1.49	21.41	3.86
April	32.13	1.771	68	
	38.55	2.38	775.81	3.09
	46.9	2.35	840.35	3.52
May	26.83	2.654	31	
	39.7	2.39	577.83	5.1
	47.36	1.84	698.04	3.60
	51.83	2.05	123.44	2.29
June	40.68	2.04	800	
	47.59	1.33	333.94	4.09
	53	2.91	13	2.54
July	26	1.34	20	
	40.73	2.35	764	7.95
	49.86	2.14	654.1	4.07
August	41.19	2.01	817	
	47.03	2.06	309.66	2.89
	51	1.75	56.25	2.04
September	33.31	3.99	87	
	41.4	1.75	1864.47	2.81
	48.32	3.04	654.11	2.88
October	28	2.368	24	
	42.12	1.99	398	6.48
	47.97	2.35	285.36	2.69
November	31.88	2.65	75	
	41.43	1.68	363.91	4.40
	47.68	2.63	153.49	2.9
December	33.88	3.09	237	
	42.99	2.17	811.56	3.45
	47.64	2.03	163.91	2.21

	57	5.86	18.84	2.36

Table 16. Growth parameters of *A. foliacea* in the Ionian Sea.

Sex	L_∞ (mm)	K	t_o
Males	44.97	0.635	-0.13
Females	64.086	0.460	-0.192

Table 17. Growth parameters of *A. foliacea* in the European waters.

Sex	L_∞ (mm)	K	t_o	Region	Reference
Females	65.5	0.67	0.87	Sicilian Channel	Ragonese *et al.*, 1994b
Males	41.5	0.96	02.8		
Females	60.83-78.73	0.29-0.61	-0.18	N. Ionian Sea	Matarrese *et al.*, 1997
Females	73.19	0.62	0.19	Central Tyrrhenian	Leonardi & Ardizzone, 1994
Females	53.85-87.85	0.26-0.66		S. Tyrrhenian	Spedicato *et al.*, 1994
Females	65-73			Algeria	Yahiaoui, 1994
Males	44-45				

Table 18. Estimated values of the parameters of the length-weight relationship of *P. longirostris.*

Males				
	a	b	r^2	N
Winter	0.002852	2.485777	0.77	518
Spring	0.012098	2.026973	0.77	651
Summer	0.005028	2.260939	0.78	441
Autumn	0.002773	2.458129	0.81	729
Females				
	a	b	r^2	N
Winter	0.00536	2.274899	0.84	343
Spring	0.012392	2.022556	0.68	73
Summer	0.005195	2.278878	0.89	154
Autumn	0.004556	2.315975	0.85	248

Table 19. Parameters of the carapace length-weight relationship of *P. longirostris* in the European waters.

Sex	a	b	r^2	Region	Reference
Males	0.0075	2.192	0.99	S. Portugal (winter)	Ribeiro-Cascalho & Arrobas, 1987
Females	0.0055	2.306	0.99		
Males	0.0022	2.56	0.95	Atlantic Moroccan Coast	Sobrino & Garcia, 1994
Females	0.0094	2.12	0.84		
Combined	0.0061	2.266		Sicilian Channel	Levi *et al.*, 1995

Table 20. Identified age groups from the CL-frequency analysis of *P. longirostris*, (males) during the twelve monthly sampling cruises using Bhattacharya's method. S.D.: standard deviation; S.I.: separation index; C.L.: carapace length (mm); N: number of individuals.

	Mean C.L.	S.D.	N	S.I.
January	22.47	1.51	89	
	26.02	1.01	80.09	2.80
February	24.83	1.43	213	
	28.11	0.55	15.46	3.31
March	25.56	1.49	565	
April	25.26	1.08	201	
	27.86	0.87	51.74	2.65
May	24.79	1.20	155	
	28.49	0.96	34.76	3.41
June	26.32	1.24	179	
	31.17	0.8	5.35	4.74
July	17.82	1.53	25	
	25.27	1.86	536.88	3.81
August	26	1.62	424	
	30.48	1.41	8.69	2.94
September	24.83	1.87	872	
October	25	1.27	328	
	27.69	0.41	18.24	3.17
November	23.34	1.00	130	
	25.63	0.98	116.77	2.29
	19.63	1.41	37	
December	25	1.43	278.47	3.76
	29.6	1.64	27.9	2.98

Table 21. Identified age groups from the CL-frequency analysis of *P. longirostris*, (females) during the twelve monthly sampling cruises using Bhattacharya's method. S.D.: standard deviation; S.I.: separation index; C.L.: carapace length (mm); N: number of individuals.

	Mean C.L.	S.D.	N	S.I.
January	17.5	1.20	36	
	25.56	1.63	85.99	5.68
	29.66	0.88	30.51	3.26
	31.53	1.05	20.51	1.92
February	21.16	1.11	7	
	27.78	2.08	109.6	4.13
	31.71	0.62	8.76	2.89
March	26.95	1.08	63	
	30.66	1.17	35.49	3.29
April	25.90	1.12	135	
	29.53	1.42	148	2.84
May	23.56	1.69	9	
	27.99	1.72	87.21	2.59
	30.55	1.02	14.94	1.86
June	22	0.50	9	
	28	1.88	121	5.01
July	26.23	1.35	49	
	29.82	1.37	166.93	2.63
August	26.23	1.18	74	
	29.97	1.61	150.16	2.66
September	27.40	1.69	260	
	30.23	1.44	144.25	1.80
October	27.09	1.30	44	
	30.38	1.32	64.7	2.50
November	23.5	1.20	3	
	28.73	1.96	22.97	3.30
December	25.43	1.71	68	
	29.01	1.19	113.98	2.45

	31.8	1.94	68.11	1.78

Table 22. Growth parameters of *P. longirostris* in the Ionian Sea.

Sex	L_∞ (mm)	K	t_o
Males	33.663	0.634	-0.158
Females	37.208	0.520	0.300

Table 23. Growth parameters of *P. longirostris* in the European waters.

Sex	L_∞ (mm)	K	t_o	Region	Reference
Females	44.4	0.74	-0.13	Central Mediterranean Sea	Ardizzone *et al.*, 1990
Males	33.10	0.93	-0.05		
Females	44.00	0.70	-0.30	South Portuguese Coast	Ribeiro-Cascalho & Arrobas, 1987
Males	36.00	0.90	-0.30		

Table 24. Morphometric relationships of *N. sclerorhynchus* W: total weigh (g); L_{PA}: Pre-anal length (mm); W_o: otolith weight (g); L_o: otolith length (µm); n: number of specimens; r^2: correlation coefficient.

Correlation	n	r^2
$W=0.0024*L_{PA}^{2.52}$	1767	0.89
$W_o= 0.027*L_{PA}^{1.30}$	200	0.81
$W_o= 0.007*L_o^{2.09}$	200	0.84
$L_o=32.34+0.77* L_{PA}$	200	0.86

Table 25.The von Bertalanffy growth parameters and growth performance index (Φ) of *N. sclerorhynchus* (r^2=0.98).

Parameter	Estimate	Standard error
L_∞ (mm)	73.50	12.054
K ($year^{-1}$)	0.125	0.038
t_0 (year)	0.238	0.340
Φ	2.830	0.312

Table 26. Mean pre-anal length-at-age (mm); minimum and maximum length at age; number of observations (n) and Standard Error of mean (S.E.) of *N. sclerorhynchus.*

Age	Length	Min.	Max.	n	S. E.
2	16.3	8	21	16	1.78
3	22.5	11	32	36	1.01
4	26.7	14	35	34	1.28
5	32.4	21	42	35	1.67
6	37.9	29	45	25	1.05
7	41.5	31	46	24	1.28
8	44.9	34	51	14	1.19
9	46.8	37	53	10	1.53
10	48.1	42	60	6	1.98

Table 27. Morphometric relationships of *C. coelorhynchus*. W: total weigh (g); L_{PA}: Pre-anal length (mm); W_o: otolith weight (g); L_o: otolith length (µm); n: number of specimens; r^2: correlation coefficient.

Correlation	n	r^2
$W = 0.0011 * L_{PA}^{2.42}$	1266	0.87
$W_o = 0.013 * L_{PA}^{1.49}$	252	0.89
$W_o = 0.002 * L_o^{2.37}$	244	0.86
$L_o = 24.47 + 1.68 * L_{PA}$	244	0.85

Table 28. The von Bertalanffy growth parameters and growth performance index (Φ) of *C. coelorhynchus*. (r^2=0.97).

Parameter	Estimate	Standard error
L_∞ (mm)	106.95	35.19
K ($year^{-1}$)	0.132	0.081
t_0 (year)	-1.535	0.618
Φ	3.179	0.431

Table 29. Mean pre-anal length-at-age (mm); minimum and maximum length at age; number of observations (n) and Standard Error of mean (S.E.) of *C. coelorhynchus*.

Age	Length	Min.	Max.	n	S. E.
3	20.8	18	28	17	2.89
4	27.6	20	36	21	1.29
5	36.3	33	39	39	0.99
6	44.4	30	65	49	2.04
7	52.6	35	71	37	1.75
8	60.5	44	80	30	1.93
9	68.3	52	89	24	2.08
10	74.6	63	92	16	1.54
11	77.9	74	104	11	2.76

Table 30. Length-age key of *H. mediterraneus*.

	Age (years)										
TL (mm)	0	1	2	3	4	5	6	7	8	9	10
41-50											
51-60											
61-70	100.00										
71-80	100.00										
81-90		100.00									
91-100		100.00									
101-110		70.00	30.00								
111-120		25.71	74.29								
121-130		10.34	89.66								
131-140			89.74	10.26							
141-150			62.50	37.50							
151-160			32.50	52.50	15.00						
161-170				66.67	33.33						
171-180				31.03	68.97						

181-190					77.27	22.73					
191-200					14.29	28.57	57.14				
201-210							25.00	75.00			
211-220									66.67	33.33	
221-230										50.00	50.00
Number	56	880	3516	1688	882	89	104	56	34	22	10

Table 31. Mean back-calculated length of *H. mediterraneus*.

			Ages (years)									
Ages	TL	N	1	2	3	4	5	6	7	8	9	10
10	222.0	1	84.4	112.4	138.2	161.9	183.4	196.3	207.1	213.5	217.8	221.1
9	219.5	3	80.8	112.4	138.9	160.4	180.5	193.4	204.2	209.9	215.7	
8	214.0	2	84.4	115.6	143.6	164.0	180.2	190.9	200.6	207.1		
7	206.0	3	89.4	122.4	145.4	166.2	182.0	192.7	199.2			
6	198.1	9	88.7	120.8	146.3	168.6	186.7	194.4				
5	188.2	9	86.3	119.1	143.5	163.8	181.0					
4	173.6	57	85.6	117.7	142.4	161.0						
3	157.2	73	86.9	119.9	141.3							
2	131.1	131	87.1	116.4								
1	101.8	47	87.3									
0	72.9	19										
Mean back-calculated length (mm)			86.8	117.8	142.2	162.3	183.0	193.5	201.4	208.8	215.7	221.1
Standard deviation			4.7	6.0	5.8	6.9	5.7	3.0	3.7	2.9	1.8	
Number of specimens			335	289	157	84	27	18	9	6	4	2
Annual increment			86.8	31.0	24.4	20.2	20.6	10.5	7.9	7.4	6.9	5.5
Annual increment (%)			39.3	14.0	11.0	9.1	9.3	4.8	3.6	3.3	3.1	2.5

Table 32. Length-age key of *H. dactylopterus*.

Length class	Age (years)										Number
(mm)	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	
40-49											8
50-59	14										14

60-69	19										19
70-79	27										27
80-89		33									33
90-99		60									60
100-109		28	39								67
110-119		24	130								154
120-129			144	52							196
130-139			54	163	27						245
140-149			29	202	58						288
150-159				61	243						304
160-169				45	120	105	15				284
170-179					84	134	34				252
180-189					13	94	67				174
190-199						108	62				170
200-209							124	41			165
210-219								147			147
220-229								68	68		136
230-239									103		103
240-249										82	82
Number	67	145	395	523	545	441	301	256	171	82	

Table 33. Mean back-calculated length of *H. dactylopterus*.

Age group	Mean length	Number of fish	Mean calculated length								
			1	2	3	4	5	6	7	8	9
1	96.48	33	90.75								
2	117.41	44	88.65	109.94							
3	141.49	37	90	116.83	133.83						
4	160.58	43	91.29	120.41	138.67	151.94					
5	173.15	13	88.63	116.46	135.98	151.58	163.24				
6	186.84	13	94.49	119.15	140.49	158.47	173.8	186.4			
7	200.75	4	97.29	120.39	142.34	159.66	174.68	190.85	204.13		
8	224.75	4	96.71	120.39	144.65	161.97	177.56	192.58	206.44	217.41	
9	248.00	1	94.98	120.39	145.8	166.59	182.76	196.62	210.48	228.96	240.51
Average length			90.64	116.25	137.41	154.07	170.66	188.8	205.86	219.72	240.51
Average annual growth increment			90.64	25.61	21.16	16.66	16.59	18.14	17.06	13.86	20.79
Number of fish			192	159	115	78	35	22	9	5	1

Table 34. Length- age key of *C. agassizi* in the Ionian Sea.

Class	Age													
(mm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13
46-50	4	3												
51-55		6												
56-60		16												
61-65		9												
66-70		20	3											
71-75		15	50											
76-80			84	10										

81-85			50	23										
86-90			11	36	1									
91-95				46	7									
96-100				18	40									
101-105				11	36	4								
106-110				3	50	7								
111-115					46	16	1							
116-120					34	37	2							
121-125					28	52	4							
126-130					4	64	29	2						
131-135					1	36	69	5						
136-140						12	75	20	1					
141-145						7	41	46	1					
146-150						3	45	68	14	3				
151-155						3	25	52	39	7	1		1	
156-160						2	10	25	36	20	4	2		
161-165							5	16	39	51	9	1		
166-170								5	21	81	13			
171-175									9	79	18	3		
176-180									3	49	33	9		1
181-185									1	11	29	14	2	
186-190										2	6	15	2	
191-195												1	3	
195-200														1
201-205													1	
N	4	69	198	147	247	243	306	239	164	303	113	45	9	2

Table 35. Back calculated lengths of *C. agassizi* in the Ionian Sea.

			AGES												
Ages	N	Observed length	1	2	3	4	5	6	7	8	9	10	11	12	13
0	4	48.8													
1	69	63.8	47.3												
2	198	78.4	46.5	73.8											
3	148	90.5	46.9	74.4	86.3										
4	247	109.9	43.3	70.9	84.0	96.8									
5	243	126.0	41.4	69.8	84.2	97.6	109.8								
6	303	139.9	38.9	68.5	82.8	96.3	109.7	121.4							
7	239	149.3	37.6	65.6	79.7	92.8	106.0	118.8	130.6						
8	163	159.6	36.9	65.5	80.1	93.2	106.3	118.9	131.1	141.6					
9	304	169.5	38.5	63.8	79.2	93.3	106.5	119.6	132.2	144.3	155.6				
10	113	176.0	39.4	64.5	80.6	94.5	108.4	122.1	135.2	148.1	160.3	171.7			
11	45	181.7	39.8	64.3	79.6	93.3	106.2	120.4	133.3	146.0	158.4	170.2	181.0		
12	9	186.0	40.5	67.0	82.6	96.8	111.3	124.4	137.2	149.6	161.6	173.8	183.1	191.3	
13	2	187.0	38.6	62.7	77.5	90.3	103.8	117.8	132.3	145.7	159.5	173.7	186.5	197.6	207.1
Mean back calculated length			41.2	67.6	81.5	94.5	107.5	120.4	133.1	145.9	159.1	172.4	183.5	194.5	207.1
N	2087		2083	2014	1816	1668.0	1421.0	1180.0	875.0	636.0	473.0	169.0	56.0	11.0	2.0

Table 36. Identified age groups of males *G. melastomus* per season.

	Winter			Spring			Summer			Autumn		
Age	Length	S.I	S.D	Length	S.I	S.D	Length	S.I	S.D	Length	S.I	S.D

1	21.46	-	2.76	18.83	-	2.41	17.20	-	2.92	19.24	-	1.03
2	27.63	1.95	3.53	26.46	2.12	3.69	24.43	5.20	1.98	27.50	2.91	1.37
3	39.66	4.06	1.42	43.74	5.22	1.12	33.57	4.03	2.53	34.20	2.50	3.29
4	48.17	4.43	1.88	-	-	-	44.77	4.54	2.10	44.43	4.73	2.75
5	-	-	-	-	-	-	51.58	3.36	2.32	-	-	-

Table 37. Identified age groups of females *G. melastomus* per season.

	Winter			Spring			Summer			Autumn		
Age	Length	S.I	S.D	Length	S.I	S.D	Length	S.I	S.D	Length	S.I	S.D
1	14.45	-	1.11	20.16	-	2.80	22.79	-	2.64	17.30	-	1.17
2	22.67	3.84	3.15	27.69	2.69	2.77	28.43	2.223	2.41	27.88	3.96	4.15
3	29.47	2.45	1.83	35.69	3.79	1.44	36.03	3.70	1.69	38.22	3.48	1.26
4	34.62	2.97	2.10	43.27	4.26	2.11	46.54	5.70	1.98	42.36	2.07	2.23
5	41.56	4.45	1.61	52.48	3.64	1.35	-	-	-	51.03	4.24	2.06

Table 38. Growth parameters and standard deviation (S.D.) of *G. melastomus*.

Sex	L_∞ (cm)	S.D.	K	S.D.	t_0	S.D.
Males	101.82	10.98	0.044	0.006	-1.992	0.055
Females	108.19	4.185	0.075	0.005	-1.047	0.026

Table 39. List of other shrimp species found in the Ionian Sea per season and depth zone (1 = 300-500 m, 2 = 500-750 m).

Species	Winter	Spring	Summer	Autumn
Hyppolytidae				
Ligur ensiferus (Risso, 1816)				2
Oplophoridae				
Acanthephyra pelagica (Risso, 1816)	2			
Pandalidae				
Chlorotocus crassicornis (Costa, 1871)	1			1
Parapandalus narval (Fabricius, 1787)				
Plesionika acanthonotus (Smith, 1882)	1,2	1,2	2	
Plesionika antigai Zariquiey Alvarez, 1955	1	1		1
Plesionika edwardsii (Brandt,1851)	1,2	1,2	2	1,2
Plesionika heterocarpus (Costa, 1871)	1,2	1	1,2	1,2
Plesionika gigliolii (Senna, 1903)	1,2	1,2	2	2
Plesionika martia (A. Milne Edwards, 1883)	1,2	1,2	1,2	1,2
Pasiphaeidae				
Pasiphaea sivado (Risso, 1816)	1,2	1,2	2	1,2
Processidae				
Processa canaliculata Leach, 1815	1,2		2	1

Sergestidae				
Sergestes arcticus Kroer, 1855	2			1,2
Sergestes robustus S. I. Smith, 1882	2			
Solenoceridae				
Solenocera membranacea (Risso, 1816)	1,2	1,2		2

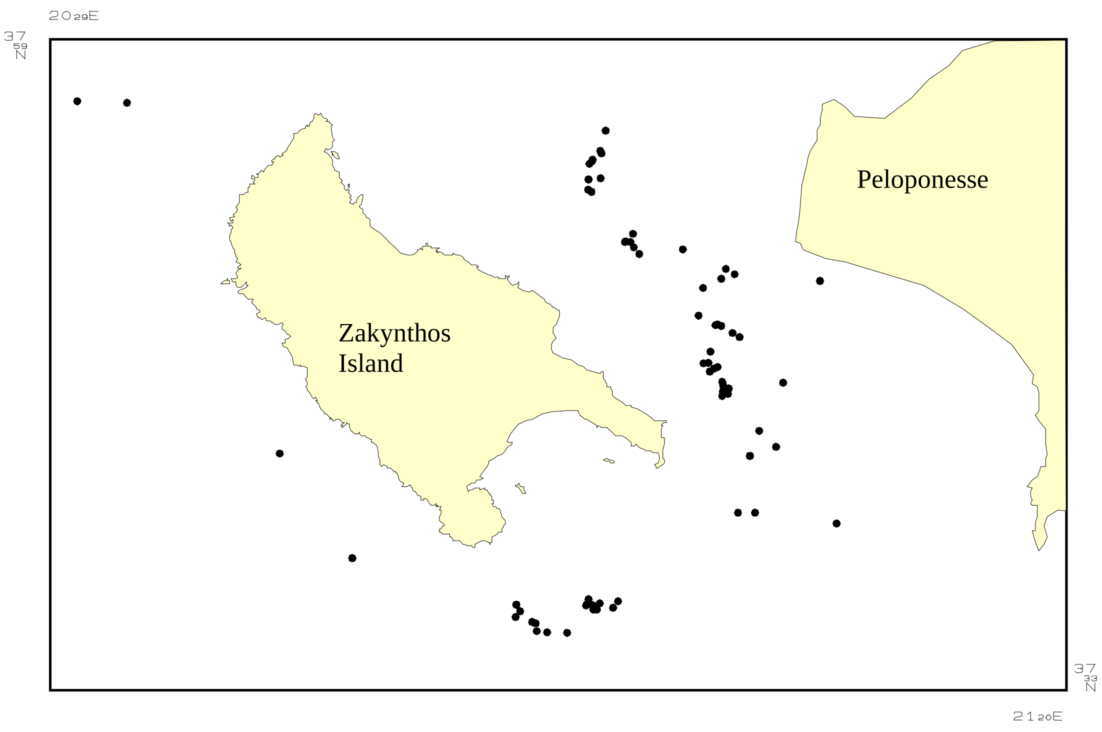


Fig. 1. Map of the sampling area with the fishing stations.

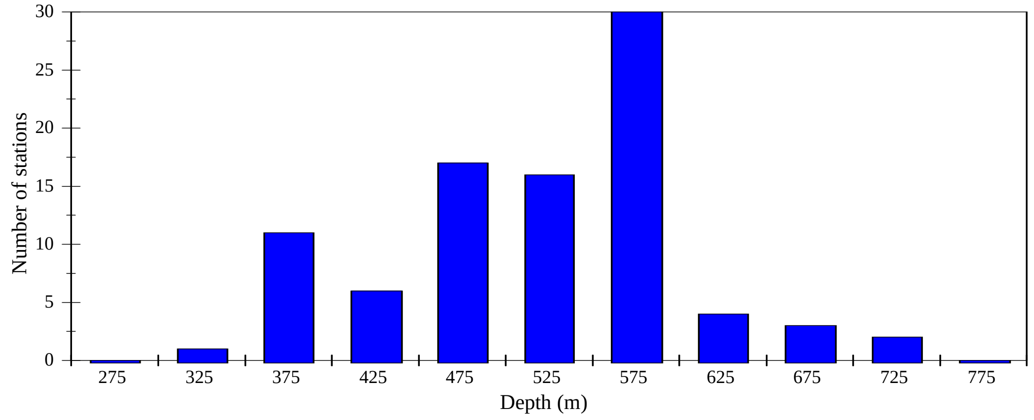


Fig. 2. Bathymetrical distribution of the sampling stations.

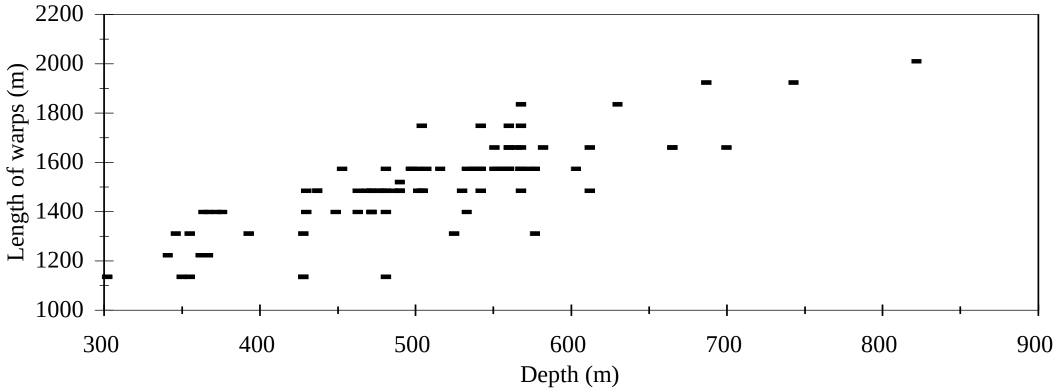


Fig. 3. Relationship between depth and length of warps.

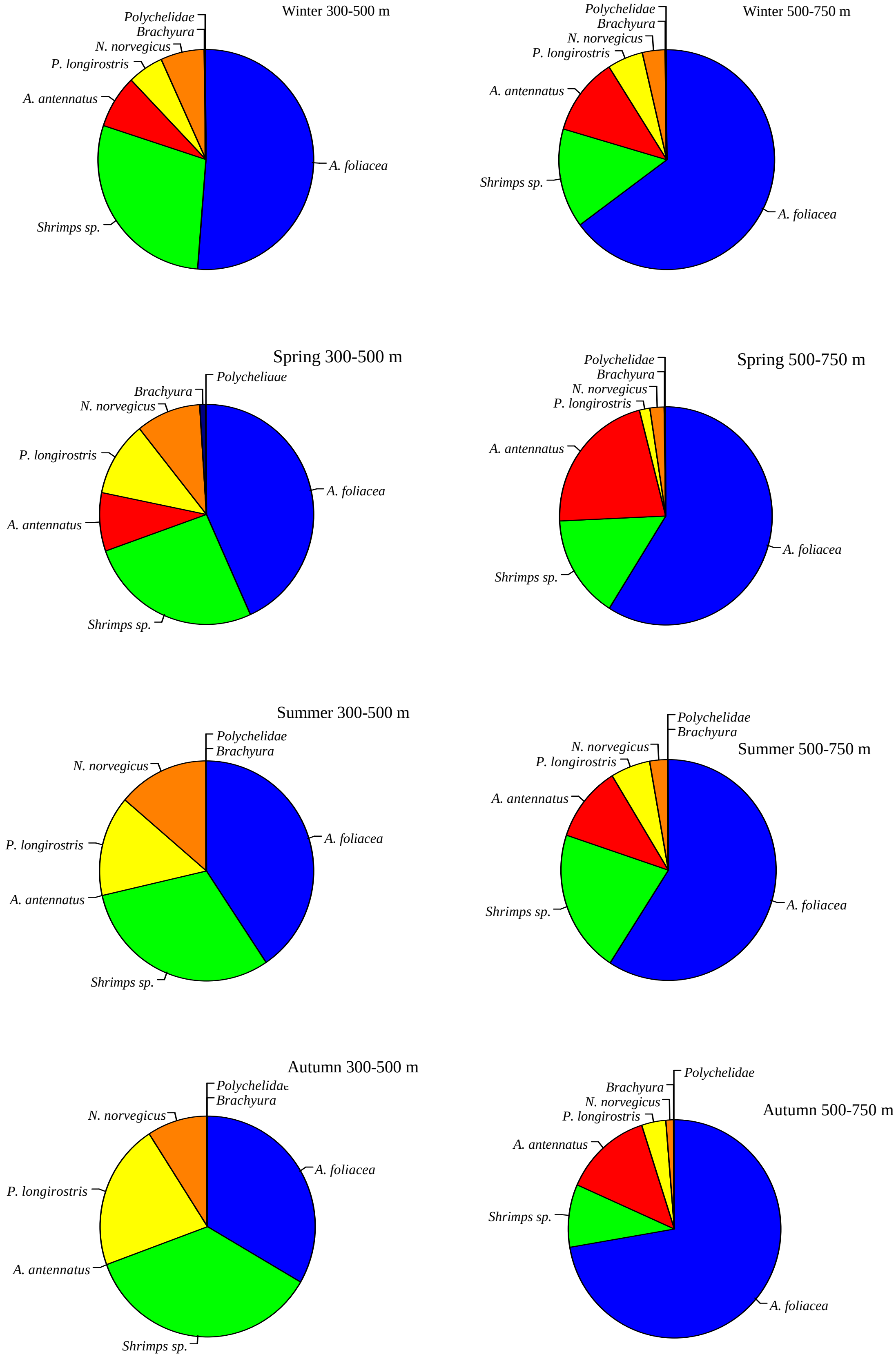


Fig. 4. Crustaceans catch composition per season and per depth zone.

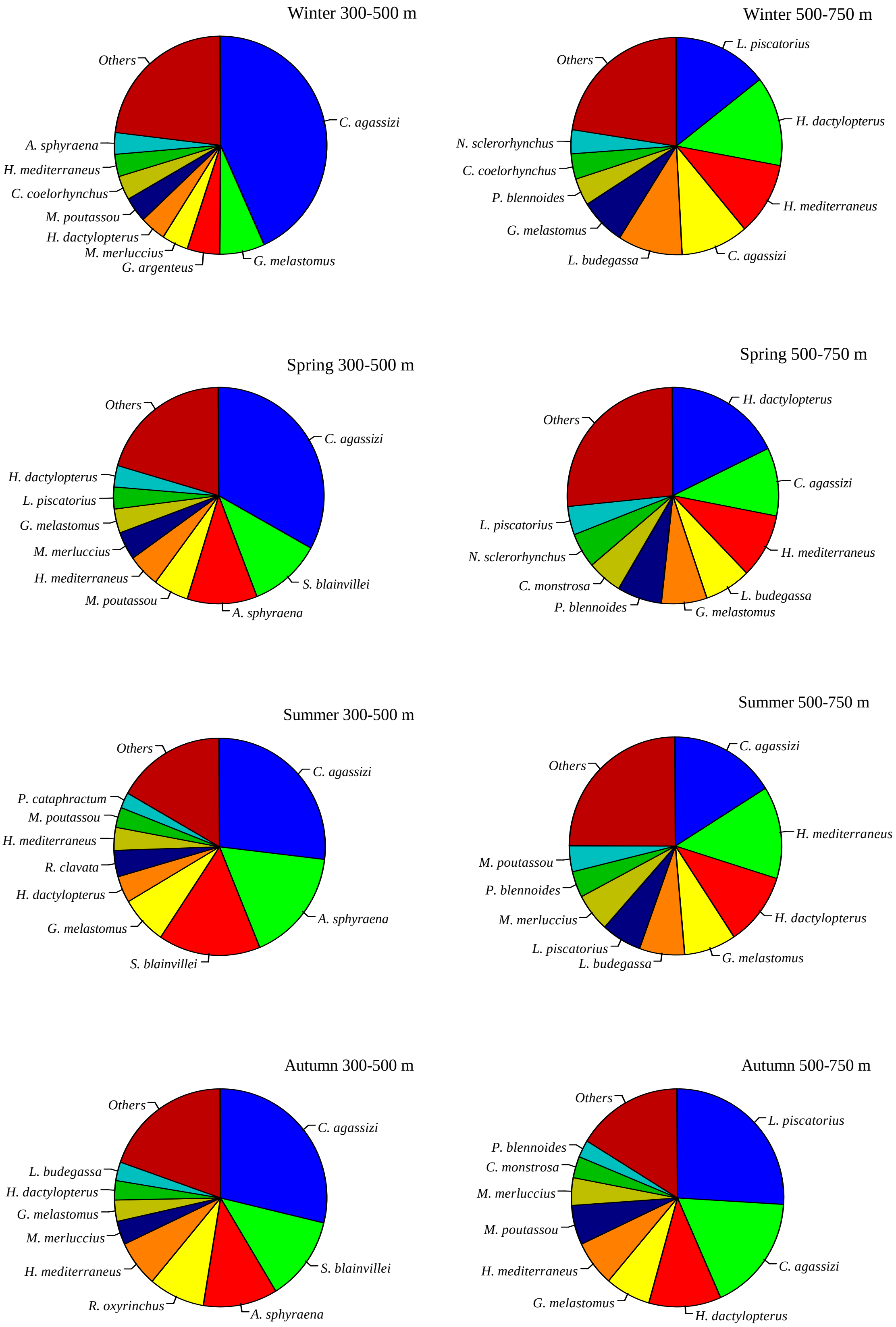


Fig. 5. Fish catch composition per season and per depth zone.

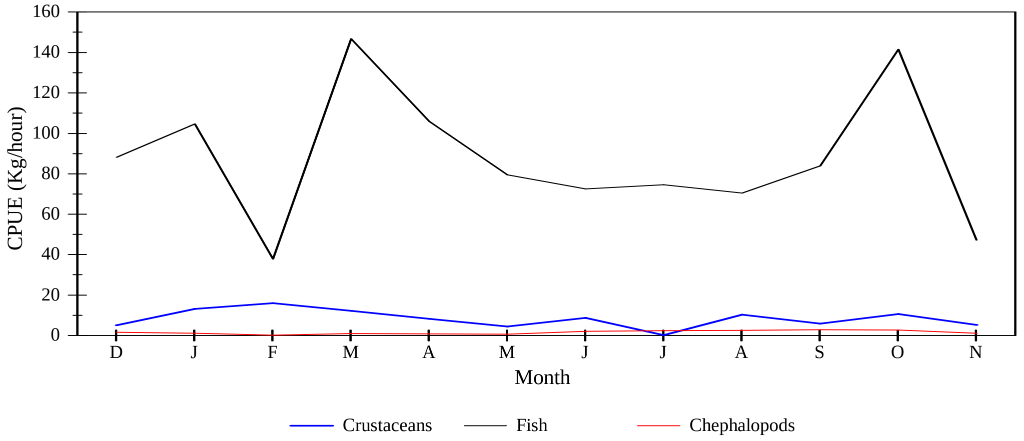


Fig. 6. Monthly fluctuation of the CPUE of the main catch categories in the 300-500 m depth zone.

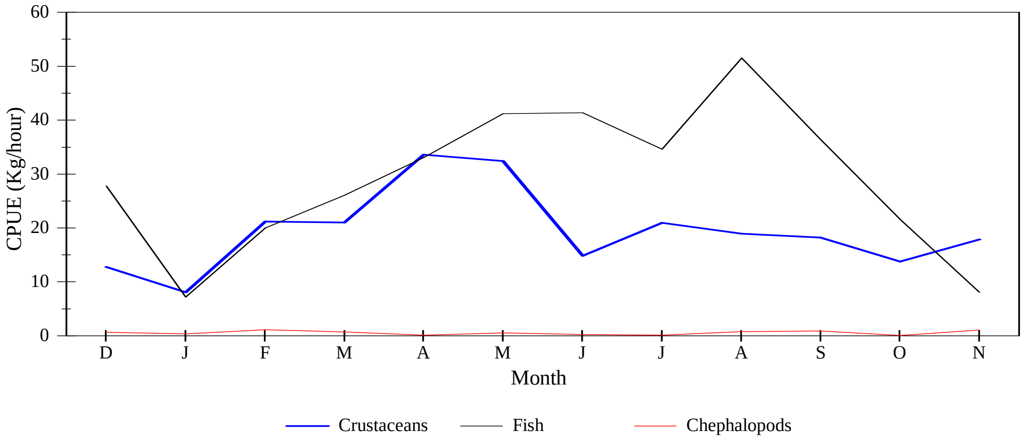


Fig. 7. Monthly fluctuation of the CPUE of the main catch categories in the 500-750 m depth zone.

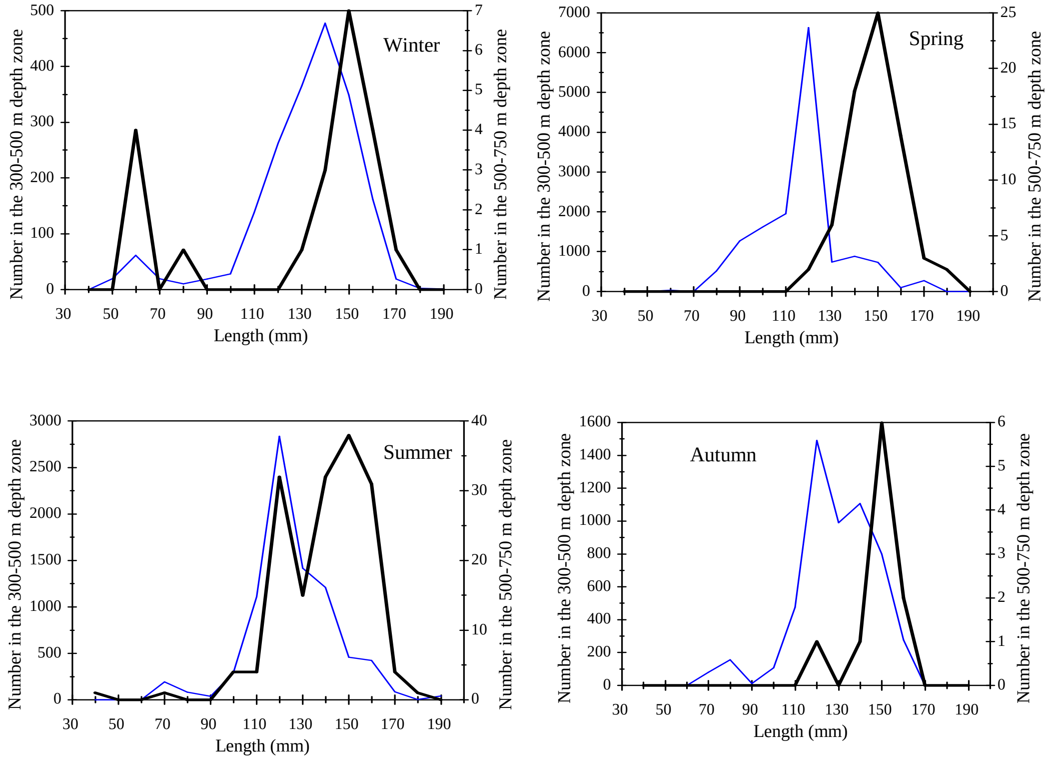


Fig. 8. Length frequency distribution of *Argentina sphyraena*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

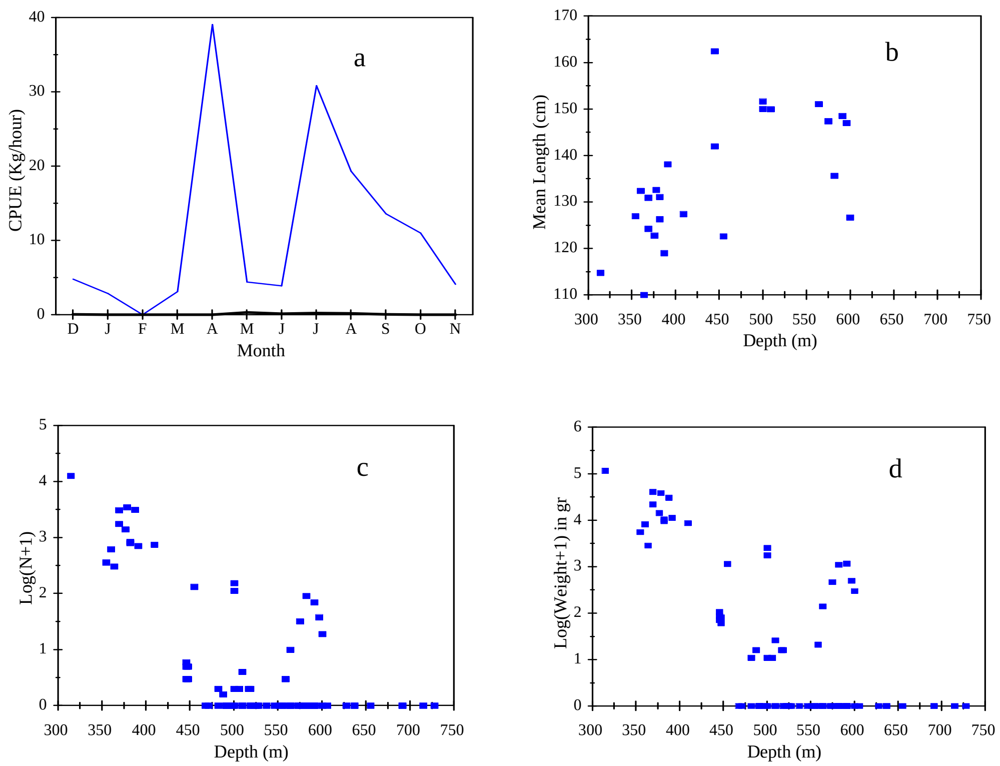


Fig. 9. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Argentina sphyraena*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

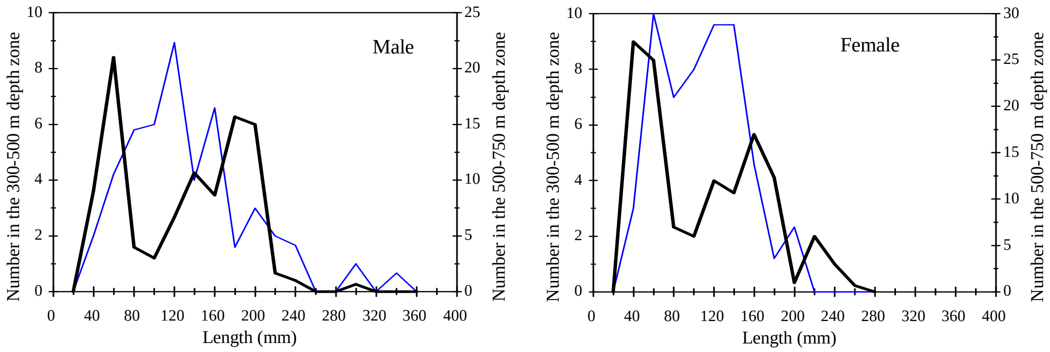


Fig. 10. Length frequency distribution of *Chimaera monstrosa*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

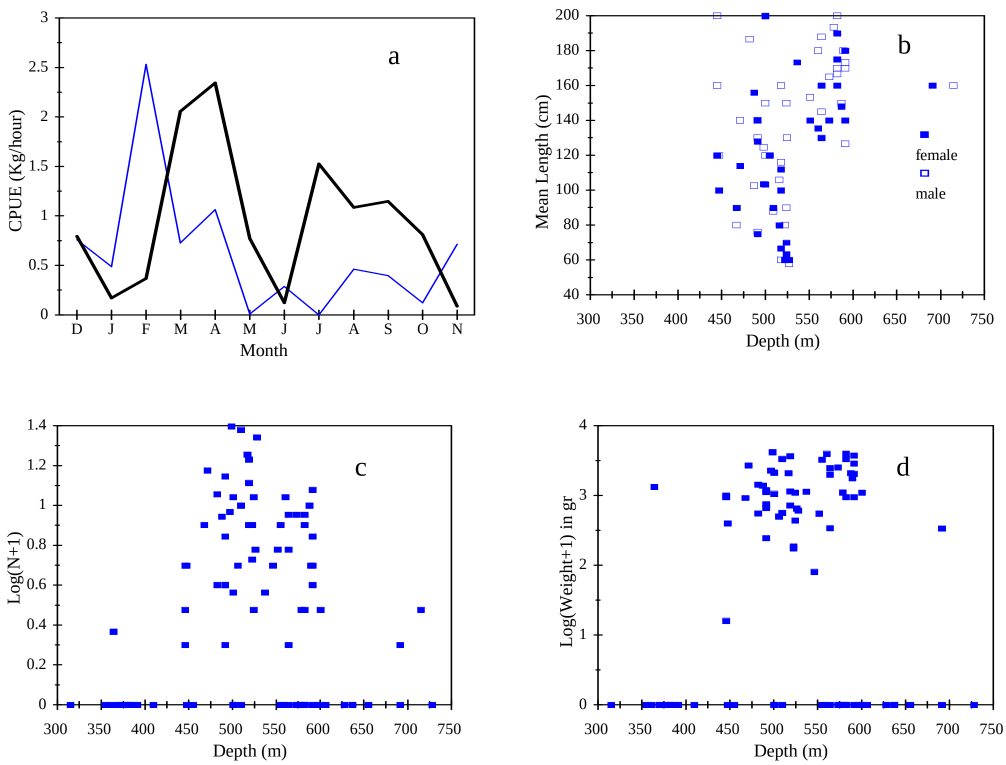


Fig. 11. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Chimaera monstrosa* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

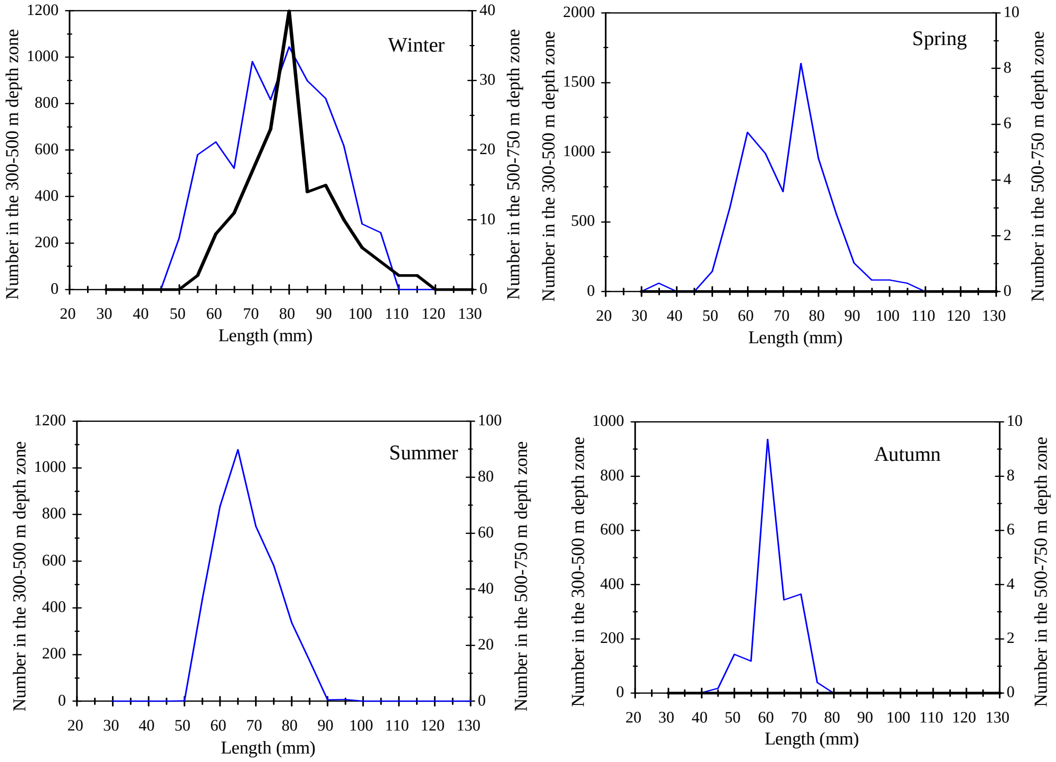


Fig. 12. Length frequency distribution of *Gadiculus argenteus argenteus*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

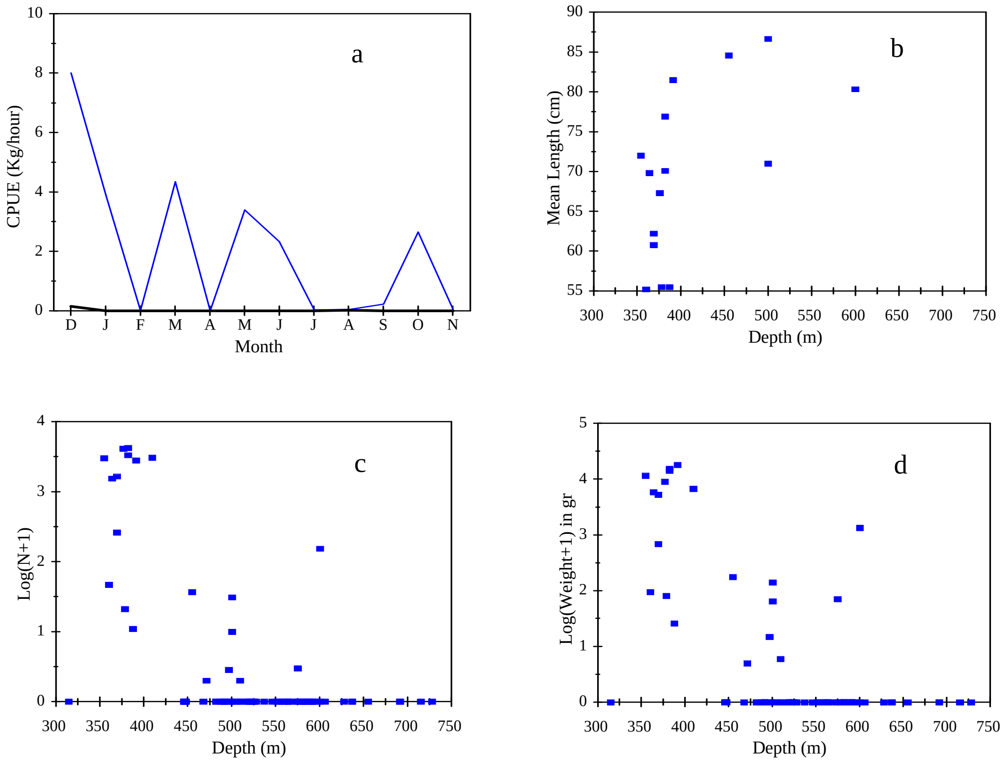


Fig. 13. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Gadiculus argenteus argenteus* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

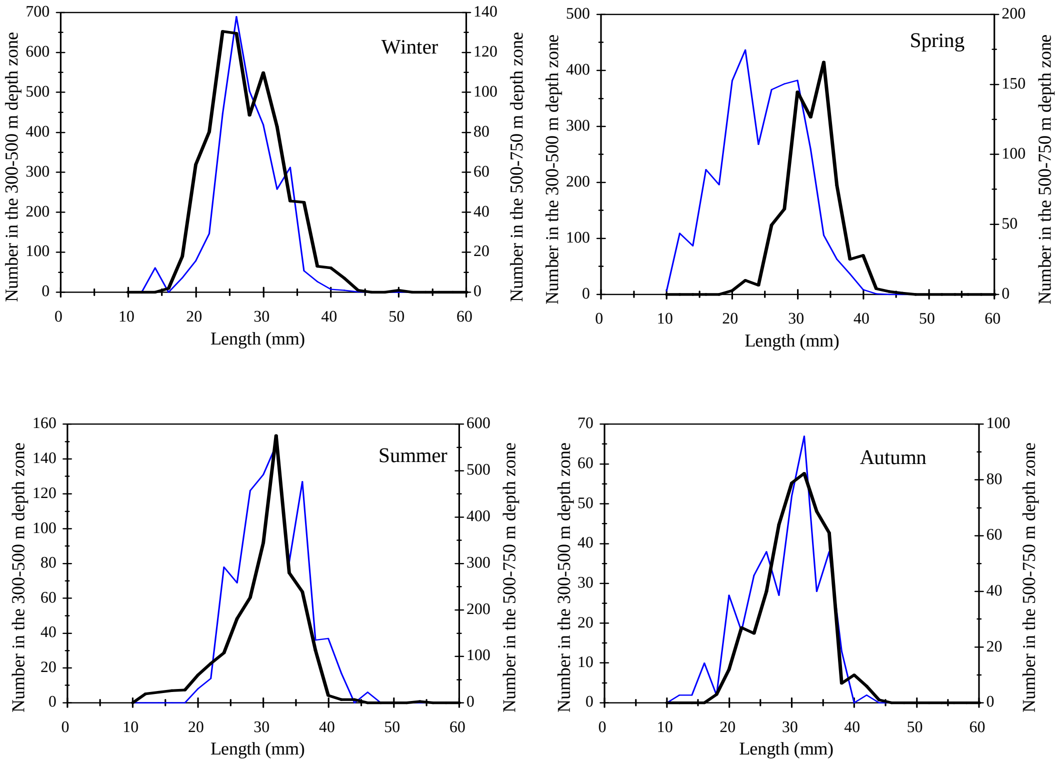


Fig. 14. Length frequency distribution of *Hymenocephalus italicus*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

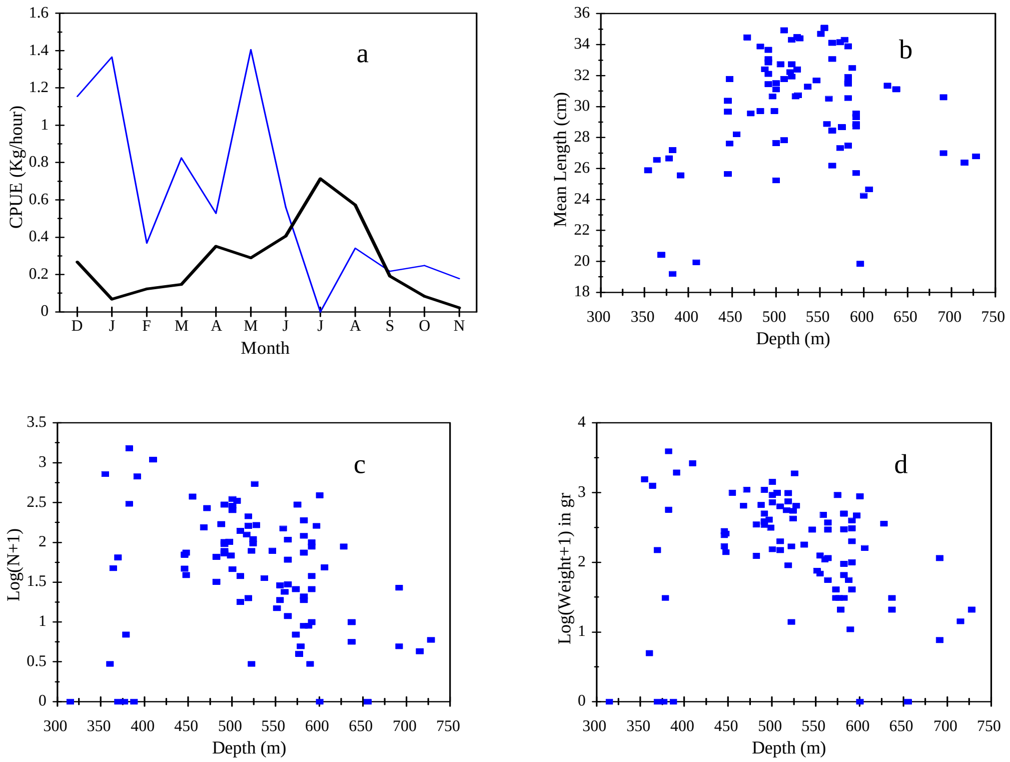


Fig. 15. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Hymenocephalus italicus* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

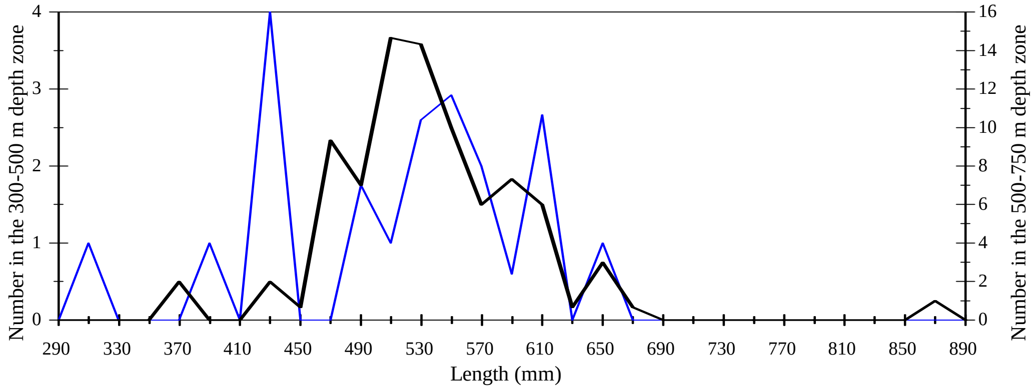


Fig. 16. Length frequency distribution of *Molva dipterygia macrophthalma*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

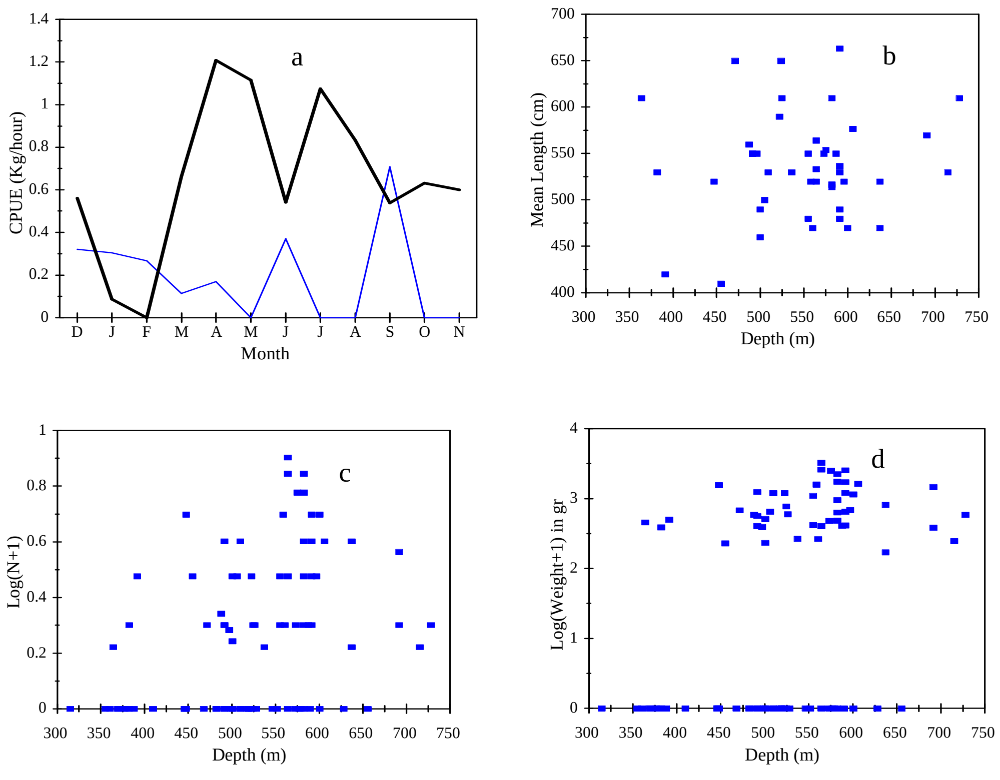


Fig. 17. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Molva dipterygia macrophthalma*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

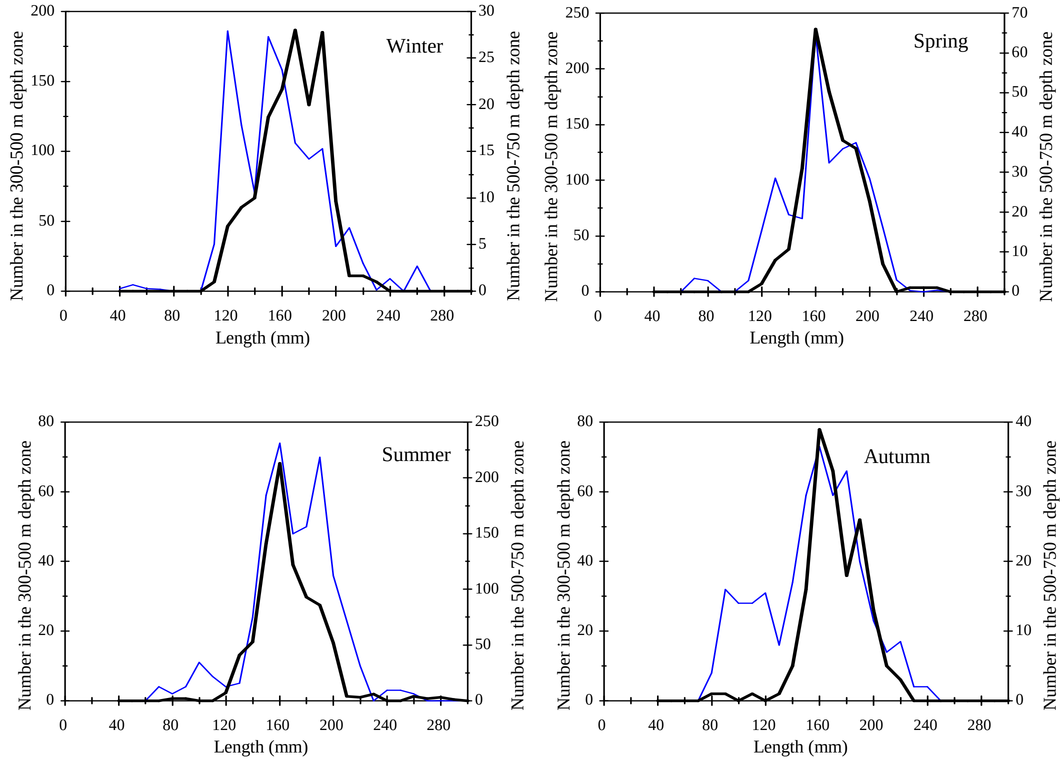


Fig. 18. Length frequency distribution of *Peristedion cataphractum*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

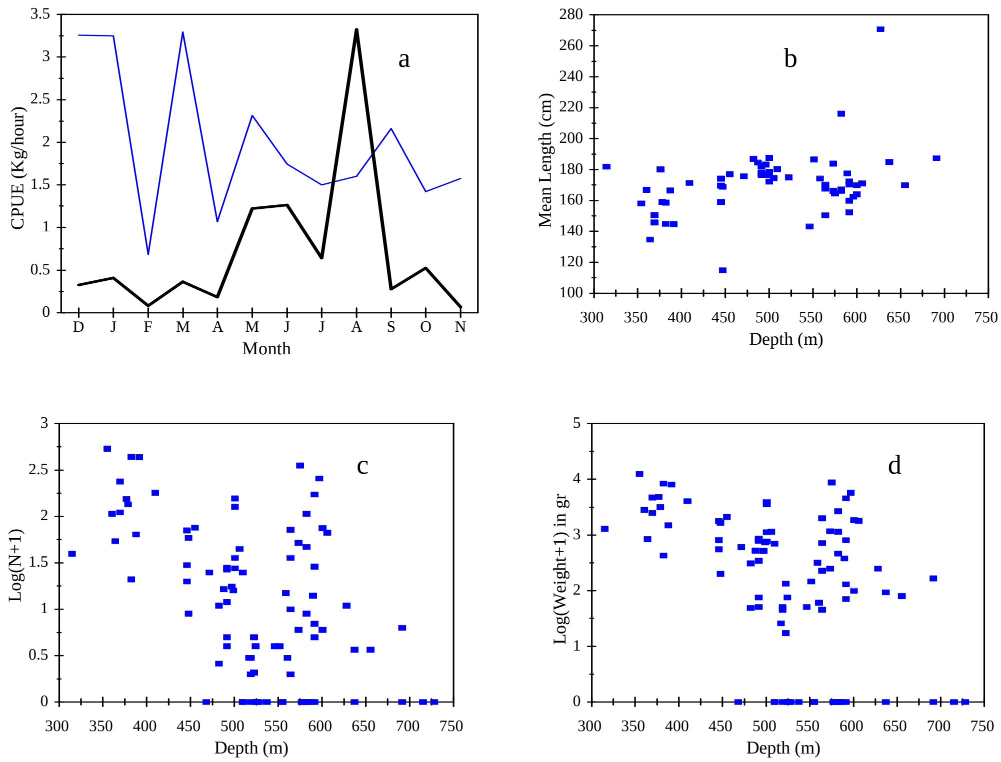


Fig. 19. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Peristedion cataphractum* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

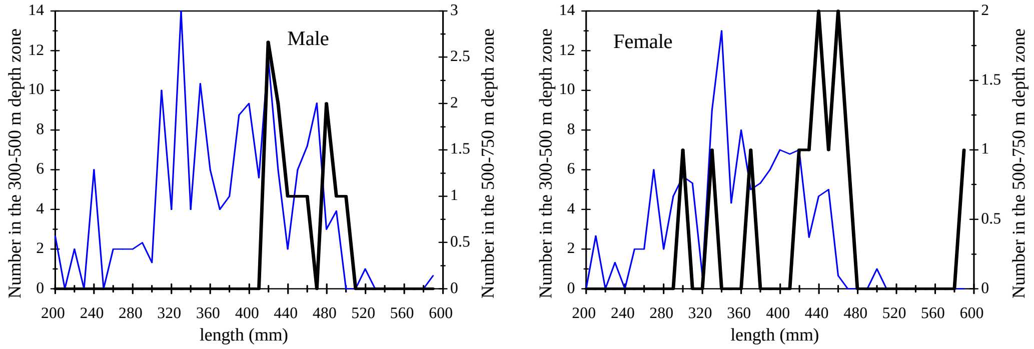


Fig. 20. Length frequency distribution of *Scyliorhinus canicula*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

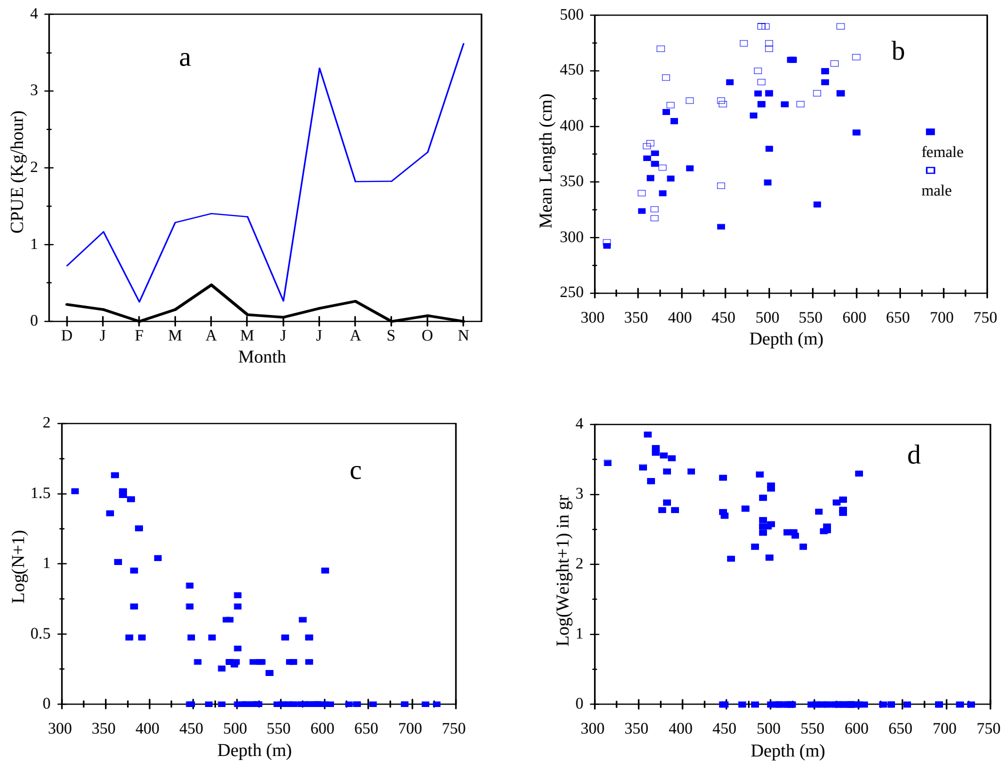


Fig. 21. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Scyliorhinus canicula* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

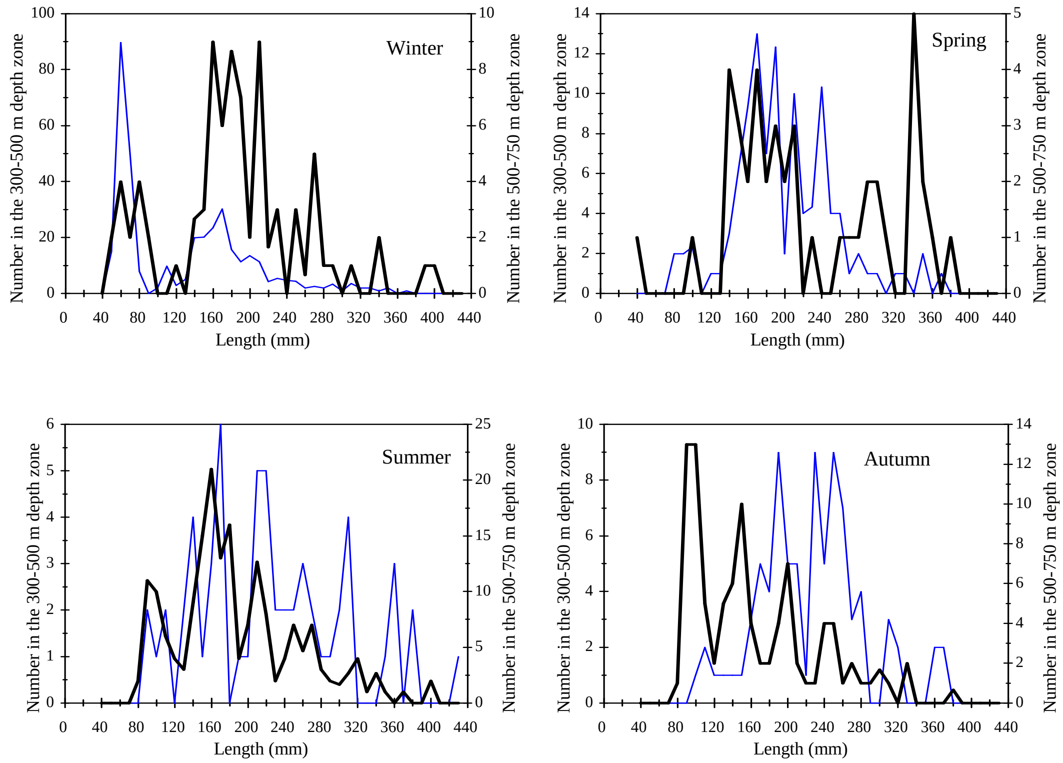


Fig. 22. Length frequency distribution of *Lepidorhombus boscii*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

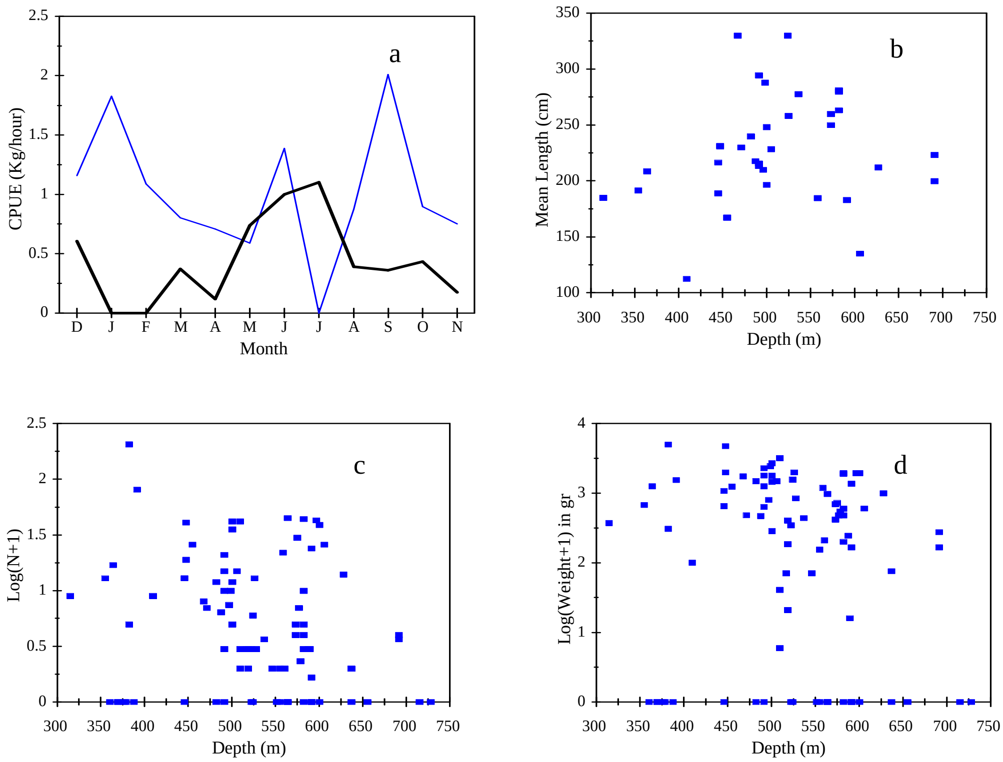


Fig. 23. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Lepidorhombus boscii* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

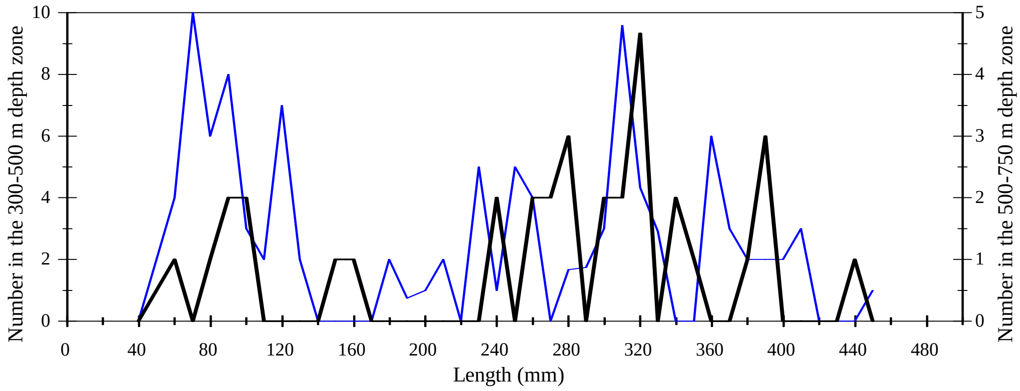


Fig. 24. Length frequency distribution of *Lepidorhombus whiffiagonis* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

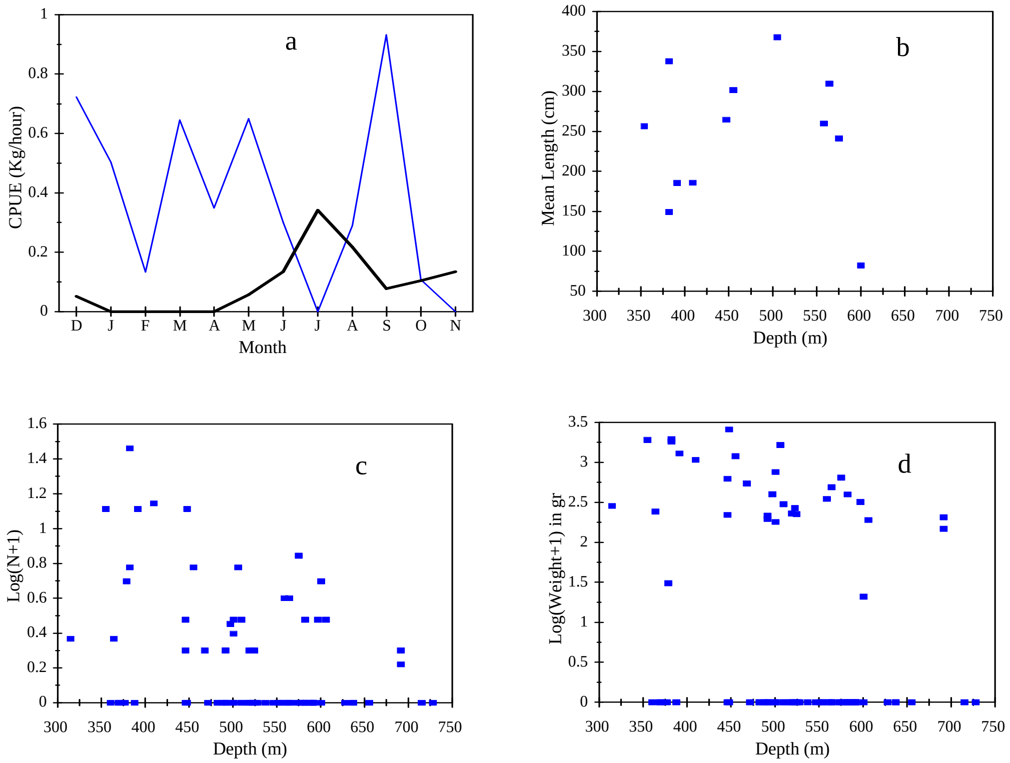


Fig. 25. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Lepidorhombus whiffiagonis* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

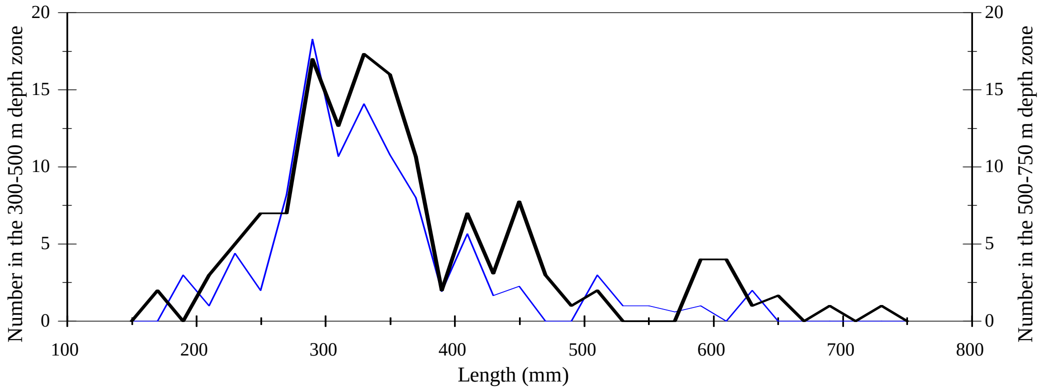


Fig. 26. Length frequency distribution of *Lophius budegassa* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

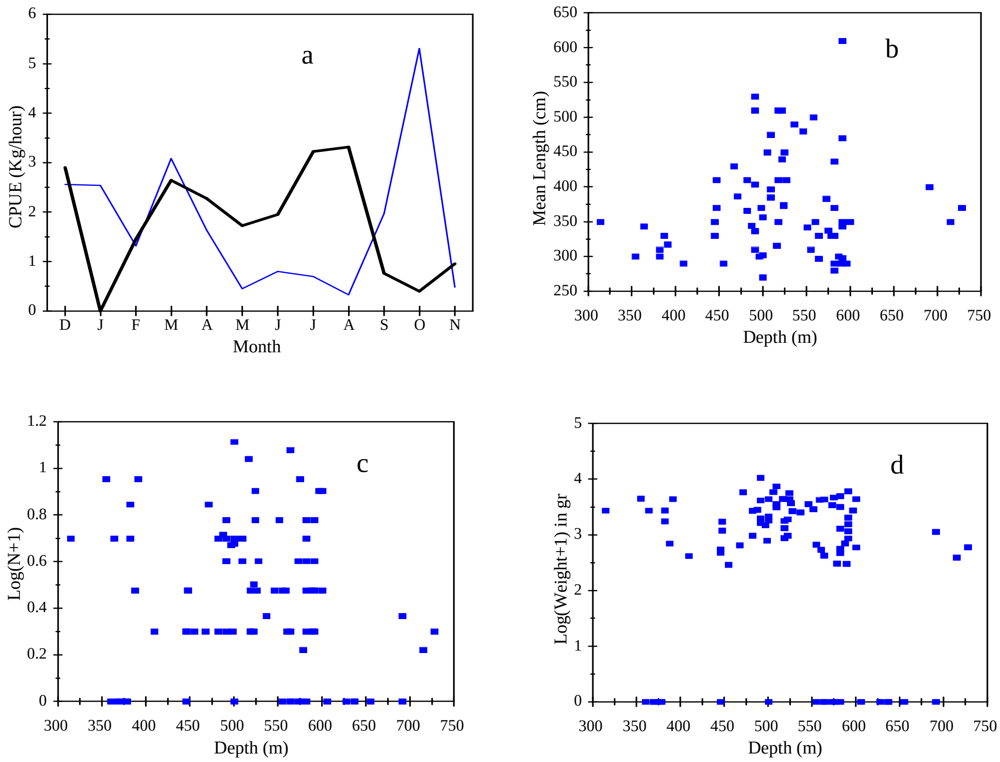
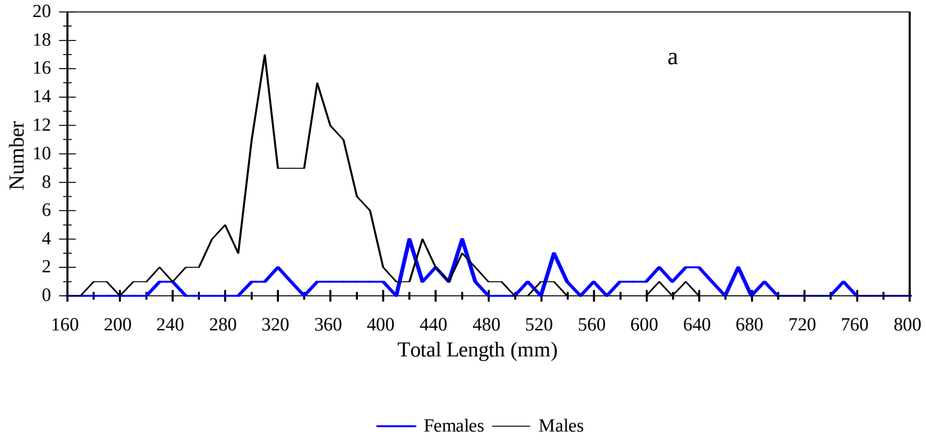


Fig. 27. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Lophius budegassa* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).



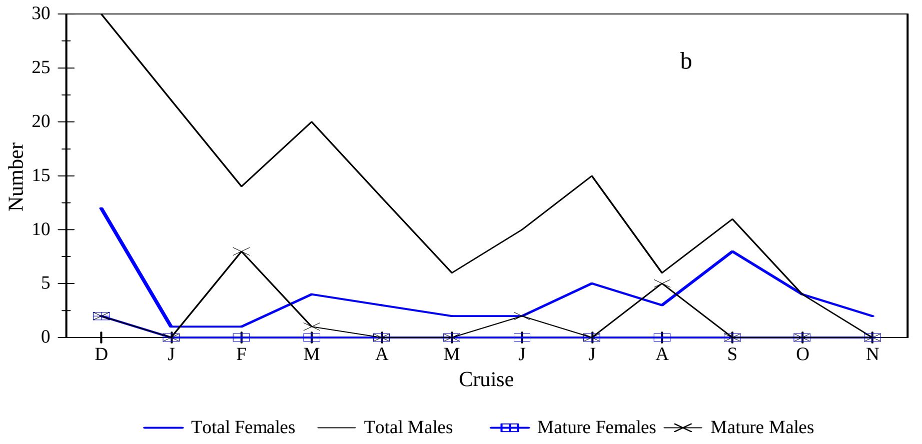


Fig. 28. Number of examined individuals per length class and per sex (a) and total number, number of mature male and female *L. budegassa* per month (b).

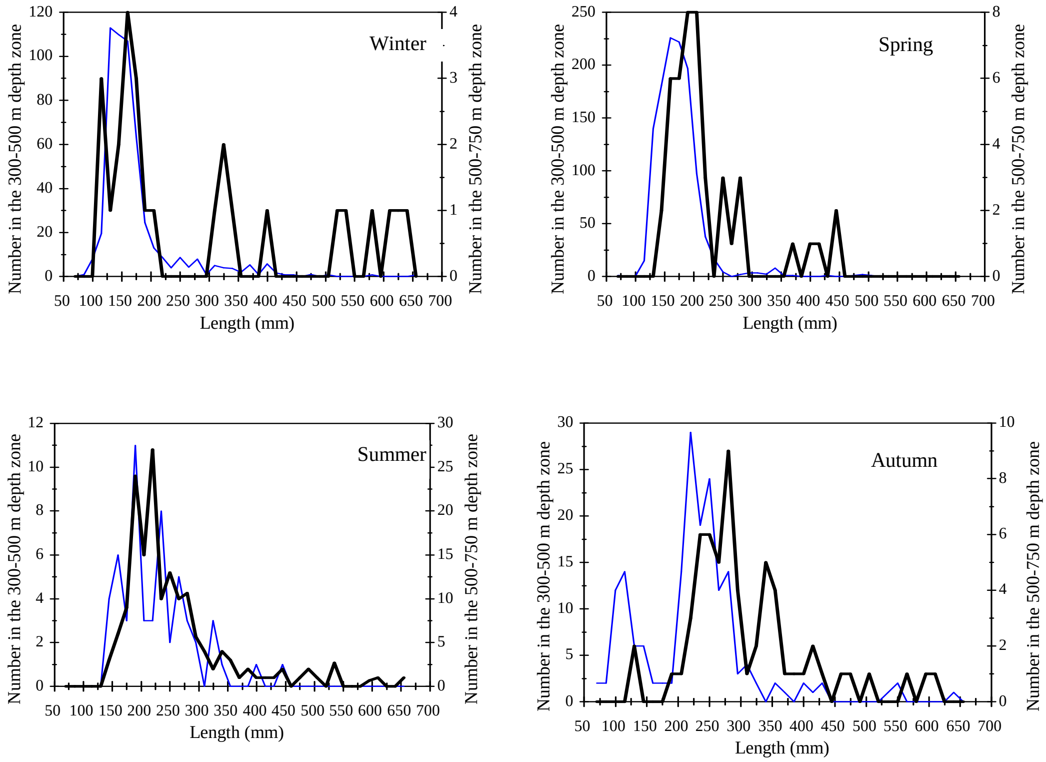


Fig. 29. Length frequency distribution of *Merluccius merluccius* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

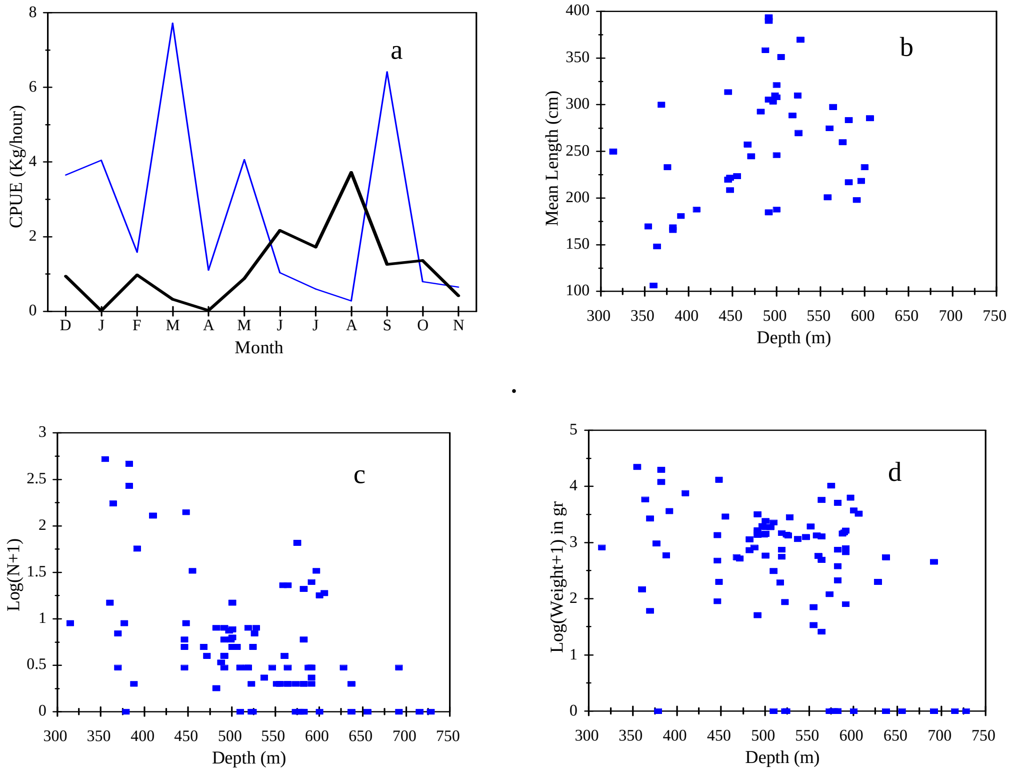


Fig. 30. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Merluccius merluccius* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

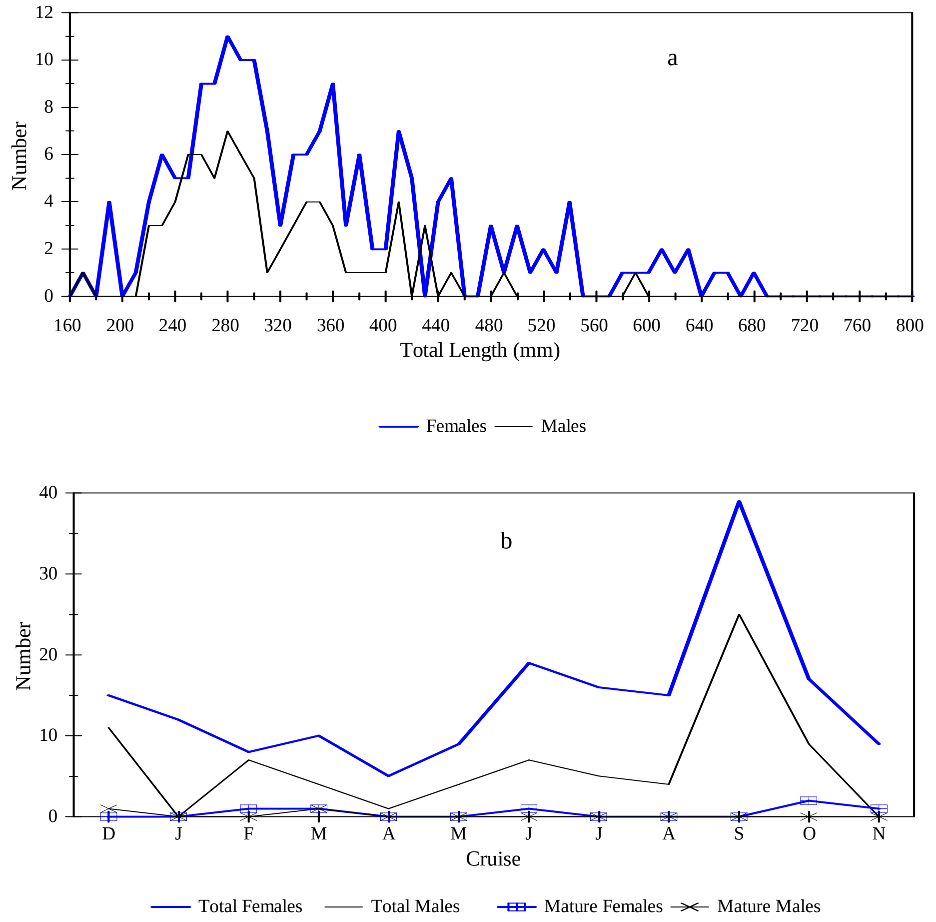


Fig. 31. Number of examined individuals per length class and per sex (a) and total number, number of mature male and female *M. merluccius* per month (b).

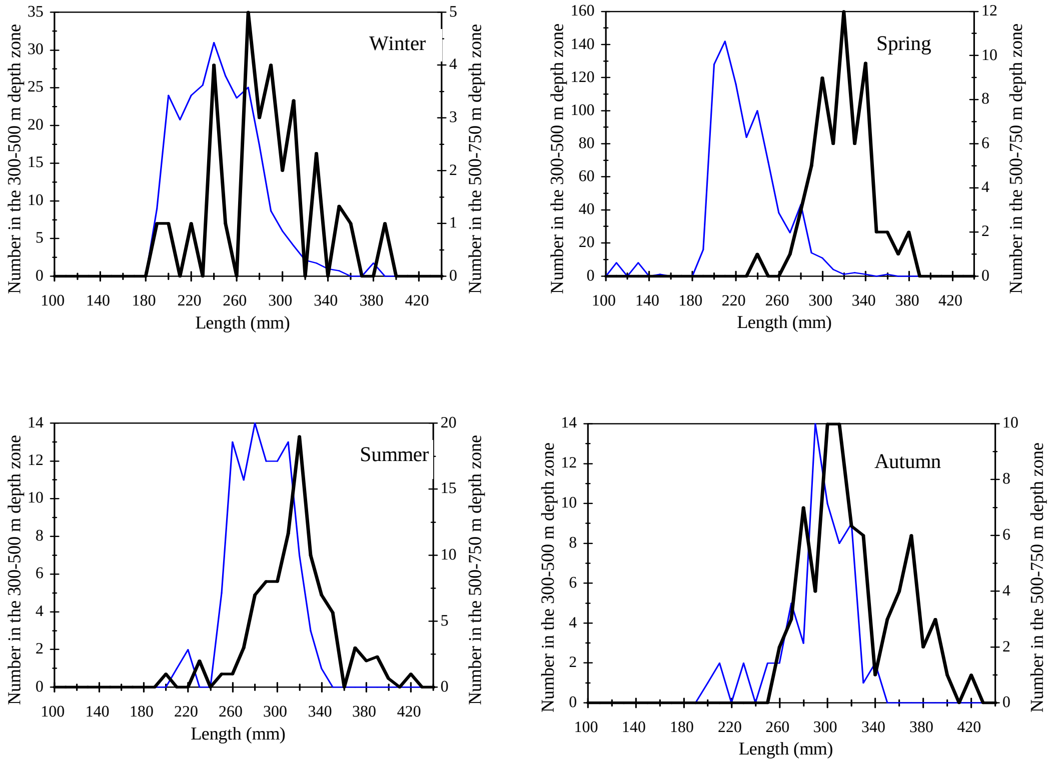


Fig. 32. Length frequency distribution of *Micromesistius poutassou poutassou* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

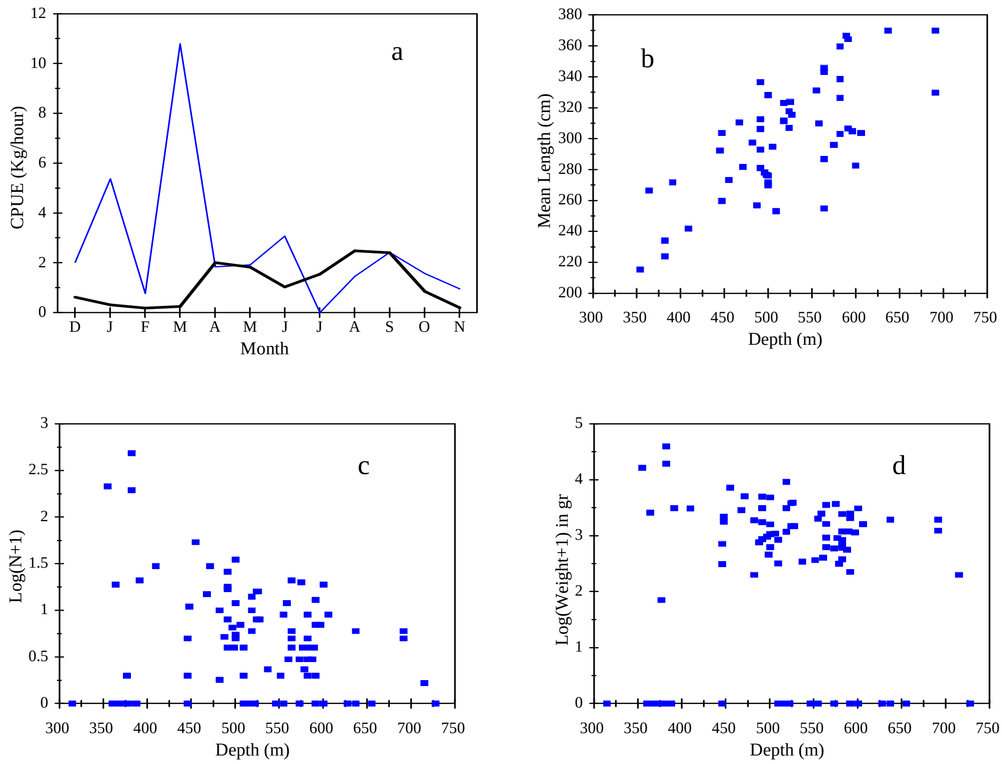


Fig. 33. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Micromesistius poutassou poutassou* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

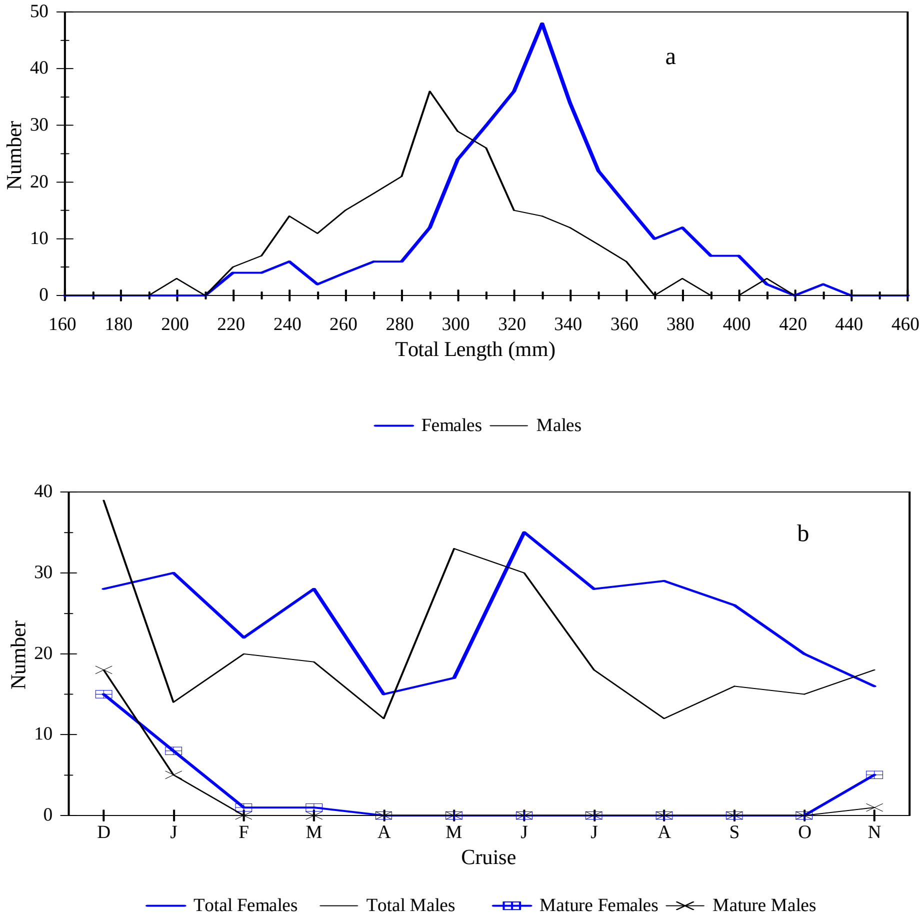


Fig. 34. Number of examined individuals per length class and per sex (a) and total number, number of mature male and female *M. poutassou* per month and number (b).

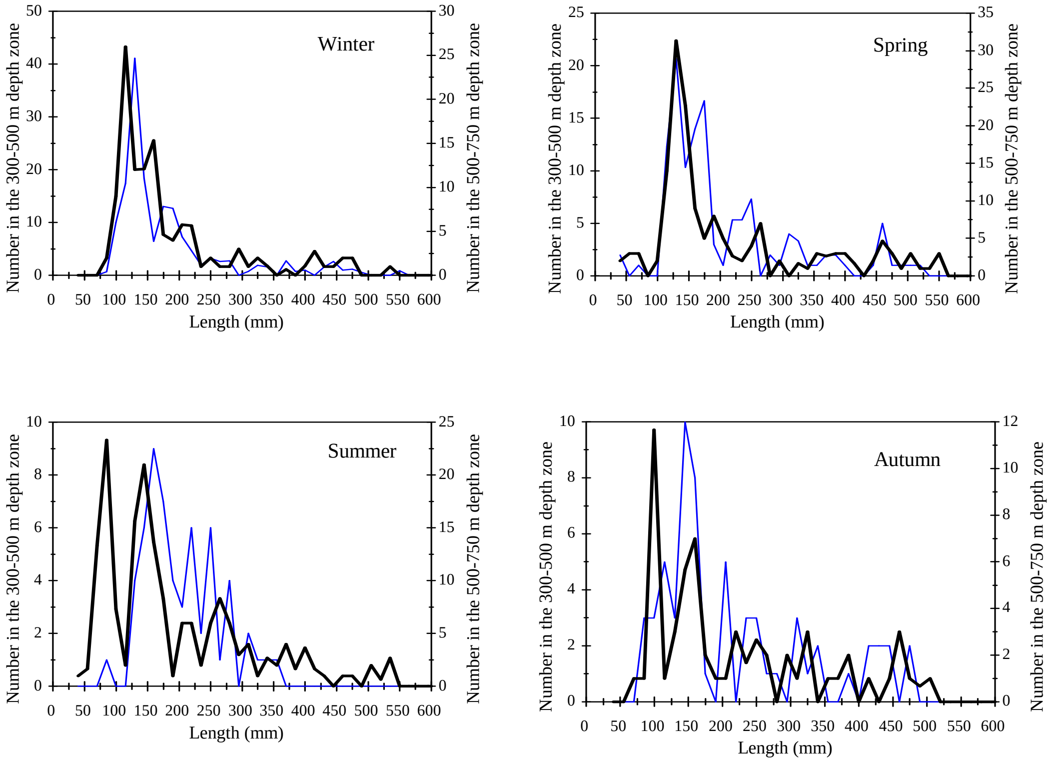


Fig. 35. Length frequency distribution of *Phycis blennoides* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

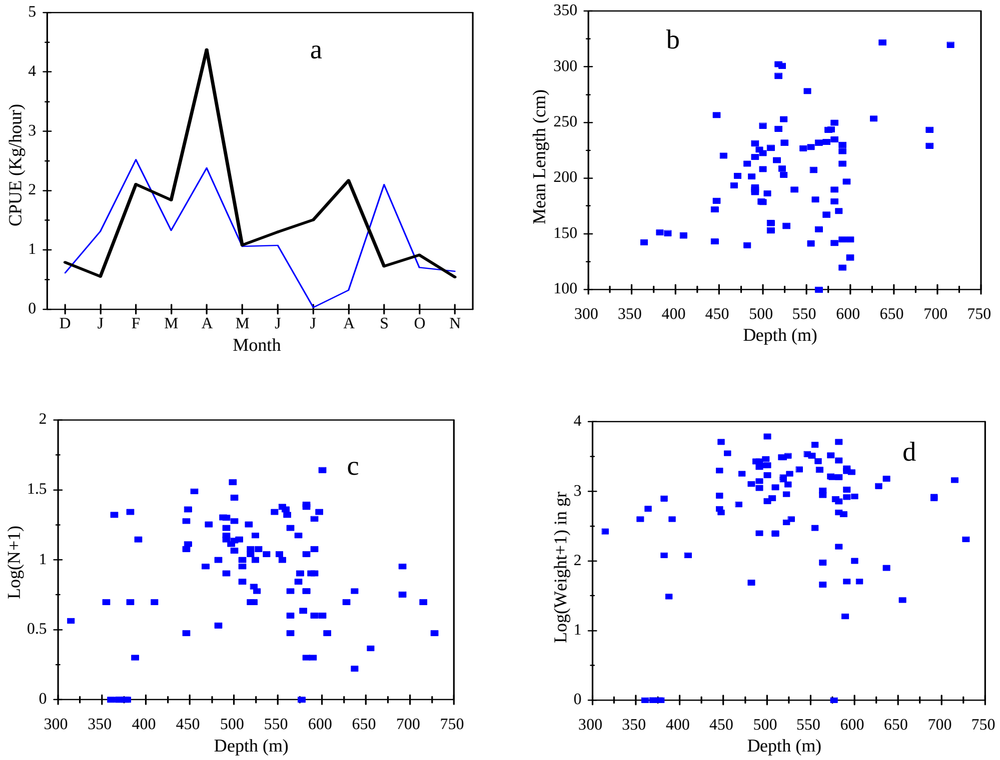


Fig. 36. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Phycis blennoides* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

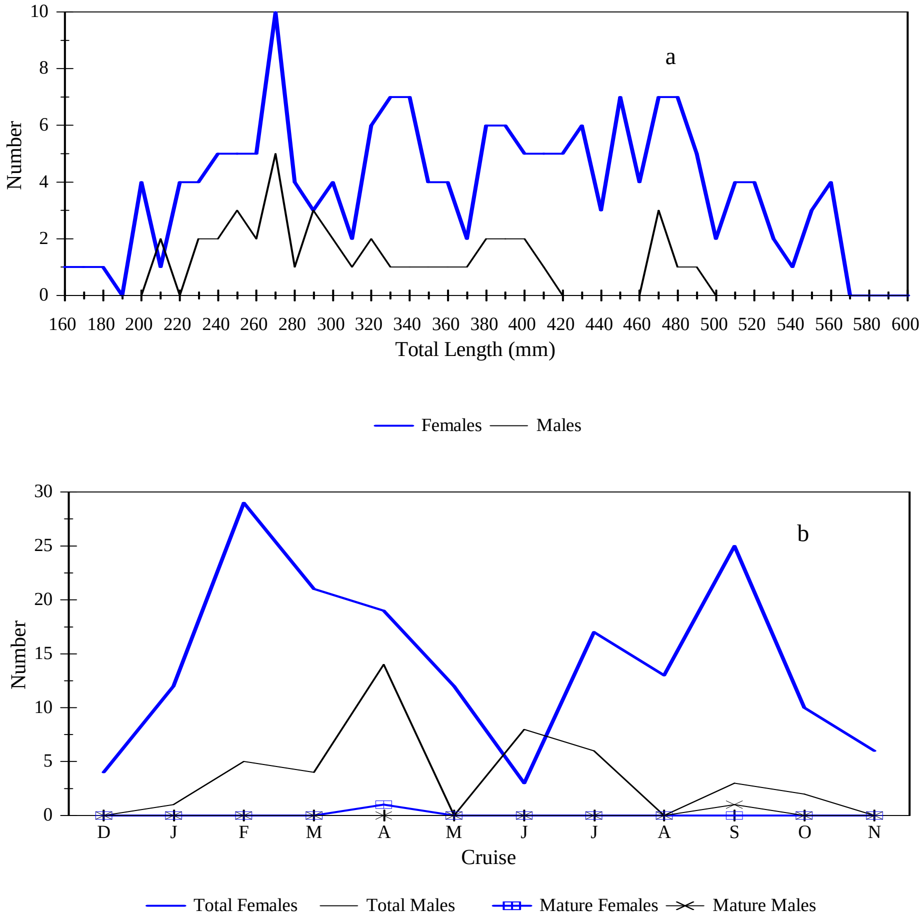


Fig. 37. Number of examined individuals per length class and per sex (a) and total number, number of mature male and female *P. blennoides* per month (b).

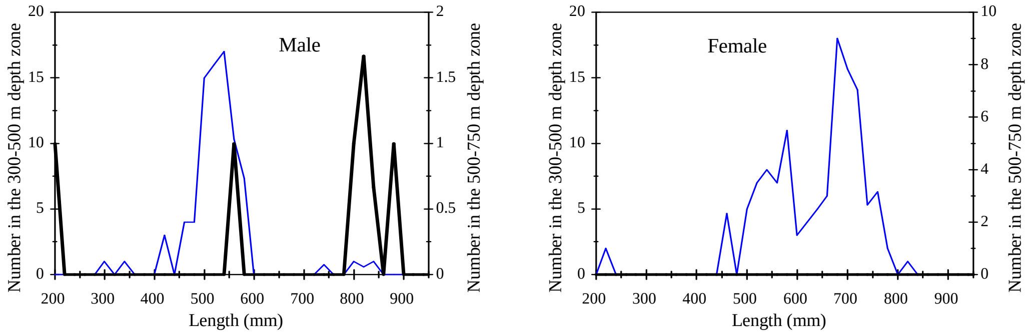


Fig. 38. Length frequency distribution of *Squalus blainvillei* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

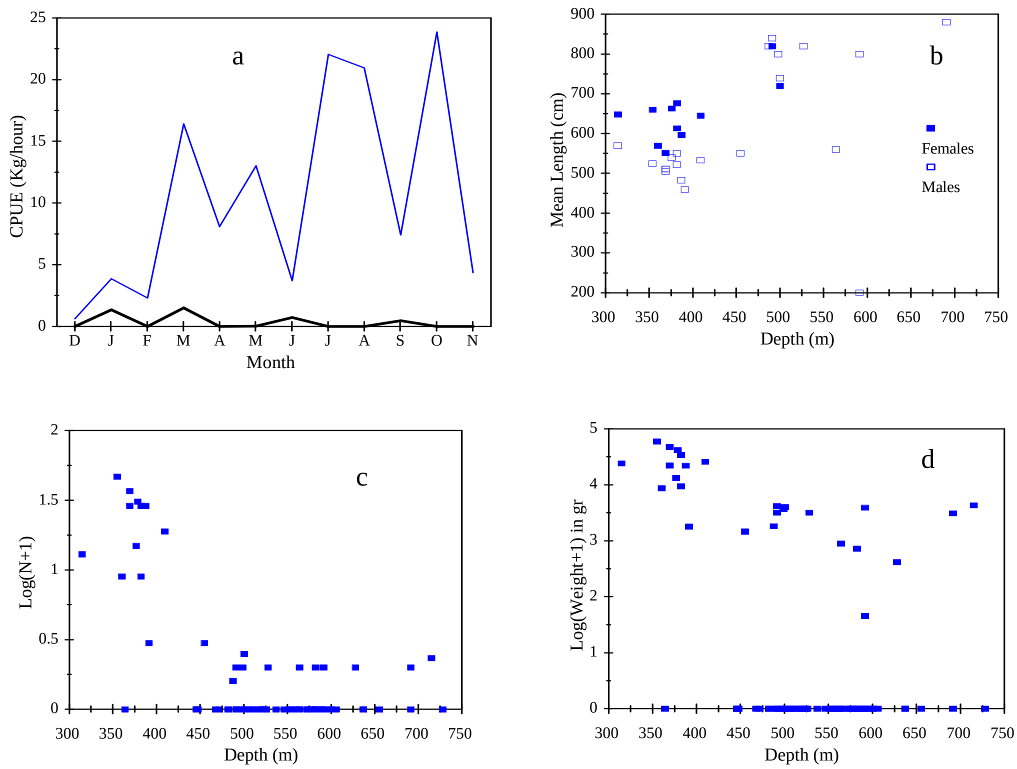


Fig. 39. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Squalus blainvillei* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

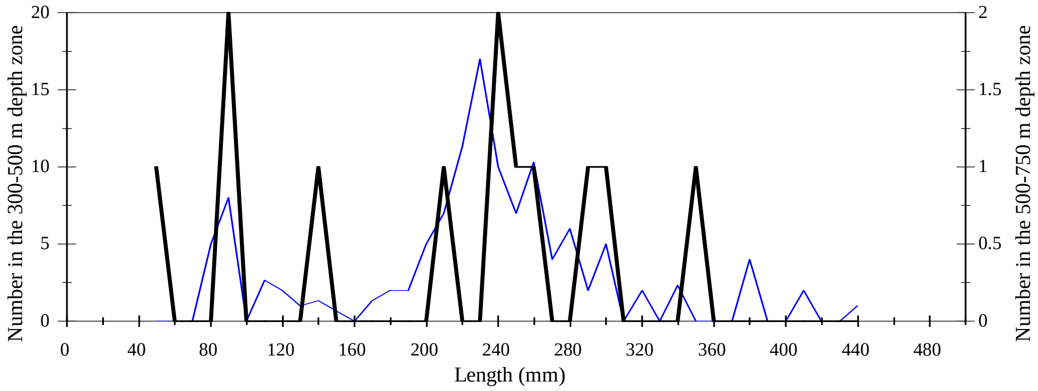


Fig. 40. Length frequency distribution of *Trigla lyra* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

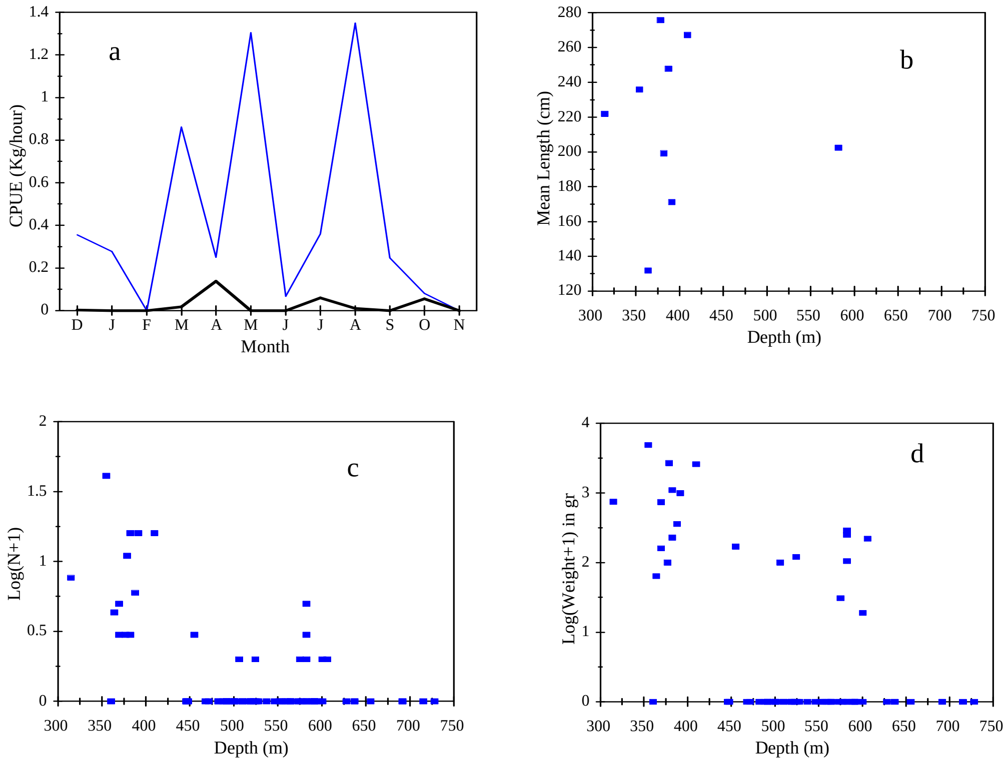


Fig. 41. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Trigla lyra* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

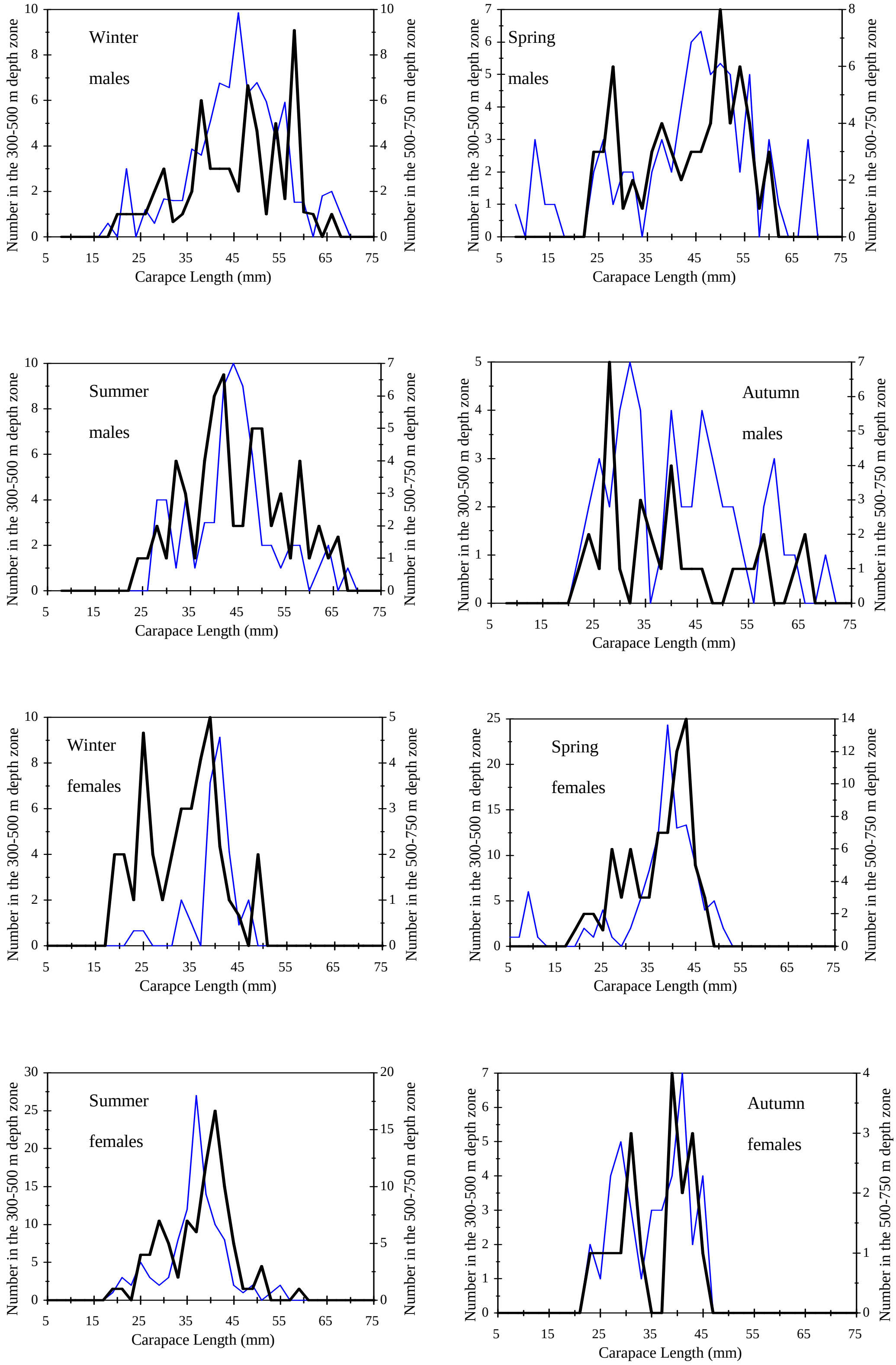


Fig. 42. Length frequency distribution of *Nephrops norvegicus* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

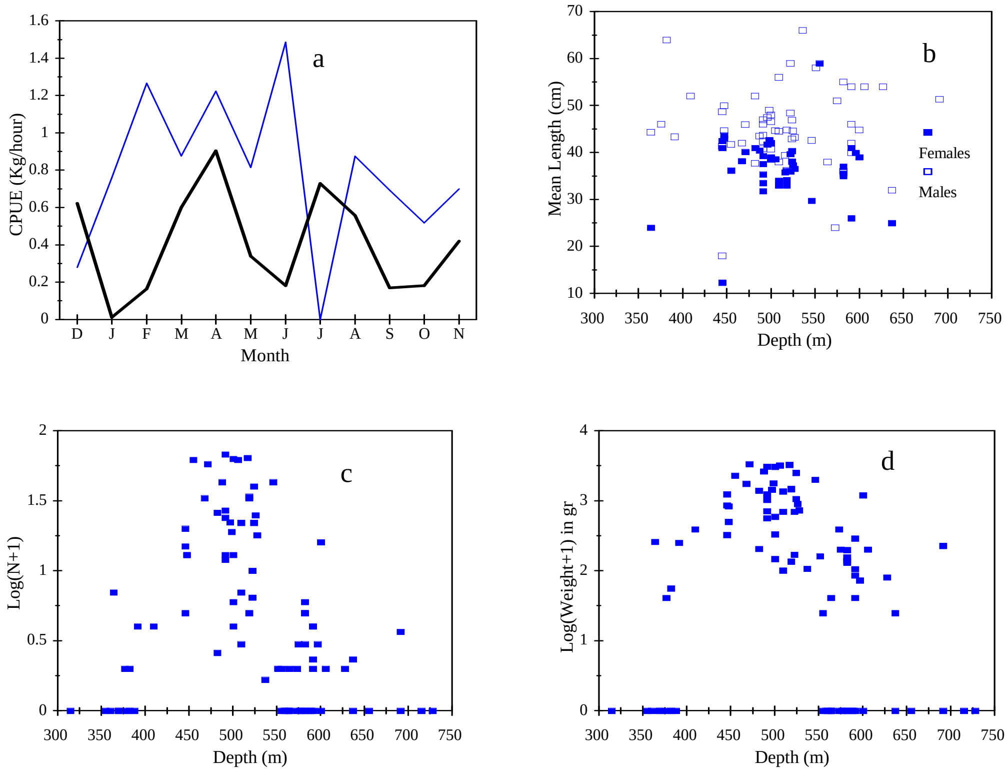


Fig. 43. CPUE fluctuation, Depth -mean length plot, Depth -Log(Number+1) plot and Depth-Log(Weight+1) plot of *Nephrops norvegicus* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

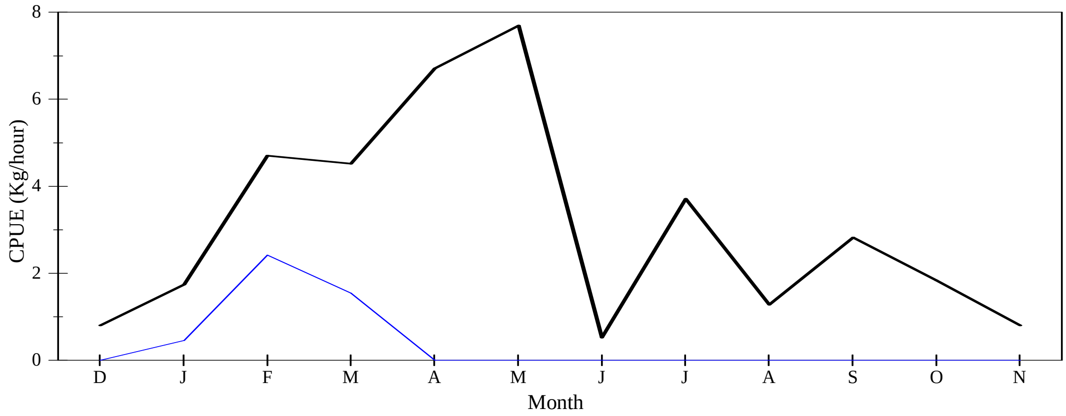


Fig. 44. CPUE fluctuation of *A. antennatus* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

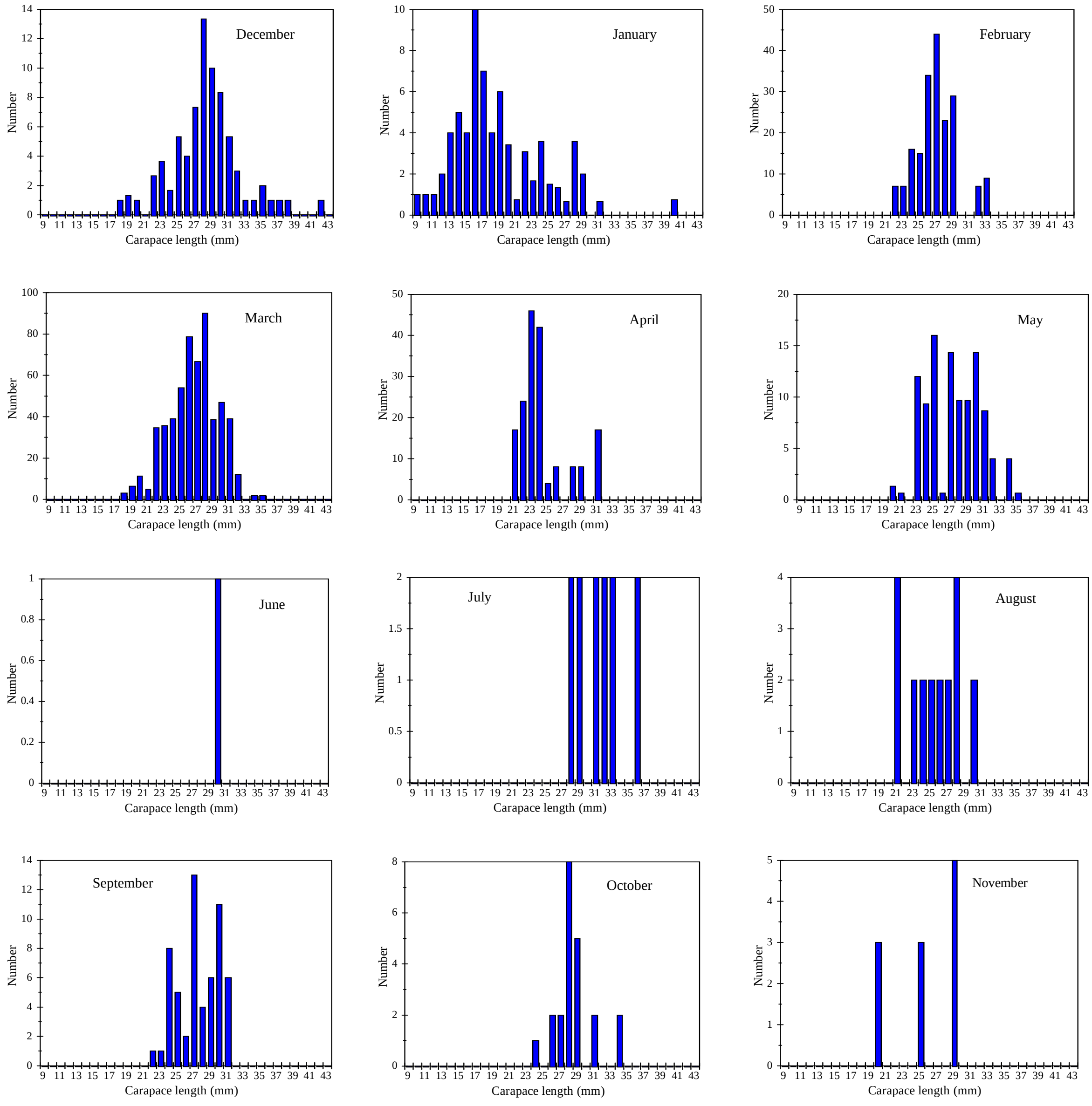


Fig. 45. Monthly length frequency distribution of the males *A. antennatus*.

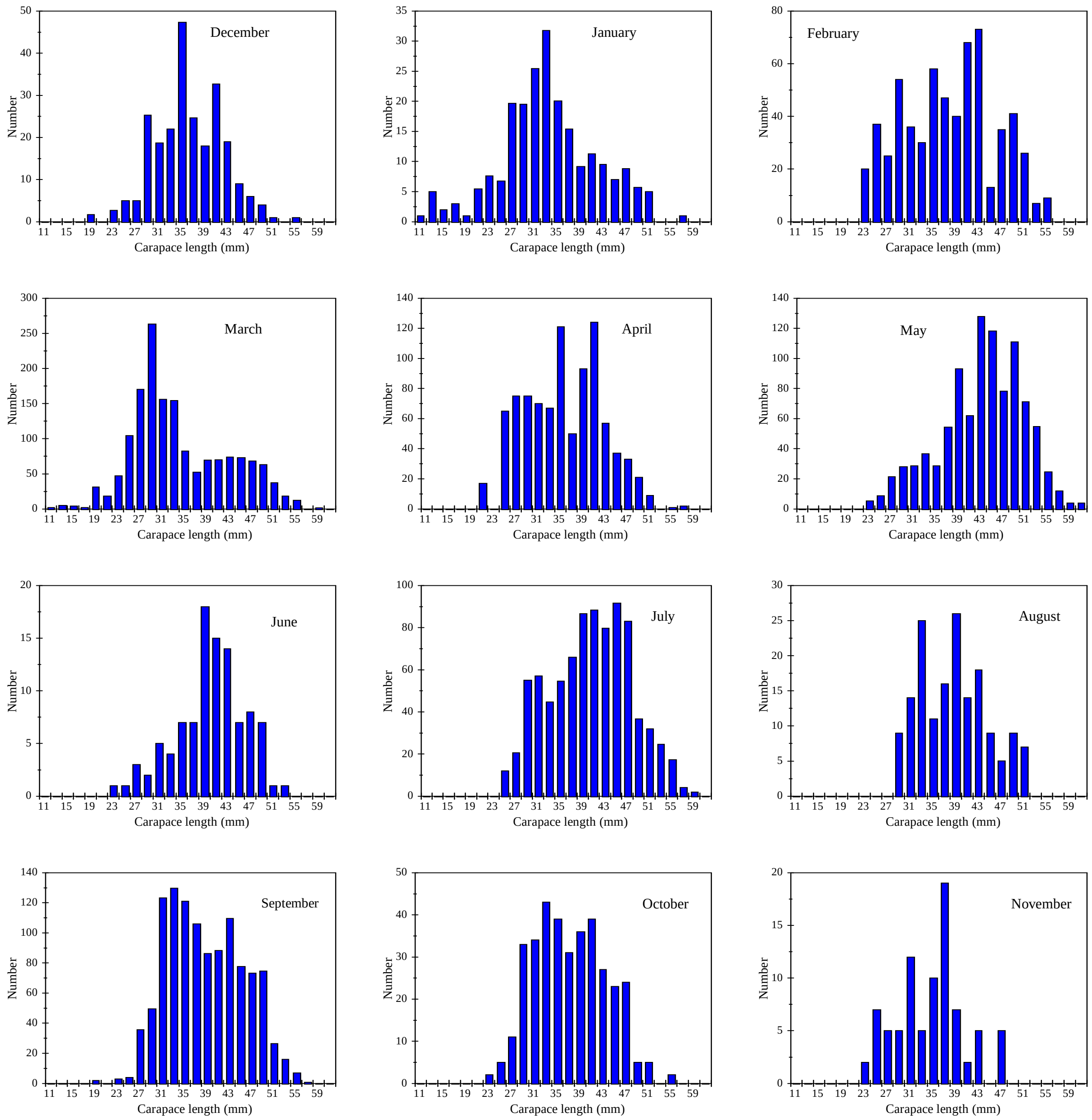


Fig. 46. Monthly length frequency distribution of the females *A. antennatus*.

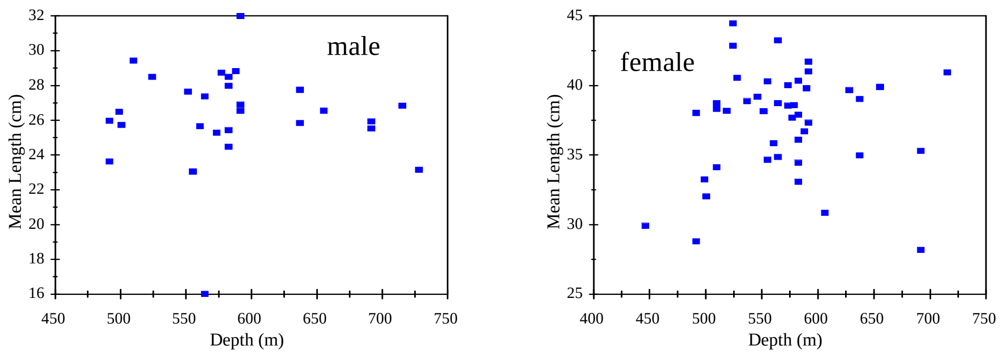


Fig. 47. Depth-mean length plot of *A. antennatus*.

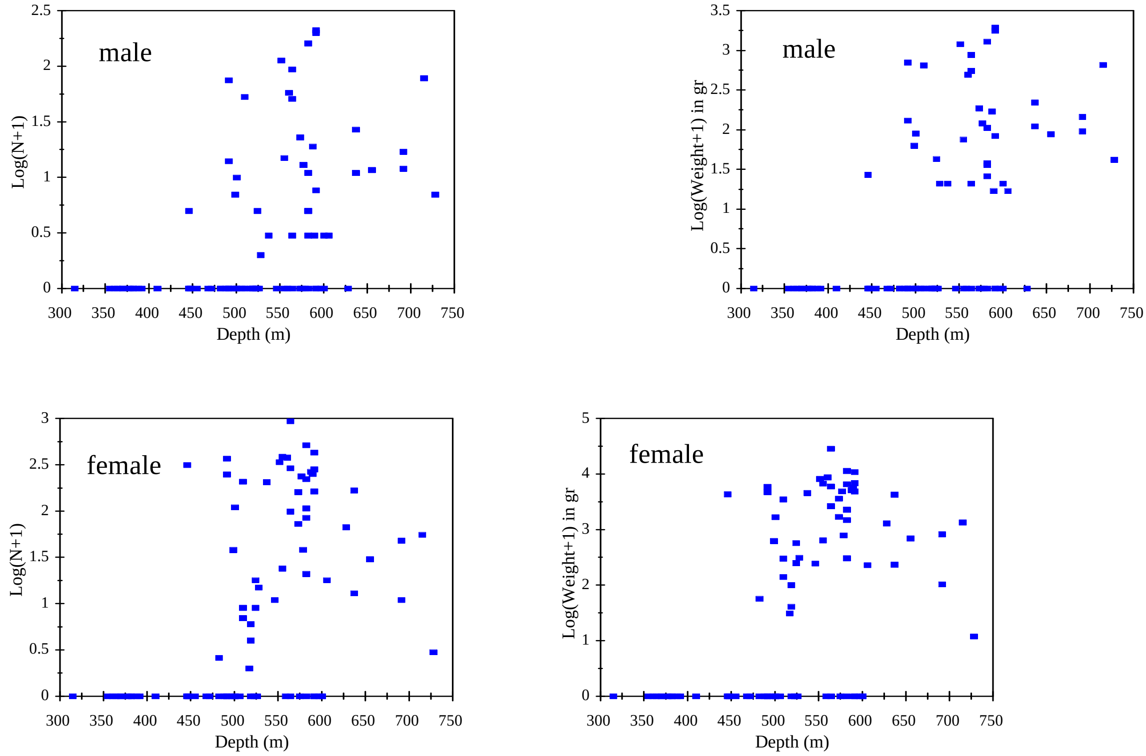


Fig. 48. Depth-Log(N+1) and Depth -Log(W+1) plot of *A. antennatus*.

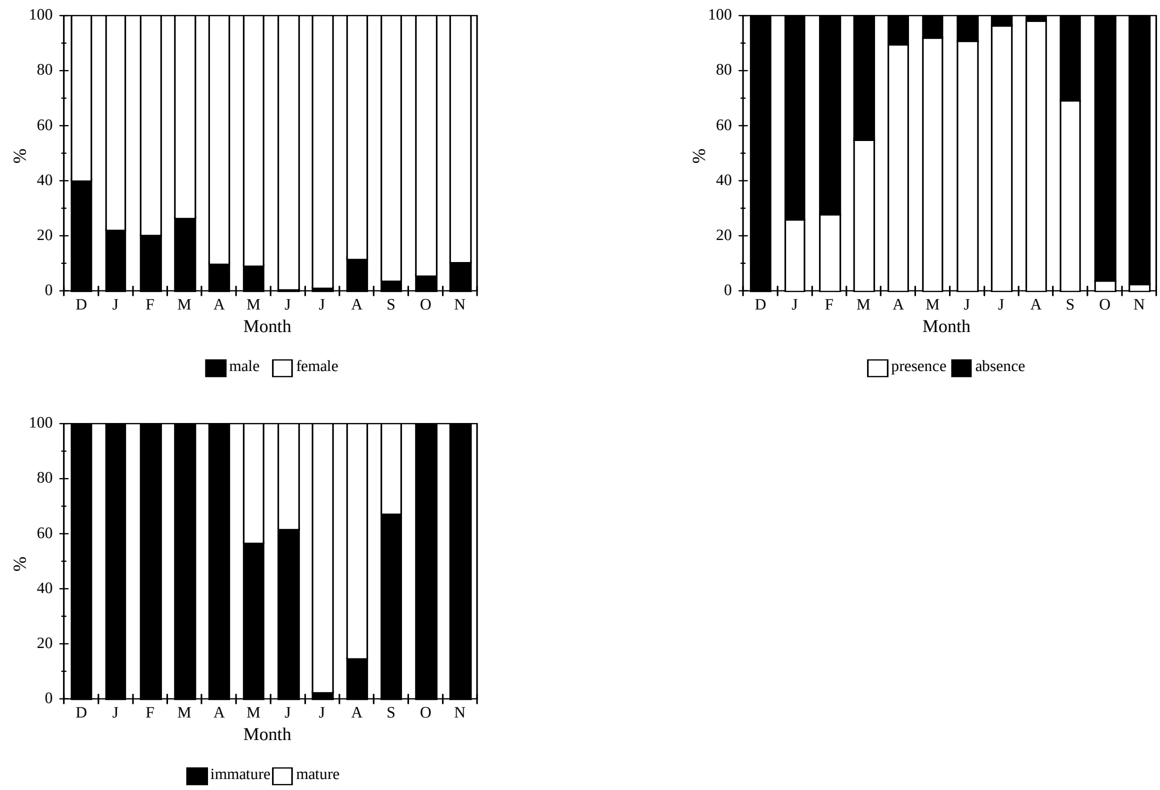


Fig. 49. Sex ratio, mature-immature ratio and presence of spermatophores of *A. antennatus*.

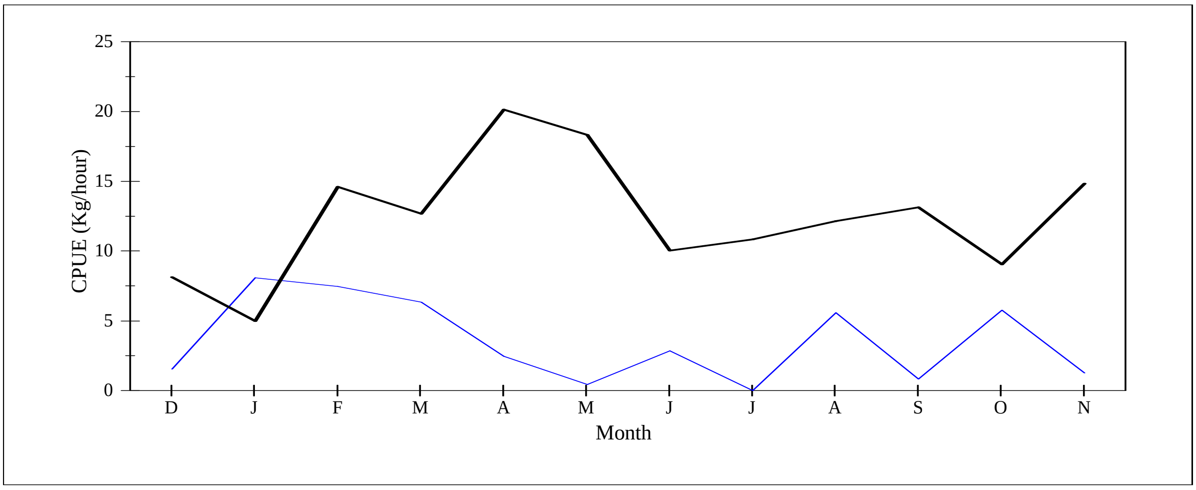


Fig. 50. CPUE fluctuation of *A. foliacea* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

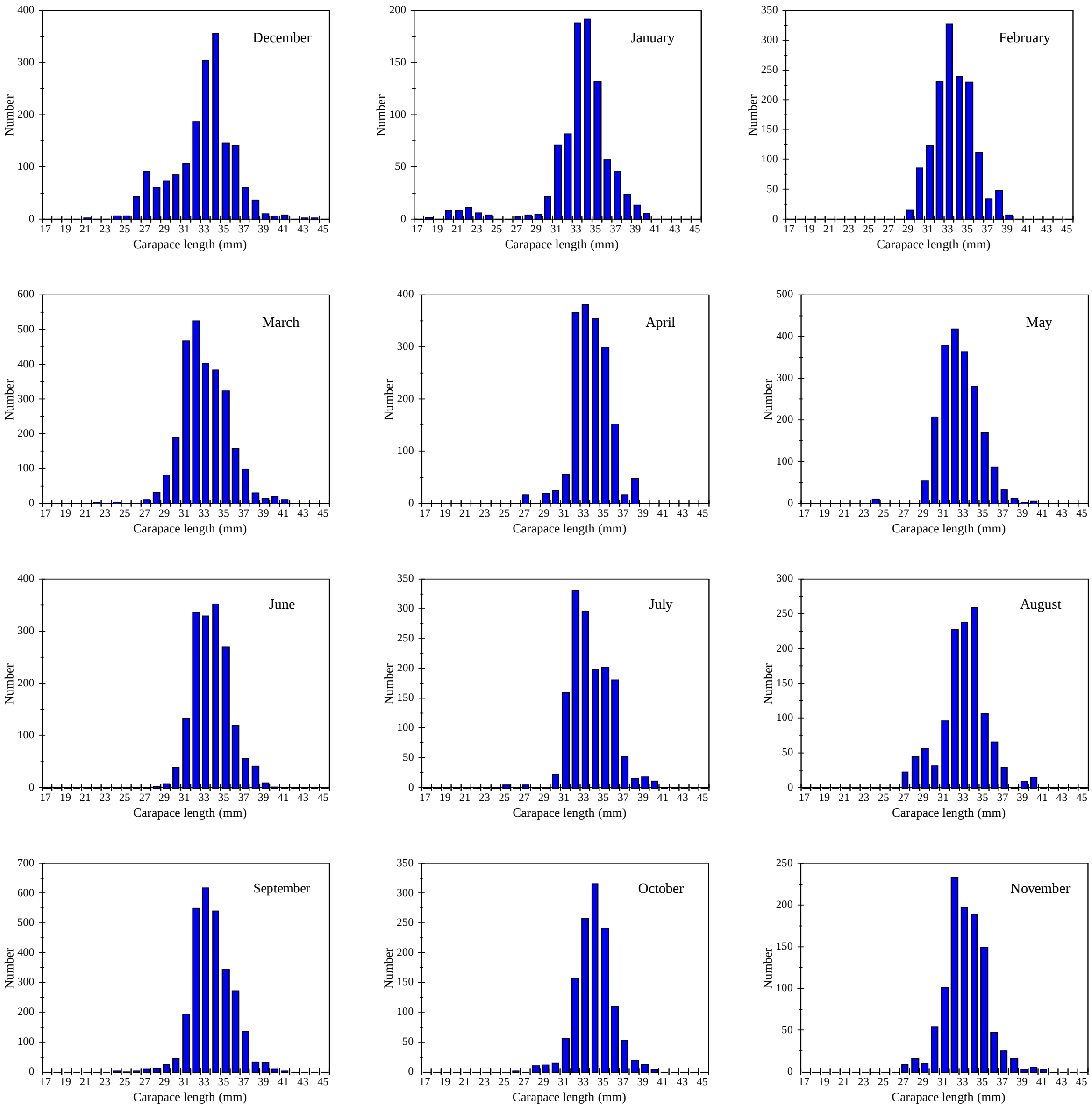


Fig. 51. Monthly length frequency distribution of the males *A. foliacea*.

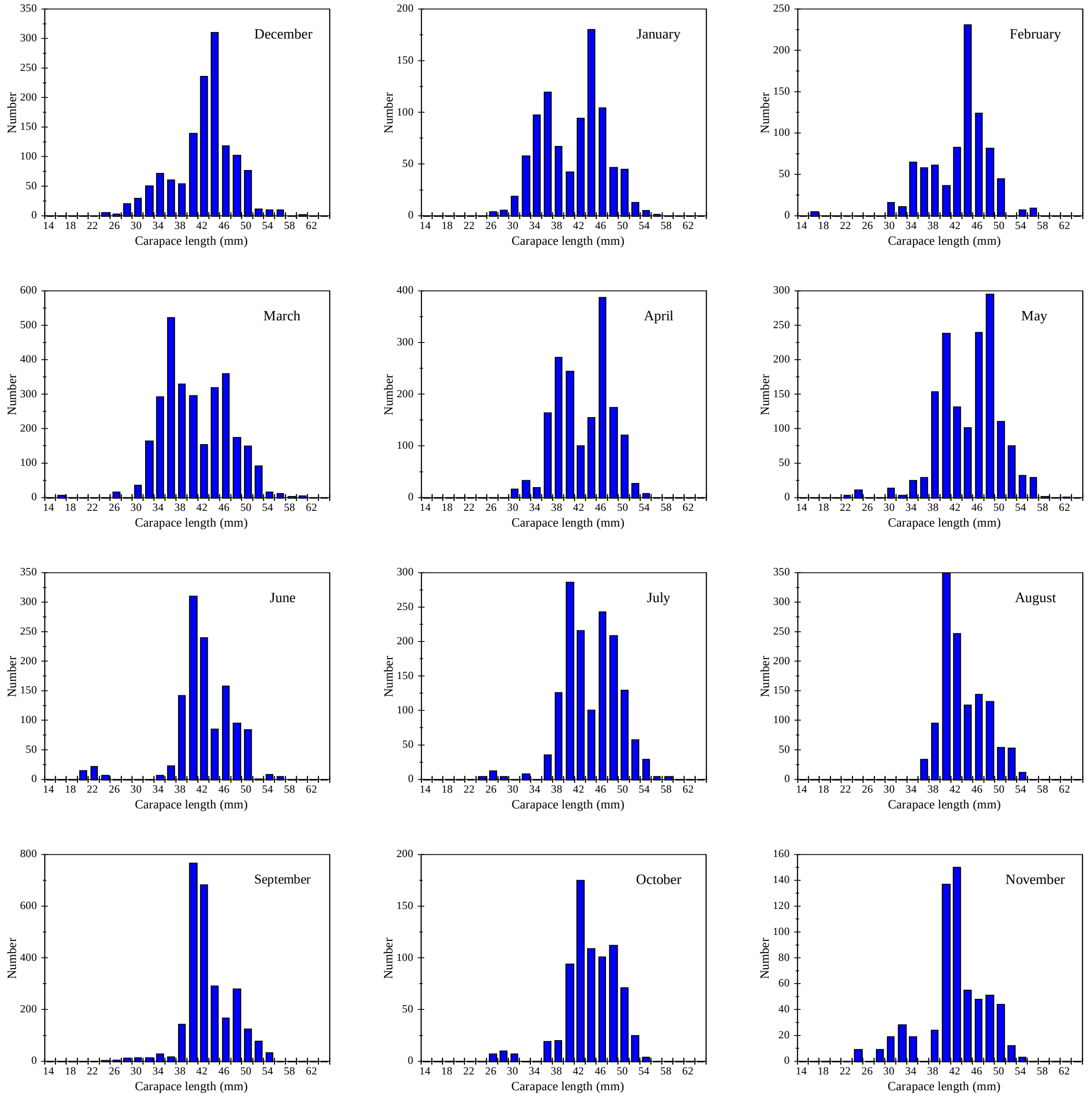


Fig. 52. Monthly length frequency distribution of the females *A. foliacea*.

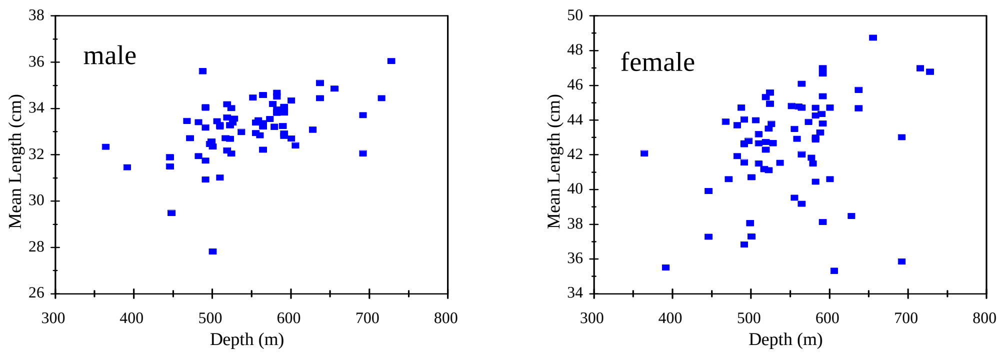


Fig. 53. Depth-mean length plot of *A. foliacea*.

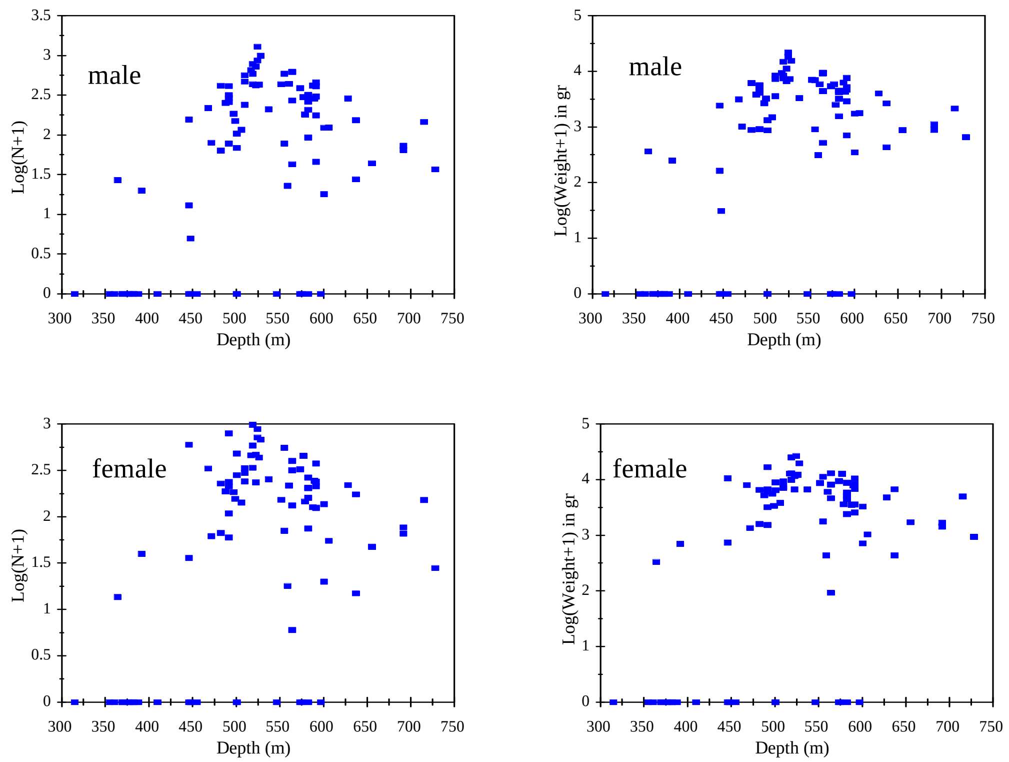


Fig. 54. Depth-Log(N+1) and Depth -Log(W+1) plot of *A. foliacea*.

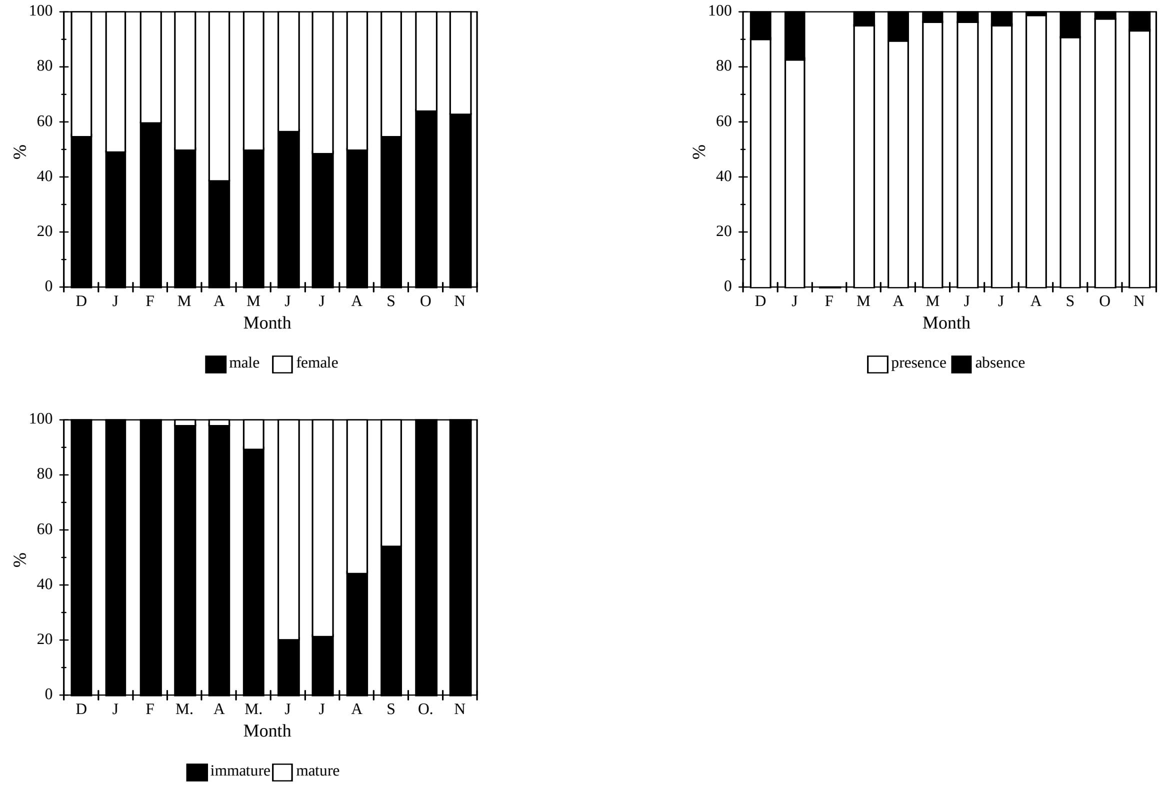


Fig. 55. Sex ratio, mature-immature ratio and presence of spermatophores of *A. foliacea*.

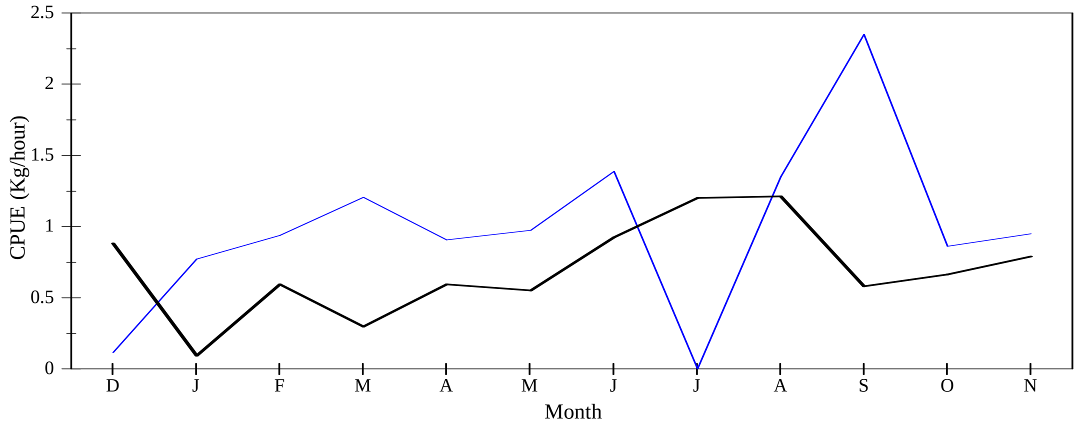


Fig. 56. CPUE fluctuation of *P. longirostris* (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

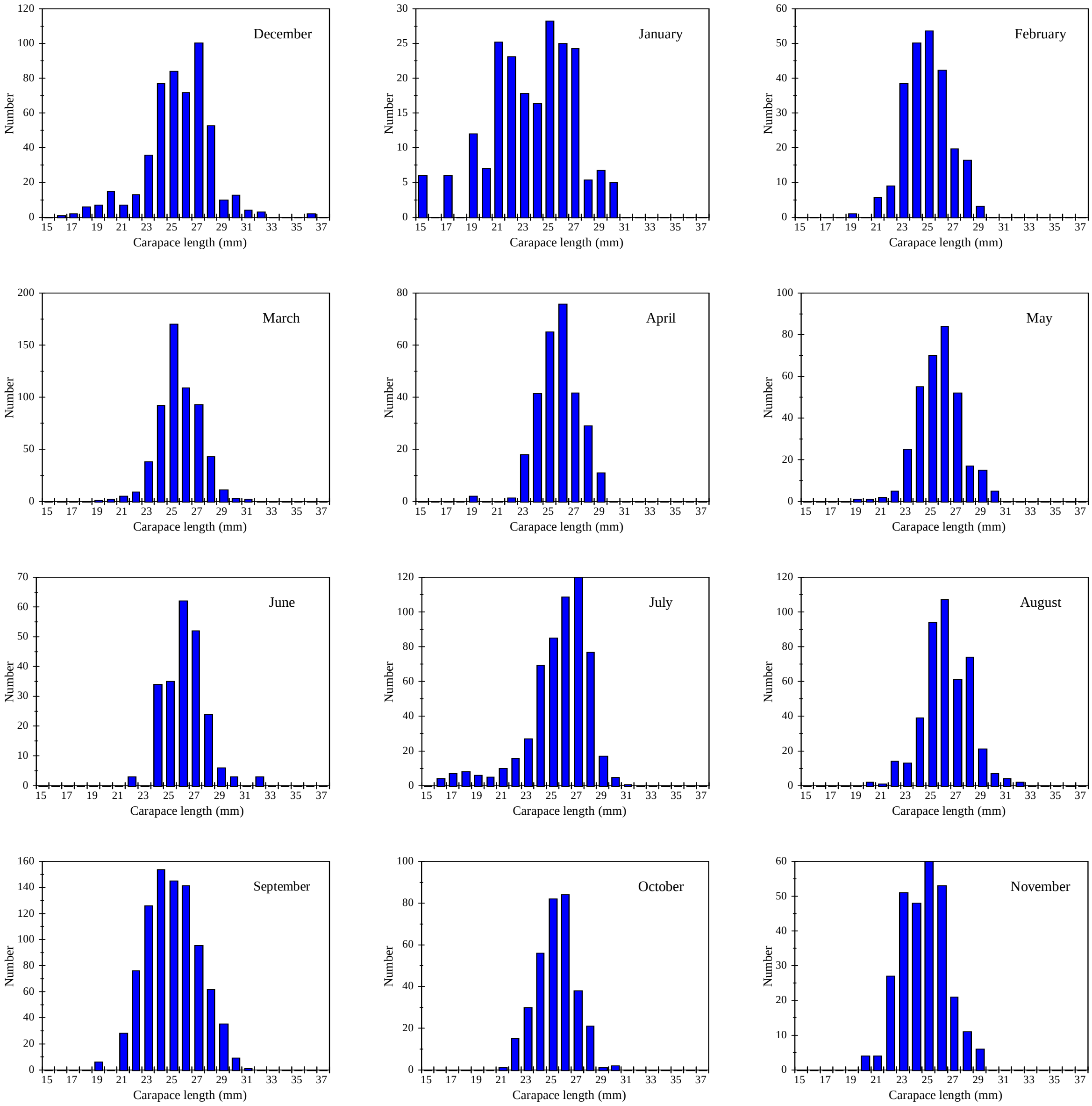


Fig. 57. Monthly length frequency distribution of the males *P. longirostris*.

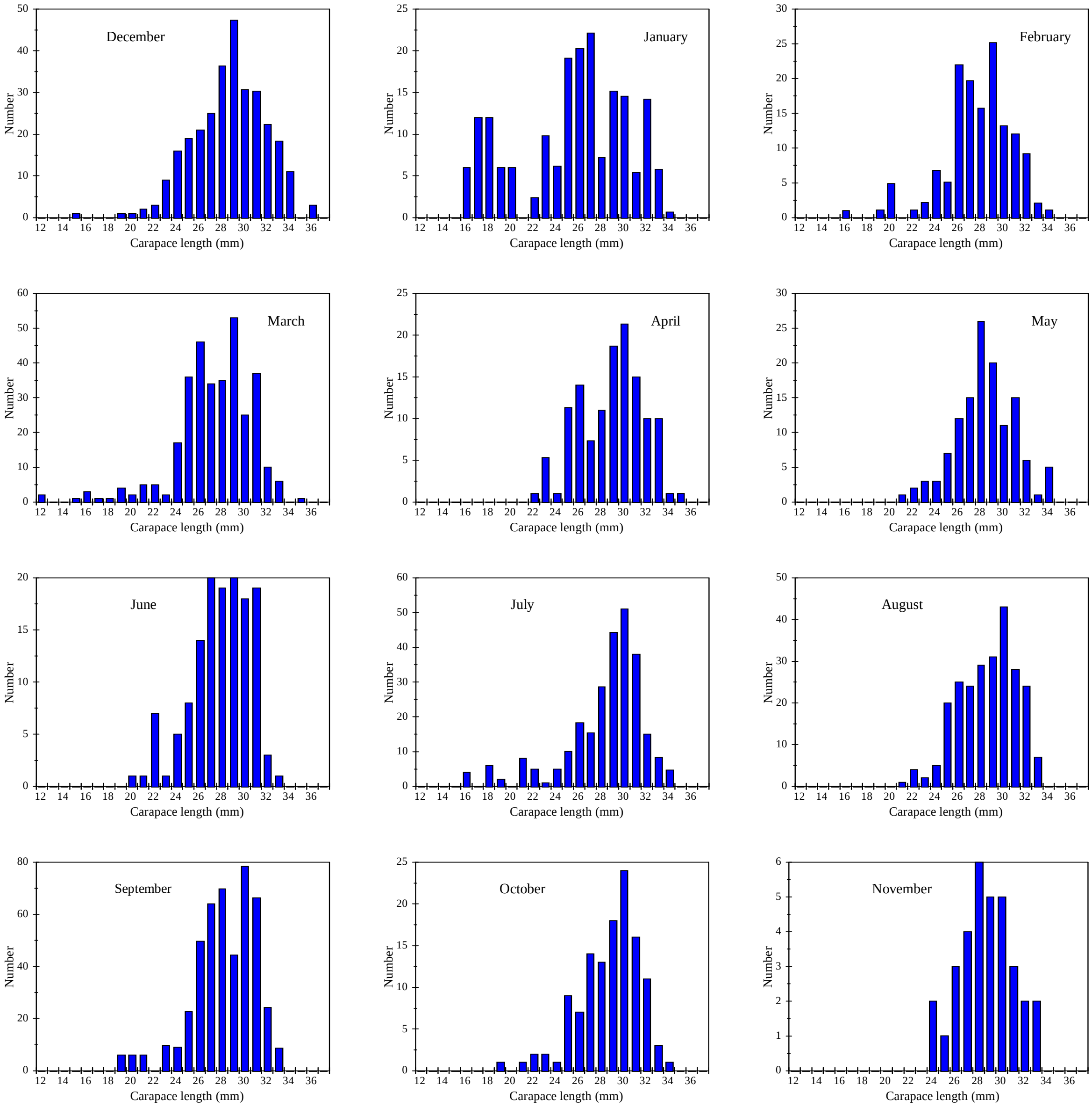


Fig. 58. Monthly length frequency distribution of the females *P. longirostris*.

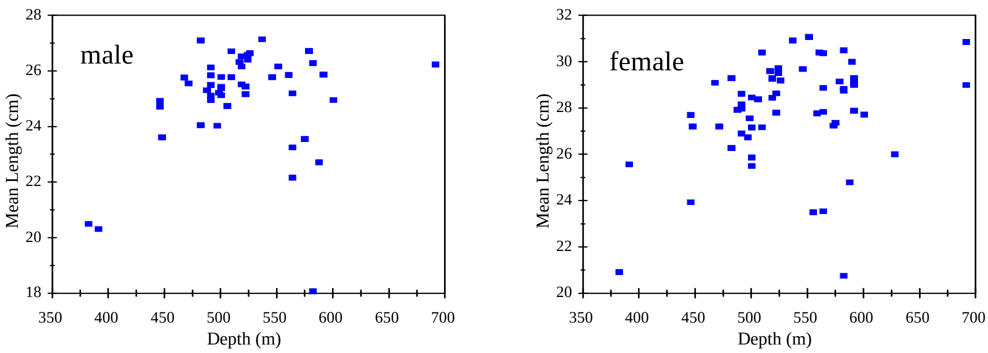


Fig. 59. Depth-mean length plot of *P. longirostris*.

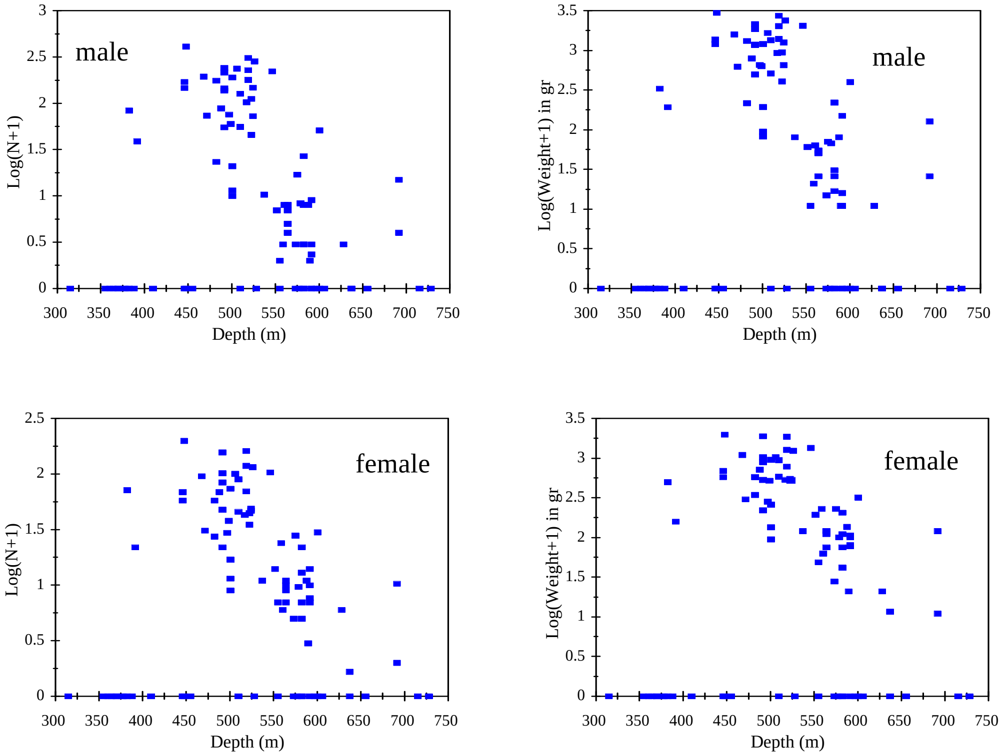


Fig. 60. Depth-Log(N+1) and Depth -Log(W+1) plot of *P. longirostris*.

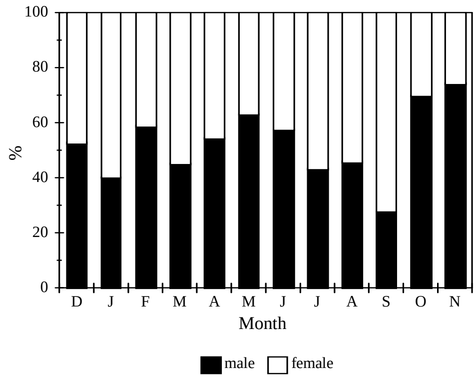


Fig. 61. Sex ratio of *P. longirostris*.

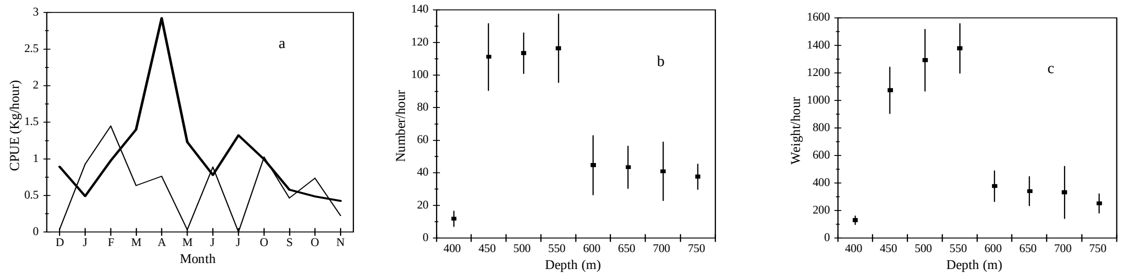


Fig. 62. CPUE fluctuations (a), bathymetrical distribution of abundance (fish/hour) (b) and biomass (g/ hour) (c) of *N. sclerorhynchus*. Mean value and confidence intervals at the 95% level are shown (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

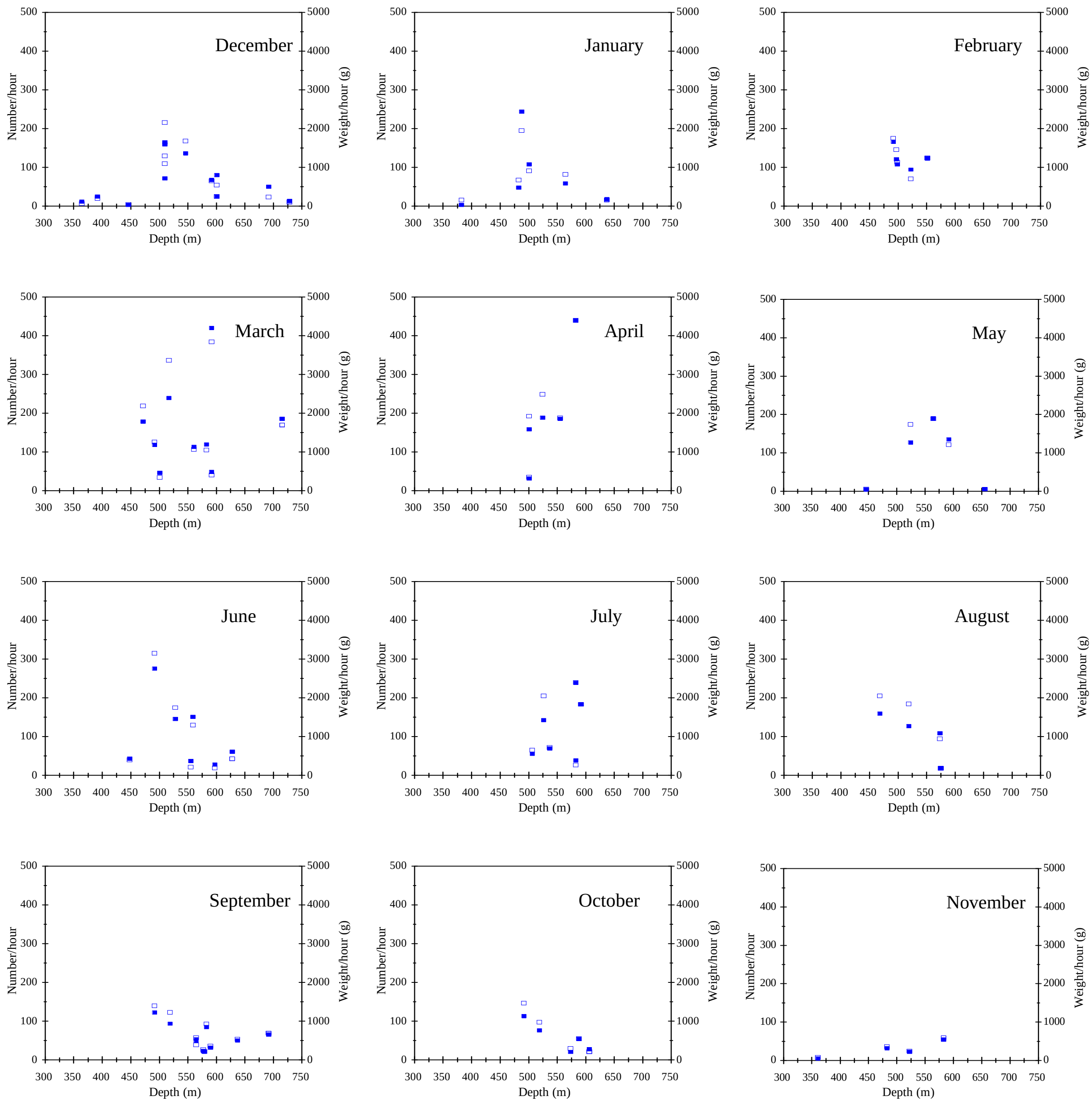


Fig. 63. Bathymetrical distribution by month of *N. sclerorhynchus*. Shadowed rectangles: abundance, open rectangles: biomass.

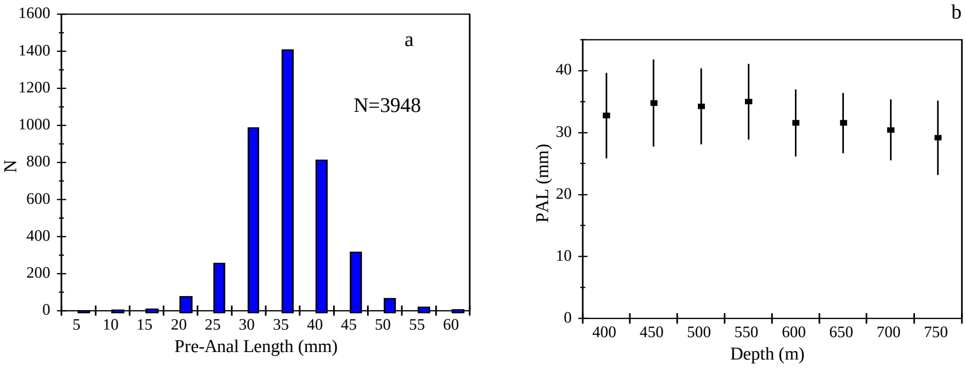


Fig. 64. Length frequency distribution (PAL, mm) (a) and bathymetrical distribution by length (b) of *N. sclerorhynchus.*

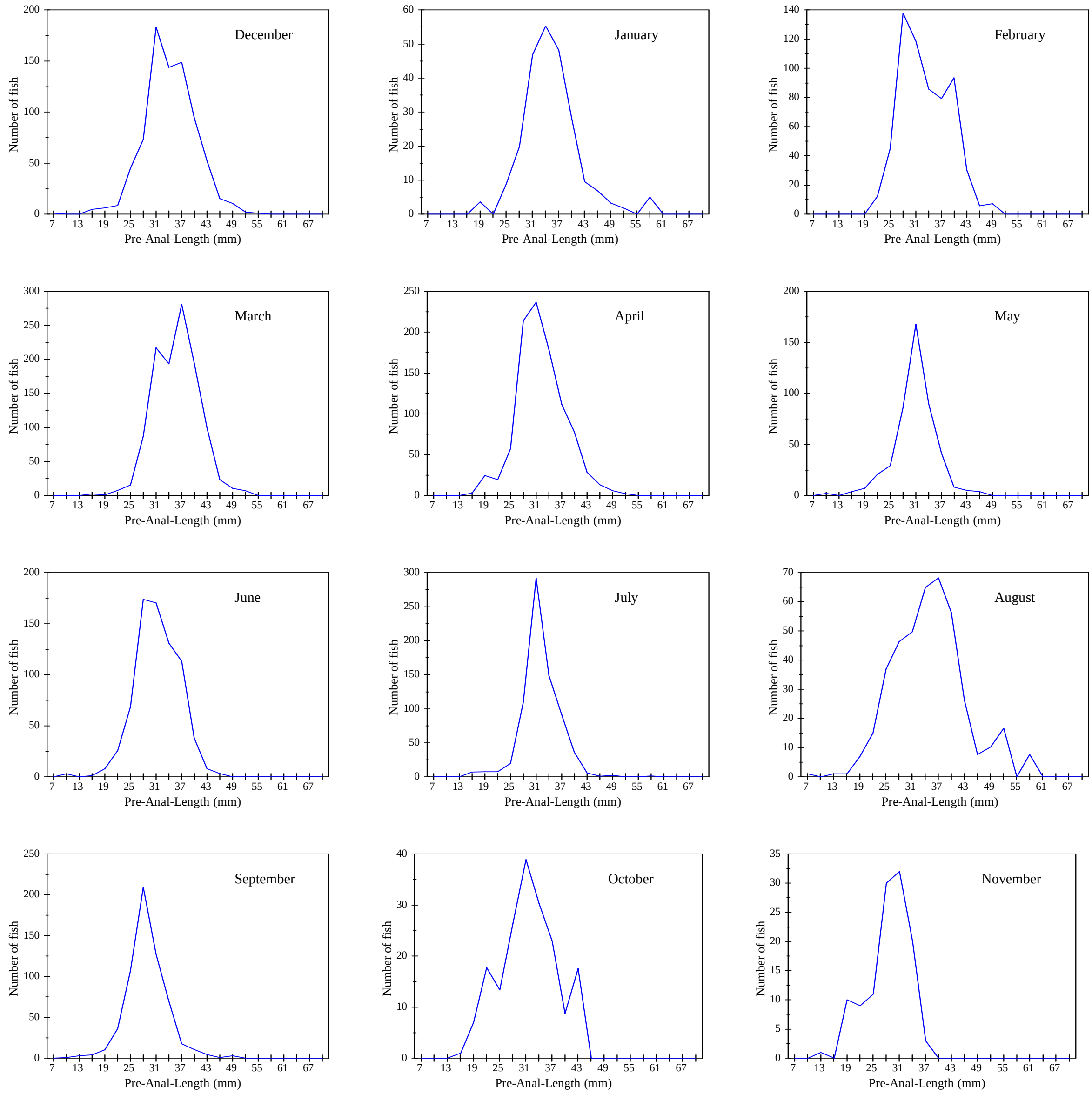


Fig. 65. Monthly length frequency distribution of *N. sclerorhynchus.*

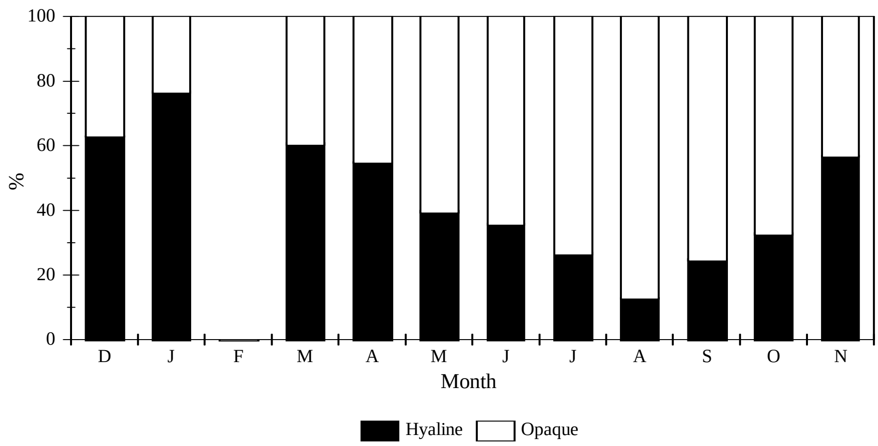


Fig. 66. Evolution of the percentage of opaque and hyaline rings at the otolith edge of *N. sclerorhynchus.*

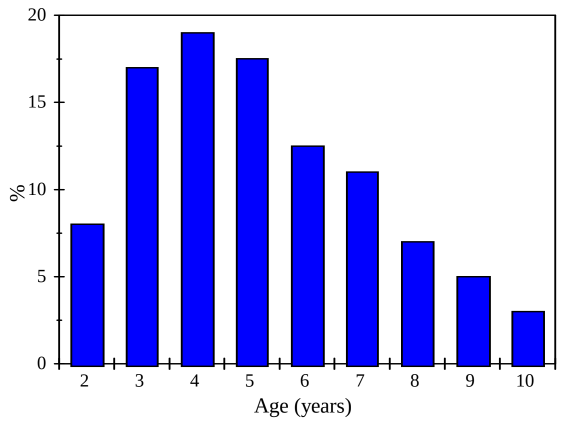


Fig 67. Age distribution % of *N. sclerorhynchus.*

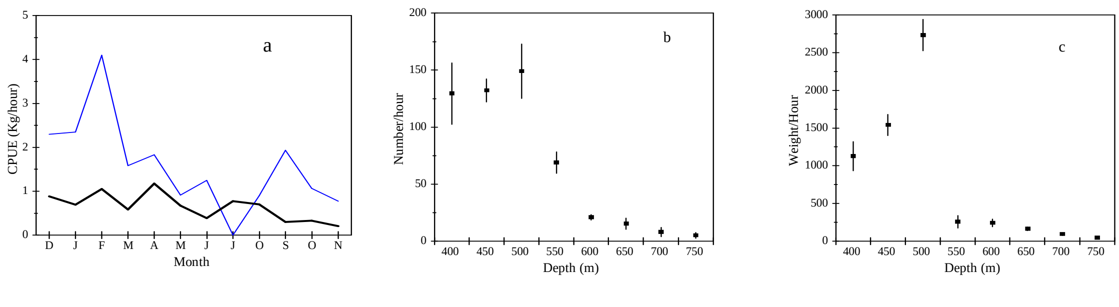


Fig. 68. CPUE fluctuations (a), bathymetrical distribution of abundance (fish/hour) (b) and biomass (g/hour) (c) of *C. coelorhynchus*. Mean value and confidence intervals at the 95% level are shown (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

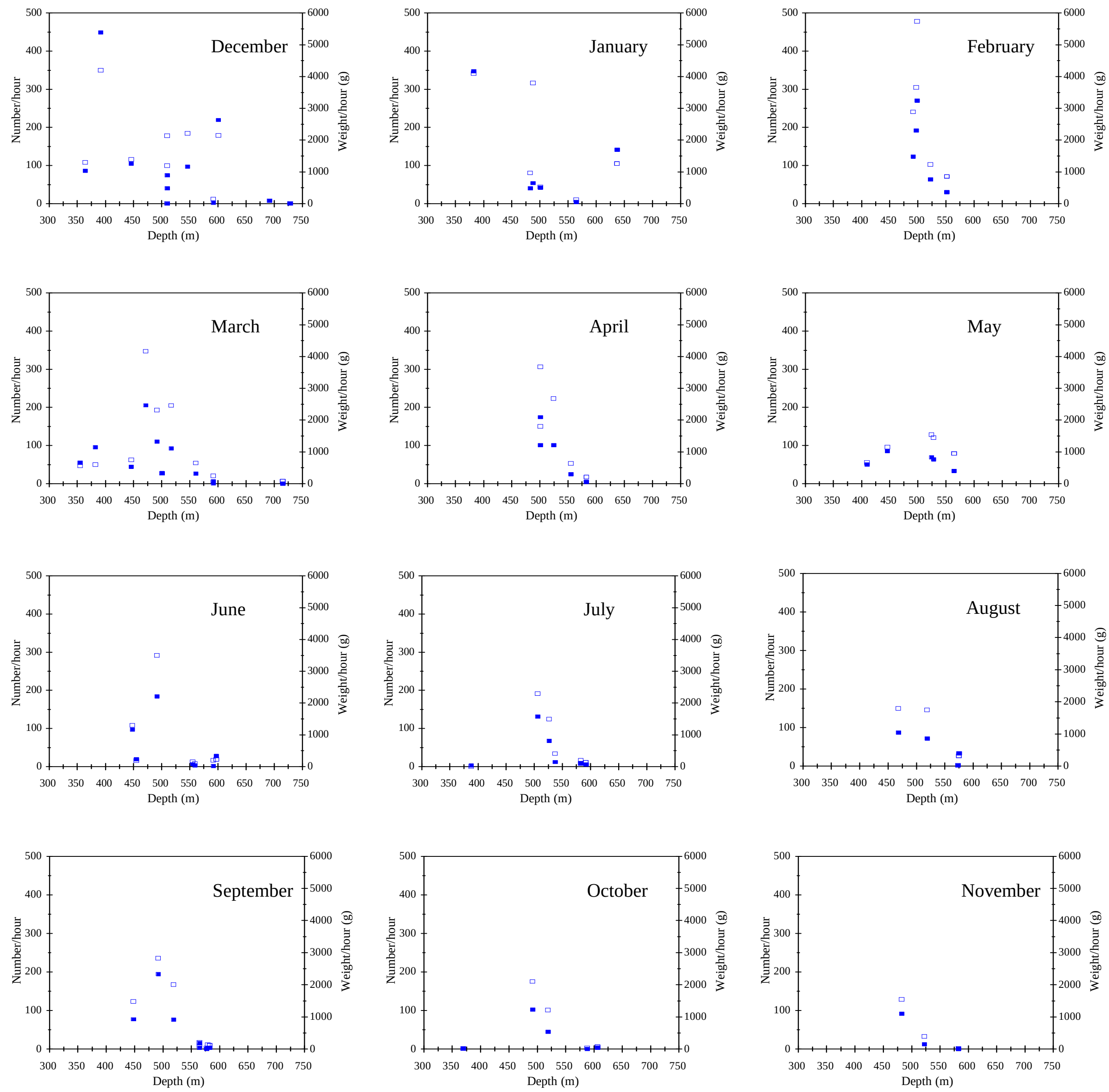


Fig. 69. Bathymetrical distribution by month of *C. coelorhynchus*. Shadowed rectangles: abundance, open rectangles: biomass.

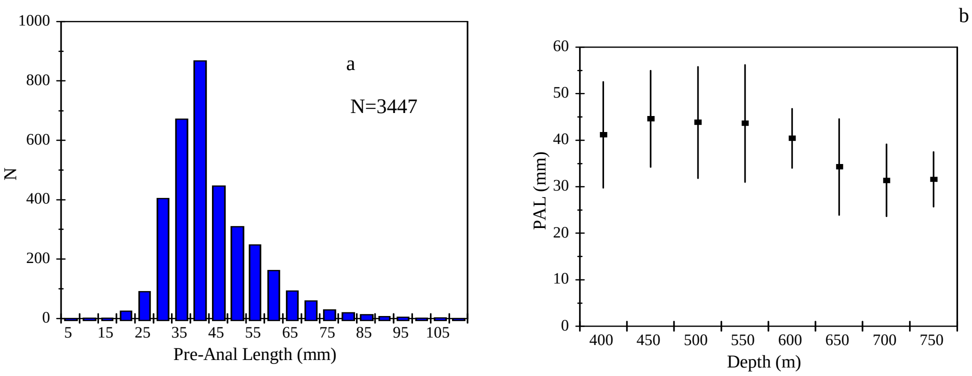


Fig. 70. Length frequency distribution (PAL, mm) (a) and bathymetrical distribution by length (b) of *C. coelorhynchus*.

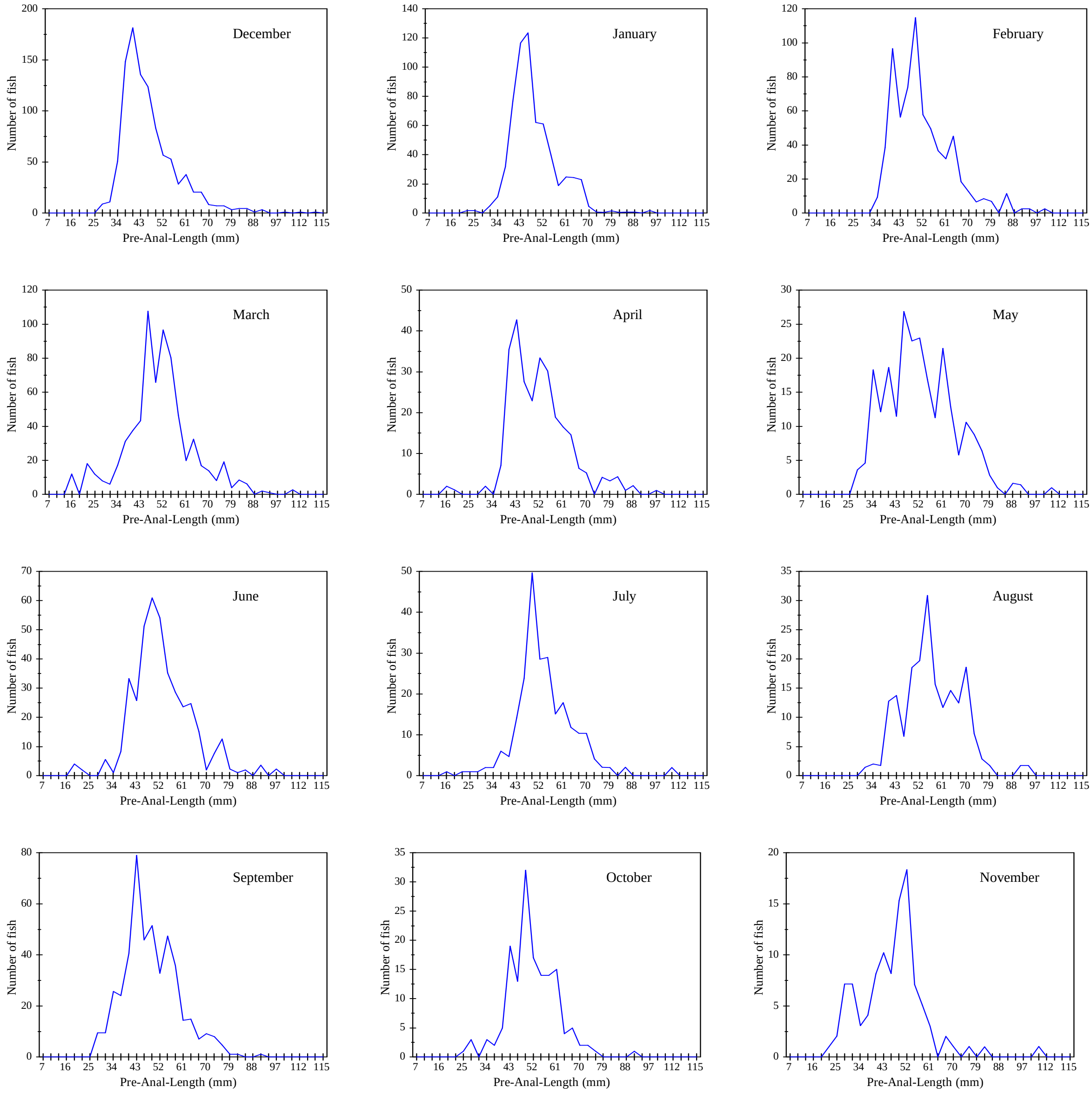


Fig. 71. Monthly length frequency distribution of *C. coelorhynchus*.

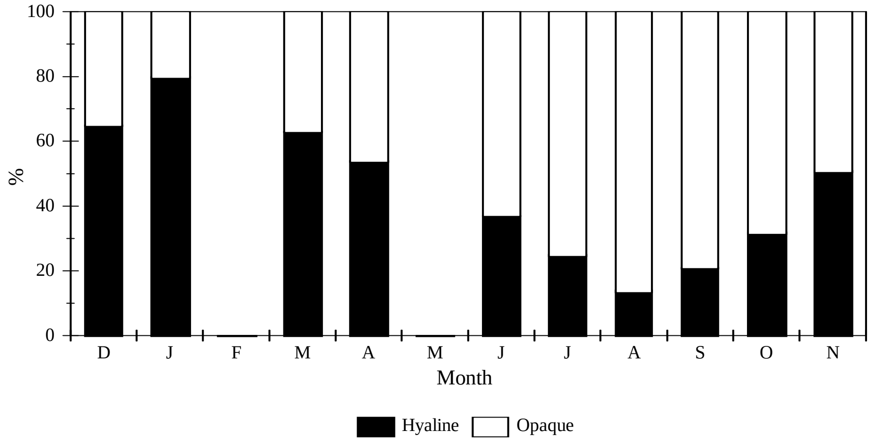


Fig. 72. Evolution of the percentage of opaque and hyaline rings at the otolith edge of *C. coelorhynchus*.

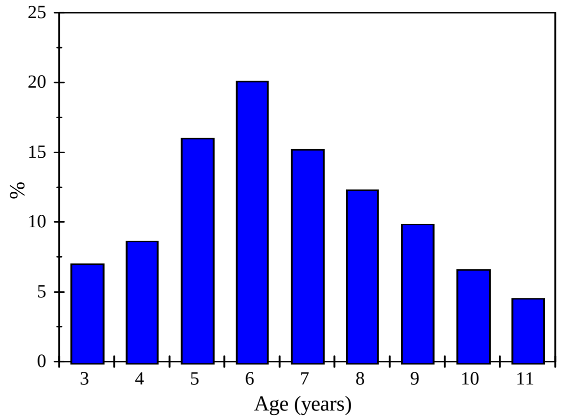


Fig. 73. Age distribution % of *C. coelorhynchus.*

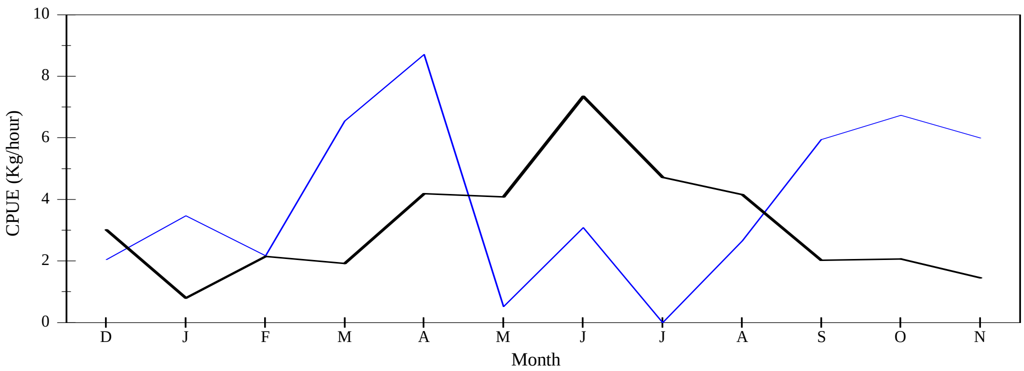


Fig. 74. CPUE fluctuations of *H. mediterraneus*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

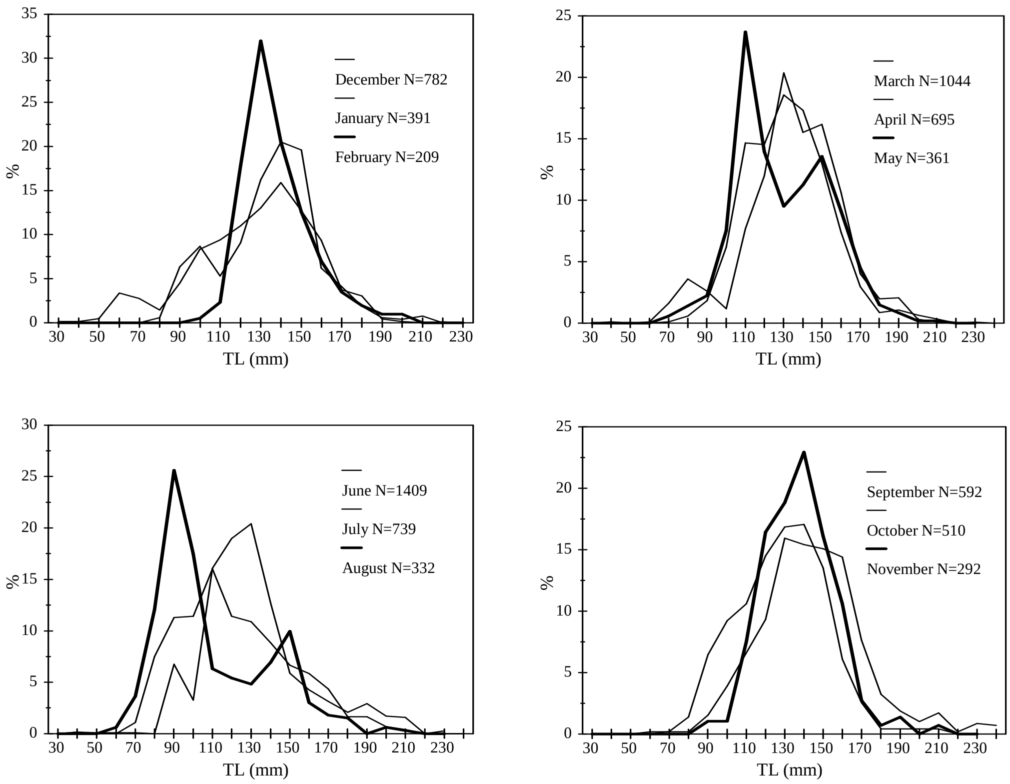


Fig. 75. Length frequency distribution of *H. mediterraneus*.

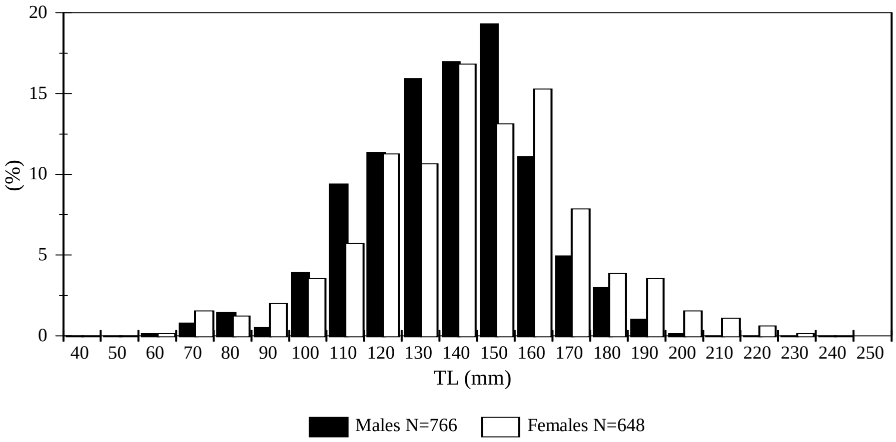


Fig. 76. Length frequency distribution of males and females *H. mediterraneus*.

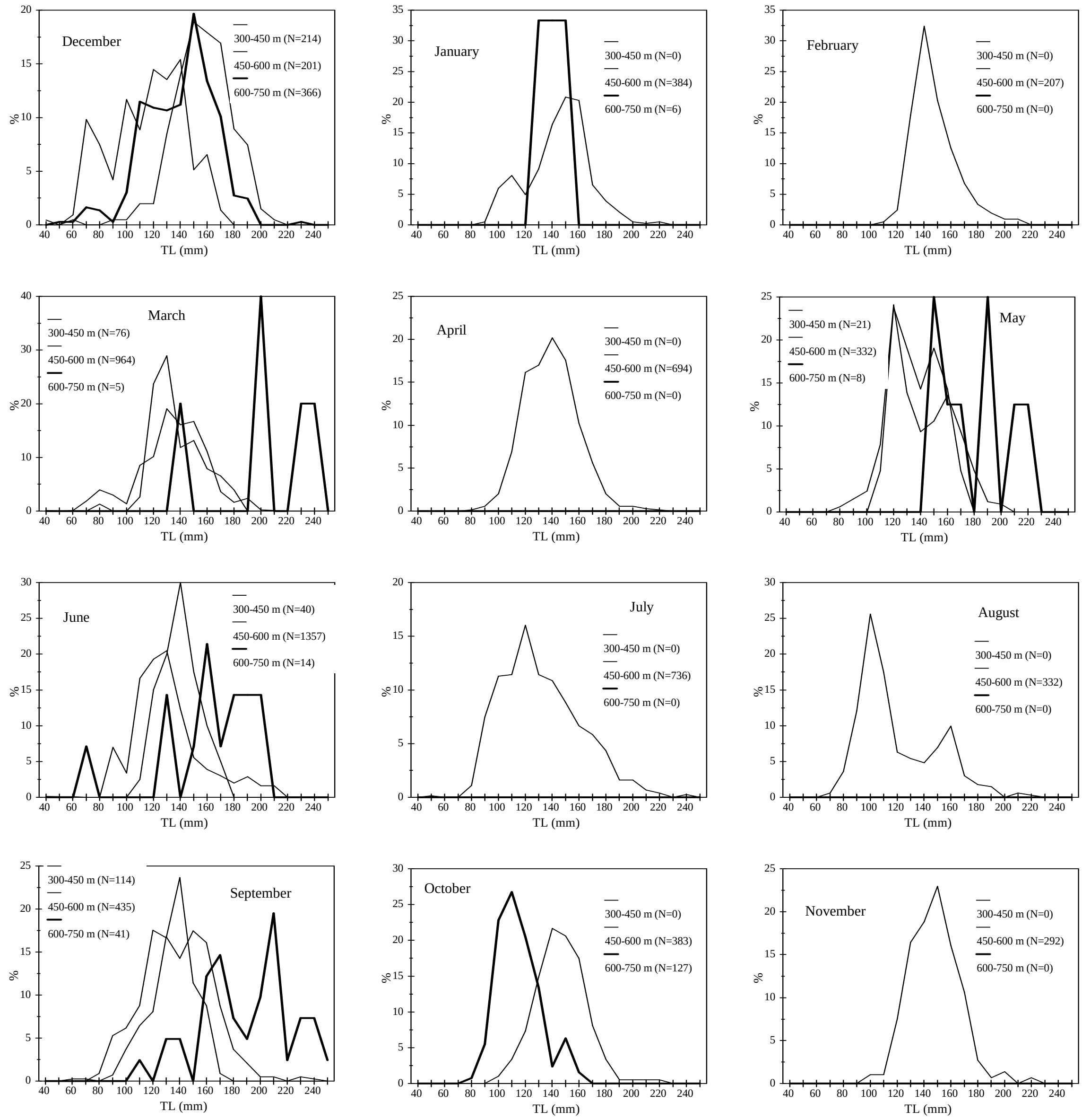


Fig. 77. Monthly bathymetrical distribution of *H. mediterraneus*.

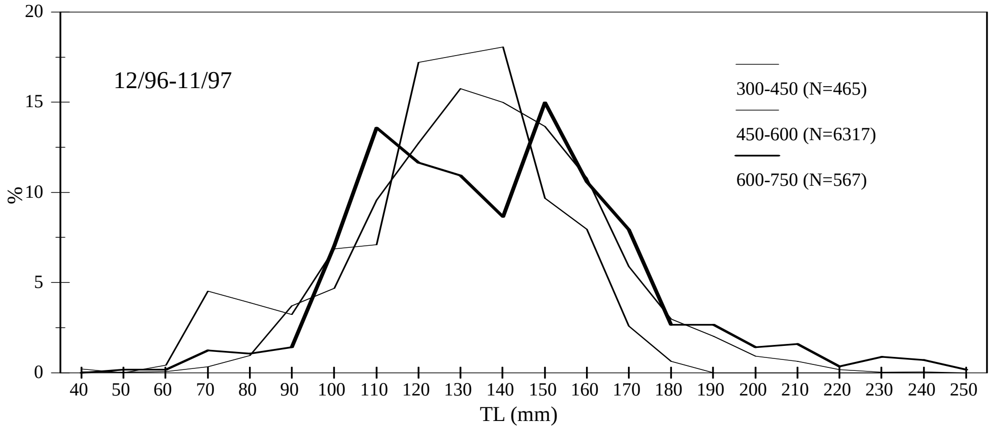


Fig. 78. Yearly bathymetrical distribution of *H. mediterraneus*.

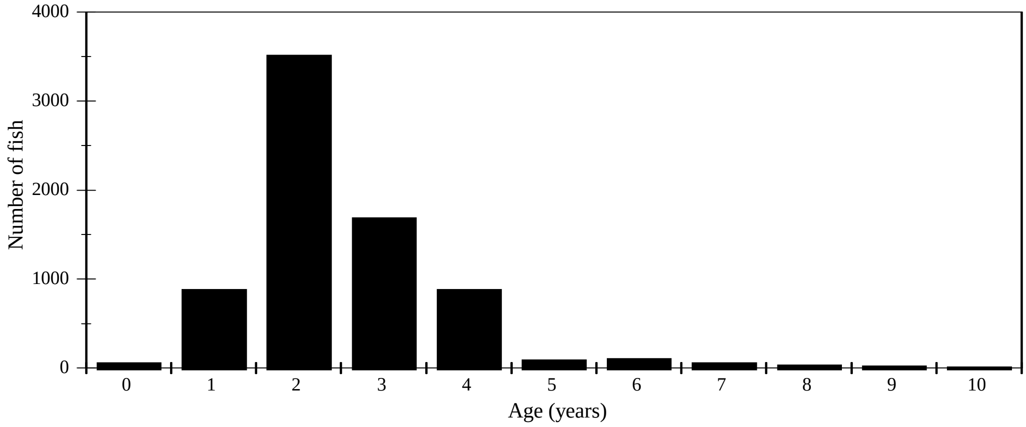


Fig. 79. Age distribution of *H. mediterraneus*.

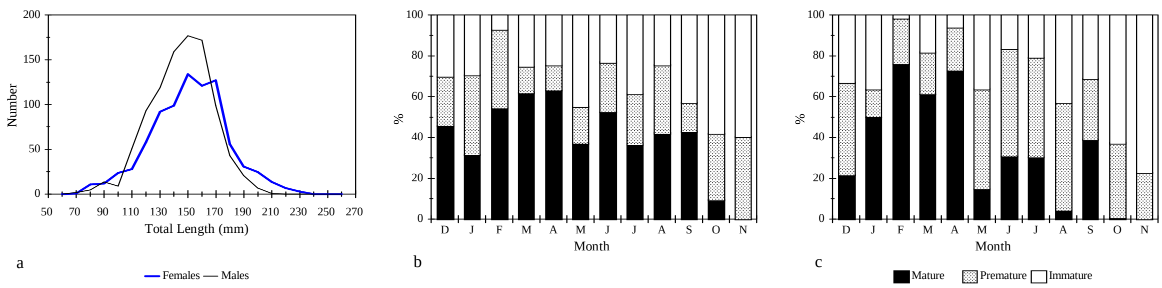


Fig. 80. Length frequency distribution of the examined *H. mediterraneus* (a) and proportion of mature, premature and immature females (b), males (c) per month.

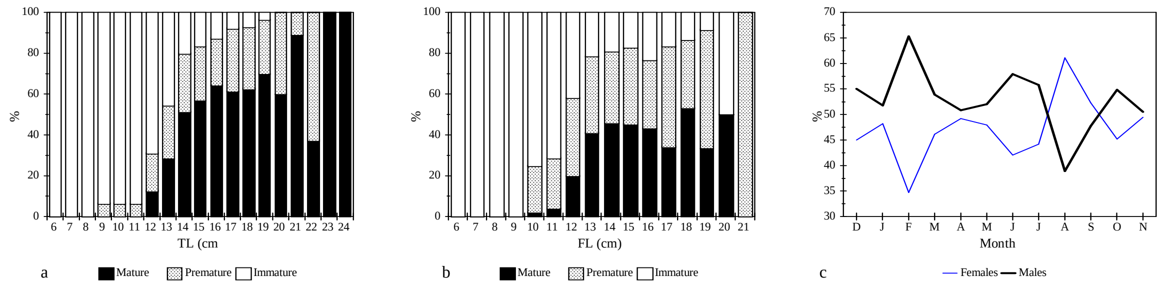


Fig. 81. Proportion of immature, premature and mature females (a), males (b) per length class and sex ratio (c) of *H. mediterraneus*.

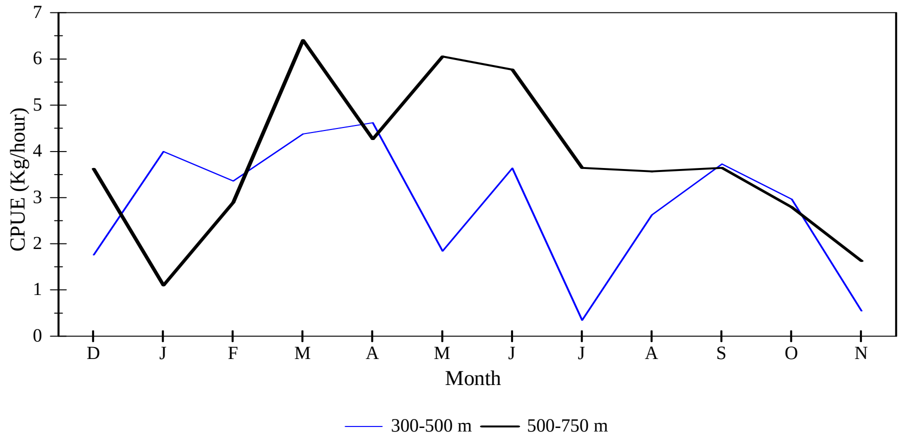


Fig. 82. CPUE fluctuations of *H. dactylopterus*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

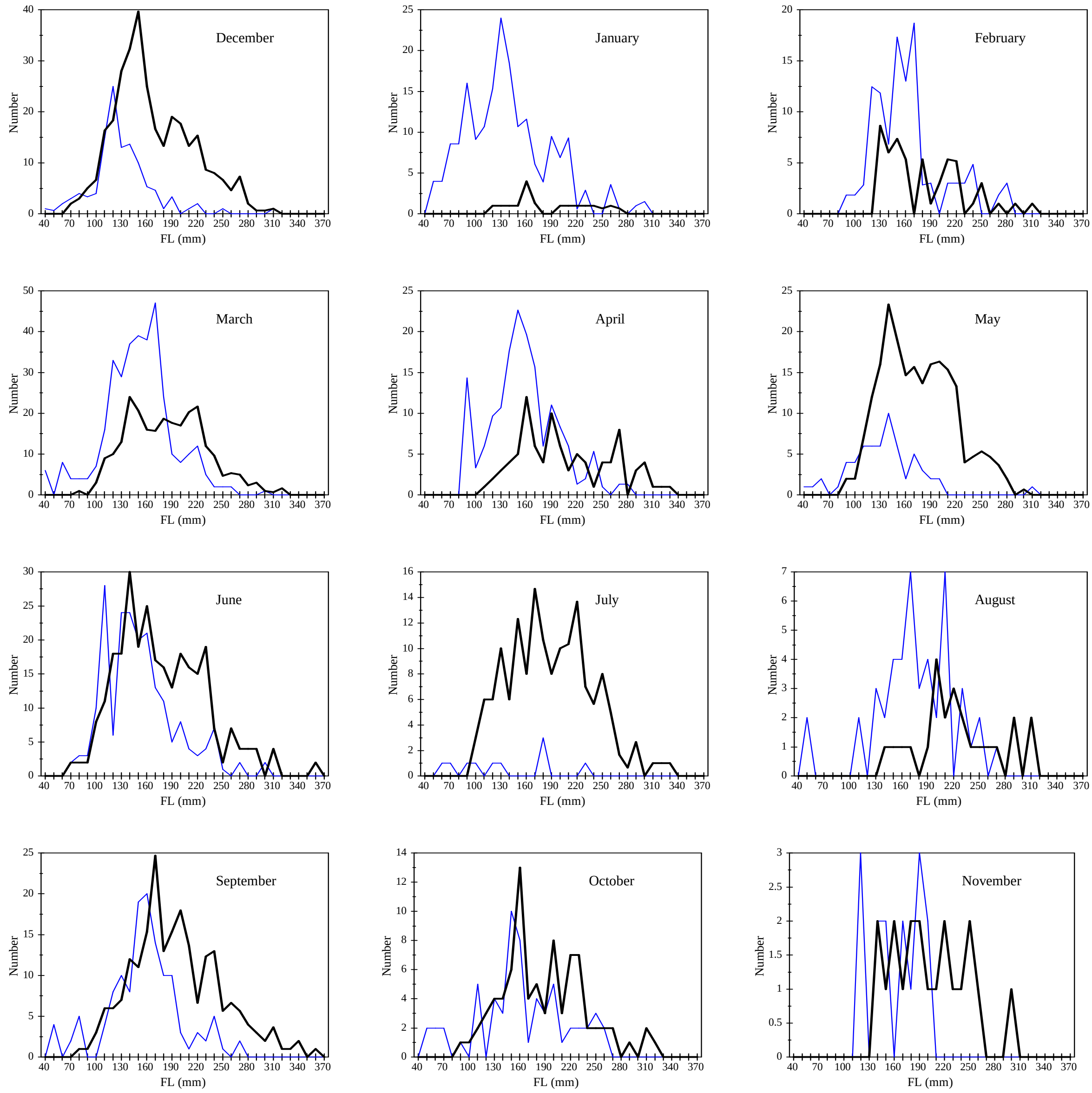


Fig. 83. Monthly length frequency distribution of *H. dactylopterus*. (Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

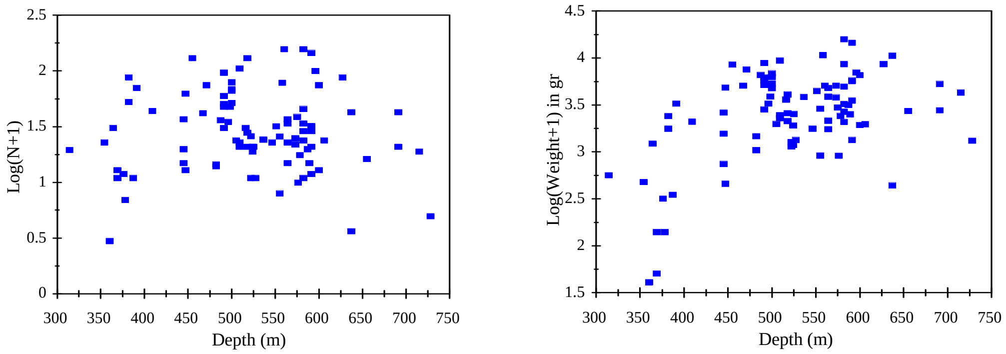


Fig. 84. Bathymetrical distribution of *H. dactylopterus* by number and by weight.

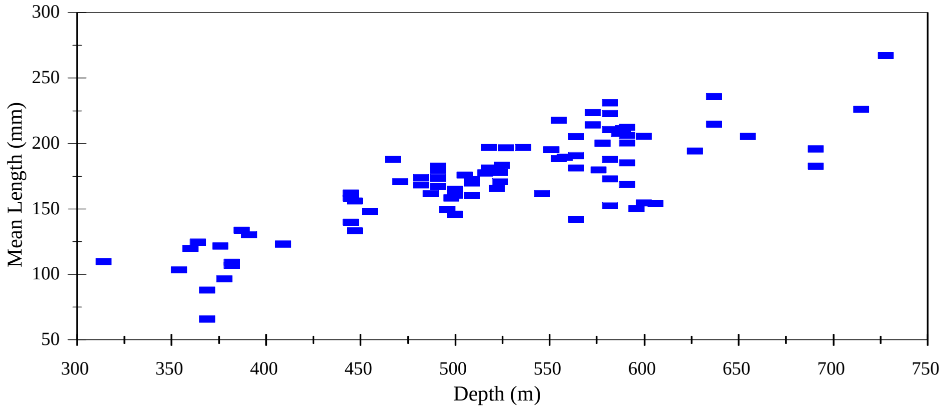


Fig. 85. Depth-mean length relationship of *H. dactylopterus*.

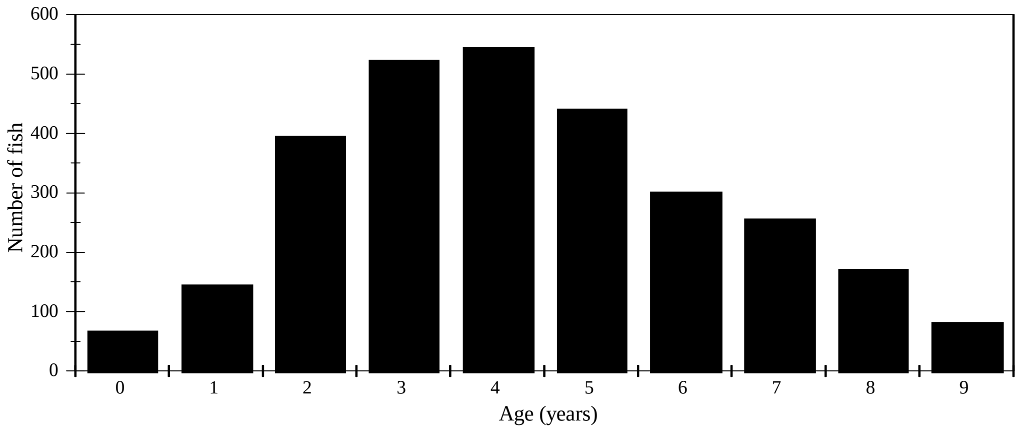


Fig. 86. Age distribution of *H. dactylopterus*.

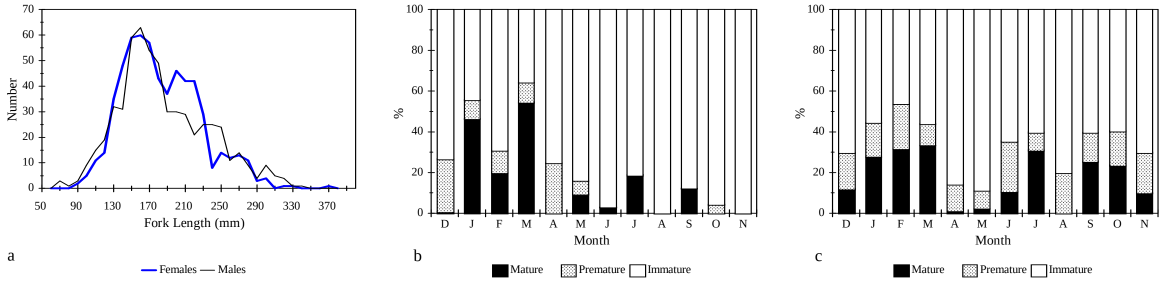


Fig. 87. Length frequency distribution of the examined *H. dactylopterus* (a) and proportion of mature, premature and immature females (b), males (c) per month.

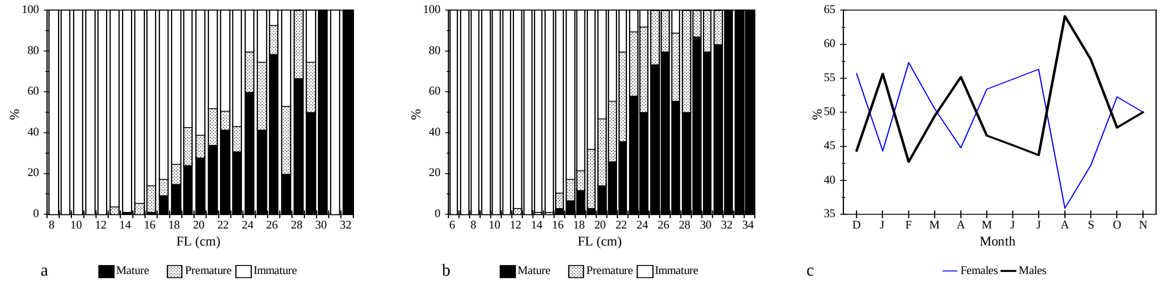


Fig. 88. Proportion of immature, premature and mature females (a), males (b) per length class and sex ratio (c) of *H. dactylopterus*.

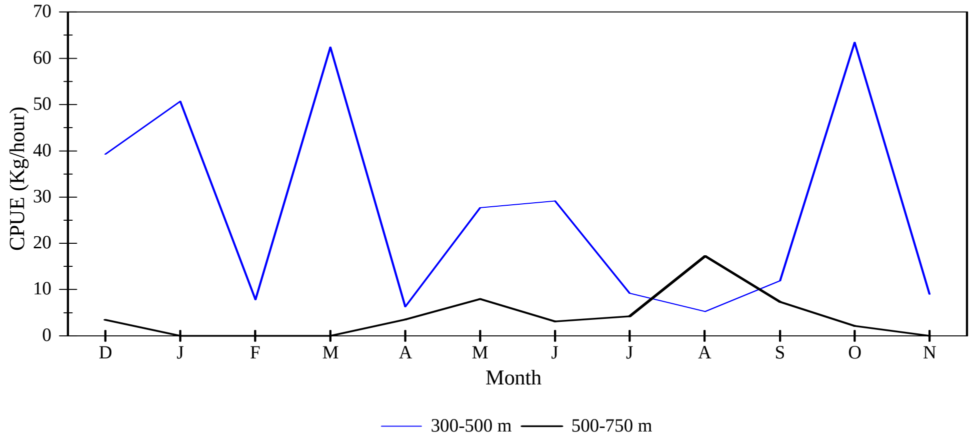


Fig. 89. CPUE fluctuations of *C. agassizi*.

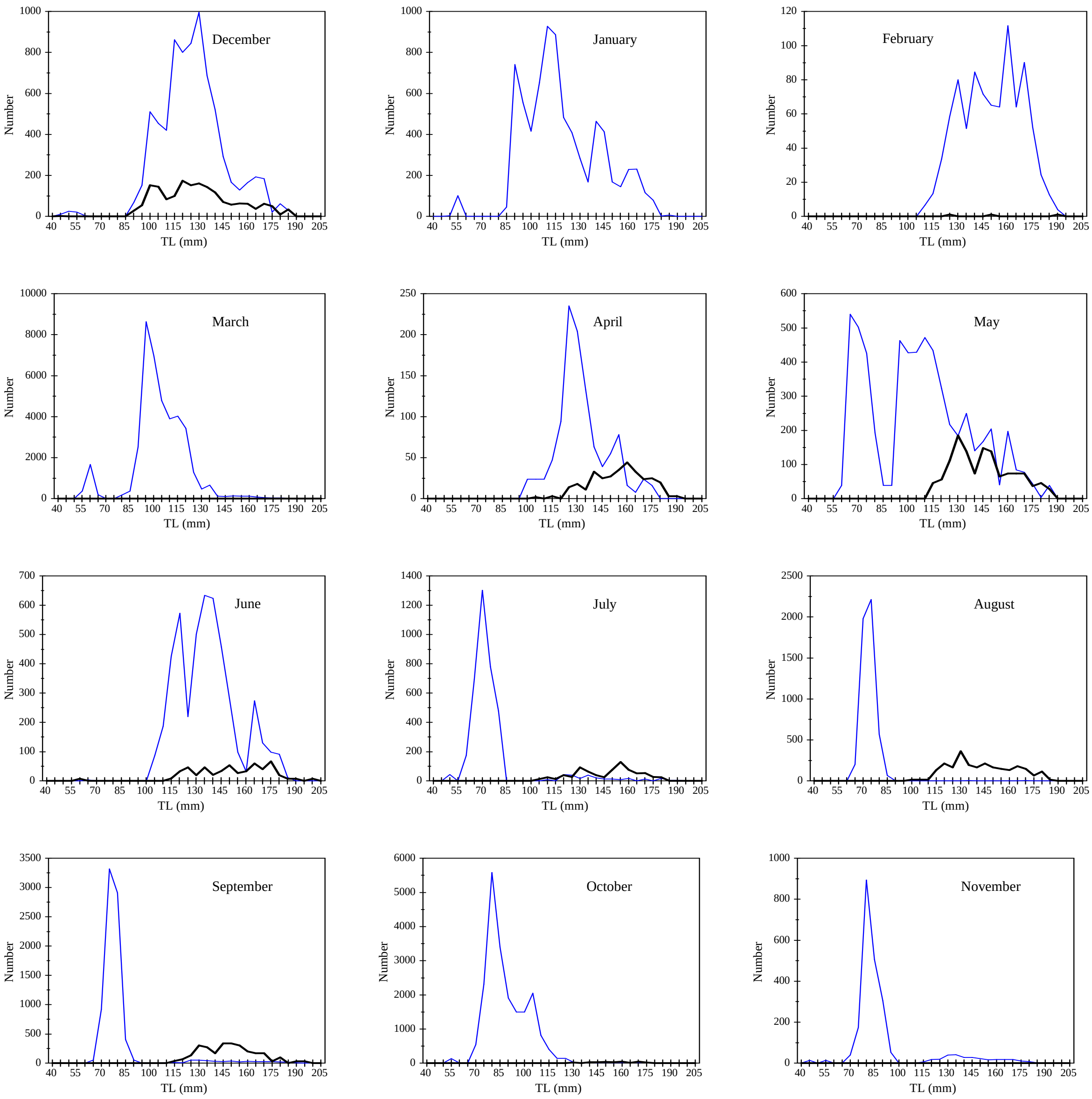


Fig. 90. Length frequency distribution of *C. agassizi*.(Thin line 300-500 m depth zone, Thick line 500-750 m depth zone).

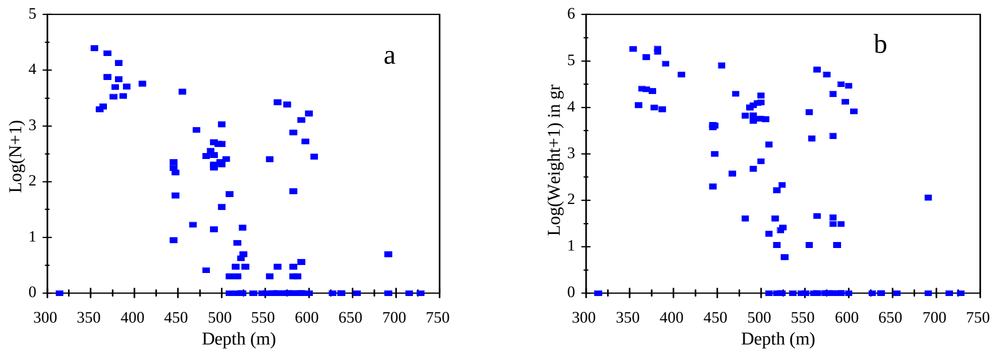


Fig. 91. Depth - abundance relationship of *C. agassizi*.

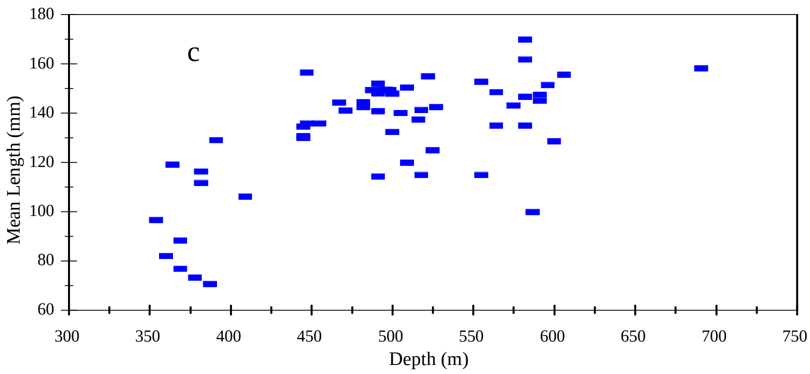


Fig. 92. Depth-mean length relationship of *C. agassizi*.

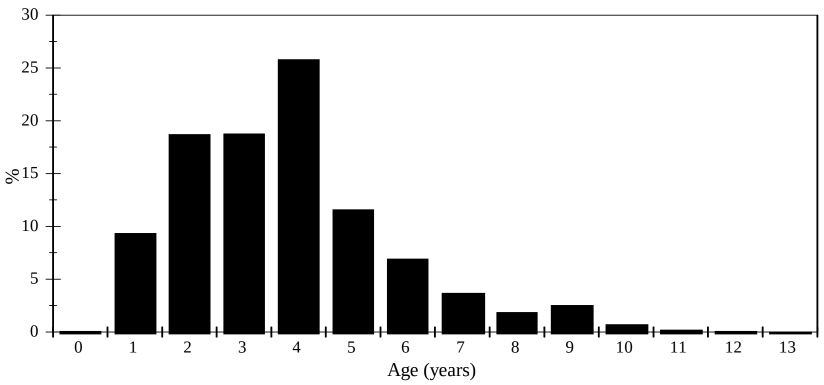


Fig. 93. Age distribution of *C. agassizi*.

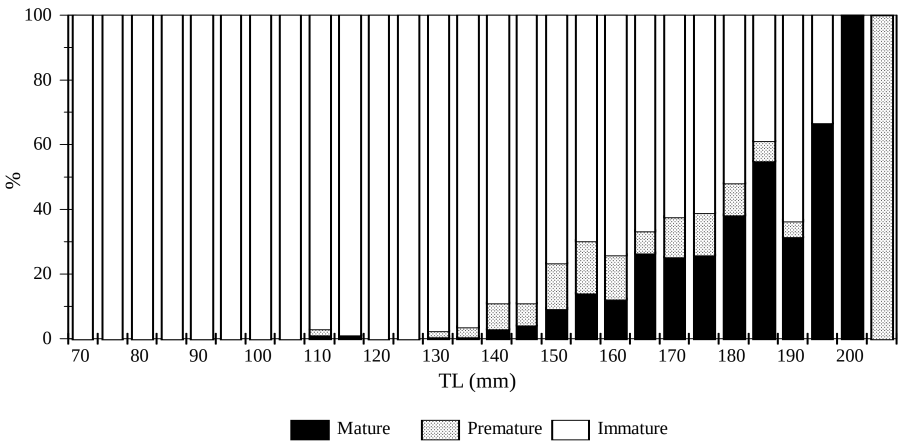


Fig. 94. Yearly proportion of maturity state per length class of *C. agassizi*.

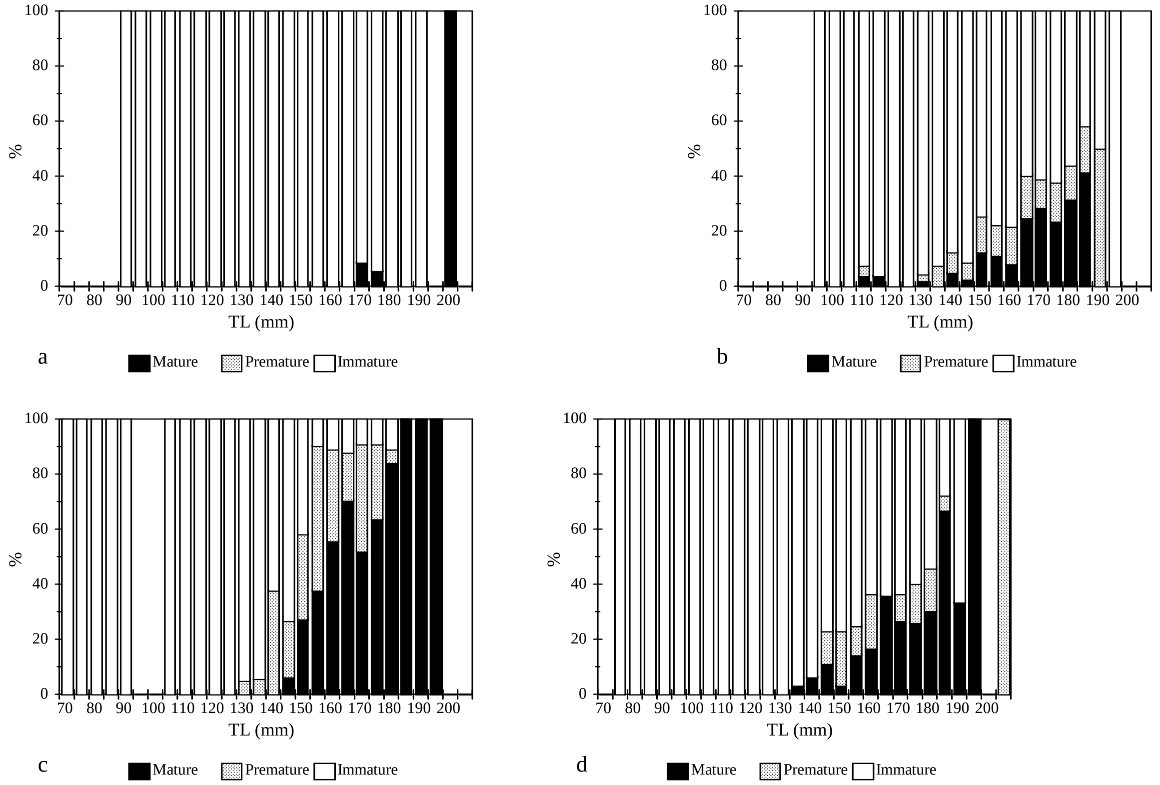


Fig. 95. Seasonal proportion of maturity state per length class of *C. agassizi*. (a) winter, (b) spring, (c) summer and (d) autumn.

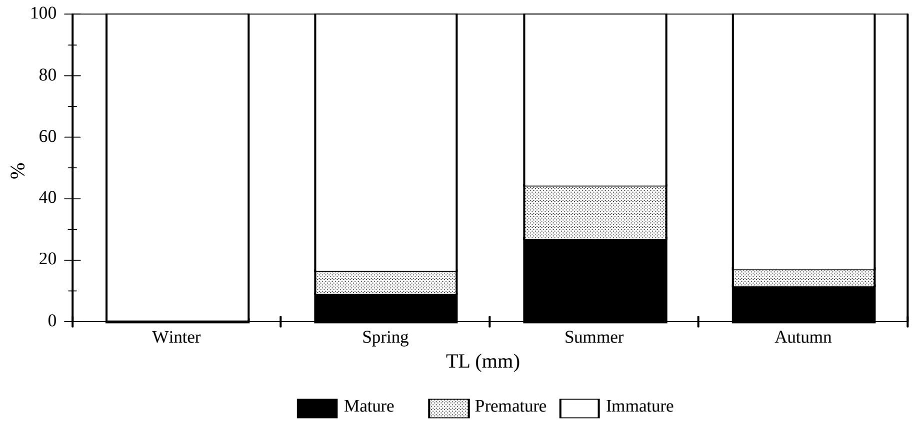


Fig. 96. Seasonal proportion of maturity state of *C. agassizi*.

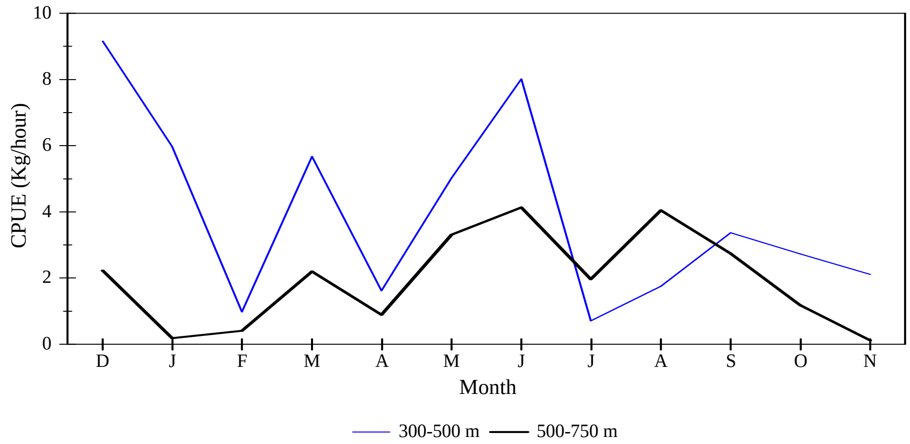


Fig. 97. CPUE fluctuations of *G. melastomus*.

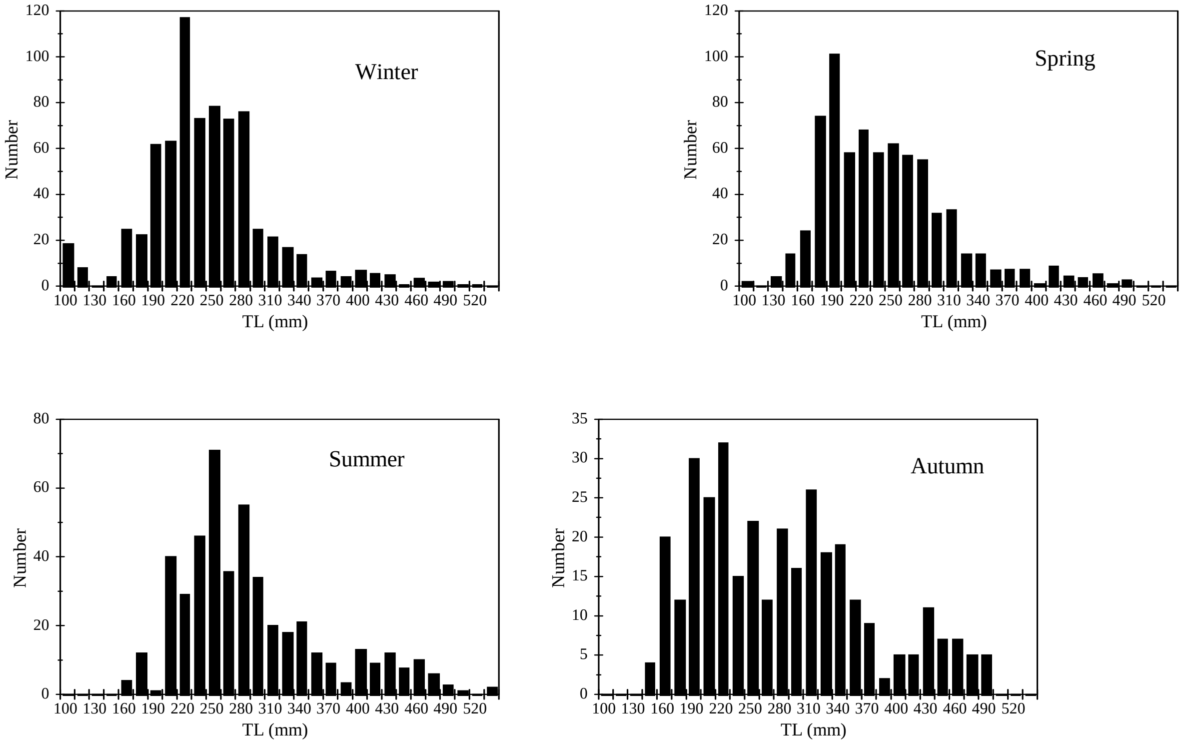


Fig. 98. Length frequency distribution of the males *G. melastomus*.

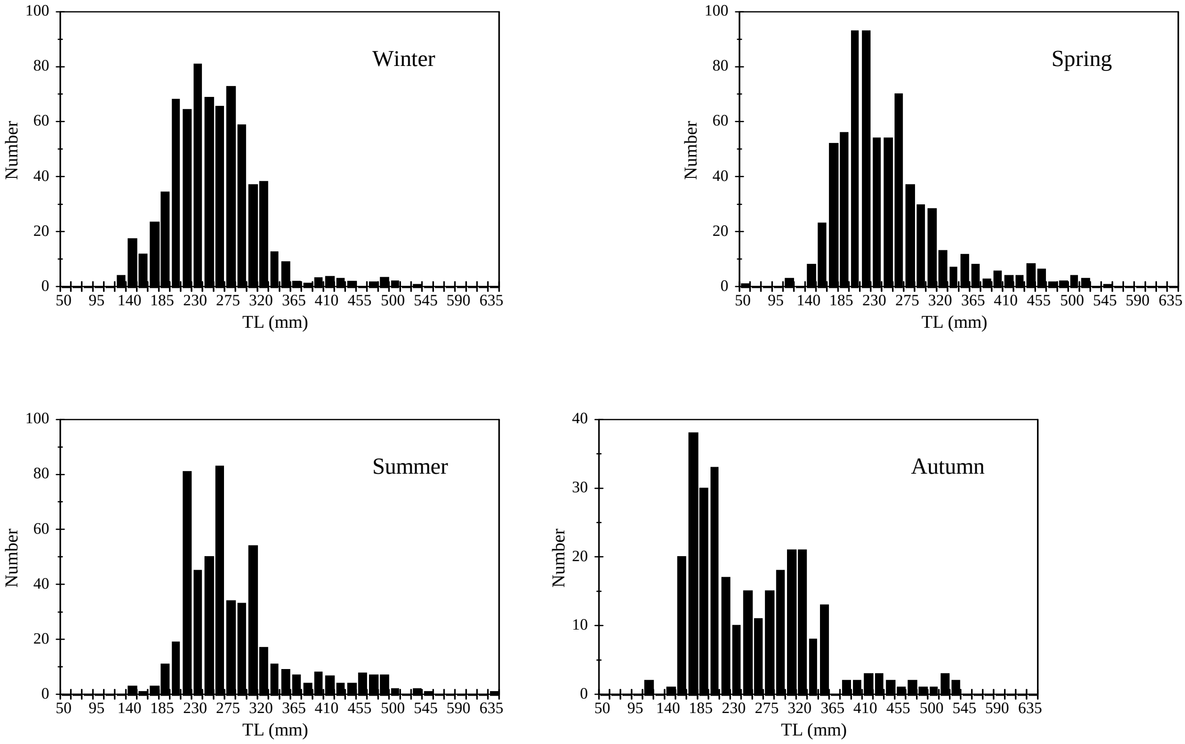


Fig. 99. Length frequency distribution of the females *G. melastomus*.

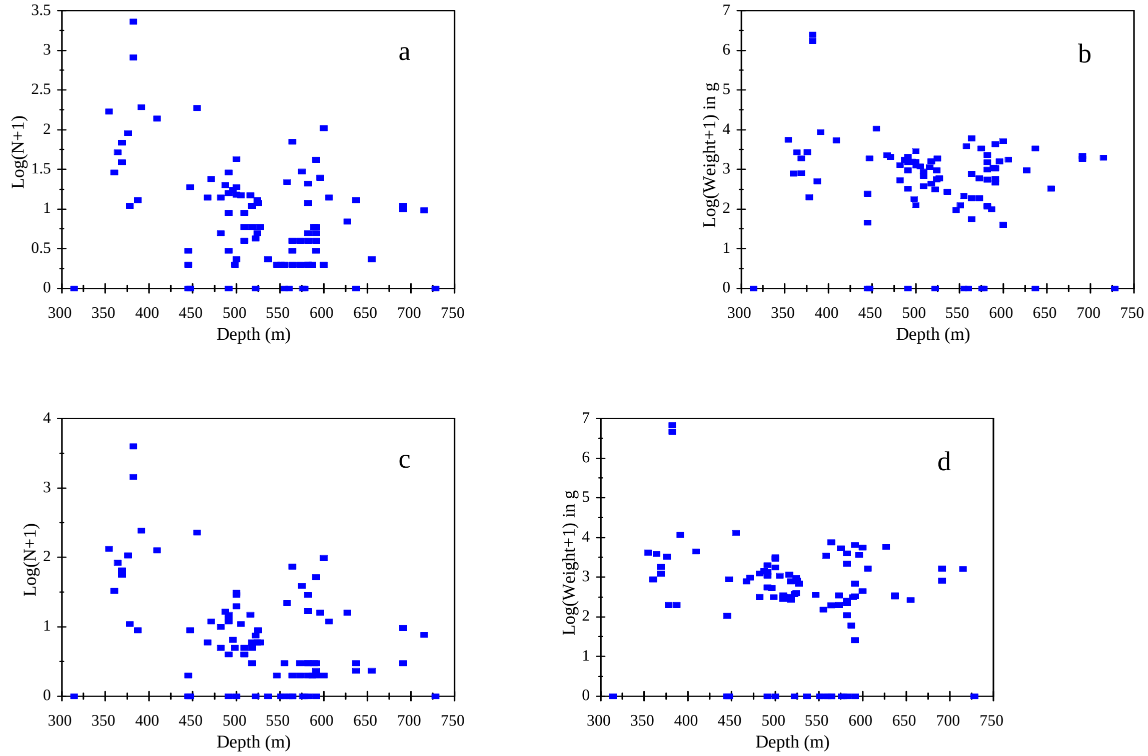


Fig. 100. Depth - abundance relationship of *G. melastomus*, (a, b males and c, d females).

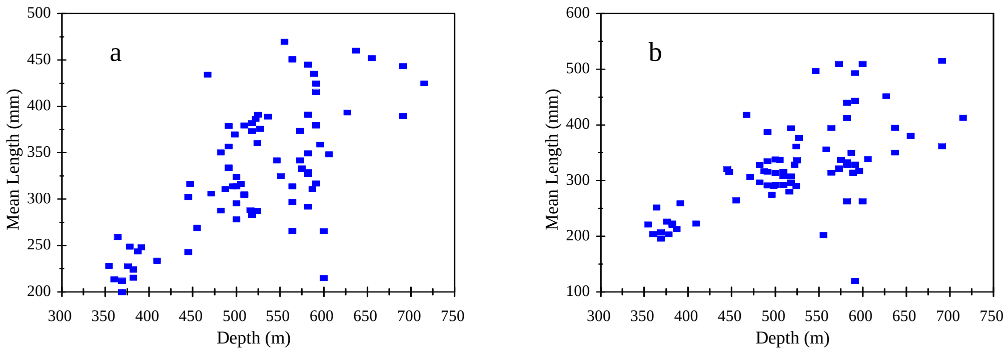


Fig. 101. Depth mean-length relationship of *G. melastomus*, (a males, b females).

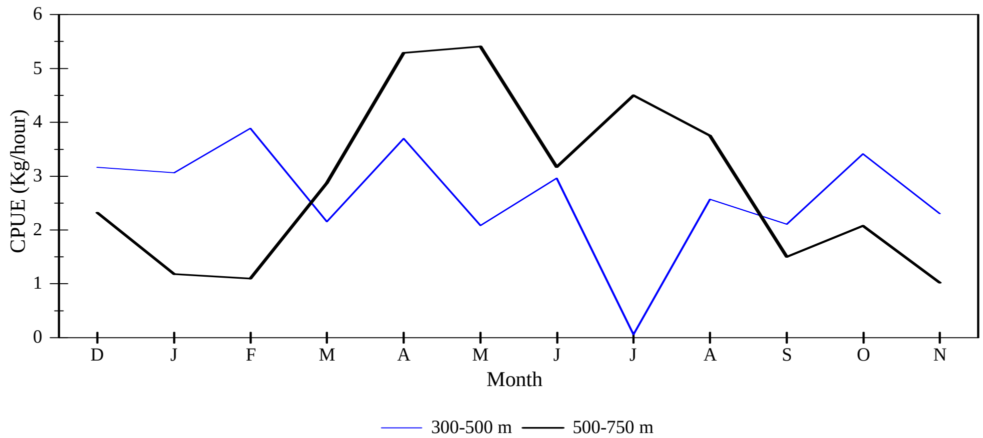


Fig. 102. CPUE fluctuations of other shrimps.

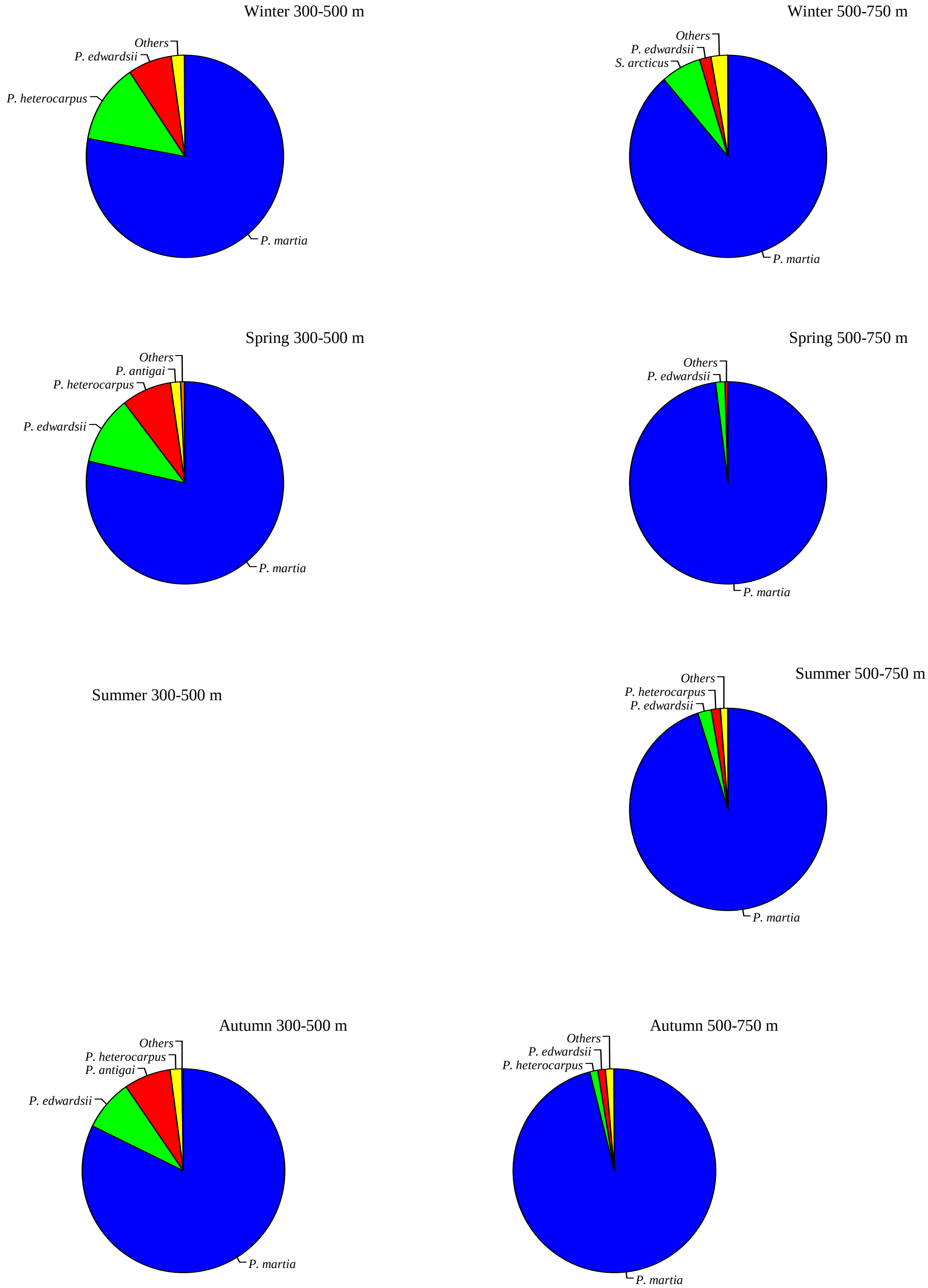


Fig. 103. Catch composition by weight of other shrimps.

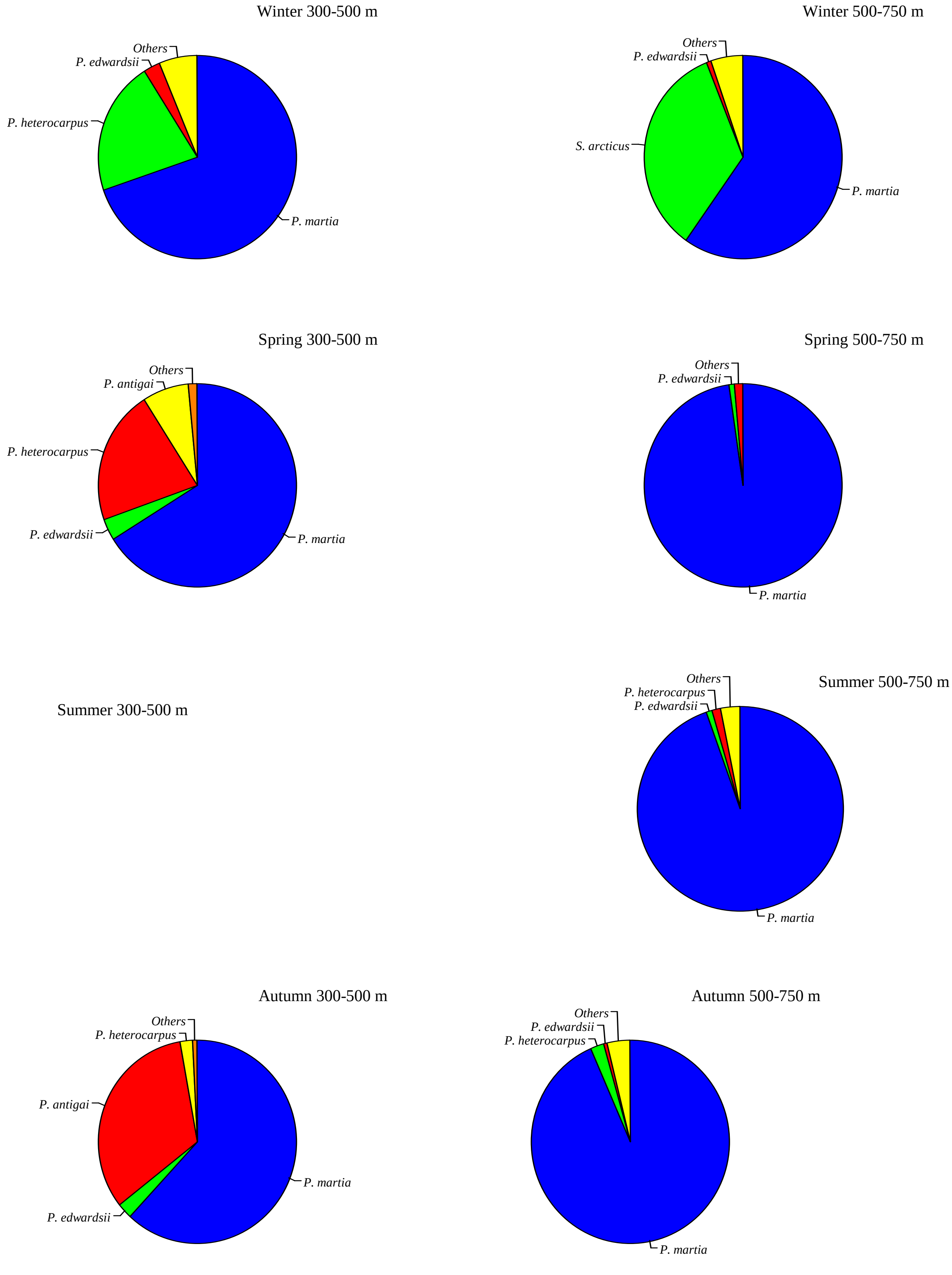


Fig. 104. Catch composition by number of other shrimps.

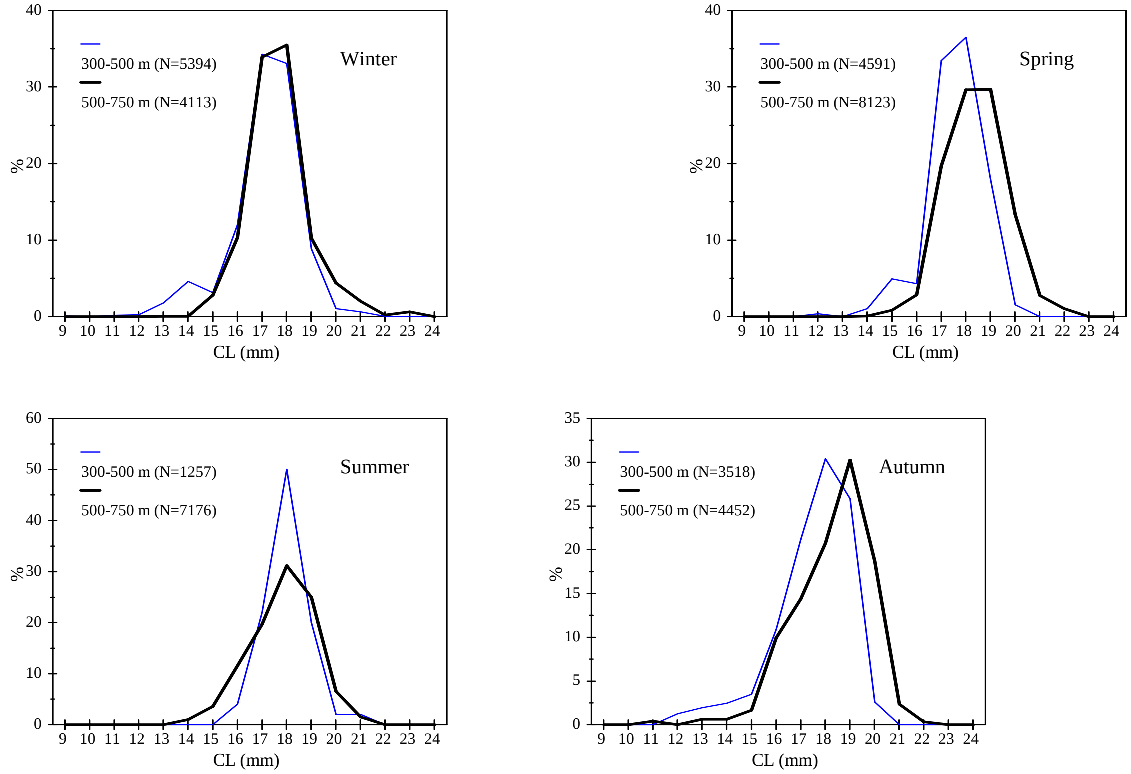


Fig. 105. Length frequency distribution of *P. martia*.

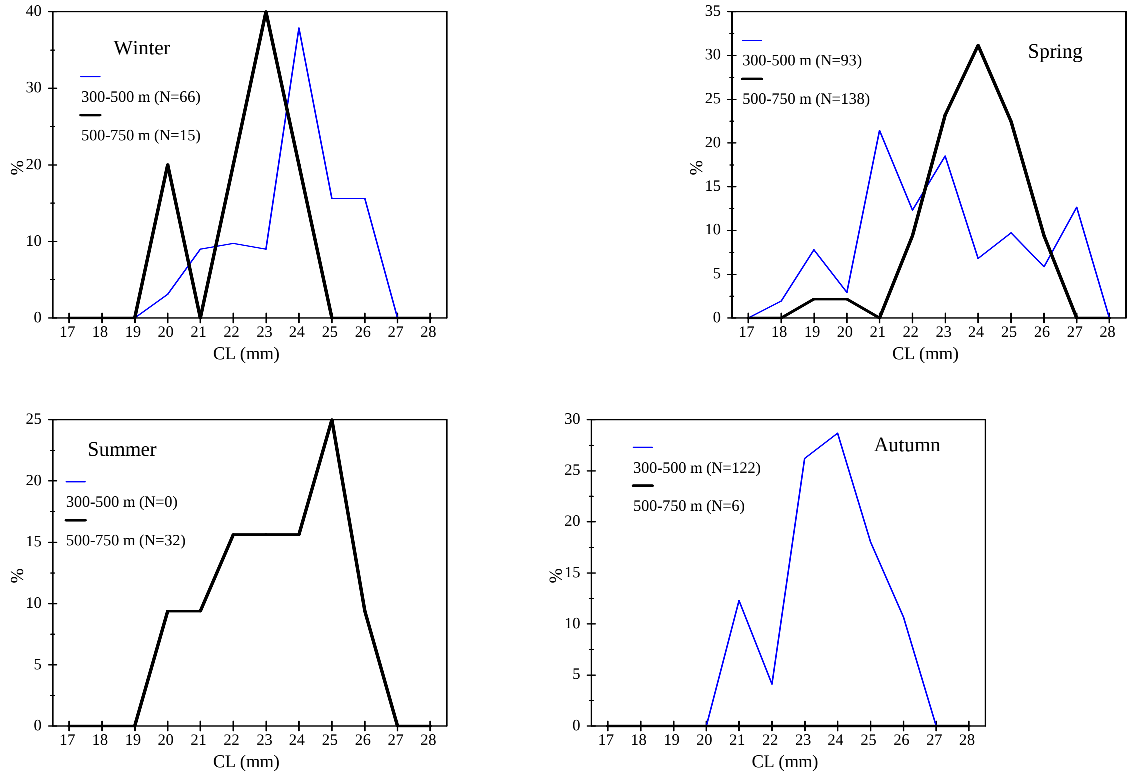


Fig. 106. Length frequency distribution of *P. edwardsii*.

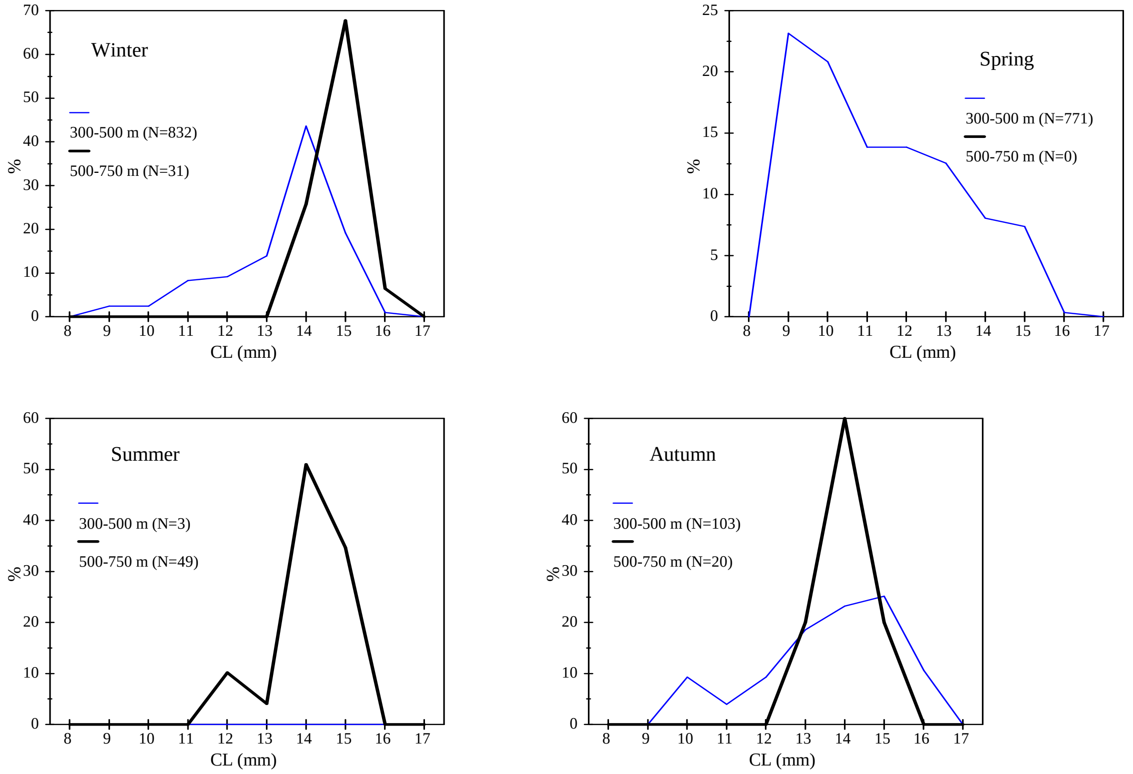


Fig. 107. Length frequency distribution of *P. heterocarpus*.

Table of contents

Sub-task 4.2: To sample the landings at Greek ports

By
Petrakis George, Chilari Anna and Terrats Anna.

Introduction

The purpose of this sub-task was to study the biology of the species *Polyprion americanum* using samples collected from the Greek ports and to develop a sampling method for the landings.

In the first interim report we explained that the attempt to sample in the Greek ports was unsuccessful. The market procedure in the Greek ports is different from that of the ports in the North Sea. In Greece, the fish after the auction in the port go directly to the market and not to the fish industry. In addition, the fishermen at the port classify the fish according to their length. In general, any attempt to measure lengths or to collect other data is not welcomed by the fishermen.

During the survey period, fish of *Polyprion americanum* were no exported on a daily basis at the fishing port. So, whenever the staff of the laboratory was going to the port, they could not get any fish for the study. We tried to overcome this problem by requesting for the collaboration of the fishermen but they did not show any interest. We asked them to phone us whenever there were fish in the fishing port but we did not receive any call.

We tried to collaborate with fishermen from the Ionian Sea. We distributed material and instructions to the fishermen asking them to measure the length, the weight and to collect scales from the fish. The result was very disappointing since the collaboration of the fishermen was very poor. We planned to send observers on the fishing vessels during the fishing period of this species, in order to collect the data. But while interviewing the fishermen for the purposes of the task 1, we realized that the fishermen in Greece were very rare targeting to *P. americanum* because of the collapse of the stock.

The species *Pagellus bogaraveo* attracted our attention since it was fished in significant quantities with long lines in the deep waters of the Ionian Sea. During the second year of the project, a gill net fishery with very good catches, started. The biology of this species is completely unknown and shows great interest since the juveniles (1-2 years old) are aggregated in shallow waters and the adults in deep waters (Papaconstantinou *et al*., 1995). Information on the life history of the species (age and growth, reproduction, recruitment) will be very useful for managing purposes.

According to Bauchot *et al.,* (1986) *Pagellus bogaraveo* is a demersal fish common in the Mediterranean, absent from the Black Sea, occurring in the Atlantic from Norway (65^{o} N) to Cape Blanco, Madeira and the Canaries, exceptionally farther south. It occurs in depths from the inshore waters above various bottoms (rocks, sand and mud), up to 400 m in the Mediterranean and 700 m in the Atlantic. The young individuals are found near the coast, while the adults on the slope of the shelf. Its spawning period extends through the whole year with peak spawning activities according to the region (in British Isles from August to October, in the Bay of Biscay from January to April, in Morocco from January to March and in the Mediterranean from January to May) and with spawning migrations to the coast. *Pagellus* *bogaraveo* is characterised generally by protandric hermaphroditism. Fecundity estimates range from 70,000-500,000 oocytes for fish between 31 and 41 cm. First maturity occurs at the age of 4 or 5 years and the length at first maturity ranges from 22 to 25 cm.

Information on age and growth of *Pagellus bogaraveo* from the Cantabrian Sea, French and Morocco waters were published by Olivier (1928), Coupé (1954), Ramos *et al.* (1967), Gueguen (1969) and Sanchez (1983). In Asturian waters a biological and population analysis of *Pagellus bogaraveo* is presented by Alcazar *et al.* (1987) and from the Azores a study was published by Krug (1989). Some notes on reproduction from British, French, Cantabrian, Moroccan and Azorean waters were published by Williamson (1910), Olivier (1928), Sanchez (1983) and Krug (1990).

We decided to study the fishery and the age and growth of *P. bogaraveo* instead of *P. americanum*. The biology of the fish in Greek waters and generally in the Mediterranean is almost unknown and there is no estimation about the stock size. The geomorphology of the Greek seas (large areas with appropriate depths for the species) and the high commercial value of the species indicate that it is a profitable resource for the fishermen. In this work we described the fishery and we studied the age and growth of the species. These are the first published information about the adult stock population in Greece. In order to make a managing plan more work is needed, since more information on the biology of the species and an estimation of the stock are required.

Materials and Methods

Two scientists from the laboratory participated in two fishing cruises on a professional fishing vessel. Sampling took place in the Ionian Sea (Fig. 1) during 16-21/6/1998. The length of the vessel was 16 m. The engine power was 350 HP and it was equipped with bytho-meters, radar and a hydraulic winch for hauling the nets. Since the fishing grounds are generally away from the ports, each trip lasts more than one day (usually 2-3 days) and the vessel is equipped with ice and refrigerator to keep the fish fresh. The crew was consisted of the captain and two fishermen.

A multifilament gill net with 84 mm mesh size (stretched mesh) was used. The height of the net was about 4 m. The length of each piece of the net was 300 m. Small bags made from net of small mesh size with bait inside, were tied in every 10 m on the footline in order to attract the fish. The bait was *Sardina pilchardus, Sardinella aurita* or *Scomber scombrus*. The total length of the nets that the skipper had on board, was about 1800 m.

The fishing practice starts by searching for the proper fishing ground. This takes some time because the fish are segregated on rough banks in depths that range from 200 m to 600 m. The fishermen shoot the pieces of the net separately. As the distance from the surface to the bottom is quite long they have to estimate the currents in order the nets to arrive at the bottom of the place that they have chose. This is very difficult and they shoot 4-5 pieces to increase the probabilities of some pieces to have good catches. According to this practice, for each piece of net two long pieces of rope (300 m to 700 m) are needed, in order to tie the ends of the net to the buoy. The practical problem that arises is that significant space to store these ropes is needed. They start hauling the nets 5 hours after the beginning of shooting. In the middle time they search the area trying to detect for other fishing grounds. They repeat shooting in the areas where the fish were more abundant. Each day they shoot 8-11 pieces of net, depending on the catches and the weather conditions. Fishing is taking place only during daylight.

In total, 20 pieces of net were used the four days of observation (Table 1). The depth of the stations ranged from 260 to 580 m. The number and the weight per species were recorded for each piece of net. The lengths of all the fish were measured and scales were collected from *P. bogaraveo* in order to study the age and growth of the species.

In order to measure the productivity of the gill nets the Catch per unit of Effort (CPUE) was estimated as Kg/300 m of netting.

Age was determined by scale reading. Scales were sampled from the left side of the body, midway between the insertion of the dorsal fin and the belly, beneath the tip of the pectoral fin and they were kept in envelopes. They were cleaned in 5% sodium peroxide and six scales from each specimen were placed with the sculptured side up, between glass slides labelled and held together with masking tape. Scales were viewed under a binocular stereoscope at 12 x magnification. All malformed, regenerated and otherwise atypical scales were discarded. The diameter of the scales and the growth fields were measured to the nearest mm along a line passing through the focus and roughly bisecting the anterior field, by using an optical micrometer.

From a total of 179 samples 177 scales (98,88%) were aged successfully. Two samples were considered unreadable and were excluded from the analysis. The back calculated lengths at age were estimated according to Ricker (1975). The relationship between length and scale radius was estimated as:

$$L=a+b*R,$$

where L is the length of the fish and R the radius of the scale.

Growth was expressed in terms of the von Bertalanffy's (1938) equation:

$$L_t = L_\infty \left(1 - \exp.^{-k(t-to)} \right),$$

where the length L at the time t is expressed as a function of three parameters: the asymptotic length L_∞ (the length of fish of infinite age), the growth constant k (a measure of the speed at which the length approaches L_∞) and an extrapolated constant t_o (which is, in biological terms, the age at which L_o=0). The growth parameters, k and L_∞ and t_o were estimated according to the Ford & Walford plot (Walford, 1946) and by using the software package STATGRAPHICS according to Machias *et al*., (1998). The parameters of the von Bertalanffy's equation were estimated by using the mean observed and calculated lengths per age class.

Individuals of *Pagellus bogaraveo* were grouped into 10 mm size class and by direct reading of the scales the length–age key was done. The mean length and the standard deviation of each age group were estimated.

Results

Catch composition by number

In total, 946 specimens belonging to 14 species were caught during four days of sampling (Table 2, Fig. 2). 13 of them were fish species and 1 was crustacean. This fishery appears to be highly species selective in terms of number and *P. bogaraveo* consisted 90.2% of the catch.

Helicolenus dactylopterus was contributed by 2.54%. Another one species that belongs to the Centrolophidae family but has not been recognized to the species level consisted 2.96%. These were the mains by catch species. The Centrolophidae spp. was unknown to the local fishermen. They caught it for the first time when they started developing the gill net *P. bogaraveo* fishery. Its price in the market is low because the customers do not know the species, its color is black and its appearance is not appealing.

Catch composition by weight

In total 477.6 Kg of fish were caught during four days of fishing. The catch of *P. bogaraveo* was 278.3 Kg and consisted 58.3% of the total catch (Fig. 3). Centrolophidae and *M. merluccius* were contributed by 30.8% and 4.5%, respectively. The specimens of Centrolophidae were large in size and despite the low contribution by number, the contribution by weight was high. The smaller fish of Centrolophidae was weighting 2.5 Kg.

CPUE

The total catch per station ranged from 0 Kg (in station 17) to 99.7 Kg (in station 4) (Fig. 4). The highest values for *P. bogaraveo* were observed in stations 4 and 10 (60 and 57 Kg, respectively) and for Centrolophidae in stations 4, 6 and 10 (32.8, 26.6 and 25 Kg, respectively). Good catches were observed for both species in the same stations. Generally, the catches the last two days were much lower than the catches the first two days.

The CPUE of the total catch was 23.9 Kg/300 m of netting, of *P. bogaraveo* 13.9 Kg/300 m of netting, of Centrolophidae 7.35 Kg/300 m of netting and of *M. merluccius* 1.1 Kg/300 m of netting.

Length distributions

The length of the caught specimens of *P. bogaraveo* ranged from 16 to 42 cm (total length) (Fig. 5). The gill nets are very selective gears and they catch a narrow range of length classes. The 85% of the fish belonged to 7 length classes (between 25 and 30 cm). The shape of the curve is the typical one for gill nets. The majority of the fish were gilled or meshed. The species was represented in the catch of all the stations in depths from 260-580 m, except from station 17 where the nets caught nothing.

The length of Centrolophidae ranged from 52 to 84 cm but more common were fish with lengths between 68 to 72 cm (Fig. 6). All the fish were entangled in the net. They were too big to be caught in a different way. The fish were caught in stations deeper than 500 m. During the survey we did not catch juveniles and this cannot be attributed to the selectivity of the net. Probably the young fish are not segregated in these depths or they live in the column of the water.

Age distribution of *P. bogaraveo*

The age of *P. bogaraveo* in the catch ranged from 2-11 years (Fig. 7). Most abundant were the fish of 5 and 6 years old (30.2% and 40.5%, respectively). The gill nets are very selective gears and as we have used one mesh size for sampling, we can not come to any conclusion about the situation in the population. Young fish with age between 2 and 4 years old formed 4.8% of the catch. Fish of 7 years old formed 14.5% while the older ones formed 10% of the catch.

Age and growth

In total, 179 fish were aged. The lengths of the examined fish ranged from 16 to 39 cm (Fig. 8). Fish that belonged in the lowest (16-24 cm) and in the highest (34-38 cm) length classes were recorded in very low numbers (less than 6 specimens per length class). Scale reading revealed 10 age groups, from age group 2 to age group 11. Fish with age between 0 and 1 years old were not caught in the sample. The young fish are concentrated mainly in shallow waters. Fish with ages between 0 and 3 years old were caught in shallow waters (<100 m) in the Thracian Sea (Papaconstantinou *et al*., 1995) and in the Ionian coasts (Petrakis, 1998).

Back calculation

Length in terms of age was back calculated from the scale radius / fish length. Regression derived by plotting the radius of the scale on total fish length.

$TL=49.38+35.2*R$, ($r^2 = 0.85$ and Standard Error of coefficient=1.1).

The growth of *P. bogaraveo* as estimated using the back calculated method in the first year was 14.1 cm (Table 3). During the second year the fish increased 3.1 cm and the following years the growth rate was reducing slowly (Fig. 9). The age-length key of the species is presented in Table 4.

von Bertalanffy's equation parameters

The parameters of the equation were estimated according to Ford-Walford (1946) (Fig. 10,11) and also by using the statistical package STATGRAPHICS (Fig. 12,13). Both the observed and the calculated lengths were used. The number of observations in the Ford-Walford method for the observed lengths is 9 because we did not catch fish one year old. The results are summarized in Table 5.

L_∞ was estimated between 473.61 mm and 533.65 mm, K between 0.082 and 0.115 and t_o between -1.94 and -2.69. The lowest value of L_∞, t_o and the highest value of K were estimated while using the observed lengths and the STATGRAPHICS.

Discussion

According to Bauchot, *et al*., (1986) the bathymetrical distribution of the species is extending in depths down to 400 m. The species is common in deeper waters since it has been caught in high abundance in the Ionian sea in depths down to 580 m. Data on sex and maturity were not collected, but some observations were made on the fish that had been damaged during hauling. All of them were immature. Bauchot, *et al*., (1986) referred that the fish is spawning through the whole year. According to Krug (1990) the spawning period of the species is extended from January to April in Azorean waters. More work is required in order to define the spawning period of the species in the Ionian Sea.

The gill net fishery of *P. bogaraveo* is a new fishing activity in the Ionian Sea. There is not any estimation about the stock of the species and there is the question if the degree of exploitation is the proper one and furthermore, for how long this fishery will exist with the same catch rates. So far, it is the most productive of the net metiers that have been studied in Greek waters. In sole (S*olea vulgaris*) trammel net metier the CPUE of sole was 9.1 Kg/1000 m of netting, in cuttlefish (*Sepia officinalis*) trammel net metier the CPUE of cuttlefish in 1996 and in 1997 were 4.1 and 2.1 kg/1000 m of netting respectively and in hake gill net metier the CPUE of hake was 3.7 Kg/1000 m of netting (Petrakis, 1998). In the *P. bogaraveo* gill net metier in the Ionian Sea the CPUE of *P. bogaraveo* was 13.9 Kg/300 m of netting (or 46.3 Kg/1000 m of netting).

P. bogaraveo shows regional differences in growth (Table 6). According to Krug (1989), the maximum length of *Pagellus bogaraveo* in Azores, obtained by direct method is 58.50 cm and by back calculation is 57.45 cm. In Asturian waters, the calculated maximum length according to Alcazar *et al.* (1987) is 48.66 cm. According to Sanchez (1983), the maximum length of *Pagellus bogaraveo* in the North Western Atlantic is 45.86 cm, while the maximum lengths estimated by Gueguen (1969) and Ramos *et al.* (1967) are 56.80 cm and 53.86 cm respectively in the bay of Biscay and in the Cantabrian Sea. In the Ionian Sea, the maximum length obtained by direct reading on scales is 45.32 cm according to the Ford-Walford plot and 42.08 cm estimated by statgraphics while the maximum lengths obtained by back calculation are 46.42 cm and 45.89 cm respectively. The difference between the L_∞ in the Ionian Sea and the other areas could be attributed to the fact that the fish caught by the gill nets were smaller.

Comparing the growth constant k (Table 6), *P. bogaraveo* in the Ionian Sea indicates a slower growth rate than those reported by Sanchez (1983) in the North Western Atlantic and Alcazar *et al.* (1987) in Asturian waters, but similar to those presented by Krug (1989) in Azores, Gueguen (1969) in the bay of Biscay and Ramos *et al.* (1967) in the Cantabrian Sea.

In Azorean waters Krug (1989) used direct otolith reading and reported a maximum age of 15 years for a 49 cm-length fish. From a population analysis in Asturian waters, Alcazar *et al.* (1987) reported a maximum age of 13 years. From an analysis of the length frequency distribution, Sanchez (1983) found the maximum age to be 10 years, whereas Ramos *et al.* (1967) and Coupé (1954) found a maximum age of 12 years from otoliths and scales, respectively. Olivier (1928) and Gueguen (1969) used direct reading on scales and reported 16 and 20 years respectively. In the Ionian Sea, from direct reading on scales a maximum age of 11 years was determined for a 38.5 cm-length fish.

According to Règlement (CE) N^{o} 1626/94 Du Conseil the minimum landing size of *Pagellus spp.* is 12 cm. In Greek waters there are three species in this genus, *P. erythrinus, P. acarne* and *P. bogaraveo*. Their maximum length and the length at first maturity differs. All the *P. bogaraveo* in this fishery had marketable size since the smallest fish was 16 cm. Taking into account that the length at first sexual maturity is corresponding to 27.7 cm for males and 34.6 cm for females (Krug, 1990) this regulation should be reconsidered and a different minimum landing size should be established for *P. bogaraveo*. Furthermore, fish with lengths less than 15 cm are discarded.

Dissemination

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Table 1. Fishing stations description

Date	Station	Latitude	Longitude	Depth	Hauling time
16/6/98	St1	375858	201708	530	13:30
16/6/98	St2	375730	201810	560	14:30
16/6/98	St3	375715	201850	580	15:30
16/6/98	St4	380107	201902	580	14:30
17/6/98	St5	380181	201761	350	11:00
17/6/98	St6	375857	201708	520	12:00
17/6/98	St7	375992	201755	455	14:30
17/6/98	St8	380017	201757	445	15:20
17/6/98	St9	380170	201750	520	17:50
17/6/98	St10	375869	201713	545	18:40
17/6/98	St11	380020	201800	455	19:50
20/6/98	St12	380065	205076	270	13:00
20/6/98	St13	380081	205056	305	14:30
20/6/98	St14	380070	205040	290	17:30
20/6/98	St15	380067	205119	260	18:10
21/6/98	St16	373193	205492	455	12:25
21/6/98	St17	373178	205483	455	12:40
21/6/98	St18	373151	205470	530	13:15
21/6/98	St19	373191	205440	565	14:00
21/6/98	St20	373202	205478	490	14:40

Table 2. List of the species caught in the *P. bogaraveo* gill net fishery.

Species	Number	Weight (Kg)
Pagellus bogaraveo	853	278.3
Centrolophidae	28	147
Helicolenus dactylopterus	24	5.46
Merluccius merluccius	13	21.7
Galeus melastomus	7	2.4
Squalus blainvillei	7	12.7
Nephrops norvegicus	4	0.44
Scorpaena scrofa	3	4.8
Scyliorhinus canicula	2	0.4
Conger conger	1	2.3
Phycis blennoides	1	0.2
Raja clavata	1	1.5
Synodus saurus	1	0.25
Zeus faber	1	0.15
Sum	946	477.6

Table 3. Mean calculated length and annual growth increments of *P. bogaraveo*.

Age	Number	Mean calculated length										
group	of fish	1	2	3	4	5	6	7	8	9	10	11
1	0											
2	1	130.6	157.7									
3	5	135.5	166.4	192.9								
4	10	138.7	170.4	199.4	222.2							
5	41	139.9	172.9	202.2	228.2	250.4						
6	50	141.4	173.2	201.6	228.8	253.2	273.7					
7	29	141.4	172.1	199.7	226.9	252.8	275.9	294.2				
8	21	141.3	173.2	199.1	224.9	248.4	271.7	292.9	310.5			
9	14	142.8	173.8	201.0	227.1	250.9	273.4	293.7	315.4	330.4		
10	3	146.0	174.0	201.9	227.2	251.6	271.4	292.2	311.2	327.4	341.9	
11	3	135.1	167.6	193.8	216.4	240.8	267.8	292.2	308.5	326.5	345.5	359.9
Average length		140.7	172.5	200.6	227.1	251.3	273.6	293.5	312.1	329.4	343.6	359.9
Annual growth		140.7	31.7	28.1	26.5	24.2	22.3	19.1	18.5	17.3	14.3	16.2
Observed mean lengths			168	186.6	234.1	262.83	285.94	301.83	320.95	335	347	371.33
Number of fish		177	177	176	171	161	120	70	41	20	6	3

Table 4. Age length key of *P. bogaraveo.*

Length class	Age											Number
(mm)	1	2	3	4	5	6	7	8	9	10	11	
160-169		1										1
170-179			1									1
180-189			2									2
190-199			2									2
200-209												0
210-219				3								3
220-229				2								2
230-239				2	1							3
240-249					4							4
250-259				1	12	1						14
260-269				2	13	3						18
270-279					8	14						22
280-289					2	15	3	1				21
290-299					1	8	6					15
300-309						5	15	3				23
310-319						3	4	4	3			14
320-329						1	1	7	1	1		11
330-339								4	4			8
340-349								1	4			5
350-359								1	2	2	1	6
360-369												0
370-379											1	1
380-389											1	1
Number	0	1	5	10	41	50	29	21	14	3	3	177
Mean length		168.0	186.6	234.1	262.8	285.9	301.8	321.0	335.0	347.0	371.3	
Std. deviation			6.2	16.9	11.8	14.8	8.7	14.7	11.7	14.9	11.4	

Table 5. Von Bertalanffy's equation parameters of *P. bogaraveo*. (n=number of observations, a, b, and r^2 constant, slope and correlation coefficient of the relationship between length and scale radius).

Method	Lengths	n	a	b	r^2	K	L_∞	t_o
Ford-Walford	Observed	9	48.33	0.91	0.98	0.099	509.56	-2.01
	Calculated	10	42.76	0.92	1	0.085	521.94	-2.68
Statgraphics	Observed	177			0.86	0.115	473.61	-1.94
	Calculated	1122			0.98	0.087	515.98	-2.65

Table 6: Growth parameters of *P. bogaraveo* according to various authors. (Direct = use of observed lengths, Indirect = use of calculated lengths)

References	Methods	t_o	k	L_∞	Age
		(years)		(cm)	(years)
Present study	Ford-Walford, direct	-2.01	0.099	45.32*	2-11
	Ford - Walford indirect	-2.68	0.085	46.42*	1-11
	statgraphics direct	-1.94	0.115	42.08*	2-11
	statgraphics indirect	-2.65	0.087	45.89*	1-11
Krug 1989	otoliths, direct	-1.55	0.117	58.5	1-14
	otoliths, indirect	-1.13	0.102	57.45	1-14
Alcazar et al.1987	otoliths, indirect	-0.47	0.196	48.66	1-13
Sanchez 1983	otoliths, indirect	-0.53	0.209	45.86*	1-12
Gueguen 1969	scales, direct	-2.92	0.092	56.8	1-20
Ramos et al. 1967	otoliths, direct	-1.02	0.128	53.86	2-12
Coupé 1954	scales, indirect	-	-	-	1-12
Olivier 1928	scales, direct	-	-	-	3-16

* Changed TL to FL to compare with other authors

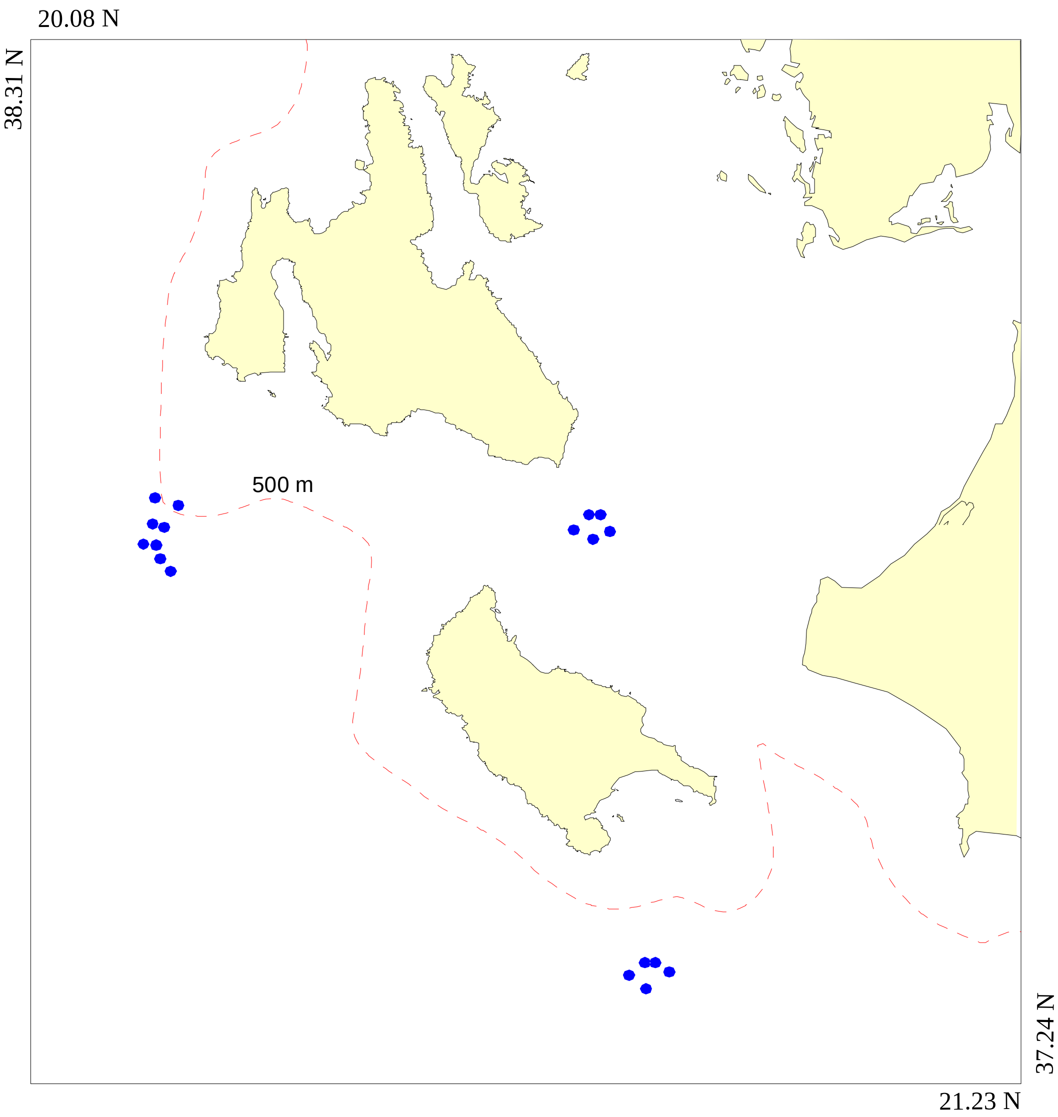

Fig. 1. Map of the sampling area with the fishing stations.

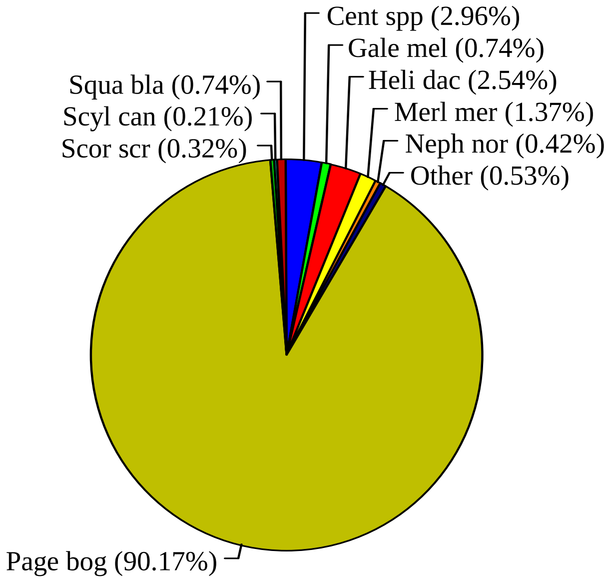

Fig. 2. Catch composition by number. (Cent spp. = *Centrolophidae*, Gale mel = *Galeus melastomus*, Heli dac = *Helicolenus dactylopterus*, Merl mer = *Merluccius merluccius*, Neph nor = *Nephrops norvegicus*, Page bog = *Pagellus bogaraveo*, Scor scr = *Scorpaena scrofa*, Scyl can = *Scyliorhinus canicula* and Squa bla = *Squalus blainvillei*.)

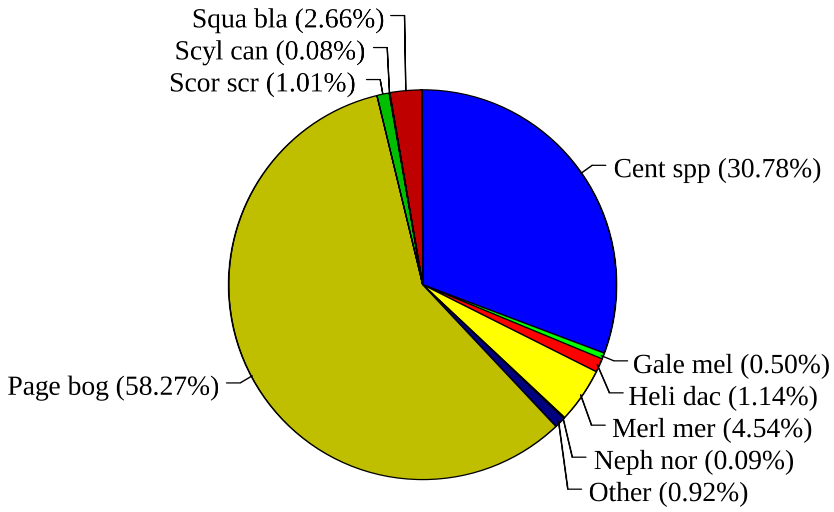

Fig. 3. Catch composition by weight. (Cent spp. = *Centrolophidae*, Gale mel = *Galeus melastomus*, Heli dac = *Helicolenus dactylopterus*, Merl mer = *Merluccius merluccius*, Neph nor = *Nephrops norvegicus*, Page bog = *Pagellus bogaraveo*, Scor scr = *Scorpaena scrofa*, Scyl can = *Scyliorhinus canicula* and Squa bla = *Squalus blainvillei*.)

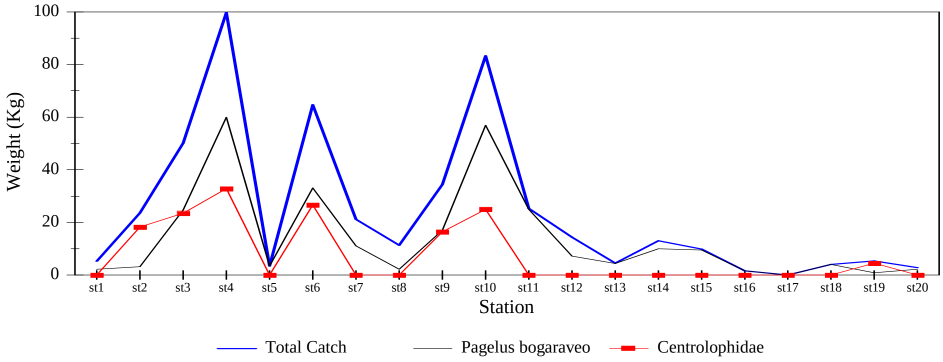

Fig. 4. Fluctuation of the total catch and of the catch of the main species per station.

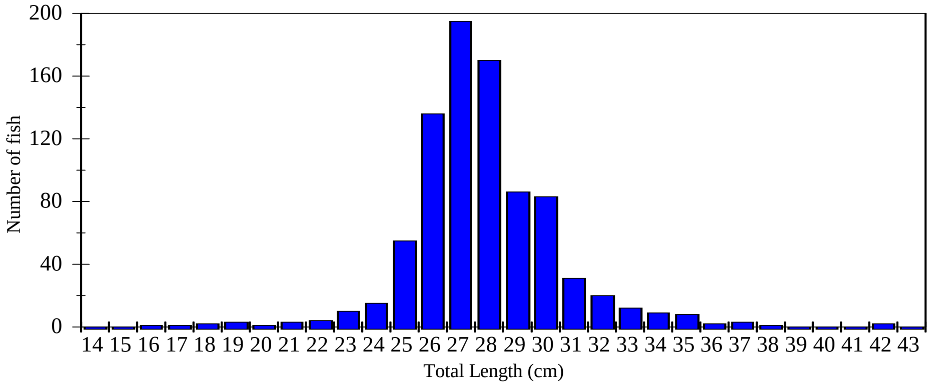

Fig. 5. Length distribution of *P. bogaraveo*.

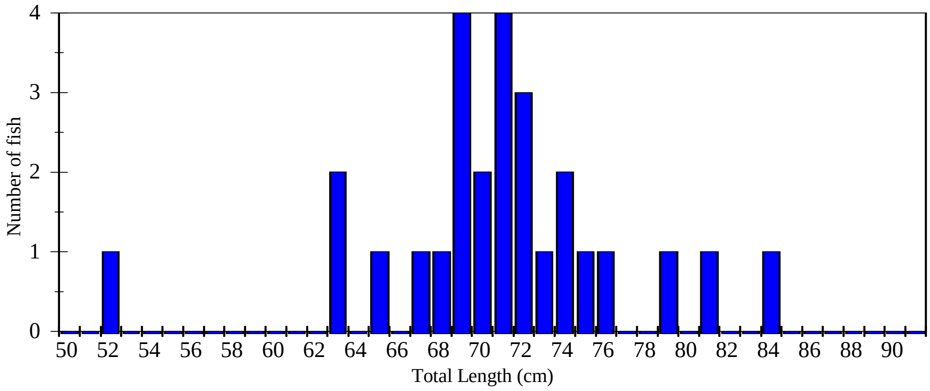

Fig. 6. Length distribution of Centrolophidae spp.

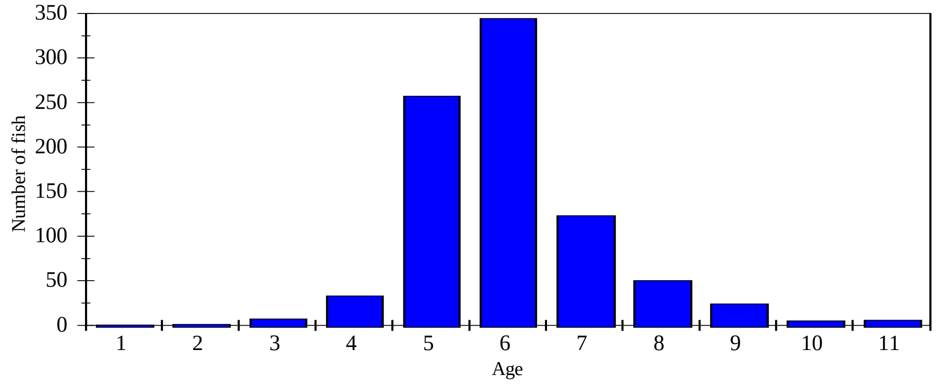

Fig. 7. Age distribution of the examined *P. bogaraveo*.

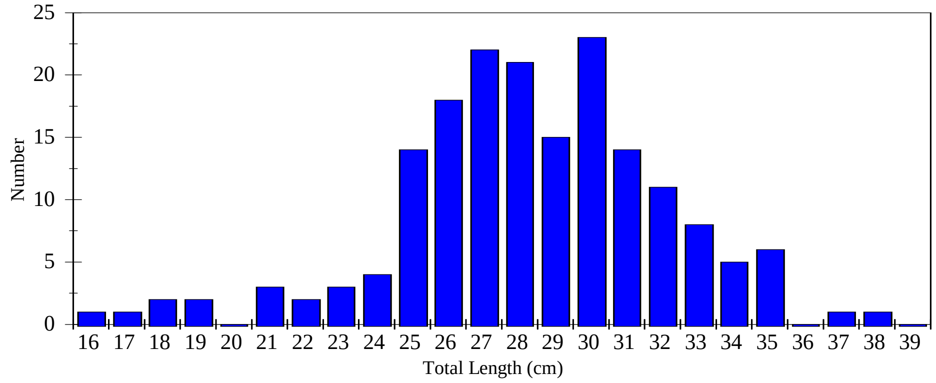

Fig. 8. Length distribution of the examined *P. bogaraveo*.

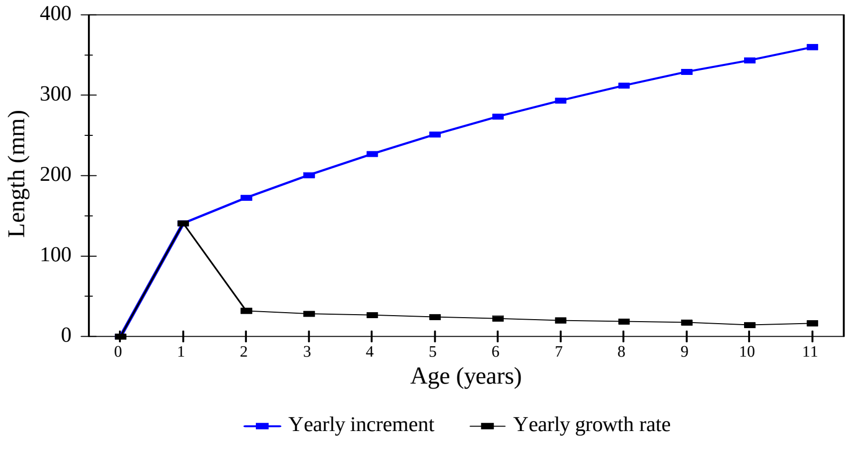

Fig. 9. Yearly increment and yearly growth rate of *P. bogaraveo*.

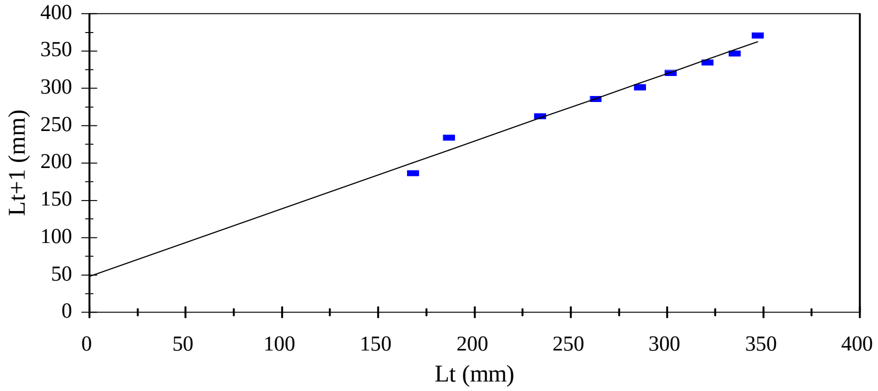

Fig. 10. Ford-Walford plot of observed lengths of *P. bogaraveo*.

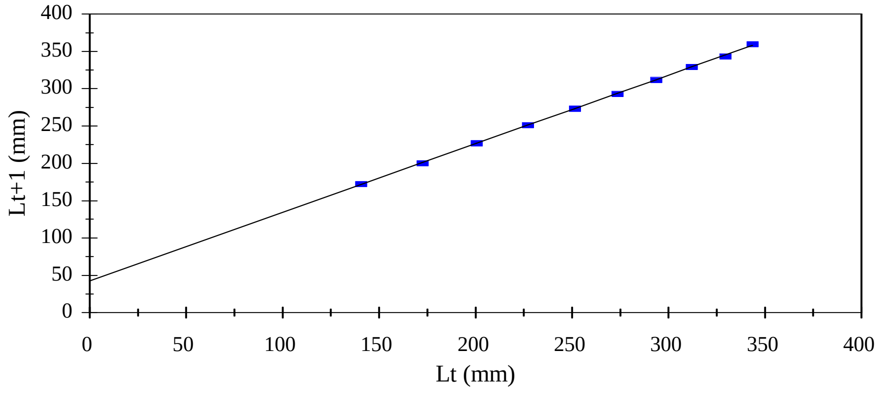

Fig. 11. Ford-Walford plot of calculated lengths of *P. bogaraveo*.

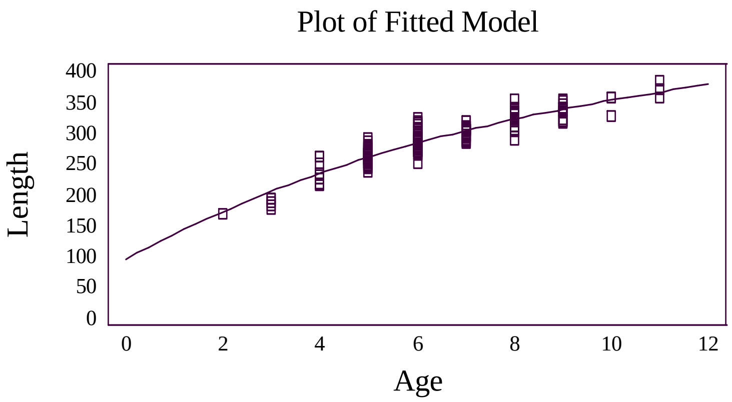

Fig. 12. Plot of fitted model of *P. bogaraveo* using observed lengths.

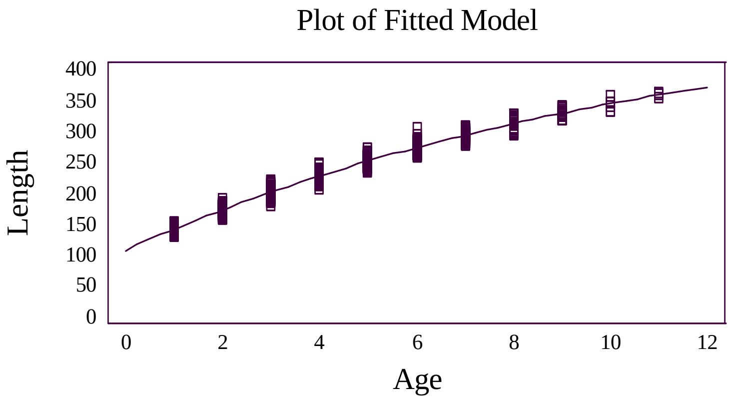

Fig. 13 Plot of fitted model of *P. bogaraveo* using calculated lengths.

Sub-task 3.3: Discards studies in Greek waters

By Mytilineou, Ch., Petrakis, G., Fourtouni, A. and Kavadas, S.

Introduction

The proposed program by the NCMR in this subtask had the following objectives.

1. To estimate the quantity of the by catch species.
2. To estimate the quantity of the undersized fish of the commercial species.

The term "Discards" includes: a) the undersized specimens of the commercial species which either have no commercial value or are characterised as illegal to be sold, b) the specimens of species which have no commercial value and c) the marketable specimens of commercial species which are discarded when the vessel has no available quota.

In the Mediterranean only the first two categories of discards exist. The Community managing method based on TACs and quotas has no applicability in this area. Fishery in the Mediterranean and particularly in Greece, presents a high diversity in terms of fished species and gears used. The restrictions mainly concern regulations of the minimum landing size and not of the landing quantity. In addition, closed periods for some gears, areas or particular species exist.

The quantity of the discards depends on various factors such as the gear, the vessel, the duration of the haul, the fishing practice, the season, the fishing ground, the depth, the availability of the fishery products in the market, the local customs of the purchasing public etc. Information on discards from the Mediterranean is scarce. Recently, an attempt to this direction was made by two projects financed by EC (MED-92/018 and MED-94/065), concerning the discards from the bottom trawl fishery in the Hellenic and Italian waters (Tsimenidis *et al*., 1995; Tsimenidis *et al*., 1997). However, since fishery in the hellenic waters is mainly exercised down to 400 m of depth, the results of these works concern principally shallower depths. No information on discards in deep sea waters concerning professional fishery is available.

In this task, the qualitative and quantitative composition of the catches is examined for the deep waters, up to 300 m of depth. The analysis of this report is based on data that have been collected during experimental surveys carried out by the Fishery Laboratory of NCMR. These surveys were conducted by the NCMR in the framework of various projects which have been carried out from 1983 to 1994. Furthermore, the data collected during the surveys in the Ionian Sea in the framework of the "Deep fisheries project" have been used. The aim is to approach the estimate of the proportion of the discards in the total catch and the proportion of each discarded species in the total quantity of discards, by area and depth zone.

In the interim reports, the analysis was based on the data collected during the North Aegean Sea, Thracian Sea and Ionian Sea (1983-1985) surveys. In the final report we summarised the results of the previous reports and we analysed the data which have been collected during the deep water fisheries surveys. In addition, the numerical proportion of the discarded fish of the commercial species during all the surveys has been estimated.

Material and Methods

The study was based on the historical data of three different research projects conducted by the NCMR in the past and on the data collected during the “Deep fisheries project”.

The aim of the previous projects was to study the situation of the demersal resources and the biology and dynamic of some demersal fish populations. They covered three areas: Northern Aegean Sea, Thracian Sea and Ionian Sea (Fig. 1). The project in the Northern Aegean Sea was carried out from 1990 to 1993, the project in the Thracian Sea was carried out from 1991 to 1994 and the project in the Ionian Sea from 1983 to 1985. In each project 8 seasonal sampling cruises were carried out. The sampling design in the three projects was random stratified. The surveys were carried out using hired commercial vessels and the sampling took place only during the day light. Since these projects were mainly carried out in depths shallower than 300 m, only the hauls that took place in greater depths were used for the analysis in the present work. Because of the low number of stations in the deep waters in the above projects, all the stations were congregated in one depth zone (300 to 500 m). All the data were standardised to one hour of towing, since the hauls had not always lasted the same time. The catch of each haul was firstly weighed and then sorted to the species level. Even thought all the fish species were identified, this was not accomplished for cephalopods and crustaceans. The number of specimens per fish species was recorded. The weight of the economically important species was also weighed. Length data were collected for the most abundant or the economically important species of each area.

For more details about the Northern Aegean Sea, Thracian Sea and Ionian Sea projects see Papaconstantinou *et al.* 1987; 1988; 1993 and 1995.

The sampling design and the methodology of the “Deep water fisheries project” are reported in sub-task 5.6. Since the stations in this project extended from 300 to 750 m in order to obtain results comparable as possible to those of the earlier studies, two depth zones were considered: 300–500 m and 500-750 m.

For the purposes of the present sub-task, the species caught during the several projects were classified into three categories, according to their commercial value: (a) as “commercial” (“C”) were classified the species with commercial value (the small undersized specimens were included in this category), (b) as “non commercial” (“NC”) were classified the species that have no commercial value and are always discarded by the fishermen and (c) as “possibly commercial” (“PC”) were classified the species which have a possibly (usually low) commercial value, especially for their large specimens or that could be commercialised under particular conditions in the market (e.g. lack of other commercial species). According to this classification, all the “non commercial” species as well as part of the “possibly commercial” species and the undersized specimens of the “commercial” species constitute discards.

A part of the commercial species catch is discarded due to different reasons. The smallest fish up to a certain length are always discarded. There is a range of lengths where the fish are discarded or landed, depending on the abundance of the catch, the situation in the market etc. And finally, after a certain length the fish are always landed. Data collected during observation on professional bottom trawlers were used in order to classify the fish in three categories (Vassilopoulou and Bekas, personal communications). According to this classification, the fish were characterised as “always discarded”, “partly discarded” and “always landed”. The ranges of lengths per category of *Merluccius merluccius*, *Micromesistius poutassou*, *Lophius budegassa*, *Lepidorhombus boscii*, *Phycis blennoides*, and

Trigla lyra are presented in Table 1. The proportion of the fish per category in each project was estimated.
In each study area, the numerical proportion of each category (“C”, “NC”, “PC”) to the total catch was estimated. Moreover, the species composition in terms of numbers of the “NC” and “PC” part of the catch was examined. The total catch composition and the species composition analysis were made in terms of weight only for the data of the Deep water fishery project in the Ionian Sea, since weight data were not always available from the other projects. In the “NC” category the discarded specimens of the commercial species were not included. A separate analysis has been made in order to estimate the proportion of the discarded individuals of the commercial species in each area.

Results

Number of species per category in each area

In the N. Aegean Sea, during 1990-1993, the total number of the fish species, caught in depth 300-500 m, was found to be 91, from which 51 were characterised as “NC” (Table 2). The estimation of their percentages gave the following results per category: “C”: 30.8 %, “NC”: 56.0 % and “PC”: 13.2 %. The percentage of the category “NC” was ranging between 49 and 61% among the various cruises (results not shown here). The percentage of the category “PC” ranged between 9 and 15% and that of the category “C” was found to be between 27 and 39%.

In the Thracian Sea, during 1991-1994, the total number of the fish species was found to be 59, from which 34 were characterised as “NC”. The estimation of their percentages gave the following results per category: “C”: 32.2%, “NC”: 57.6% and “PC”: 10.2%. The percentage of the category “NC” ranged from 40 to 67% among the various cruises (results not shown here). The values of the category “PC” were found to be between 6 and 17% and those of the category “C” between 26 and 47%.

In the Ionian Sea, during 1983-1985, the total number of the fish species was found to be 63, from which 30 were characterised as “NC” (Table 2). The estimation of their percentages gave the following results per category: “C”: 42.9%, “NC”: 47.6% and “PC”: 10.2%. The percentage of the category “NC” was found to be between 35 and 54% among the various cruises (results not shown here). The percentage of the category “C” was ranging from 39 to 55% among the various cruises. That of the category “PC” was found between 7 and 23%.

In the Ionian Sea, during 1996-1998, at the 300–500 m depth zone, the total number of the fish species was found to be 61, from which 32 were characterised as “NC” (Table 2). The estimation of their percentages gave the following results per category: “C”: 32.8%, “NC”: 52.5% and “PC”: 14.8%. The percentage of the category “NC” was found to be between 37 and 63% among the various cruises (results not shown here). The percentage of the category “C” was ranging from 23 to 42% among the various cruises. That of the category “PC” was found between 11 and 21%.

At the >500 m depth zone, the total number of the fish species was found to be 62, from which 37 were characterised as “NC” (Table 2). The estimation of their percentages gave the following results per category: “C”: 25.8%, “NC”: 59.7% and “PC”: 14.5%. At this depth zone in the Ionian Sea, the percentage of “NC” species presented slightly higher values (50–61%) than in the 300–500 m depth zone. On the other hand, the percentage of “C” species was lower (28–34%) and that of the “PC” species almost the same (13–17%).

Composition of the total catch (by number)

The total number of the fish in each category was calculated. The percentage of each category was estimated for the various cruises of all the projects.

Northern Aegean Sea

In the Northern Aegean Sea the percentage of the "NC" fish ranged between 50 and 83% among the various cruises. The percentage of the "PC" fish was always low (<3.7%) and that of the "C" fish was found to be between 15 and 46%. The proportion of the "NC" fish during all the cruises was 70.5%, of the "PC" fish was 2.3% and of the "C" fish was 27.2% (Fig.2).

Thracian Sea

In the Thracian Sea the percentage of the "NC" fish ranged from 61 to 87%. The percentage of the "PC" fish was always very low (<1.6%) and this of the "C" fish ranged between 12 and 38%. The proportion of the "NC" fish during all the cruises was 72.0%, of "PC" fish was 1.3% and of "C" fish was 26.7% (Fig. 2).

Ionian Sea (1983-1985)

In the Ionian Sea (1983-1985) the percentage of the "NC" fish was ranging between 85 and 98%. That of the "PC" fish was found to be near zero (<1.3%). The percentage of the "C" fish was low, ranging from 2 to 14% among the various cruises. The proportion of the "NC" fish during all the cruises was 94.2%, of the "PC" fish was 0.3% and of "C" fish was 5.5% (Fig. 2).

Ionian Sea (1996-1998)

In the Ionian Sea at the 300-500 m depth zone, the percentage of the "NC" fish was ranging between 82 and 99.5%. The percentage of the "PC" fish was found to be near zero (0 - 5%). That of the "C" fish was very low ranging from 0.4 to 12.8% among the various cruises. The proportion of the "NC" fish estimated for the total catch during all the cruises, was 96.4%, of the "PC" fish was 0.5% and of the "C" fish was 3.1% (Fig. 2).

At the >500 m depth zone, the percentage of the "NC" fish was ranging from 70 to 93%. The percentage of "PC" fish ranged from 0.5 to 14% and that of "C" fish from 6 to 16%. From the analysis of all the data, the proportion of the "NC" fish was 84.9%, of the "PC" fish was 4.2% and of the "C" fish was 10.9% (Fig. 2), indicating lower percentage for "NC" and higher for "C" and "PC" fish in the deeper depth zone than in the shallower one.

Composition of the total catch (by weight)

The percentage of each category in the total catch, in terms of weight, was estimated for the Ionian Sea "Deep fisheries" project (1996-1998).

Ionian Sea (1996-1998)

The analysis of the fish catch composition in terms of weight for each cruise, depth zone and category, showed that in the Ionian Sea at the 300-500 m depth zone, the percentage of the "NC" category was ranging between 52 and 88%. The percentage of the "C" category was lower, ranging from 9 to 41% among the various cruises. That of the "PC" category was found to be between 2 and 11%. The proportion of the "NC" category during all the cruises was 72.6%, of the "C" category was 23.1% and of the "PC" category was 4.3% (Fig. 3).

At the >500 m depth zone, the percentage of the "NC" category was ranging from 25 to 61%. The percentage of "C" ranged from 34 to 48% and that of "PC" from 4.5 to 22%. From the analysis of all the data, the proportion of each category during all the cruises, was estimated as following: “NC”: 43.3%, “C”: 43.8% and “PC”: 13% (Fig. 3), indicating: 1) similar percentages for the “C” and the “NC” category in this depth zone and 2) lower percentage for the “NC” and higher for the “C” and the “PC” category in this depth zone than in the shallower one.

Species composition of the discarded catch (by number)

Northern Aegean Sea

The analysis of the “NC” and “PC” fish species composition in terms of numbers for each area, cruise and depth zone, showed that in the Northern Aegean Sea the most abundant species during all the cruises was *Gadiculus argenteus argenteus*. Its percentage ranged between 31 and 67% among the various cruises. *Hymenocephalus italicus* was the second important species with percentage values ranging between 7.5 and 27.6%. However, it was found in a lower status during two sampling periods (summer 1991 and spring 1992). *Argentina sphyraena* and *Coelorhynchus coelorhynchus* followed with fluctuations in their percentages during the various cruises. *A. sphyraena* presented its highest percentage (23.4%) in autumn 1991, whereas its lowest (2.5%) in spring 1991. The percentage values of *C. coelorhynchus* ranged between 9 and 18%. Other species, such as *Nezumia sclerorhynchus, Chlorophthalmus agassizi, Galeus melastomus, Etmopterus spinax* and *Hoplostethus mediterraneus* showed a regular presence with percentages lower than 5%. The proportions of the most abundant discarded species during all the cruises were the following: *G. a. argenteus* 47.3%, *H. italicus* 18.5%, *C. coelorhynchus*13.3%, *A. sphyraena* 12.4% (Fig. 4).

Thracian Sea

In the Thracian Sea the most important discarded species was *Hymenocephalus italicus*. Its percentage ranged between 15.7 and 79.4% among the various cruises. *Gadiculus argenteus argenteus* was the second important species with percentage values ranging between 0.8 and 78.9%. However, it was found in the first position during two sampling periods (summer 1992 and autumn 1992). *Argentina sphyraena* and *Coelorhynchus coelorhynchus* followed with fluctuations in their percentages during the various cruises. However, their percentage values were always lower than 10%. Other species, such as *Etmopterus spinax, Chimaera monstrosa, Hoplostethus mediterraneus, Chlorophthalmus agassizi* and *Galeus melastomus* followed with percentages lower than 5%. The proportions of the most abundant discarded species during all the cruises were: *H. italicus 27.9*%, *G. a. argenteus* 16.1% (Fig. 4).

Ionian Sea (1983-1985)

In the Ionian Sea (1983-1985) the most abundant species during all the cruises was *Gadiculus argenteus argenteus*. Its percentage values were always very high, ranging between 58.4 and 96.3%. *Argentina sphyraena, Coelorhynchus coelorhynchus* and *Lepidotrigla dieuzeide* followed with fluctuations in their percentages during the various cruises. *A. sphyraena* presented its highest percentage (17.6%) in summer 1983, whereas its lowest (0.3%) in winter 1983. The percentage values of *C. coelorhynchus* ranged between 0.1 and 13.4%. Other species, such as *Chlorophthalmus agassizi*, *Galeus melastomus* and *Raja clavata* followed with percentages lower than 5%. The most abundant discarded species during all the cruises was *G. a. argenteus* with percentage value equal to 88.5%. All the other species represented values lower than 5% (Fig. 4).

Ionian Sea (1996-1998)

In the Ionian Sea at the 300–500 m depth zone, the most abundant species during all the cruises (except in April 1997) was *Chlorophthalmus agassizi.* Its percentage ranged between

50 and 82% among the various cruises. *Argentina sphyraena* and *Gadiculus argenteus argenteus* followed with fluctuations in their percentages during the various cruises. *A. sphyraena* presented its highest percentage (93%) in April 1997, whereas its lowest in February 1997. The percentage values of *G. a. argenteus* ranged between 0 and 28%. Other species, such as *Hymenocephalus italicus, Coelorhynchus coelorhynchus, Peristedion cataphractum, Hoplostethus mediterraneus, Nezumia sclerorhynchus* and *Capros aper* showed a regular presence with percentages usually lower than 5%. The proportions of the most abundant discarded species during all the cruises were: *C. agassizi* 59%, *A. sphyraena* 16%, *G. a. argenteus* 13% (Fig. 4).

At the >500 m depth zone, the most abundant species during many of the cruises was *Chlorophthalmus agassizi*. However, its percentage values ranged between 0 and 62% among the various cruises. *Nezumia sclerorhynchus, Hymenocephalus italicus* and *Hoplostethus mediterraneus* followed with fluctuations in their percentages during the various cruises. The highest percentage of *N. sclerorhynchus* was 36%, whereas the lowest 6%. The percentage values of *H. italicus* ranged between 4 and 29% and those of *H. mediterraneus* between 6 and 36%. Other species, such as *Coelorhynchus coelorhynchus, Peristedion cataphractum, Raja oxyrhynchus, Etmopterus spinax* and *Dalatias licha* showed a regular presence with percentages usually lower than 5%. The proportions of the most abundant discarded species during all the cruises were: *C. agassizi* 32%, *N. sclerorhynchus* 15%, *H. italicus* 14%, *H. mediterraneus* 13% (Fig. 4).

Species composition of the discarded catch (by weight)

Ionian Sea (1996-1998)

The analysis of the "NC" and "PC" fish species composition in terms of weight for each cruise and depth zone, showed that in the Ionian Sea, during 1996-1998, at the 300–500 m depth zone, the most abundant species was *Chlorophthalmus agassizi*. Its percentage values ranged between 12 and 72% among the various cruises. *Argentina sphyraena* followed with percentages that were presenting a great variation and were ranging from 0 to 81% during the various cruises. The species *G. a. argenteus, H. mediterraneus, P. cataphractum* and *C. coelorhynchus* showed a regular presence but with low percentage values. Most abundant species in this depth zone were *C. agassizi* (53%), *A. sphyraena* (16%), *H. mediterraneus* (6%) and *G. a. argenteus* (4%) (Fig. 5).

At the >500 m depth zone, *Chlorophthalmus agassizi* and *Hoplostethus mediterraneus* constituted the species with the highest percentage values in terms of weight. These percentage values fluctuated more for the first species, ranging between 0 and 50% among the various cruises, than for the second one whose values ranged between 10 and 28%. *Raja oxyrhynchus, Etmopterus spinax, Chimaera monstrosa, Raja clavata, Dalatias licha, Galeus melastomus and Nezumia sclerorhynchus* followed with percentages ranging mainly between 5 and 15%. The proportion of *C. agassizi* was 22%, of *H. mediterraneus* 17%, of *R. oxyrhynchus* 9% and of *E. spinax* 8%(Fig. 5).

Discarded fish of the commercial species

Merluccius merluccius

The percentage of the "always discarded" hake in the North Aegean Sea was 26.5% and of the "partly discarded" was 41.6%, whereas in the Thracian Sea it was 18.3% and 9.3%, respectively (Fig. 6). In the Ionian Sea (1983-1985) the proportion of the "always discarded" fish was the highest (60.8%) and of the "partly discarded" was 18.9%. In the Ionian Sea

(1996-1998) in the 300-500 m depth zone the proportion of the "always discarded" was 17.3% and of the "partly discarded" was 60.5%, whereas in the 500-750 m depth zone it was 2% and 25.4%, respectively. The highest proportions of the "always landed" were observed in the Thracian Sea (72.5%) and in the 500-750 m depth zone in the Ionian Sea (72.6%).

The minimum landing size of hake is 20 cm TL. According to this legislation, all the "partly discarded" fish should be discarded. Nevertheless, a part of them goes to the market illegally.

Lepidorhombus boscii

The species was not very abundant in the Thracian Sea (Fig. 7). In the North Aegean the proportion of the "always discarded" was 61.9% and only a small proportion of 6.7% was marketable. In the Ionian Sea during the 1983-1985 surveys, 10% was "always discarded", 43.3% was "partly discarded" and a significant proportion (46.7%) was "always landed". During the Deep water fishery project surveys the proportion of the "always discarded" was 31.2% and 17.3% in the 300-500 m and the 500-750 m depth zone, respectively. The proportion of the "partly discarded" was 35.2% and 45.2%, whereas the proportion of the "always landed" was 33.6% and 37.5% in the two depth zones, respectively.

Micromesistius poutassou

The proportion of the "always discarded" fish was almost the same in the North Aegean Sea and the Thracian Sea (35.6% and 35.4%, respectively), but the proportion of the "always landed" was higher in the North Aegean Sea than in the Thracian Sea (39.6% and 15.2%, respectively)(Fig. 8). In the Ionian Sea in both studies, the proportion of the "always discarded" was much lower (4.1%, 1.4% and 0.0% for the 1983-1985 surveys and for the 300-500 m, 500-750 m depth zones of the 1996-1998 surveys, respectively). During the 1996-1998 surveys, the proportion of the "always landed" was very high (84% and 98.9% for the 300-500 m and 500-750 m depth zone, respectively).

Lophius budegassa

The proportion of the "always discarded" in the North Aegean Sea and the Thracian Sea was very high (76.7% and 87.3%, respectively) (Fig. 9). In these areas the proportion of the "always landed" was very low (14.8% and 3.5%, respectively). In the Ionian Sea (1983-1985), the proportion of the "always discarded" was lower than in the other areas (29.5%). More than 1/3 of the catch was "always landed" (39.1%). During the 1996-1998 surveys, the proportion of the "always discarded" was very low (3.0% and 1.5%, in the 300-500 m and in the 500-750 m depth zone, respectively). A high proportion of the species was "always landed" (81.4% and 82.4% per depth zone, respectively).

Phycis blennoides

The proportion of the "always discarded" in the North Aegean Sea was 33.8%, in the Ionian Sea during 1983-1985 it was 41.5% and in the Ionian Sea during 1996-1998 it was 30.7% and 36.3% for the 300-500 m and the 500-750 m depth zone, respectively (Fig. 10). The proportion of the "always landed" was the highest in the North Aegean Sea (38.1%) and the lowest in the Ionian Sea during the 1983-1985 surveys (14.3%). The species had been caught in very low abundance in the Thracian Sea.

Trigla lyra

In the North Aegean Sea almost the total of the catch was "always discarded" or "partly discarded" (86.5% and 9.6%, respectively) (Fig. 11). In the Thracian Sea the abundance was low. In the Ionian Sea in both surveys, the situation was different than in the North Aegean Sea. In the 500-750 m depth zone during the 1996-1998 surveys, the number of the fish that had been caught was low. In the 300-500 m depth zone during the 1983-1985 surveys, the proportion of the "always discarded" was 5.4%, while during the 1996-1998 surveys it was 16.9%. A high proportion of the catch was "always landed" (80.6% and 74.6%, respectively) (Fig. 11).

Discussion

Estimations on the discards based on data collected during experimental surveys are not very accurate. The fishing practice (e.g. duration of the hauls) is different. In this report, the quantity of the discards was estimated by making assumptions which have reduced the accuracy of the results. Moreover, the data used in this work have been collected during experimental fishing surveys that have been carried out for other purposes and not for the estimation of the discards. In addition, the sampling conditions between the various areas were different (e.g. number of stations, fishing boat) and the comparison between the areas was difficult. Nevertheless all the above contradictions, these data have been used in order to extract any possible information on the discards in deep waters since they are the only source of information in deep Greek waters.

The highest number of species was found in the Northern Aegean Sea (91 species) and the lowest one in the Thracian Sea (59 species). The percentage of the number of species in the "NC" category ranged from 47.6% to 59.7% among the different areas. The percentage of the "C" category ranged from 25.8% to 42.9% and of the "PC" category ranged from 9.5% to 14.8%. The number of the non commercial species was always higher than the number of species in the other two categories in both depth zones.

The composition of the catch (by number) in the N. Aegean Sea and the Thracian Sea was similar (commercial part ~27%, non commercial ~71% and possibly commercial ~2%). In the Ionian Sea during both surveys (1983-1985 and 1996-1998) and in both depth zones (300-500 m and 500-750 m) the proportion of the non commercial part was higher than in the other areas (more than 85%). The commercial part of the catch in the 500-750 m depth zone was higher than in the 300-500 m depth zone (10.9% and 3.1%, respectively). In the 300-500 m depth zone the species *C. agassizi* that belongs to the "non commercial" category was caught in large quantities and contributed to the high proportion of the non commercial part.

The commercial part of the catch (by weight) in the 500-750 m depth zone of the Ionian Sea 1996-1998 surveys was higher than in the 300-500 m depth zone (43.8% and 23.1%, respectively). The proportion of the commercial part by weight is higher than the proportion by number in both depth zones of the Ionian Sea. This is attributed to the presence of large specimens of *L. budegassa* and *L. piscatorius* in the catch of the 500-750 m depth zone.

The analysis of the species composition of the catch (in terms of numbers) shows regional differences. One of the most abundant species was *Gadiculus argenteus argenteus* which was caught in large quantities in all the study areas except the 500-750 m depth zone in the Ionian Sea. However, *Hymenocephalus italicus* and *Chlorophthalmus agassizi* were the most abundant species caught in the Thracian Sea and the Ionian Sea during 1996-1998 (27.9%, 59% for the 300-500m depth zone and 32% for the 500-750 m depth zone, respectively). In the Ionian Sea during the 1983-1985 surveys, *G. argenteus argenteus* was the dominant species among the non commercial species whereas during the 1996-1998 surveys in the same area the dominant species was *C. agassizi*.

The minimum mesh size of the cod-end that is used in the commercial bottom trawl fishery in Greece is 28 mm and the gear is not selective. Thus, significant quantities of young fish of commercial species are caught and discarded, either because they have lengths less than the minimum landing size or because they have no commercial value. The fishing mortality of the discarded young fish is affecting the stocks by reducing the yield per recruit and reducing the probabilities that the young fish will achieve the length of first maturity.

Significant regional differences have been observed among the areas and among the species that have been examined in this work. The differences could be attributed up to a certain degree to sampling (depth, year, vessel effect) but they mainly reflect differences in the distribution of the juvenile specimens.

The proportion of the discarded *M. merluccius*, which is the most important species for the bottom trawl fishery in Greece, was very high in the N. Aegean Sea and in the 300-500 m depth zone of the Ionian Sea, whereas it was low in the Thracian Sea and in the 500-750 m of the Ionian Sea. Young hake are concentrated in waters >200 m in the N. Aegean Sea (Papaconstantinou, *et al.* 1993) and the area is considered to be a nursery ground of the species. In the Thracian Sea and in the 500-750 m depth zone in the Ionian Sea the population of hake was consisted of larger specimens and the proportion of the landing was more than 70%. The results of the surveys in waters >500 m in the Ionian Sea indicated that bottom trawl fishing in these depths is not harmful for the hake population since the catch is consisted of large commercial specimens. However, more work is needed in order to verify these results. In the Thracian Sea and in the 500-750 m depth zone of the Ionian Sea where the proportion of the discarded is lower, the maximum length of hake was higher. The minimum landing size of the species is 20 cm. Even that specimens of lengths between 14 to 20 cm are landed illegally.

The large specimens of *L. boscii* which is one of the by catch species in bottom trawl fishery in Greece, have commercial value. It was not abundant in the Thracian Sea and the Ionian Sea during the 1983-1985 surveys. In the N. Aegean Sea only a very small proportion was “always landed” whereas in the Ionian Sea during 1996-1998, this proportion was higher in both depth zones.

M. poutassou have a low commercial value. It is quite abundant in waters deeper than 300 m. The large individuals live in deeper waters than the juveniles and almost all the specimens in both depth zones in the Ionian Sea during 1996-1998 were “always landed”. Larger specimens were caught in the Ionian Sea than in the other two areas.

Significant differences have been observed in the proportion of the “always discarded” *L. budegassa* between the areas. The great majority of the catch (more than 75%) in the N. Aegean Sea and in the Thracian Sea belonged to this category. In the Ionian Sea during 1983-1985 the proportion of the “always discarded” was 30% and during 1996-1998 it was very low (less than 3%).

The proportion of the “always landed” *P. blennoides* was higher in the N. Aegean Sea. In the Ionian Sea during both surveys the proportion of the discarded juveniles was very high. The bathymetrical distribution of the species is not well known. It is possible that the juveniles are concentrated in deeper waters than the mature fish.

T. lyra occur mainly in depths down to 500 m. The species was not abundant in the Thracian Sea and in the 500-750 m depth zone in the Ionian Sea. In the N. Aegean Sea almost all the fish (96%) were classified as “always discarded” or “partly discarded” whereas in the Ionian Sea in both surveys they were classified as “always landed” (more than 74%).

According to the preceding analysis it looks like that in the 500-750 m depth zone in the Ionian Sea the bottom trawl fishery is not harmful for the juvenile specimens of the species *M. merluccius, M. poutassou* and *L. budegassa* and in the 300-500 m depth zone for the juveniles of the species *M. poutassou, L. budegassa* and *T. lyra.*

Dissemination

Mytilineou, Ch., Petrakis, G., Fourtouni, A., 1998. Composition of the discarded catches from experimental bottom trawl surveys in Greek waters. Poster, ICES CM 1998/ O:38.

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Table 1. Ranges of length per species.

Species	Always discarded (cm)	Partly discarded (cm)	Always landed (cm)
Merluccius merluccius	<12	13-19	>19
Lepidorhombus boscii	<12	13-19	>19
Micromesistius poutassou	<15	16-20	>20
Lophius budegassa	<21	22-26	>26
Phycis blennoides	<14	15-20	>20
Trigla lyra	<16	17-20	>20

Table 2. Total number and percentage of fish species per area, depth zone and category.

Area	Depth zone (m)	"Commercial"	"Non commercial"	"Possibly commercial"
N. Aegean Sea 1990-1993	300-500	28	51	12
	%	30.8	56.0	13.2
Thracian Sea 1991-1994	300-500	19	34	6
	%	32.2	57.6	10.2
Ionian Sea 1983-1985	300-500	27	30	6
	%	42.9	47.6	9.5
Ionian Sea 1996-1998	300-500	20	32	9
	%	32.8	52.5	14.8
	> 500	16	37	9
	%	25.8	59.7	14.5

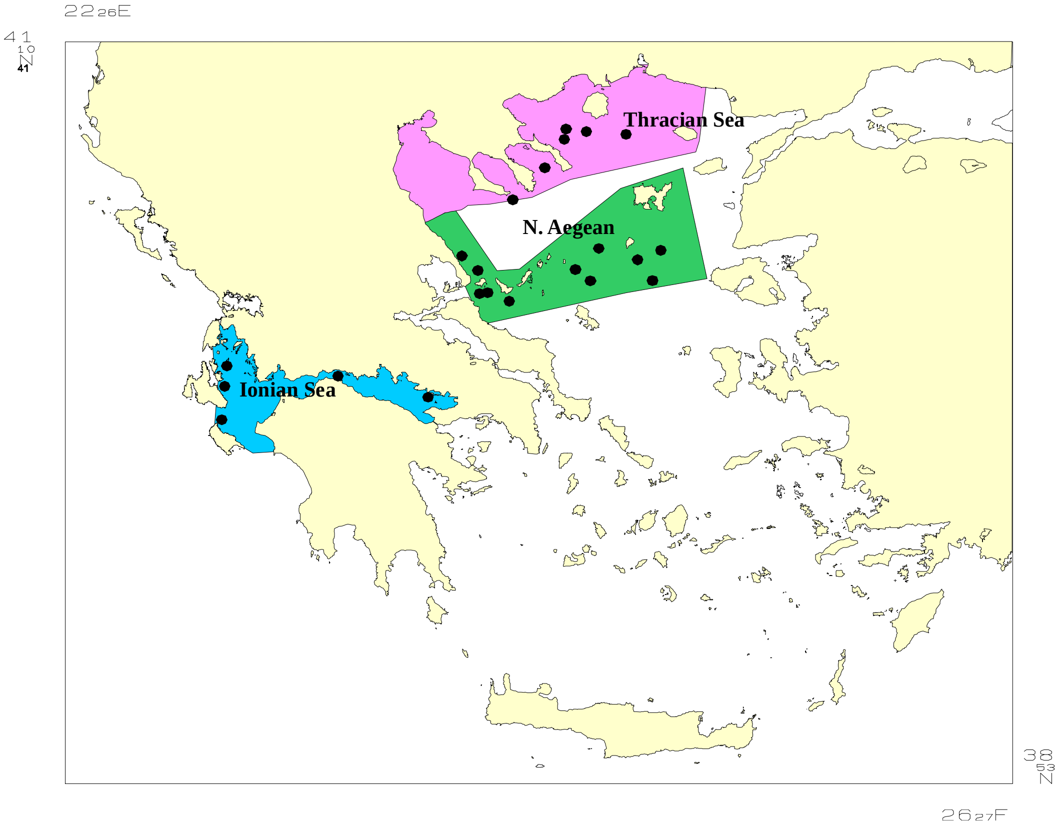

Fig. 1. Map of Greece showing the areas covered by the projects.

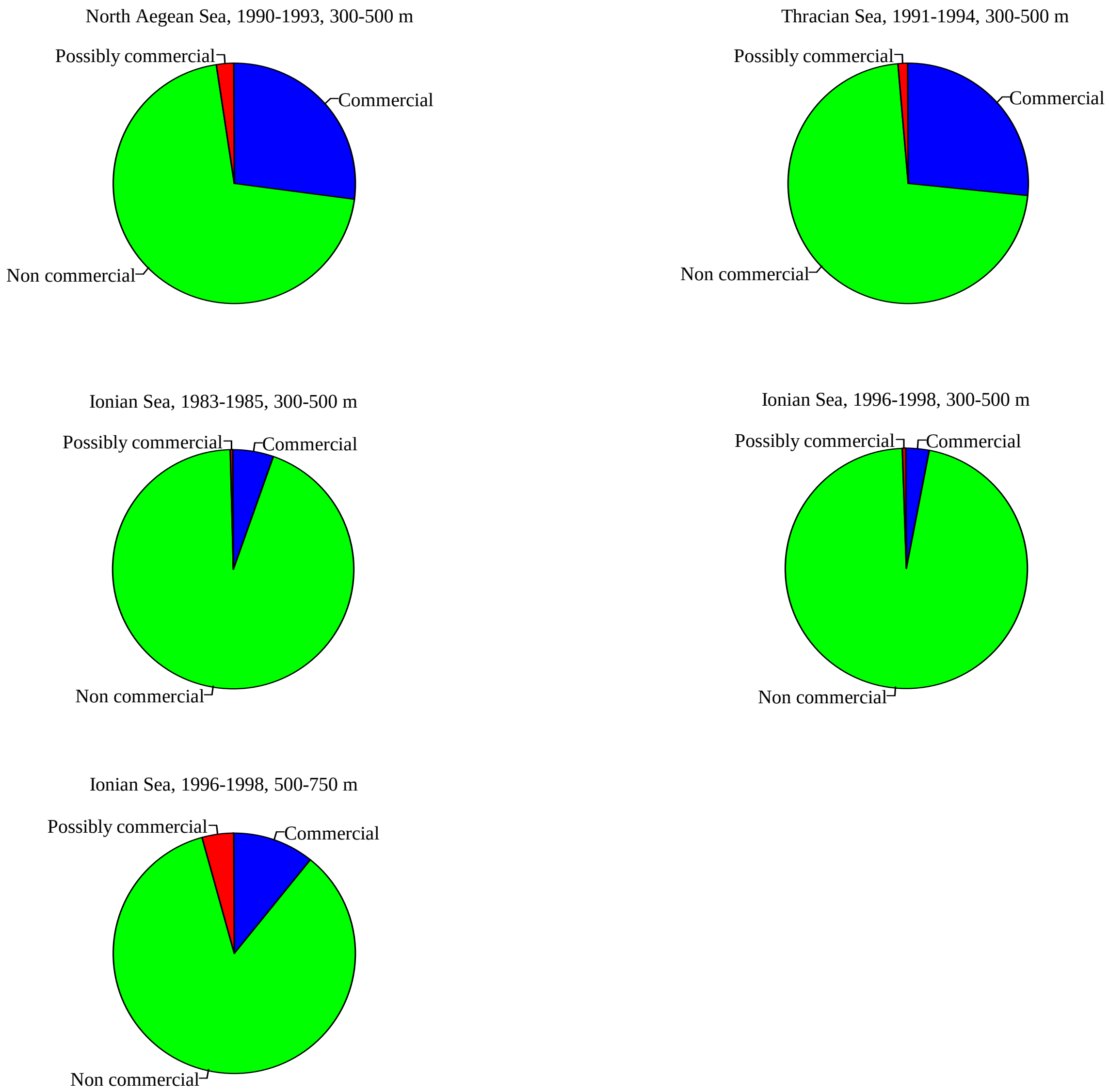

Fig. 2. Proportion of each category to the total catch per area (by number).

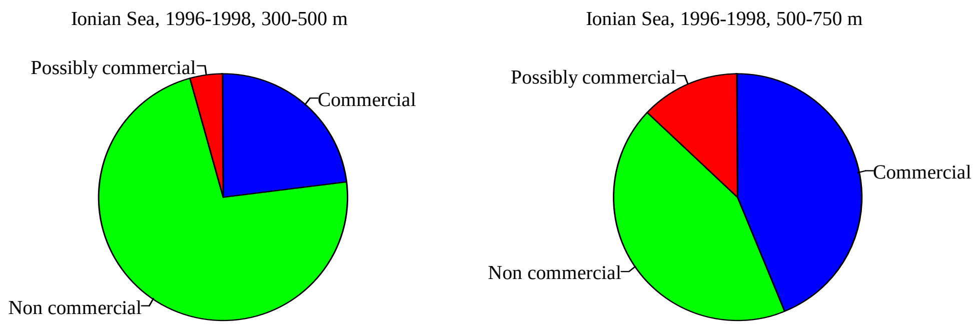

Fig. 3. Proportion of each category to the total catch in the Ionian Sea (1996-1998) (by weight).

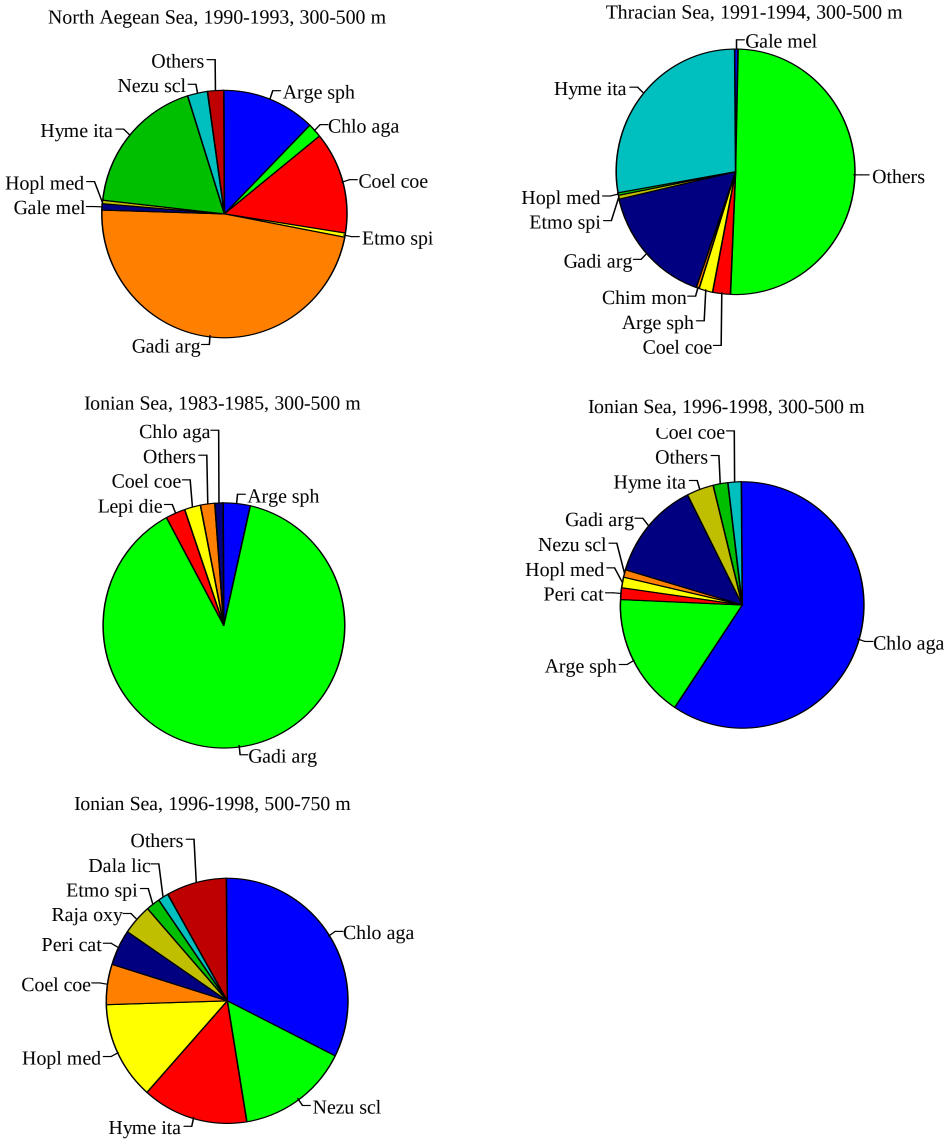

Fig. 4. Composition of the discarded catch in terms of number.

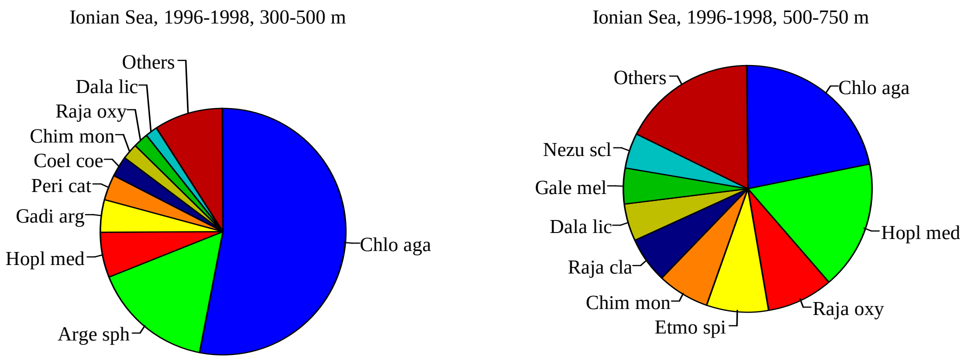

Fig. 5. Composition of the discarded catch in terms of weight .
(Arge sph=*Argentina sphyraena*, Chim mon=*Chimaera monstrosa*, Chlo aga=*Chlorophthalmus agassizi*, Coel coe=*Coelorhynchus coelorhynchus*, Dala lic=*Dalatias licha*, Etmo spi=*Etmopterus spinax*, Gadi arg=*Gadiculus argenteus argenteus*, Gale mel=*Galeus melastomus*, Hopl med=*Hoplostethus mediterraneus*, Hyme ita=*Hymenocephalus italicus*, Lepi die=*Lepidotrigla dieuzeide*, Nezu scl=*Nezumia sclerorhynchus*, Peri cat=*Peristedion cataphractum*, Raja cla=*Raja clavata*, Raja oxy=*Raja oxyrhynchus*.)

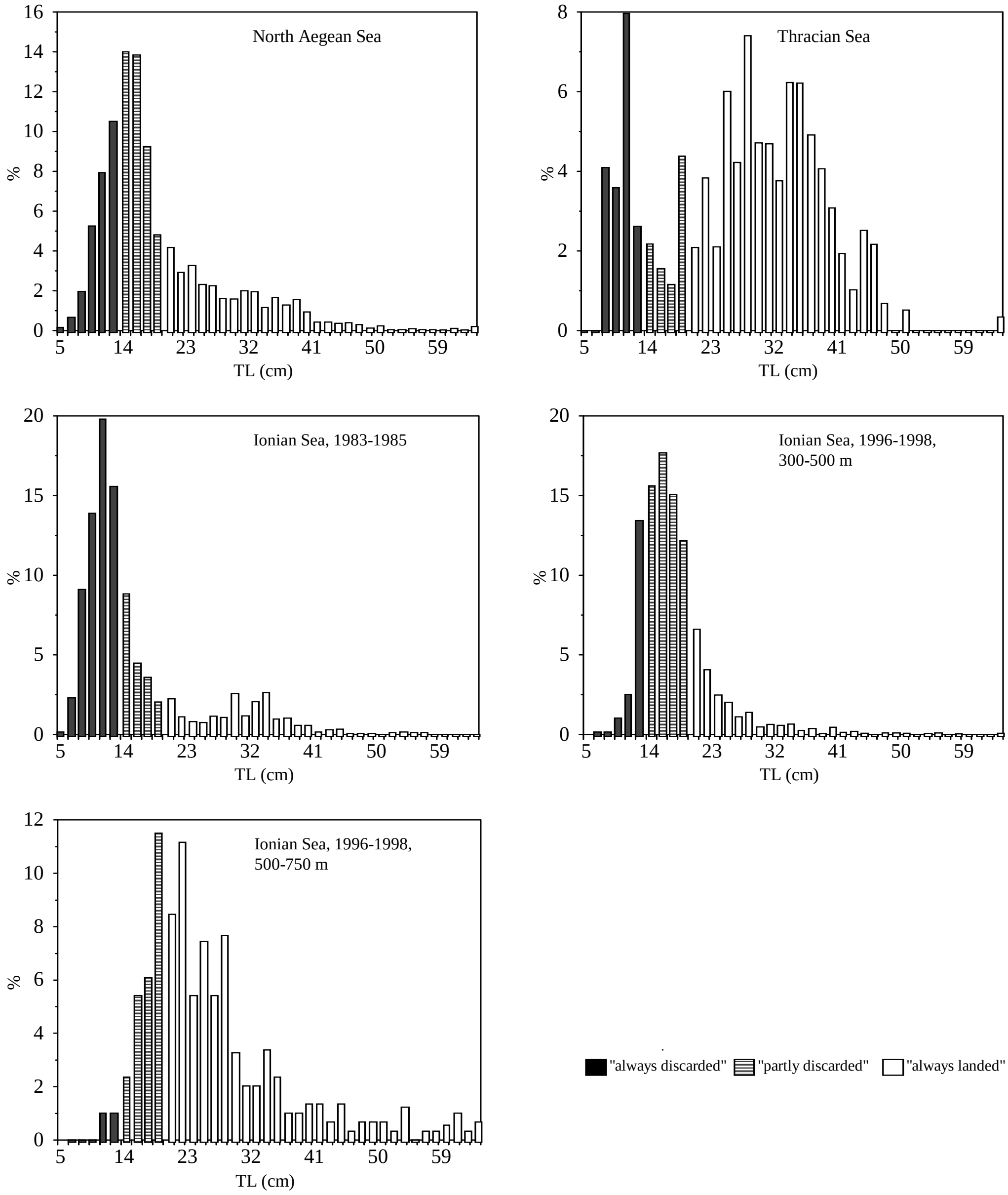

Fig. 6. Length distribution of *Merluccius merluccius*.

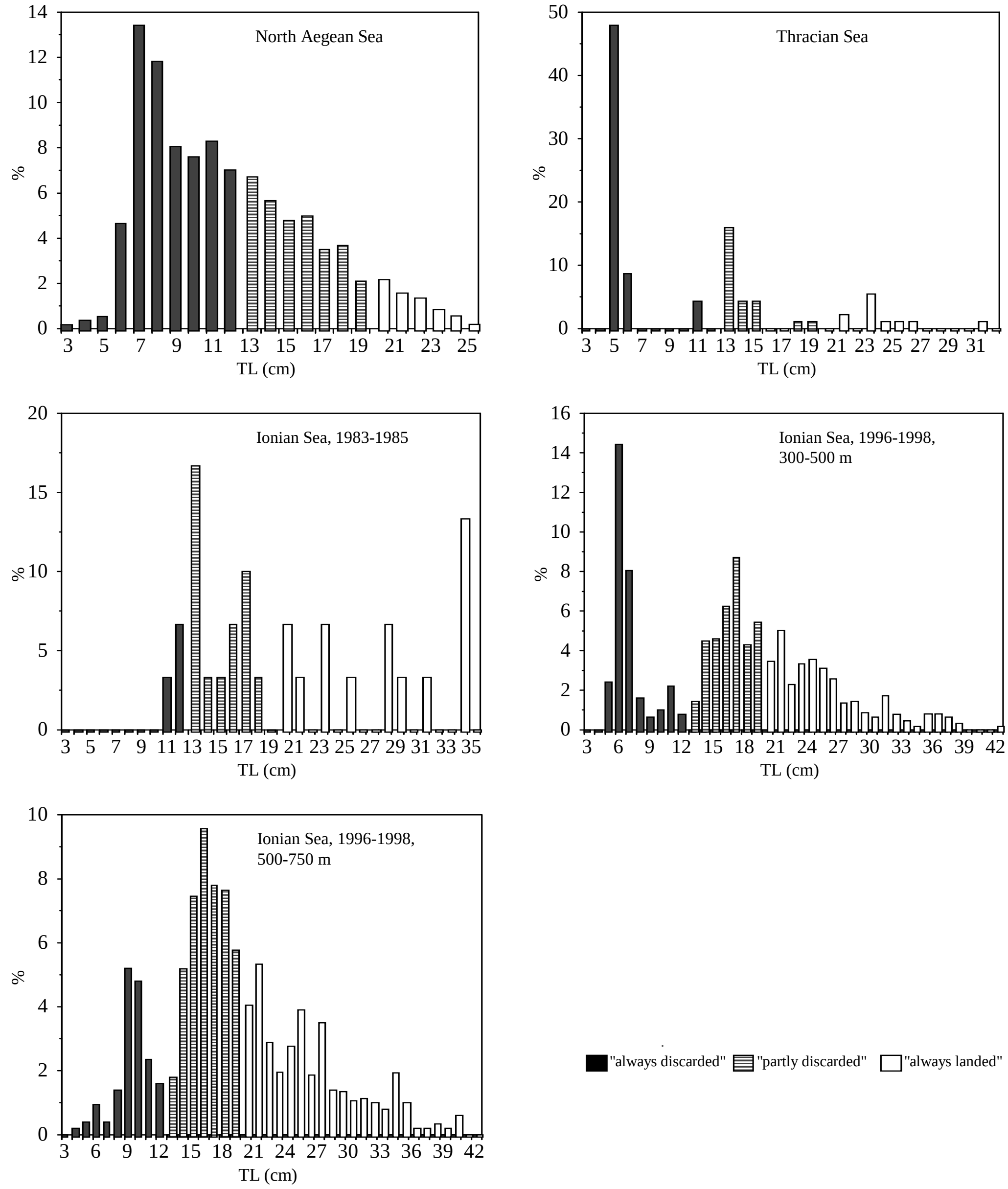

Fig. 7. Length distribution of *Lepidorhombus boscii*.

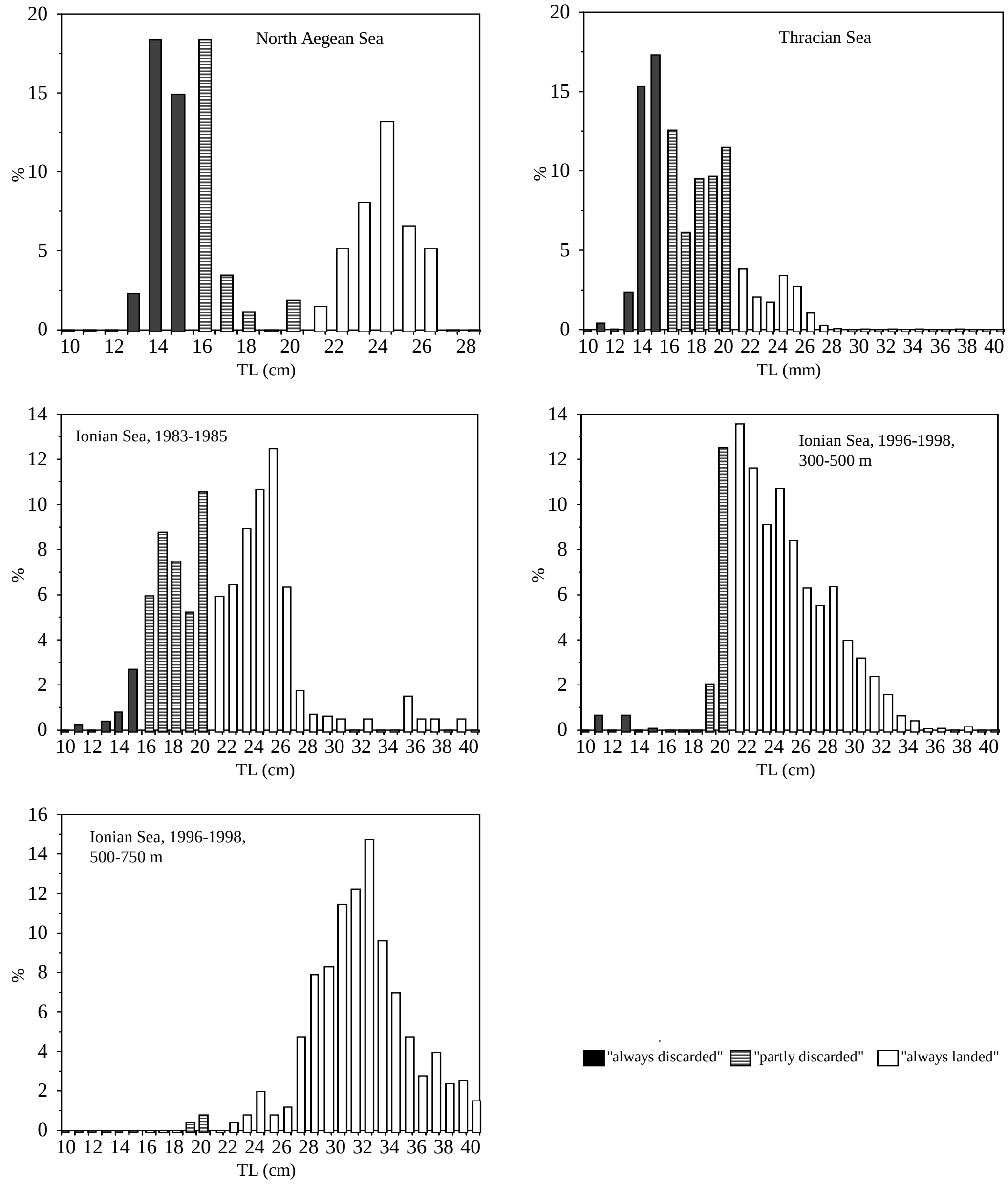

Fig. 8. Length distribution of *Micromesistius poutassou*.

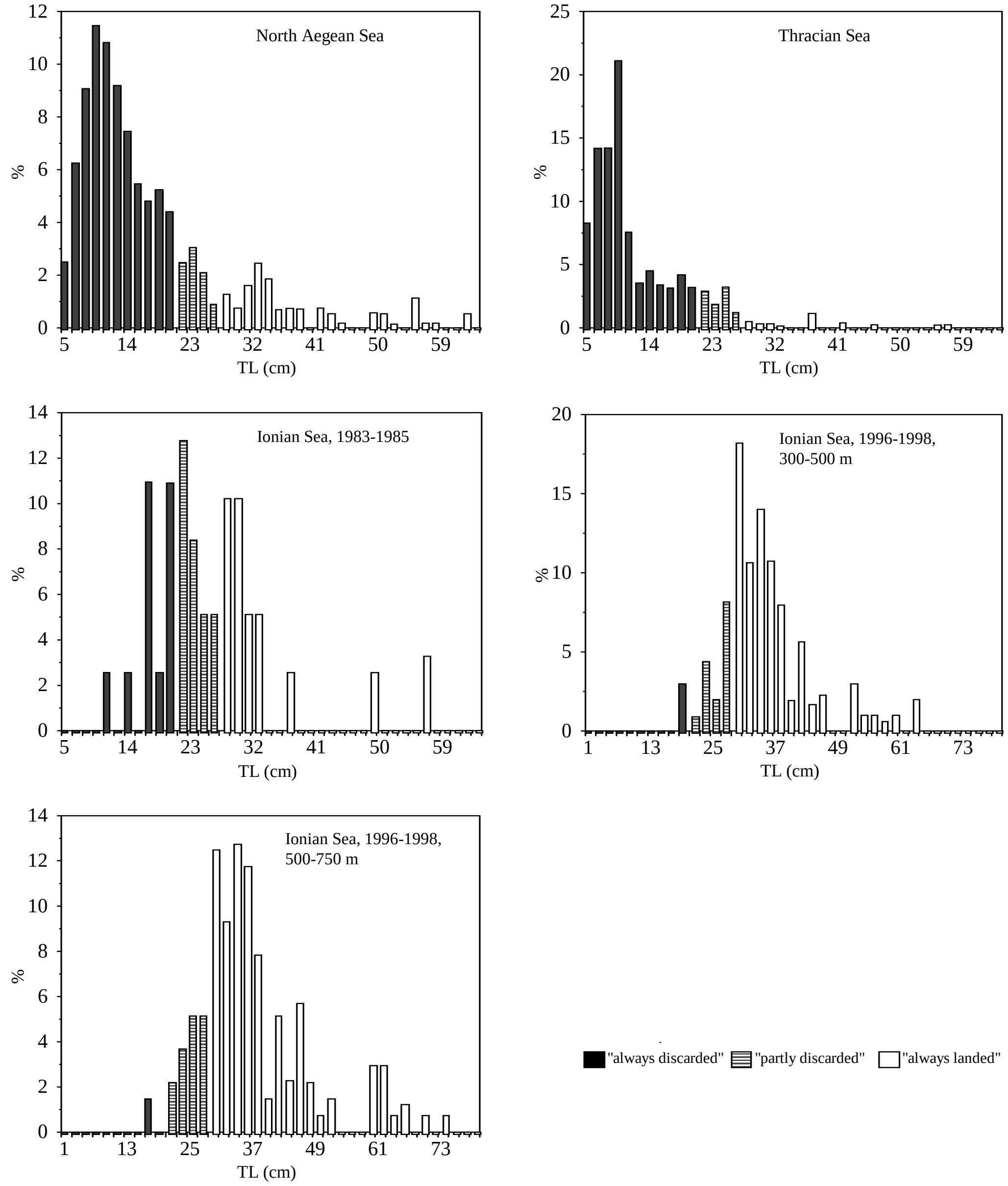

Fig. 9. Length distribution of *Lophius budegassa*.

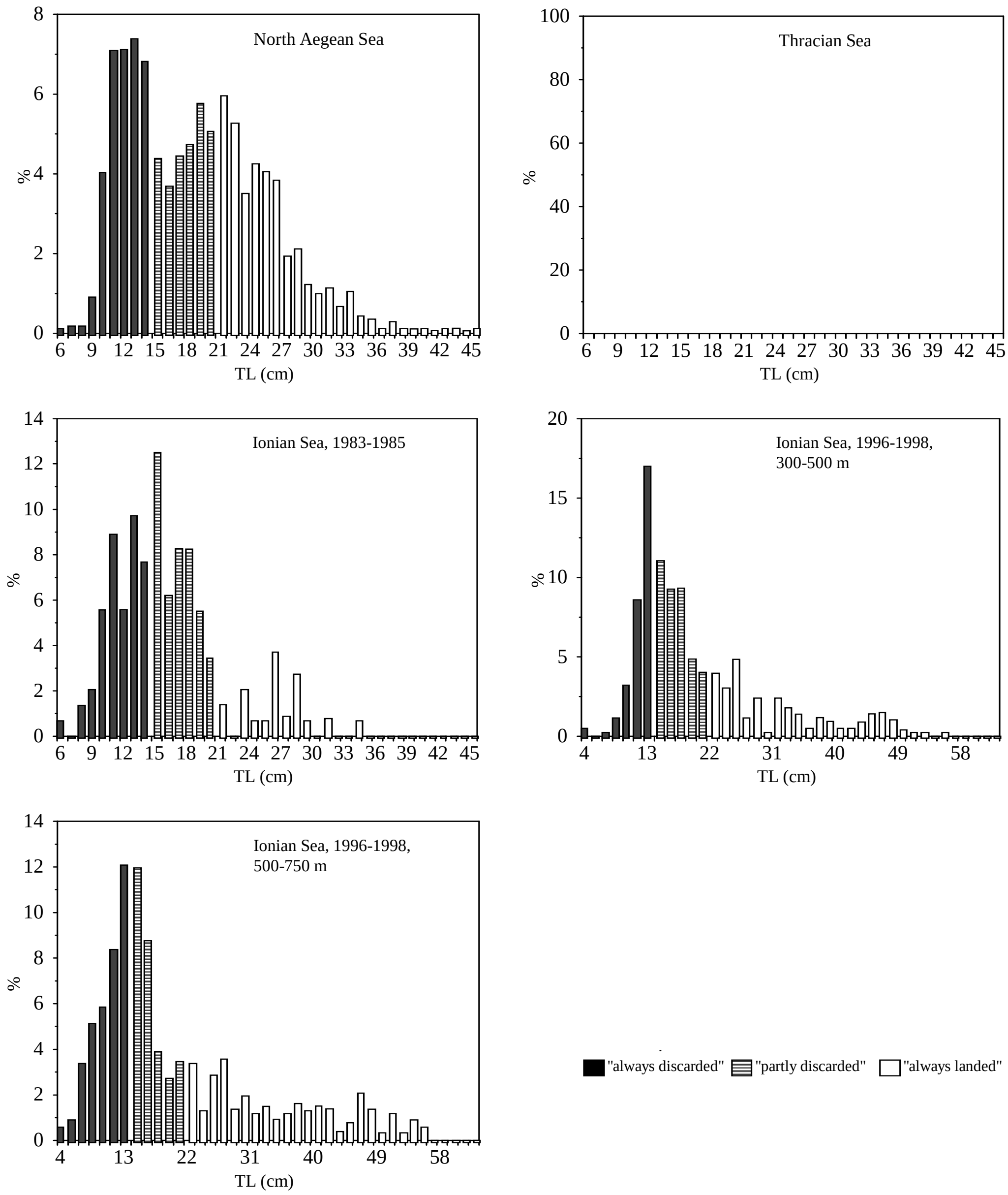

Fig. 10. Length distribution of *Phycis blennoides*.

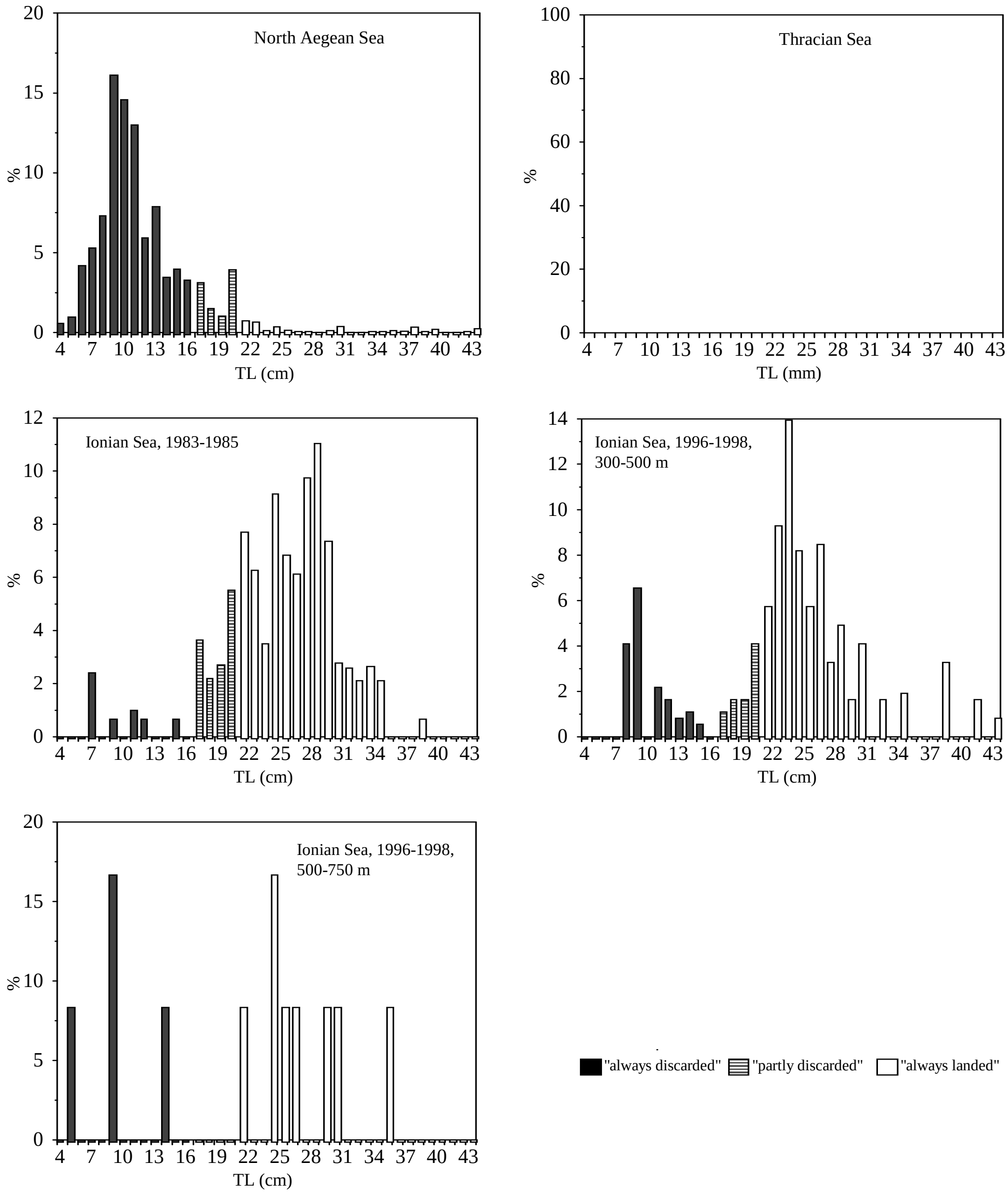

Fig. 11. Length distribution of *Trigla lyra*.

Sub-task 2.4: To collate and analyse data relating to Greek surveys of deep water species

By M. Labropoulou, C. Papaconstantinou, G. Petrakis, M. Karkani and C. Mytilineou

Computing

S. Kavadas

Introduction

The proposed program of the NCMR in this subtask had the following objectives.

1. To collate and to analyse the existing survey data.
2. To analyse the catch data of deep-water fish species.

There is a lack of information on the biology and the ecology of the fish species in the deep waters of Greece. This is mainly due to the fact that the deep waters are not exploited by the commercial fisheries. The research project, that were carried out so far in Greek waters had as objectives the study of the biology and population dynamics of the exploited fish the populations in order to provide scientific information to the Ministry of Agriculture which is responsible for the fisheries management.

Some commercial species, such as prawn and blue whiting, are distributed in quite deep waters. There are commercially exploited populations of these species in depths of 400-500 m. For this reason some tows were performed in depths more than 300 m in the framework of the above research projects. The data regarding these tows are the only available information on the deep water populations in the Greek seas.

In the framework of the Deep Water Fisheries project these data are used in order to describe the ecosystem of these areas. In this report the catch composition per area and the bathymetrical distribution of the main species is studied. Furthermore biological information for commercially important fish species such as *Merluccius merluccius* (hake), *Micromesistious poutassou* (blue whiting), *Trigla lyra* (piper), *Phycis blennoides* (greater forkbeard), *Lophius budegassa* (black-bellied angler fish) *Pagellus bogaraveo* (blackspot seabream) and *Lepidorhombus boscii* (fourspotted mergim) were found in substantial abundance at deep waters are given.

In the framework of the project it was decided to proceed species *Polyprion americanus, Lophius budegassa* and *Micromesistious poutassou* that are caught in Greek waters, in depths greater than 300 m, using various fishing gears, such as trawler-nets, bottom-nets and long-lines. This analysis was based on catch statistics data that are gathered in Greece by the National Statistical Service (NSSG) and the Fisheries Development Company S.A. (ETANAL). Before proceeding, however, with the above analysis, the methodology used for the collection of the catch statistics data by the NSSG and the ETANAL will be presented in brief, in order to evaluate the quality of these data. Survey activities by these Organizations grew independently of one another and have led to the formation of a complex structure of statistical data which are not mutually compatible.

Materials and Methods

Experimental surveys data

For the purpose of this study the historical data from three different research projects conducted by the National Centre for Marine Research (NCMR) were used. The tows which took place deeper than 300 m were selected, and the catch data of these tows were analysed. The aim of these projects was to study the situation of the demersal resources, the biology and the dynamics of the demersal fish, cephalopod and crustaceans populations. They covered three different sea areas: North Aegean Sea, Thracian Sea and Ionian Sea (Fig. 1).

The sampling design was random stratified. The surveys were carried out with hired commercial vessels and the sampling took place only during the day light. The duration of the tows ranged from 20 to 90 minutes. In 60% of the tows the duration was 60 minutes and in 30% of the tows the duration was 45 minutes. All the data were standardised to one hour of towing.

The catch of each haul was sorted at a species level. The number of specimens per species was recorded. Length data were collected for the most abundant or commercial important species of each area.

The project in the North Aegean Sea was carried out from 1990 to 1993, the project in the Thracian Sea was carried out from 1991 to 1994 and the project in the Ionian Sea was carried out from 1983 to 1986.

Two different depth zones were defined in the North Aegean Sea and in the Thracian Sea (300-400 m and >400 m). In the Ionian Sea there were no tows deeper than 400 m.

In the North Aegean Sea the number of stations per depth zone was 46 in the 300-400 m and 24 in the depth zone >400 m. In the Thracian Sea the number of stations was 21 in the 300-400 m depth zone and 3 in the >400 m depth zone. In the Ionian Sea 28 tows were carried out in the 300-400 m depth zone (Fig. 2).

In each area for each depth zone the catch composition of the fish and cephalopod catch, was estimated in terms of number. Furthermore, the bathymetrical distribution (number of individuals in relation to depth) of the most abundant species was examined.

Three different depth zones were defined in the North Aegean, Thracian and Ionian Sea (<100, 100-300 m and >300 m) in order to investigate how species richness, diversity, evenness and dominance changed with the water depth in each area. The following measures were applied to the species abundance matrix:

The Shannon-Wiener diversity index (H´) was determined according to the function:

$$H' = \sum_{i=1}^{n} (p_i)(\ln p_i)$$

where p_i = the proportion of species i in the sample.
Species richness was estimated according to the Margalef's index:

$$d = \frac{(s-1)}{\log N}$$

where S = the total number of species and N = the total number of individuals
The evenness index (J΄) was calculated according to the equation:

$$J = \frac{H'}{H_{max}}$$

where $H_{max} = \log S$ and S = species richness.

Dominance was calculated according to the Simpson's index:

$$D = \sum pi^2$$

where p*i*=the proportion of individuals for the ith species. This index is weighted towards the abundance of the commonest species rather than providing a measure of species richness, thus it is influenced by the most abundant species in the sample.

Since replicate samples were taken on a seasonal basis in each of the study area and the estimates of diversity were normally distributed, analysis of variance were used to test for significant differences in the diversity of different depth zones and seasons.

National Statistical Service of Greece (NSSG) data

The NSSG keeps records of the fishery production and the yearly number of registered fishing vessels. This information is included in annual bulletins issued by the above service since 1964. The data on vessels are provided by the port authorities and the patrolling services and are arranged in gross-tonnage and horsepower units, by fishing area and by type of gear used. The data on production refer to the annual catch by species and fishing gear, catch by species and month of fishing, and catch by species and fishing area. This information is derived by grouping together the inventories on statistical questionnaires, completed each month by the captains of vessels, with engine power higher than or equal to 20HP, unless the ship did not operate. Discards and by-catches are not monitored.

Due to difficulties in obtaining returns from all vessels, a random sampling method was adopted for the process of the collected returns, assuming that the latter constitute a representative sample of the vessel fleet. Since the information on the catches is provided exclusively by the fishermen, and the accuracy of their statements cannot be evaluated, the available data are considered to be either of low reliability, or incomplete. Another weakness of the method is that by grouping the data of vessels and production, some of the original information is lost, because it is not possible to recalculate combined parameters, for example catch by fishing area and type of year used.

Two independent surveys, conducted under the framework of the «Annual Agricultural Livestock Survey» provide fisheries information on motorized fishing vessels ≤19 HP and rowing boats, professional fishermen.

Fisheries Development Company S.A. (ETANAL)

The Fisheries Development Company is a non-profit organization under state control. It was founded by two national credit bodies (Agricultural Bank of Greece and ETBA, the former being the main shareholder) for the purpose of undertaken activities that would promote the development of fisheries. ETANAL is the official authority for managing the ten official port-markets in Greece, and is legally obliged to keep administrative statistics on the landings transacted through these markets and make them available to interested bodies. In accordance with this obligation, ETANAL has adopted an administrative system (as opposed to a statistical survey system) for data collection which based on direct measurement of the landings transacted through the fishing port-markets. This system is associated with some steps of the auctioning operation (estimation of transacted landings and values appearing in the invoices, clearence documents and dispatching notes which accompany the auctioning transactions).

ETANAL has provided the general framework and methodology of the system of measurements of landings in the fishing port-markets but is not directly involved in the collection and processing of the data. This is the responsibility of the individual fishing port-markets which have their own administration. ETANAL simply acts as a coordinating body.
Data are obtained on a daily basis by recording the quantities and prices of the transacted products. Data collection started in 1969 and initially covered only six port-markets. Gradually, with the addition of new fishing port-markets, the data collection network was extended, and it now covers 10 fishing ports.

Results and discussion

Catch composition

The fish catch composition of the two depth zones (300-400 m and >400 m) was estimated for the North Aegean Sea, the Thracian Sea and the Ionian Sea. The cephalopod catch composition was estimated for the North Aegean Sea and the Thracian Sea. The percentage of participation was estimated separately for the nine most abundant species. The percentage of all the remaining species was grouped as "other".

<u>Fish catch composition</u>

In all the three areas, two non commercial species, *Gadiculus argenteus argenteus* and *Hymenocephalus italicus* consisted the most important part of the catch. In the zone of 300-400 m of the North Aegean Sea, *Gadiculus argenteus argenteus* was dominant in the catch representing the 37.7%, and it was followed by *Micromesistius poutassou* (16.25%), *Argentina sphyraena* (9.68%), *Coelorhynchus coelorhynchus* (8.26%), *Hymenocephalus italicus* (8%), *Lepidorhombus boscii* (5.9%), *Merluccius merluccius* (5,02%), *Trigla lyra* (1.22%) and *Nezumia sclerorhynchus* (1.15%). All the others represented 6.78% of the total fish catch (Fig. 3a).

In deep waters (>400 m) *Hymenocephalus italicus* was the most important in the catch representing 37.18% by number, and it was followed by *Coelorhynchus coelorhynchus* (14.08%), *Lepidorhombus boscii* (8.97%), *Gadiculus argenteus argenteus* (7.91%), *Nezumia sclerorhynchus* (5.23%), *Micromesistius poutassou* (3.83%), *Phycis blennoides* (3.32%), *Argentina sphyraena* (3.06%) and *Chlorophthalmus agassizi* (2.82%). All the others contributed to the total catch in fish by 13.54% (Fig. 3b).

In the Thracian Sea (zone of 300-400 m) the catch differed from that of the North Aegean Sea. Here the dominant species was *Hymenocephalus italicus* (38.74%) followed by *Gadiculus argenteus argenteus* which represented 24.52%. *Micromesistius poutassou* representing 14.01% of the catch, *Lepidorhombus boscii* (7.06%), *Coelorhynchus coelorhynchus* (3.35%), *Argentina sphyraena* (2.87%), *Phycis blennoides* (2.49%), Lophius budegassa (1.5%) and *Merluccius merluccius* (0.83%). All the others represented the 4.61% of the total catch (Fig. 3c).

In deep waters (>400 m) *Hymenocephalus italicus* was again the most important catch in terms of numbers (51.66%), followed by *Micromesistius poutassou* (26.1%), *Coelorhynchus coelorhynchus* (4.43%), *Etmopterus spinax* (4.22%), *Hoplostethus mediterraneus* (3.15%), *Gadiculus argenteus argenteus* (1.95%), *Lepidorhombus boscii* (1.87%), *Phycis blennoides* (1.84%) and *Chimaera monstrosa* (1.52%). The rest of the catch represented only 3.21% (Fig. 3d).

In the zone of 300-400 m of the Ionian Sea, in the zone of 300-400 m, *Gadiculus argenteus argenteus* represented 83.31%, and it was followed by *Argentina sphyraena* (3.42%), *Lepidorhombus boscii* (2.49%), *Coelorhynchus coelorhynchus* (2.02%), *Micromesistius poutassou* (1.86%), *Merluccius merluccius* (1.39%), *Chlorophthalmus agassizi* (1.01%) and *Gobius spp*. (0,69%). All the others represented only the 2.71% of the total fish catch (Fig. 3e).

Cephalopod catch composition

In the zone 300-400 m at the North Aegean Sea, in the zone 300-400 m, the not classified *Sepiolidae* represented, in terms of number, 32.66% of the cephalopod catch. It was followed by *Illex coindetii* (17.64%), *Eledone cirrhosa* (15.94%), *Octopus salutii* (7.37%), *Eledone moschata* (5.83%), *Sepia orbignyana* (5.79%), *Loligo vulgaris* (4.41%), *Sepia elegans* (2.62%) and *Loligo forbesii* (2.47%). All the others represented the 5.29% of the total catch of cephalopods (Fig. 4a).

In deep waters (>400 m) *Eledone cirrhosa* and *Bathypolypus sponsalis* were the dominant species representing 29.94% and 27.85% respectively, and they were followed by the not classified *Sepiolidae* (15.7%), *Octopus salutii* (11.77%), *Todarodes sagittatus* (5.51%), not classified cephalopods (5.21%), *Eledone moschata* (1.49%), *Alloteuthis media* (1.49%) and *Rossia macrosoma* (0.6%) (Fig. 4b).

In the Thracian Sea (zone of 300-400 m), *Sepiolidae* were dominant (46.18%) followed by *Bathypolypus sponsalis* (21.38%), *Illex coindetii* (11.79%), *Octopus salutii* (9.01%), *Eledone cirrhosa* (4.37%), *Todarodes sagittatus* (3.6%), *Alloteuthis media* (1.01%), *Todaropsis eblanae* (0.8%) and *Sepia orbignyana* (0.49%). The others represented the 1.37% of the cephalopod catch (Fig. 4c).

In deep waters (>400 m) *Sepiolidae* represented 39.34%, followed by *Bathypolypus sponsalis* (31.15%), *Todarodes sagittatus* (26.23%) and *Octopus salutii* (3.28%) (Fig. 4d).

In the Ionian Sea the cephalopods which were caught were not classified.

Bathymetrical distribution of the most abundant species

The logarithms of the number of individuals and per species per station were plotted against the depth in order to examine the bathymetrical distribution of the most abundant species, separately for each sampling area. In addition the frequency of occurrence was estimated as the percentage of the stations where the species occur.

Merluccius merluccius (Fig. 5)

The species was fished in almost all stations of the three areas. It was found in both depth zones. Higher numbers of hake were caught in the first depth zone. A decreasing trend in the abundance was observed with depth. Comparing the three areas the abundance was lower in the Thracian Sea. The highest frequency of occurrence of the species was observed in the depth zone 300-400 m of the North Aegean (100%).

Gadiculus argenteus argenteus (Fig. 5)

The species was one of the most abundant in these depths. The highest abundance of the species was found in the depth zone 300-400 m at the Ionian Sea. The highest frequency of occurrence of the species was found in the Thracian Sea in both depth zones (100% in 300-400 m and 67% in >400 m). In the North Aegean the frequency of occurrence presented the lowest values (87% and 58% in the first and second depth zone) respectively.

Micromesistious poutassou (Fig. 5)

The species was fished in many stations at the three areas. It was found in both depth zones. The highest number of individuals was caught in the 300-400 m depth zone. The abundance was decreasing with depth in the North Aegean, but not in the other two areas. The highest frequency of occurrence of the species was found in the North Aegean (93% in 300-400 m and 83% in >400 m depth zone), whereas in the other two areas it was lower (90% and 67% in the Thracian Sea and 75% in the Ionian Sea).

Argentina sphyraena(Fig. 6)

The number of fish was decreasing with depth in all the areas. The abundance was lower in the Thracian Sea than in the other two areas for both depth zones. The highest frequency of occurrence in the 300-400 m depth zone was observed in the Ionian Sea (93%) and the lowest in the Thracian Sea (76%). In the zone >400 m, the frequency of occurrence was quite low (about 42% in the North Aegean and null in the Thracian Sea).

*Coelorhynchus coelorhynchus (*Fig. 6)

It was caught in both depth zones in nearly equal abundance. Comparing the three areas, it was lowest in the Thracian Sea for both depth zones. The highest frequency of occurrence of the species was found in depths >400 m. Comparing the three areas, it was highest in both depth zones of the Thracian Sea (86% and 100% for the first and the second depth zone, respectively) and lowest in the Ionian Sea (64%).

Hymenocephalus italicus (Fig. 6)

The highest number of individuals per station was quite similar for both depth zones. Comparing the three areas, the abundance of the species was lowest in the Ionian Sea. The frequency of occurrence of the species was almost similar in both depth zones (about 75% in the North Aegean and 100% in the Thracian Sea for both depth zones).

Lepidorhombus boscii (Fig 7)

The species was more abundant in the first depth zone (300-400 m). The number of fish was decreasing in the deeper waters of the North Aegean and the Thracian Sea. Generally, the number of fish was lower in the Ionian Sea. The frequency of occurrence in the depth zone 300-400 m was high in both the North Aegean and the Thracian Sea (100%), whereas it was low in the Ionian Sea (46%). For the second depth zone, it was highest in the North Aegean Sea (83%).

Trigla lyra (Fig. 7)

The highest value of the number of individuals per station was found to be similar for both depth zones in the North Aegean. However, in the other two areas the general trend was a decrease with depth. Moreover, in the Thracian Sea the species was absent from the second depth zone. The highest frequency of occurrence was observed in the 300-400 m depth zone.

Comparing the three areas, it was highest in the North Aegean (85% in 300-400 m and 42% in >400 m) and lowest in the Thracian Sea (62% in 300-400 m and null in >400 m).

Nezumia sclerorhynchus (Fig. 7)

The species was not caught in the Ionian Sea but it was found in both depth zones in the other two areas. The highest value of individuals per station was found in the 300-400 m depth zone. Comparing the three areas for this depth zone, the species was more abundant in the North Aegean. The highest frequency of occurrence of the species was found in depths >400 m (67% in the North Aegean and 33% in the Thracian Sea). In the 300-400 m depth zone the frequency of occurrence was very low (~14%) in both areas.

Chlorophthalmus agassizi (Fig. 8)

The highest value for the number of individuals of this species per station was found to be quite similar for both depth zones in the North Aegean. However, in the Thracian Sea the species was absent from the second depth zone. The highest frequency of occurrence of the species was found in the first depth zone. It was about 55% in the three areas. For the depths >400m, its abundance was quite low in the North Aegean (33%) and null in the Thracian Sea.

Phycis blennoides (Fig. 8)

The species was generally fished in low abundance in almost all the stations of the three areas. The highest number of individuals per station was very similar in both depth zones. Comparing the three areas, for the depth zone 300-400 m, the highest number of individuals per station was found in the Thracian, whereas for the second depth zone the highest number of individuals per station in the North Aegean. The frequency of occurrence of the species was similar in the North Aegean and the Thracian Sea for both depth zones (about 90% for 300-400 m and 96% for >400 m). It was lower in ION (79% in the first depth zone).

Chimaera monstrosa (Fig. 8)

This species was not fished in the Ionian Sea. It was found in both depth zones at the North Aegean and the Thracian Sea. Generally, it presented very low abundance. The highest number of individuals per station was quite similar in both depth zones. Comparing the two areas, the highest values were found in the second depth zone at the North Aegean and in the first one of the Thracian Sea. The highest frequency of occurrence of the species was found in depths >400 m in both the North Aegean (67%) and the Thrasian Sea (67%). For the first depth zone its frequency of occurrence was found quite low in both areas (17% and 29% for the North Aegean and the Thracian Sea respectively).

Etmopterus spinax (Fig. 9)

This species was fished in few stations of the North Aegean and the Thracian Sea and it was not fished at all in the Ionian Sea. It was found in both depth zones. The highest value for the number of individuals per station in the North Aegean was found in the first depth zone, whereas in the Thracian Sea the highest value was observed in the second zone. The highest frequency of occurrence of the species was found in depths >400 m for both the North Aegean (50%) and the Thracian Sea (33%). For the first depth zone, its frequency of occurrence was found quite low (about 20%) in both areas.

Lophius budegassa (Fig. 9)

This species was fished in many stations of all the three areas. It was found in both depth zones. Generally, it presented low abundance. The highest value for the number of individuals per station was found to be quite similar for both depth zones in the North Aegean. However, in the Thracian Sea it was higher in the first depth zone. Comparing the three areas, for the first depth zone, the frequency of occurrence of the species was found to be similar in the North Aegean and the Thracian Sea (~90%) and it was lower in the Ionian Sea (~61%). For the second depth zone, its frequency of occurrence was higher in the North Agean (92%) than in the Thracian Sea (97%).

Length distribution of *Merluccius merluccius*

The European hake, *Merluccius merluccius* L., 1758, is a gadoid species distributed throughout the Mediterranean Sea and in the Atlantic Ocean from Iceland to Morocco (Whitehead et al., 1986), occurring at depths from shallow waters to 1000 m. It ranks among the commercially most important demersal species in the Mediterranean Sea.

The biology of hake has been extensively studied in the western Mediterranean Sea but this is not the case for the eastern Mediterranean, where most information is derived from the Hellenic Seas in which the biology, feeding ecology and dynamics of hake have been intensively studied in the last decade. Hake is a very common, and one of the most valuable foodfish in the Greek seas; its annual catch, between 1990-1995, amounted to about 3.000-6.500 t (Papaconstantinou and Stergiou, 1995). Although considerable research has been devoted to the study of the biology of hake in the Greek seas (Yannopoulos, 1977; Papaconstantinou and Caragitsou, 1987, 1994, Papaconstantinou and Stergiou 1988; Papaconstantinou et al. 1988, 1993), certain questions have arisen concerning the seasonal migration and oscillation in abundance of 0 and I+ age groups. In general, it has been found that the abundance of the 0-age group hake declines abruptly between September and early November in areas considered to be nursery grounds, as compared with areas where mature hake predominate where the decline of the abundance is not pronounced. Hake in the Italian Ionian Sea and in the Adriatic Sea extends is found down to 1000 m where it is caught with longlines; however, it is mainly abundant at depths ranging from 100 to 300 m (Zupanovic and Jardas, 1986). In the Greek Seas it is fished down to 550 m depth but its abundance is higher at depths of 100-300 m (Papaconstantinou et al. 1988, 1993). However, this probably is not the lower bathymetric limit inasmuch as Hellenic trawlers do not operate at depths > 470-530 m.

<u>Northern Aegean Sea</u>

Hake was fished in the North Aegean Sea between 25 and 550 m, whilst the lengths of the individuals caught range from 52 to 635 mm. The seasonal length frequency distribution in relation to depth was different in the study area, corroborating the view that hake undertakes migrations in the different depth zones. A shift of larger fish towards greater depths is apparent, since most of the specimens larger than 300 mm were caught at depths > 300 m. This trend was more pronounced in areas where sites with relatively greater depths were sampled.

The length-frequency polygons reveal several modes. Young-of-the-year were distributed in different depth zones during the two years of the study (summer 1990-spring 1992). At depths > 400 m, they appear in the trawlable fishing grounds for the first time in June 1990, when their length varied from 50-140 mm (Fig. 10). It is clear that the young-of-the-year migrate from deeper waters (> 400 m) to shallower depths during autumn and winter 1990. A delay of the recruitment was observed during 1991, when the recruits appeared in autumn at both zones comparing to 1990, when they appeared in summer.

For both years the dominant 0-group in summer 1990 and autumn 1991 was easily followed from September 1990 (95-145 mm) and November-December 1991 (110-185 mm) respectively, to November-December 1990 (110-170 mm) and March 1992 (125-230 mm), and to the following June 1991 (140-230 mm). The shift towards even greater lengths was more obvious in spring which coincided with the period of rapid growth in hake, comparing to winter.

Ionian Sea

In the Ionian Sea hake was found at depths down to 320 m. However it is possible that this is not the bathymetric limit in this area, since no samples were taken at greater depths. From the seasonal length-frequency distribution it is evident that the peaks in recruits of lengths 60-130 mm appear in the trawl fishery for March to June and in September-December (Fig. 11). The occurrence of juveniles in the catches throughout the year provides very strong evidence that hake in the Ionian Sea has a protracted spawning period.

Papaconstantinou et al. (1988) reported that there are two different stocks of hake that migrate to the spawning grounds in the Patraikos Gulf and in the deeper waters of the Ionian Sea. However, the juveniles from both areas are mixed at depths > 300 m; hence no clear seasonal trends in length distribution are noticed. In general juveniles between 50-80 mm are fully recruited to the bottom trawl fisheries in the Ionian Sea at depths > 300 m, whereas the majority of specimens older than one year are concentrated at shallower waters. The observed mean length at age I ranges from 280 to 211 mm (Papaconstantinou et al. 1988); therefore more than 92% of the catches at the depth range examined were specimens less than one year old.

Thracian Sea

The seasonal length-frequency distribution of hake in the Thracian Sea shows a length range in the catches of 50 to 730 mm (Fig. 12). However, the majority of the specimens caught (95%) does not exceed 300 mm. Hake was found to occur at depths between 25 to 450 m, with large individuals generally encountered in depths greater than 300 m. Juveniles are fully recruited to the bottom trawl fisheries at depths < 300 m, whereas the majority of older specimens are concentrated at deeper waters. This distribution pattern is not in agreement with those observed in the Aegean and Ionian Sea. In autumn, the juveniles of 70-140 mm length appear in the trawlable fishing grounds at depths of 300-400 m. However they migrate to shallower waters (< 300 m) and decline progressively thereafter. It could be concluded that older specimens predominated in depths greater than 300 m at this area.

Length distribution of *Trigla lyra*

The piper (*Trygla lyra* L., 1758) is distributed in the Mediterranean and in the Eastern Atlantic, from the West coasts of the British Isles to the Gulf of Guinea (Whitehead et al. 1986). It is commercially the most important triglid species in Greek waters and it is generally found over soft substrates at depths between 150 and 450 m. Papaconstantinou (1981, 1983) and Caragitsou and Papaconstantinou (1994) studied the age, growth, diet and distribution of piper in the Saronikos Gulf, while Tsimenides et al. (1991, 1992) examined its bathymetrical distribution on the Cretan shelf. The length frequency distribution of piper in the Saronikos Gulf revealed that young specimens tended to inhabit greater depths. Young specimens were generally found in depths between 300-400 m, while larger ones were usually caught at depths < 300 m. The distribution patterns of piper on the Cretan shelf suggest that it inhabits almost exclusively depths > 160 m in all seasons. However, in spring it shows a relatively high concentration, particularly in terms of biomass at the shallowest limits of its distribution. The spring movement towards shallower waters could be associated with the spawning activities of the species.

Northern Aegean Sea

The seasonal length-frequency distribution of piper in the Northern Aegean Sea shows a length range in the catches of 40 to 475 mm (Fig. 13). From autumn to spring specimens between 40 and 85 mm predominated in the catches. It is interesting to note that during autumn and winter, although mean length was similar in both zones, smaller individuals predominated in the deeper waters. The opposite is true in spring, when specimens > 70 mm length clearly dominated the catches in the shallow zone. Furthermore, in spring this species shows a relatively high concentration in terms of abundance at this depth range. A similar pattern appears during summer; however in this case larger specimens (110-175 mm) were present in the shallower zone.

Ionian Sea

The seasonal length-frequency distribution of piper in the Ionian Sea shows a length range in the catches of 55 to 385 mm (Fig. 14). Although the abundance of piper in this area was low throughout the sampling period due to the small number of stations sampled at depths greater than 300 m, some general trends in the distribution patterns are evident. In summer specimens between 175 and 280 mm length predominated the catches, whereas in autumn and spring a shift towards larger specimens is observed.

Length distribution of *Lophius budegassa*

The black-bellied angler fish (*Lophius budegassa*, Spinola, 1807) is a benthic species and its bathymetric distribution extends from shallow waters down to 800 m. The black-bellied angler fish is distributed in the Mediterranean and in the Atlantic, from the coasts of the British Isles down to Senegal (Whitehead et al. 1986). It is one species of considerable and growing commercial importance in European and Greek waters (Tsimenides, 1980; Afonso-Dias and Hislop, 1996). However, little has been published on the biology of this species. Tsimenides (1980, 1984) has studied the age and growth of black-bellied angler fish in Greek waters. He concluded that females are comparatively longer than males after age I and have longer life span. The highest annual growth for both sexes occurred in the first year of life.

Northern Aegean Sea

The seasonal length-frequency distribution of black-bellied angler fish in the Northern Aegean Sea shows a length range in the catches of 50 to 630 mm (Fig. 15). In autumn, winter and summer small specimens (50-110 mm) predominated the catches of the shallower zone. The number of specimens caught in depths > 400 m was comparatively low. However, in autumn 1991 abundance was higher in deeper waters, whereas specimens with lengths from 70 to 530 mm were caught. In spring a wider size range appeared in the catches but the majority of the specimens were found in shallower zone.

Ionian Sea

The seasonal length-frequency distribution of black-bellied angler fish in the Ionian Sea shows a length range in the catches of 110 to 490 mm (Fig. 16). The number of specimens caught was very low. However, during spring larger individuals were found.

Thracian Sea

The seasonal length-frequency distribution of black-bellied angler fish in the Thracian Sea shows a length range in the catches of 50 to 570 mm (Fig. 17). The distribution pattern was similar to that observed in the Northern Aegean Sea. Small individuals (70-110 mm length) predominated in the catches from summer to winter, while in spring a shift towards larger fish is evident. Since the number of stations in the deeper zone was very low, no clear pattern of length-frequency distribution could be established.

Length distribution of *Micromesistious poutassou*

The blue whiting *Micromesistious poutassou* (Risso, 1826), is a mesopelagic species that occurs from the eastern Atlantic to the Mediterranean Sea (Fisher et al. 1987). It is generally found at depths from 150 to 600 m, but it is most abundant between 200-400 m. Even though the blue whiting is very abundant in the Greek Seas it is of low commercial importance (Papaconstantinou et al. 1993).

<u>Northern Aegean Sea</u>

The blue whiting was found to occur down to 369 m depth, but it was very rare in the trawl catches at the depth range of 300-400 m where it was caught only during autumn 1990 (Fig. 18). The length frequency distribution in autumn 1990 revealed two modes: specimens of 100 mm and 175 mm predominated in the catches, whereas the maximum length of the specimens appeared was 300 mm.

<u>Ionian Sea</u>

The blue whiting in the Ionian Sea was found at depths down to 361 m and, in general, it was relatively abundant during all seasons. The seasonal length distribution of the blue whiting shows a length range in the catches of 125 to 475 mm (Fig. 19). The length-frequency distribution was quite similar throughout the sampling period, with specimens of 200-250 mm to predominate the catches in each season. Furthermore, specimens larger than 300 mm were present only in spring 1985.

<u>Thracian Sea</u>

The blue whiting in the Thracian Sea was found at depths down to 416 m, but it was more abundant at depth 300-400 m (Fig. 20). The species was present at depths > 400 m only during autumn and at this season the largest specimens predominated in the deepest zone. The seasonal length-frequency distribution revealed that the length range in the catches was restricted between 150 to 250 mm. The length-frequency polygons revealed only one mode ranging from 150 to 200 mm. In spring 1993 a few larger specimens (320-380 mm) were present at depth between 300-400 m.

Length distribution of *Phycis blennoides*

The greater forkbeard *Phycis blennoides* (Brünnich, 1768) is a gadoid fish widely distributed in the north-eastern Atlantic, from the Scottish waters (Davis and Edwards, 1988), Norway and Island (Tortonese, 1975) to the coast of Moroco. In the Mediterranean it is common at depths between 60-700 m (Fisher et al. 1987). In general only few studies on the biology of this species are available in the literature, while no information exists on the biology of the species in the Greek waters, probably because is of low commercial importance at least in Greek markets.

<u>Northern Aegean Sea</u>

The great forkbeard in the Northern Aegean Sea was found up to 490 m depth. The majority of the specimens were caught between 300-400 m, although they were present at depths below 400 m during all seasons (Fig. 21). The seasonal length-frequency distribution of great forkbeard shows a length range in the catches of 70 to 425 mm, while larger individuals generally encountered in depths greater than 400 m. Juveniles are recruited to the bottom trawl fisheries at both depth zones in summer and autumn, and they migrate to deeper waters in winter and spring. However, large specimens are still present in the shallower zone, thus no clear separation with fish size in the depth zones examined can be established.

Ionian Sea

The great forkbeard in the Ionian Sea was found at depths down to 361 m. The number of specimens caught was very low and their lengths ranged from 60 to 325 mm (Fig. 22). The seasonal length-frequency distribution revealed that during summer and autumn small specimens predominated the catches, while in spring larger individuals were found.

Length distribution of *Lepidorhombus boscii*

The four-spotted mergim *Lepidorhombus boscii* (Risso, 1810) is distributed in the Mediterranean Sea and in the Eastern part of the Atlantic from the British Isles to Angola and it is found mainly at depths between 100 and 400 m (Bauchot, 1987). There are only few studies on the biology of this species in the Atlantic and the Mediterranean Sea (Bello & Rizzi, 1987, Ungaro & Marano 1995, Vassilopoulou 1994), although the four-spotted mergim is a commercially important component of the trawl catches in the areas of its distribution. In the eastern Mediterranean, it constitutes a significant component of the trawl fisheries (Papaconstantinou et al. 1993), and it is the subject of an important fishery exploitation especially in the north Aegean Sea where it made up 3.5% by number of the total 1990-1992 trawl catches (Papaconstantinou et al. 1993).

Northern Aegean Sea

The seasonal length-frequency distribution of the four-spotted mergim in the Northern Aegean Sea, at depths below 300 m, shows a length range in the catches of 50 to 340 mm (Fig. 23). The majority of the specimens were caught in depths between 300 to 400 m during all seasons, with the exception of winter 1991 when the highest abundance of the species was found at depths > 400 m. In summer and winter 1990 and spring 1991 smaller specimens (50-80 mm) predominated the catches of the deepest zone. During the rest of the seasons examined, the length frequency distribution of the species does not differ between the two depth zones, although in summer 1991 and in spring 1992 there was a tendency for larger specimens to be found in depths > 400 m. However, the number of specimens caught in depths > 400 m was comparatively low.

Ionian Sea

The four-spotted mergim was very rare in the trawl catches of the Ionian Sea, since it was found only during the summer and autumn 1983. However, the number of specimens caught was very low in both seasons. The seasonal length-frequency distribution of the four-spotted mergim in the Ionian Sea shows a length range in the catches of 120 to 340 mm (Fig. 24), with the largest individuals present during the autumn.

Thracian Sea

The four-spotted mergim was very rare in the trawl catches of the Thracian Sea, since it was found only during the winter 1992 and autumn 1993. The species was present only in the depth range between 300 to 400 m, but the number of specimens caught was very low in winter 1992. The seasonal length-frequency distribution of the four-spotted mergim in the Thracian Sea shows a length range in the catches of 50 to 310 mm (Fig. 25). The smallest specimens (50-150 mm) however were caught in autumn 1993.

Length distribution of *Pagellus bogaraveo*

The blackspot seabream Pagellus bogaraveo (Brünnich, 1768) is a demersal sparid species which occurs along the continental shelf and slope of the Eastern Atlantic Ocean from

Norway to the Canaries and the Mediterranean Sea (Fisher et al. 1987). It is common in rocky, sandy and muddy bottoms down to 800 m, but the juveniles are usually found in inshore waters. Longline and handline represent the most important fisheries for this species catches, but the juveniles are often caught by demersal trawls. From a commercial point of view, blackspot seabream is very important demersal species, although it is considered as a very rare species in the eastern Mediterranean. Published information on blackspot seabream includes some notes on age and growth (Ramos and Cendrero 1967, Sanchez 1983, Krug 1989) and reproduction (Sanchez 1983, Krug 1990).

Ionian Sea

The blackspot seabream in the Ionian Sea was found exclusively at the depth zone of 300-400 m. The seasonal length-frequency distribution shows a length range in the catches of 90 to 125 mm (Fig. 26). This pattern was consistent throughout the sampling period indicating that only small specimens of this species are caught by trawling. Since the length of the specimens found in the study area was restricted to a very narrow range, no conclusions on the trends in the distribution pattern of the species could be inferred.

Thracian Sea

The blackspot seabream in the Thracian Sea was found only during spring and summer 1993, and occurred solely in the depth zone of 300-400 m (Fig. 27). However, the abundance of this species was very low at both seasons, while the lengths of the specimens caught were between 125-175 mm. Therefore, it is not possible to establish any trend of the distribution pattern of this species in the study area.

Depth patterns in abundance and species diversity

A total of 119 fish species, 25 crustacean species and 26 cephalopod species were collected from 717 trawls. The faunistic composition of frequency of occurrence by species in each area is given in table 1.

Northern Aegean Sea

A total of 215 stations were sampled on a seasonal basis between Summer 1990 and Spring 1992. 59 trawls were taken at depths <100 m, 93 at depths between 100 and 300 m and 63 at depths greater than 300 m. The composition of the catches for each depth interval revealed that 109 species were found at depths <100 m, 136 species between 100 and 300 m and 109 at depths >300 m.

The depth-gradient characteristics of species diversity are given in table 2. Overall species richness was the highest at depths < 100 m, evenness and diversity exhibited their highest values at depths between 100-300 m where dominance was the lowest.

On a seasonal basis, species richness, was found to be the highest at depths < 100 m and significantly decreased at depths below 100 m. On the contrary no clear trend of dominance was found between the depth zones examined, but in general it decreased at depths between 100-300 m and slightly increased at depths > 300 m. Although species richness did not change considerably with depth, species evenness and diversity decreases with depth getting their lowest values at depths > 300 m.

ANOVA tests revealed that the effect of both season and depth on species richness and diversity measurements was always significant (P< 0.000). In general the seasonal trends observed were rather similar with those described for the overall diversity characteristics of the community in the study area.

The faunistic composition of abundance, by species, for each depth zone is given in table 3. *Mullus barbatus* and *Serranus hepatus* were among the dominant species at depths <100 m, as were *Gadiculus argenteus*, *Hymenocephalus italicus* and *Nephrops norvegicus* in the bathymetric range deeper than 300 m. At intermediate depths, between 100 and 300 m, *Argentina sphyraena*, *Gadiculus argenteus*, *Capros aper* and *Merluccius merluccius* were among the dominant species.

Ionian Sea

A total of 216 stations were sampled on a seasonal basis between Summer 1983-Summer 1985 in the Ionian Sea. 117 trawls were taken at depths <100 m, 71 at depths between 100 and 300 m whereas 28 at depths greater than 300 m. The composition of the catches for each depth interval revealed that 107 species were found at depths <100 m, 99 species between 100 and 300 m and 66 at depths >300 m.

The depth-gradient characteristics of species diversity are given in table 4. Overall species richness, evenness and diversity were found to be the highest at depths <100 m, where species dominance is the lowest. On the contrary species dominance was the highest at depths >300 m, while species richness, evenness and diversity at these depths are the lowest, due to the dominance (83.65 %) of *Gadiculus argenteus* in the catches.
On a seasonal basis, species richness, evenness and diversity were found to be the highest at depths <100 m and significantly decreased at depths below 300 m. On the contrary species dominance was the lowest at these depths and significantly increased at depths >100 m.

ANOVA tests revealed that the effect of both season and depth on species richness and diversity measurements was always significant (P< 0.000). In general the seasonal trends observed are rather similar with those described for the overall diversity characteristics of the community in the study area.

The faunistic composition of abundance, by species, for each depth zone is given in table 5. *Merluccius merluccius*, *Spicara flexuosa* and *Mullus barbatus* were among the dominant species at depths <100 m, as were *Gadiculus argenteus* species in the bathymetric range deeper than 300 m. At intermediate depths, between 100 and 300 m, *Gadiculus argenteus* and *Merluccius merluccius* were among the dominant species.

Thracian Sea

A total of 286 stations were sampled in the Thracian Sea on a seasonal basis between Autumn 1991 and Autumn 1993. 183 trawls were taken at depths <100 m, 79 at depths between 100 and 300 m whereas 24 at depths greater than 300 m. The composition of the catches for each depth interval revealed that 158 species were found at depths <100 m, 121 species between 100 and 300 m and 81 at depths >300 m.

The depth-gradient characteristics of species diversity are given in table 6. Overall species richness, evenness and diversity were the highest at depths <100 m, where species dominance is the lowest. On the contrary species dominance is the highest at depths >300 m, while species richness, evenness and diversity at these depths are the lowest.
On a seasonal basis, species richness, evenness and diversity were found to be the highest at depths <100 m and significantly decreased at depths below 100 m. On the contrary species dominance was the lowest at these depths and significantly increased at depths >100 m.

ANOVA tests revealed that the effect of both season and depth on species richness and diversity measurements was always significant (P< 0.000). In general the seasonal trends observed are rather similar with those described for the overall diversity characteristics of the community in the study area.

The faunistic composition of abundance, by species, for each depth zone is given in table 7. *Serranus hepatus*, *Trisopterus minutus capelanus* and *Mullus barbatus* were among the dominant species at depths <100 m, as were *Hymenocephalus italicus*, *Gadiculus argenteus* and *Micromesistius poutassou* in the bathymetric range deeper than 300 m. At intermediate depths, between 100 and 300 m, *Micromesistius poutassou*, *Gadiculus argenteus* and *Trisopterus minutus capelanus* were among the dominant species.

Landings data analysis

The analysis of catch statistics data on *P. americanus, L. budegassa* and *M. poutassou* collected by the NSSG from 1991 till 1996 is presented below. This study will provide in a simple way: (a) the geographical distribution of catch data per species in all 18 fishing areas, where the Greek marine territory is divided according to NSSG (fishing sub-areas 1 and 2, that not shown in the Figure, refer to the Atlantic Ocean and the north coast of Africa, respectively)(Fig. 28), and (b) the monthly variation of the catches in all species per sub-area from 1991 till 1996. The official port-markets where the ETANAL is collected data showed in the Figure 28.

<u>Geographical distribution of catch data.</u>

Lophius budegassa (black-bellied angler)

Catches of the species exhibited maxima in the Thermaikos and the Thracian Sea during the whole period of the survey, while decreased production appeared in the Ionian-Patraikos, in the Euboean, in the Pagassitikos and in the Argosaronikos Gulf (Fig. 29). These areas are close to fishing grounds that are characterized by sandy bottoms, extended continental shelf and appropriate depth for the distribution of the species. The fact that there are large cities in the vicinity products, does not seem to affect the determination of the catches by the NSSG, since the latter is based on data from all landing sites and not only from the main fishing ports (ACS, 1994). Annual fluctuations of the catches were rather limited, except in the Thermaikos Gulf and Thracian Sea. In the Pagassitikos the catches doubled in 1996. The fact that the NSSG data are in close relations with the actual catches of the species in the various areas suggests that the fluctuation of the catches constitute a good reflection of the fluctuation of the abundance of the species' stock.

Micromesistious poutassou (blue whiting)

This species presents the highest fishing production in the Thracian Sea and then in the Euboean Gulf and the Ionian Sea and in the Patraikos Gulf (Fig. 30). A considerable fluctuation of the abundance appeared in the above areas from 1991 to 1996. Lower abundance values were displayed in the Cyclades, the Saronikos Gulf and the W. Aegean Sea. The blue whiting exhibits low commercial value and thus the landed yield is in direct relation with the fluctuations of the commercial part of the total catches rather, than the true condition of the fish stock.

Polyprion americanus (Wreckfish)

The species presents the highest production value in the Thracian Sea (Fig. 31). Then production values follow a decreasing course in the Ionian Sea, the Patraikos, the Pagassitikos, the Saronikos and the Thermaikos Gulf. This species is mainly caught using long-lines, thus a lot of information appears to be lost in the way making the reliability of the existing data rather low.

Monthly variation in landings

The analysis of the monthly data concerning the landings in all fish markets shows that the variation in the catches for each species depends on the fishing gear used. Thus black-bellied angler fish and blue whiting, which are fished mainly by otter trawl, are almost absent from the landings between June and September because during these months commercial trawling activities are not allowed in Greek waters.

Black-bellied angler fish

The landings of black-bellied angler fish in each month do not vary considerably during the first semester of each year, but they are much higher in October (Fig. 32). This species is caught exclusively by trawling, thus fishing effort does not change considerably during the first half of the year. On the contrary, since the trawling season starts in October, fishing effort appears to be much higher during this month, therefore the landings are getting their highest values in October.

Blue whiting

The landings of blue whiting in the Greek markets by month, appeared to be the highest during the winter with a gradual reduction in spring (Fig. 33). In October the landings are raised but in general are lower than those in the winter. These variations are related to the fact that blue whiting is a mesopelagic species, which is not caught exclusively by trawl due to the vertical migrations off the bottom. It is also possible that fishing effort is different during each month, therefore the fluctuation in the landings reflect the differential fishing effort between different months. There is evidence that blue whiting is found near the bottom during the winter months, therefore it is more abundant in the trawl catches and the landings are the highest.

Wreckfish

Wreckfish in Greek waters is caught by means of both otter trawl and long lines. The landings of this species are very low during summer, probably because there are no trawling activities at this time of the year (Fig. 34). It should also be noted that most of the transacted quantities of this species through the fish markets during the summer are imported from Africa. Hence the landings of wreckfish are much more lower than those presented in Fig. ???. The landings of the wreckfish by month appeared to be the highest in spring, lower in the winter, whereas the highest quantities in fall are found in October.

These variations are mainly due to the fact that this species migrate into deeper waters during the winter where no fishing activities are taking place together with the restricted operation of the long lines due to inclement weather at this time of the year.

Geographical variations in landings

Black-bellied angler fish

The variations in the landings for black-bellied angler fish in the different fish markets are related to their distance from the fishing grounds of the species (Fig. 35). Hence the highest quantities are transacted from the fish markets of Thessaloniki, Alexandroupolis and Kavala because are very close to the Thracian Sea and Thermaicos Gulf where this species is very abundant. The transacted quantities from the fish markets of Chalkis and Patras are much lower, while this species is almost absent from the landings of the rest of the fish markets. The fish market of Pireus is an exception since the transacted quantities of the landings are very high because they are gathered from all the fishing grounds around the country. It is important to note that the increasing trend in the landings of the species from 1991 to 1996 is correlated with the increasing demands of the consumers for this species.

Blue whiting

Even though the blue whiting is very abundant in the Greek Seas it is of low commercial importance. The transacted quantities in the fish markets are depended on the demands of the consumers as well as the availability of other fish species in the fish markets. The landings in the fish market of Piraeus are the highest because this market covers the demands of nearly the half of the Greek population (Fig. 36). The absence of this species from the landings in the fish market of Thessaloniki is due to the fact that blue whiting is not found in Thermaicos Gulf. The fluctuations in the landings in the different fish markets are related to their distance from the fishing grounds of the species together with the demands of the consumer for this species. The variations in the landings of blue whiting are not very important for the period 1991-1996 for each of the fish market examined in the present study.

Wreckfish

The majority of the landings for wreckfish is found at the fish market of Pireus, while the quantities transacted in the fish markets of Patras, Kavala, Chalkis and Chios are relatively low (Fig. 37). This geographical patterns is related more to the demands of the consumers than to the distance of a specific fish market from the fishing ground of the species. The fluctuations of the landings are not particularly important during the six years analysed, except from Piraeus where the maximum quantities were found in 1993 and the lowest in 1991.

Dissemination

Conclusion

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Table of contents

Table 1. Faunistic composition (frequency of occurrence) by species in each area.
C: crustaceans, F: Fish, M: Molluscs. +: presence. -: absence.

Species		N. Aegean Sea	Thracian Sea	Ionian Sea	Deep Fisheries
Acanthephyra pelagica	C	-	-	-	+
Aristaeomorpha foliacea	C	-	-	-	+
Aristeus antennatus	C	-	-	-	+
Brachyura (unid.)	C	-	-	-	+
Chlorotocus gracicornis	C	-	-	-	+
Crangonidae (unid.)	C	-	-	-	+
Ligur ensiferus	C	-	-	-	+
Natantia (unid.)	C	-	-	+	-
Nephrops norvegicus	C	+	+	-	+
Parapandalus narval	C	-	-	-	+
Parapenaeus longirostris	C	-	-	-	+
Pasiphaea sivado	C	-	-	-	+
Plesionika acanthonotus	C	-	-	-	+
Plesionika antiyai	C	-	-	-	+
Plesionika edwardsii	C	-	-	-	+
Plesionika gigliolii	C	-	-	-	+
Plesionika heterocarpus	C	-	-	-	+
Plesionika martia	C	-	-	-	+
Polycheles typhlops	C	-	-	-	+
Polychelidae (unid.)	C	-	-	-	+
Processa canaliculata	C	-	-	-	+
Sergestes arcticus	C	-	-	-	+
Sergestes atlanticus	C	-	-	-	+
Sergestes robustus	C	-	-	-	+
Solenocera membranacea	C	-	-	-	+
Argentina sphyraena	F	+	+	+	+
Argyropelecus hemigymnus	F	+	+	+	+
Arnoglossus laterna	F	+	-	+	-
Arnoglossus rueppelli	F	-	-	-	+
Aspitrigla cuculus	F	+	+	+	+
Bellottia apoda	F	+	+	-	+
Boops boops	F	+	-	-	+
Callionymus lyra	F	+	-	-	-
Callionymus maculatus	F	+	+	+	+
Callionymus rissoi	F	-	+	+	-
Capros aper	F	+	+	+	+
Carapus acus	F	+	-	-	-
Centracanthus cirrus	F	+	-	-	+
Centrolophus niger	F	+	-	-	+
Cepola rubescens	F	-	+	-	-
Ceratoscopelus maderen	F	+	-	+	-
Chauliodus sloani	F	+	+	-	+
Chimaera monstrosa	F	+	+	-	+
Chlorophthalmus agassizi	F	+	+	+	+
Chromogobius quadrivit	F	-	-	+	-
Citharus linguatula	F	+	+	+	-
Coelorhynchus coelorhynchus	F	+	+	+	+
Conger conger	F	+	+	+	+
Culiceps gracilis	F	+	-	-	-

Dalatias licha	F	+	-	-	+

Table 1 (continued)

Species		N. Aegean Sea	Thracian Sea	Ionian Sea	Deep Fisheries
Deltentosteus quadrimaculatus	F	-	-	+	-
Dentex macrophthalmus	F	+	-	-	-
Diaphus metopoclampus	F	-	-	-	+
Diaphus rafinesqei	F	-	-	-	+
Engraulis encrasicolus	F	-	+	-	-
Epigonus denticulatus	F	+	-	-	+
Epigonus telescopus	F	+	-	-	+
Etmopterus spinax	F	+	+	-	+
Eutrigla gurnardus	F	+	-	+	-
Gadella maraldi	F	-	-	+	+
Gadiculus argenteus argenteus	F	+	+	+	+
Gaidropsarus sp	F	+	+	+	+
Galeus melastomus	F	+	+	+	+
Gnathophis mystax	F	-	-	+	+
Gobiidae (unid.)	F	+	+	+	+
Helicolenus dactylopterus	F	+	+	+	+
Heptranchias perlo	F	-	-	-	+
Hexanchus griseus	F	+	-	-	+
Hoplostethus mediterraneus	F	+	+	+	+
Hygophum benoiti	F	+	-	-	-
Hymenocephalus italicus	F	+	+	+	+
Labridae (unid.)	F	-	-	*	-
Lampanyctus crocodilus	F	+	+	+	+
Lepadogaster lepadogas	F	-	+	-	-
Lepidopus caudatus	F	+	+	+	+
Lepidorhombus boscii	F	+	+	+	+
Lepidorhombus whiffiagonis	F	+	+	+	+
Lepidotrigla cavillone	F	+	-	+	+
Lepidotrigla dieuzeide	F	+	-	+	+
Lesueurigobius friesii	F	+	-	-	-
Lophius budegassa	F	+	+	+	+
Lophius piscatorius	F	+	+	+	+
Macroramphosus scolopax	F	+	+	+	-
Maurolicus muelleri	F	+	-	-	-
Merlangius merlangus euxinus	F	+	-	-	-
Merluccius merluccius	F	+	+	+	+
Microchirus variegatus	F	-	+	-	-
Micromesistius poutassou	F	+	+	+	+
Microstoma microstoma	F	-	-	+	-
Molva dipterygia macrophthalma	F	+	+	+	+
Mora moro	F	-	-	-	+
Mullus barbatus	F	+	-	+	-
Mullus surmuletus	F	+	-	+	+
Myctophidae (unid.)	F	+	+	+	+
Myctophum punctatum	F	+	-	-	-
Nettastoma melanurum	F	-	+	+	+
Nezumia sclerorhynchus	F	+	+	+	+
Notocanthus bonapartei	F	+	-	-	+

Notoscopelus sp.	F	+	-	-	-
Ophidion rochei	F	-	+	-	-

Table 1 (continued)

Species		N. Aegean Sea	Thracian Sea	Ionian Sea	Deep Fisheries
Ophisurus serpens	F	-	+	-	-
Oxynotus centrina	F	-	-	-	+
Pagellus acarne	F	+	+	+	+
Pagellus bogaraveo	F	+	+	+	+
Pagellus erythrinus	F	-	-	*	-
Paralepis coregonoides	F	-	-	-	+
Peristedion cataphractum	F	+	+	+	+
Phycis blennoides	F	+	+	+	+
Phycis phycis	F	-	-	-	+
Raja asterias	F	+	-	-	-
Raja clavata	F	+	+	+	+
Raja milaretus	F	+	-	+	-
Raja montagui	F	+	+	-	-
Raja naevus	F	+	-	-	-
Raja oxyrinchus	F	+	+	+	+
Raja sp.	F	+	-	-	+
Ruvettus pretiosus	F	-	-	-	+
Sardina pilchardus	F	-	-	+	-
Scorpaena notata	F	-	-	-	+
Scorpaena porcus	F	-	-	*	-
Scorpaena scrofa	F	-	-	+	+
Scyliorhinus canicula	F	+	+	+	+
Scyliorhinus stellaris	F	+	-	-	-
Serranus hepatus	F	+	-	-	-
Spicara smaris	F	+	-	-	-
Squalus acanthias	F	+	+	-	+
Squalus blainvillei	F	+	+	+	+
Stomias boa	F	+	+	-	+
Symphodus sp.	F	+	-	-	+
Symphurus ligulatus	F	+	+	+	-
Symphurus nigrescens	F	+	+	-	+
Symphurus sp.	F	+	+	-	-
Synchiropus phaeton	F	+	+	-	+
Syngnathus rubescens	F	+	-	-	-
Syngnathus sp.	F	+	-	-	-
Torpedo marmorata	F	+	-	-	+
Trachinus draco	F	+	-	+	-
Trachurus mediterraneus	F	+	-	+	-
Trachurus trachurus	F	+	+	+	+
Trachyrhynchus trachyrhynchus	F	+	-	-	-
Trigla lyra	F	+	+	+	+
Trisopterus minutus capelanus	F	+	+	+	-
Uranoscopus scaber	F	-	+	+	-
Zeus faber	F	+	-	-	+
Abralia veranyi	M	-	+	-	+
Alloteuthis media	M	+	+	-	+
Bathypolypus sponsalis	M	+	+	-	-

Bivalvia (unid.)	M	+	-	-	-
Cephalopoda (unid.)	M	-	-	+	+
Eledone cirrhosa	M	+	+	-	-
Eledone moschata	M	+	+	-	-

Table 1 (continued)

Species		N. Aegean Sea	Thracian Sea	Ionian Sea	Deep Fisheries
Histioteuthis bonnellii	M	-	+	-	-
Illex coindetii	M	+	+	-	+
Loligo forbesii	M	+	+	-	+
Loligo vulgaris	M	+	-	-	-
Neorossia caroli	M	-	-	-	+
Octopus salutii	M	+	+	-	+
Pteroctopus tetracirrus	M	+	+	-	+
Rondeletiola minor	M	-	-	-	+
Rossia macrosoma	M	+	+	-	+
Scaeurgus unicirrhus	M	+	+	-	+
Sepia elegans	M	+	+	-	+
Sepia officinalis	M	+	-	-	-
Sepia orbignyana	M	+	+	-	+
Sepietta oweniana	M	-	-	-	+
Sepiola intermedia	M	-	-	-	+
Sepiolidae (unid.)	M	+	+	-	-
Sepiolinae (unid.)	M	-	-	-	+
Todarodes sagittatus	M	+	+	-	+
Todaropsis eblanae	M	+	+	-	+

Table 2. Diversity indices for each depth zone and season in the North Aegean Sea.

		Richness			Evenness		
Season	Depth Zones	Mean	min	max	Mean	min	max
Summer 90	<100 m	3.538	2.894	4.183	0.654	0.549	0.759
	100-300 m	3.355	2.882	3.828	0.624	0.547	0.701
	>300 m	3.04	2.5	3.579	0.634	0.547	0.722
Autumn 90	<100 m	4.262	3.659	4.865	0.632	0.534	0.73
	100-300 m	3.939	3.399	4.478	0.665	0.577	0.752
	>300 m	2.868	2.328	3.407	0.583	0.496	0.671
Winter 90	<100 m	3.7	3.055	4.344	0.564	0.459	0.669
	100-300 m	3.686	3.118	4.255	0.663	0.571	0.756
	>300 m	3.366	2.603	4.128	0.72	0.596	0.844
Spring 91	<100 m	3.513	2.91	4.116	0.614	0.516	0.713
	100-300 m	3.916	3.424	4.408	0.632	0.552	0.712
	>300 m	3.615	3.012	4.217	0.599	0.501	0.697
Summer 91	<100 m	3.481	2.836	4.125	0.646	0.541	0.75
	100-300 m	3.575	3.102	4.048	0.697	0.62	0.774
	>300 m	2.938	2.335	3.541	0.533	0.434	0.631
Autumn 91	<100 m	4.03	3.427	4.632	0.591	0.492	0.689
	100-300 m	3.66	3.204	4.116	0.632	0.558	0.706
	>300 m	3.005	2.437	3.573	0.574	0.481	0.666
Winter 91	<100 m	3.948	3.304	4.593	0.598	0.493	0.702
	100-300 m	3.544	3.004	4.083	0.605	0.518	0.693
	>300 m	2.67	1.907	3.432	0.694	0.57	0.818
Spring 92	<100	3.878	3.234	4.523	0.628	0.523	0.733
	100-300	4.035	3.543	4.528	0.621	0.541	0.701
	>300	3.132	2.529	3.735	0.601	0.503	0.699
Total	<100 m	3.79	3.16	4.42	0.62	0.51	0.72
	100-300 m	3.71	3.21	4.22	0.64	0.56	0.71
	>300 m	3.08	2.46	3.71	0.62	0.52	0.72

		Simpson			Shannon		
Season	Depth Zones	Mean	min	max	Mean	min	max
Summer 90	<100 m	0.189	0.085	0.292	2.164	1.807	2.521
	100-300 m	0.221	0.145	0.297	2.034	1.772	2.296
	>300 m	0.225	0.139	0.312	1.974	1.675	2.272
Autumn 90	<100 m	0.199	0.102	0.295	2.201	1.867	2.535
	100-300 m	0.177	0.09	0.263	2.247	1.948	2.545
	>300 m	0.272	0.186	0.359	1.756	1.457	2.054
Winter 90	<100 m	0.285	0.181	0.388	1.917	1.56	2.274
	100-300 m	0.176	0.084	0.267	2.222	1.907	2.537
	>300 m	0.158	0.035	0.28	2.176	1.753	2.598
Spring 91	<100 m	0.246	0.149	0.343	2.027	1.693	2.361
	100-300 m	0.203	0.124	0.282	2.144	1.871	2.416
	>300 m	0.226	0.129	0.323	1.987	1.653	2.321
Summer 91	<100 m	0.189	0.085	0.292	2.117	1.76	2.474
	100-300 m	0.145	0.069	0.221	2.281	2.019	2.543
	>300 m	0.348	0.251	0.444	1.677	1.343	2.011
Autumn 91	<100 m	0.243	0.146	0.34	2.074	1.74	2.408
	100-300 m	0.191	0.118	0.265	2.12	1.867	2.372
	>300 m	0.256	0.164	0.347	1.833	1.518	2.148
Winter 91	<100 m	0.219	0.115	0.322	2.065	1.708	2.422
	100-300 m	0.244	0.157	0.331	2.02	1.721	2.318
	>300 m	0.175	0.053	0.298	2.132	1.709	2.554
Spring 92	<100 m	0.235	0.131	0.338	2.088	1.731	2.445
	100-300 m	0.212	0.133	0.291	2.124	1.851	2.396
	>300 m	0.265	0.168	0.362	1.851	1.517	2.185
Total	<100 m	0.23	0.12	0.33	2.08	1.73	2.43
	100-300 m	0.19	0.12	0.28	2.15	1.87	2.43
	>300 m	0.24	0.14	0.34	1.92	1.58	2.27

Table 3. Top ranking species at each depth zone in the North Aegean Sea. Abundance is expressed as a percentage of the total catch for each depth zone

Abundance	%		%		%
<100 m		100-300 m		>300 m	
M. barbatus	46.31	*A. sphyraena*	15.42	*G. argenteus argenteus*	24.43
S. hepatus	8.97	*G. argenteus*	11.67	*N. norvegicus*	14.69
S. flexuosa	5.06	*C. aper*	8.50	*H. italicus*	10.80
M. merluccius	4.37	*M. merluccius*	7.98	*M. poutassou*	7.18
P. erythrinus	4.28	*T. trachurus*	6.69	*A. sphyraena*	6.54
T. trachurus	3.36	*L. cavillone*	5.10	*C. coelorhynchus*	5.93
C. linguatula	3.32	*M. barbatus*	4.92	*L. boscii*	4.64
T. m. capelanus	2.97	*S. canicula*	4.75	*M. merluccius*	2.24
D. annularis	2.76	*M. poutassou*	4.07	*N. sclerorhynchus*	1.62
T. mediterraneus	2.41	*T. m. capelanus*	3.62	*P. blennoides*	0.98

Table 4. Diversity indices for each depth zone and season in the Ionian Sea

		Richness			Evenness		
Season	Depth Zones	mean	min	max	mean	min	max
Summer 83	<100 m	4.057	3.583	4.531	0.619	0.56	0.679
	100-300 m	3.626	2.698	4.554	0.58	0.466	0.697
	>300 m	3.1	0.827	5.372	0.602	0.318	0.885
Autumn 83	<100 m	3.719	3.11	4.326	0.626	0.551	0.702
	100-300 m	3.697	2.894	4.5	0.568	0.468	0.668
	>300 m	2.72	1.113	4.326	0.601	0.4009	0.802
Winter 83	<100 m	4.062	3.707	4.416	0.667	0.622	0.711
	100-300 m	3.675	3.107	4.243	0.661	0.591	0.732
	>300 m	2.843	1.915	3.771	0.544	0.429	0.66
Spring 84	<100 m	4.103	3.535	4.671	0.638	0.567	0.709
	100-300 m	4.108	3.351	4.866	0.637	0.542	0.732
	>300 m	3.22	1.908	4.532	0.642	0.479	0.806
Summer 84	<100 m	3.76	3.209	4.311	0.64	0.571	0.709
	100-300 m	4.825	4.106	5.543	0.636	0.546	0.726
	>300 m	4.116	2.804	5.428	0.591	0.427	0.754
Autumn 84	<100 m	4.053	3.502	4.605	0.579	0.511	0.648
	100-300 m	3.99	3.271	4.708	0.579	0.489	0.668
	>300 m	3.533	2.221	4.845	0.635	0.471	0.799
Winter 84	<100 m	3.996	3.632	4.36	0.634	0.589	0.679
	100-300 m	3.502	2.915	4.088	0.577	0.503	0.65
	>300 m	2.611	1.683	3.539	0.558	0.442	0.674
Spring 85	<100 m	3.795	3.208	4.382	0.654	0.581	0.728
	100-300 m	3.976	2.959	4.992	0.69	0.563	0.817
Total	<100 m	2.99	2.45	3.53	0.61	0.47	0.74
	100-300 m	2.4	1.68	3.12	0.44	0.26	0.62
	>300 m	1.95	0.92	2.99	0.36	0.12	0.6

		Simpson			Shannon		
Season	Depth Zones	mean	min	max	mean	min	max
Summer 83	<100 m	0.211	0.148	0.273	2.194	1.968	2.42
	100-300 m	0.269	0.146	0.392	1.971	1.529	2.413
	>300 m	0.237	0.0637	0.5377	1.99	0.907	3.072
Autumn 83	<100 m	0.211	0.131	0.291	2.042	1.782	2.361
	100-300 m	0.301	0.195	0.407	1.858	1.475	2.241
	>300 m	0.297	0.084	0.509	1.785	1.019	2.55
Winter 83	<100 m	0.173	0.126	0.22	2.275	2.106	2.445
	100-300 m	0.21	0.135	0.286	2.156	1.886	2.427
	>300 m	0.3	0.177	0.423	1.665	1.223	2.106
Spring 84	<100 m	0.178	0.103	0.253	2.243	1.972	2.513
	100-300 m	0.199	0.099	0.299	2.223	1.862	2.584
	>300 m	0.23	0.056	0.403	1.953	1.328	2.578
Summer 84	<100 m	0.224	0.151	0.297	2.125	1.862	2.387
	100-300 m	0.211	0.116	0.306	2.282	1.939	2.624
	>300 m	0.259	0.0857	0.432	2.04	1.415	2.664
Autumn 84	<100 m	0.261	0.188	0.334	2.025	1.762	2.287
	100-300 m	0.268	0.173	0.363	2.012	1.669	2.354
	>300 m	0.273	0.1	0.447	1.88	1.255	2.504
Winter 84	<100 m	0.198	0.151	0.247	2.21	2.037	2.383
	100-300 m	0.268	0.191	0.346	1.963	1.684	2.243
	>300 m	0.285	0.162	0.408	1.713	1.271	2.155
Spring 85	<100 m	0.183	0.105	0.261	2.24	1.96	2.52
	100-300 m	0.143	0.009	0.278	2.406	1.921	2.89
Total	<100 m	0.27	0.19	0.36	1.84	1.39	2.28
	100-300 m	0.47	0.35	0.58	1.34	0.75	1.93
	>300 m	0.59	0.41	0.78	1.03	0.29	1.76

Table 5. Top ranking species at each depth zone in the Ionian Sea. Abundance is expressed as a percentage of the total catch for each depth zone.

Abundance	%		%		%
<100 m		100-300 m		>300 m	
M. merluccius	16.24	*G. argenteus argenteus*	43.78	*G. argenteus argenteus*	83.65
S. flexuosa	16.17	*M. merluccius*	23.99	*A. sphyraena*	3.43
M. barbatus	12.75	*M. poutassou*	9.80	*L. dieuzeide*	2.50
S. smaris	8.15	*C. aper*	6.98	*C. coelorhynchus*	2.03
P. acarne	7.53	*A. sphyraena*	4.24	*M. poutassou*	1.87
T. m. capelanus	6.69	*T. m. capelanus*	2.42	*S. canicula*	1.10
S. hepatus	4.74	*S. smaris*	1.02	*C. agassizi*	1.01
L. cavillone	4.56	*L. cavillone*	1.01	*M. merluccius*	0.96
D. annularis	3.39	*T. trachurus*	0.86	*D. quadrimaculatus*	0.68
T. trachurus	3.09	*S. hepatus*	0.82	*T. m. capelanus*	0.40

Table 6. Diversity indices for each depth zone and season in the Thracian Sea

Season	Depth zones	Richness Mean	Richness min	Richness max	Evenness Mean	Evenness min	Evenness max
September 91	<100	2.472	1.888	3.056	0.527	0.38	0.673
	100-300	2.231	1.618	2.843	0.393	0.239	0.547
	>300	2	0.881	3.118	0.341	0.06	0.622
June 92	<100	2.994	2.435	3.553	0.566	0.425	0.706
	100-300	2.628	1.896	3.36	0.394	0.21	0.578
	>300	1.915	0.946	2.883	0.471	0.228	0.715
August 92	<100	2.914	2.355	3.473	0.652	0.511	0.792
	100-300	2.083	0.965	3.201	0.368	0.087	0.649
	>300	1.9	1.1	2.7	0.302	0.102	0.502
November 92	<100	2.856	2.319	3.394	0.691	0.555	0.826
	100-300	2.285	1.494	3.075	0.453	0.254	0.652
	>300	2.097	1.129	3.065	0.415	0.172	0.659
March 93	<100	3.176	2.658	3.694	0.591	0.461	0.721
	100-300	2.68	2.067	3.292	0.466	0.312	0.62
	>300	1.823	0.7054	2.941	0.203	0.003	0.403
June 93	<100	3.164	2.605	3.723	0.593	0.452	0.733
	100-300	2.539	1.893	3.184	0.495	0.333	0.658
	>300	1.696	0.578	2.814	0.209	0.007	0.3988
September 93	<100	3.179	2.642	3.716	0.624	0.489	0.759
	100-300	2.093	1.447	2.738	0.367	0.205	0.53
	>300	1.886	0.768	3.004	0.36	0.079	0.641
December 93	<100	3.114	2.613	3.614	0.628	0.502	0.754
	100-300	2.732	2.047	3.417	0.543	0.371	0.715
	>300	2.322	1.354	3.29	0.39	0.147	0.633
Total	<100	3.94	3.44	4.45	0.63	0.57	0.69
	100-300	3.92	3.16	4.69	0.62	0.52	0.71
	>300	3.16	1.78	4.54	0.59	0.42	0.77

Season	Depth zones	Simpson mean	Simpson min	Simpson max	Shannon mean	Shannon min	Shannon max
September 91	<100	0.361	0.267	0.454	1.483	1.006	1.961
	100-300	0.514	0.416	0.612	1.135	0.634	1.636
	>300	0.588	0.409	0.767	0.96	0.045	1.874
June 92	<100	0.28	0.19	0.369	1.803	1.346	2.26
	100-300	0.521	0.404	0.638	1.266	0.667	1.865
	>300	0.411	0.256	0.566	1.333	0.541	2.124
August 92	<100	0.211	0.121	0.301	1.973	1.516	2.43
	100-300	0.553	0.374	0.732	1.063	0.148	1.977
	>300	0.611	0.301	0.921	0.854	0.154	1.554
November 92	<100	0.269	0.183	0.355	1.836	1.397	2.276
	100-300	0.411	0.285	0.538	1.499	0.852	2.145
	>300	0.4075	0.2525	0.562	1.383	0.591	2.175
March 93	<100	0.283	0.2	0.366	1.859	1.435	2.282
	100-300	0.4201	0.322	0.518	1.422	0.922	1.923
	>300	0.766	0.587	0.945	0.602	0.102	1.102
June 93	<100	0.26	0.171	0.35	1.87	1.413	2.327
	100-300	0.388	0.285	0.492	1.54	1.013	2.069
	>300	0.769	0.59	0.947	0.545	0.245	0.845
September 93	<100	0.228	0.142	0.314	1.933	1.493	2.372
	100-300	0.583	0.48	0.686	1.07	0.542	1.598
	>300	0.549	0.37	0.728	1.002	0.087	1.916
December 93	<100	0.233	0.153	0.313	1.952	1.543	2.361
	100-300	0.346	0.236	0.455	1.637	1.077	2.197
	>300	0.55	0.395	0.704	1.089	0.298	1.881
Total	<100	0.2	0.14	0.27	2.17	1.93	2.41
	100-300	0.23	0.13	0.33	2.11	1.75	2.47
	>300	0.27	0.1	0.45	1.86	1.2	2.52

Table 7. Top ranking species at each depth zone in the Thracian Sea. Abundance is expressed as a percentage of the total catch for each depth zone

Abundance	%		%		%
<100 m		100-300 m		>300 m	
S. hepatus	13.15	*M. poutassou*	18.24	*H. italicus*	34.09
T. m. capelanus	11.81	*G. argenteus argenteus*	16.39	*G. argenteus*	19.69
M. barbatus	10.53	*T. m. capelanus*	10.75	*M. poutassou*	12.79
A. laterna	9.29	*A. sphyraena*	10.00	*N. norvegicus*	6.12
S. flexuosa	5.56	*M. merluccius*	8.32	*L. boscii*	5.15
Gobiidae	4.89	*L. boscii*	2.94	*C. coelorhynchus*	2.94
P. bogaraveo	3.63	*A. media*	2.76	*A. sphyraena*	2.29
T. mediterraneus	2.48	*S. hepatus*	2.38	*P. blennoides*	2.10
D. annularis	2.46	*H. italicus*	2.10	*L. budegassa*	1.26
T. trachurus	2.29	*N. norvegicus*	1.73	Sepiolidae	1.22

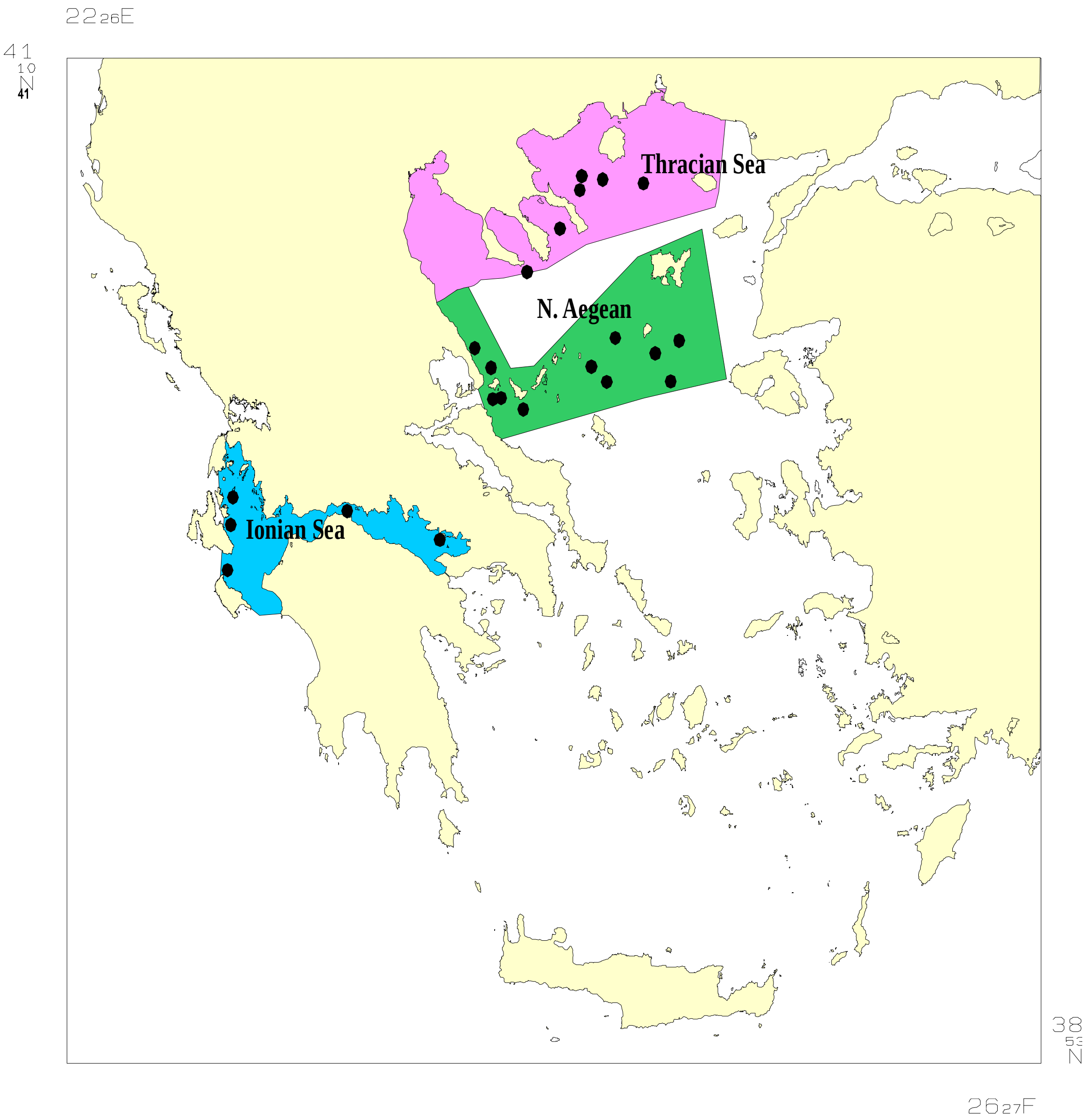


Fig. 1. Map of Greece showing the areas covered by the projects.

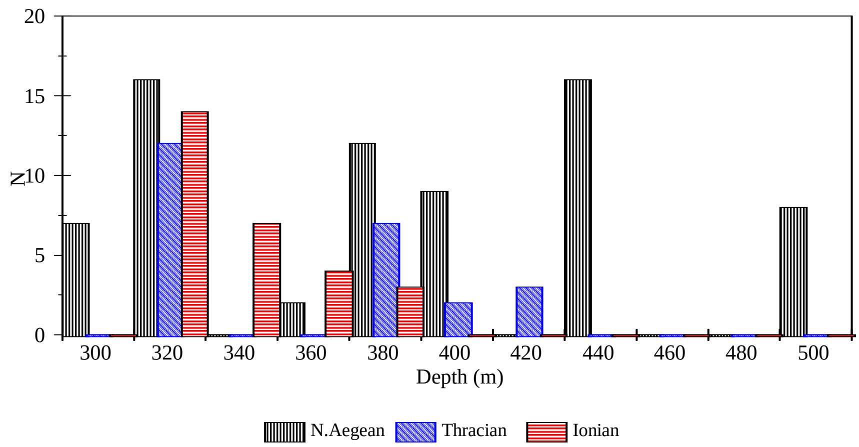


Fig. 2. Number of stations in relation to depth per project.

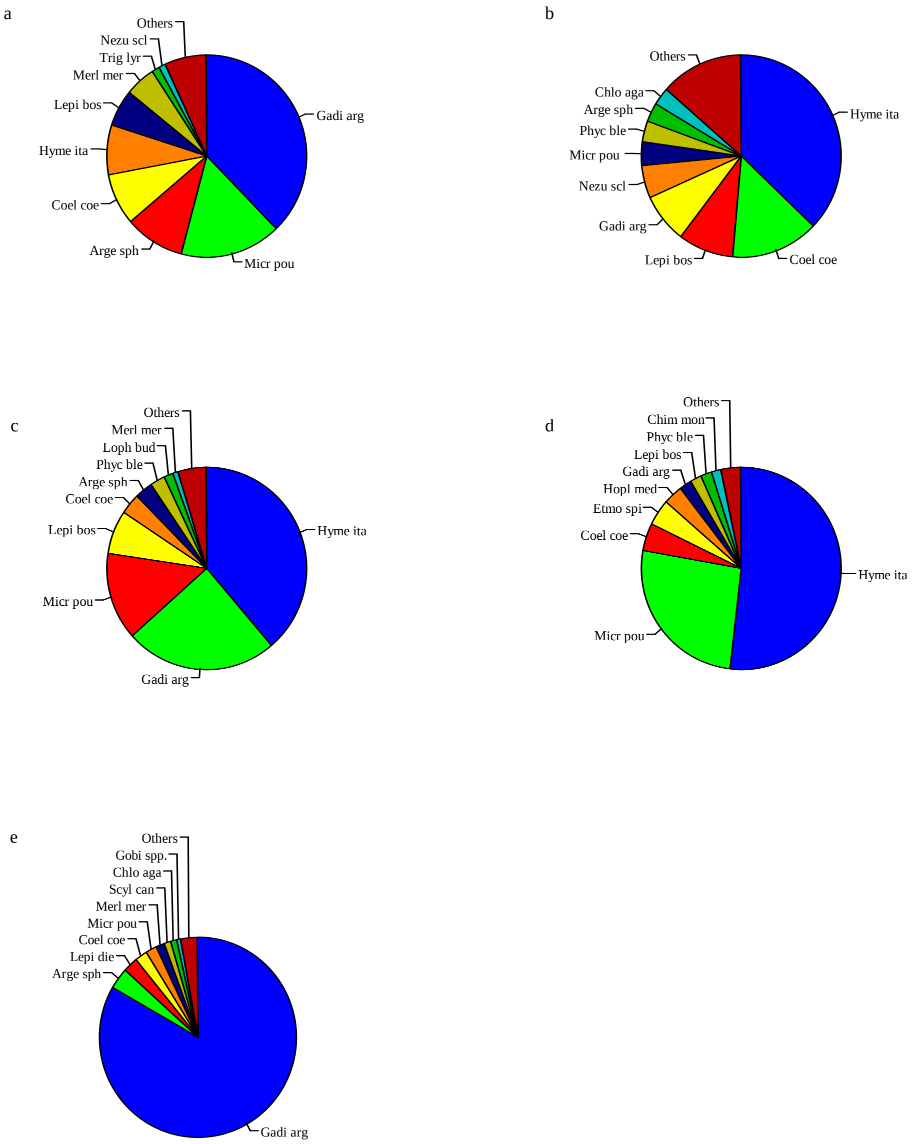


Fig. 3. Fish catch composition by number per depth in the areas: North Aegean sea (a=300-400 m, b>400 m), Thracian Sea (c=300-400 m, d>400 m) and Ionian Sea (e=300-400 m). (Arge sph=*Argentina sphyraena*, Chim mon=*Chimaera monstrosa*, Chlo aga=*Chlorophthalmus agassizi*, Coel coe=*Coelorhynchus coelorhynchus*, Etmo spi=*Etmopterus spinax*, Gadi arg=*Gadiculus argenteus*, Gobi spp=*Gobiidae*, Hopl med=*Hoplostethus mediterraneus*, Hyme ita=*Hymenocephalus italicus*, Lepi bos=*Lepidorhombus boscii*, Lepi die=*Lepidotrigla dieuzeidei* Loph *bud=Lophius budegassa*, Merl mer=*Merluccius merluccius*, Micr pou=*Micromesistius poutassou*, Nezu scl=*Nezumia sclerorhynchus*, Phyc ble=*Phycis blennoides*, Scyl can=*Scyliorhinus cnicula*, Trig lyr=*Trigla lyra*).

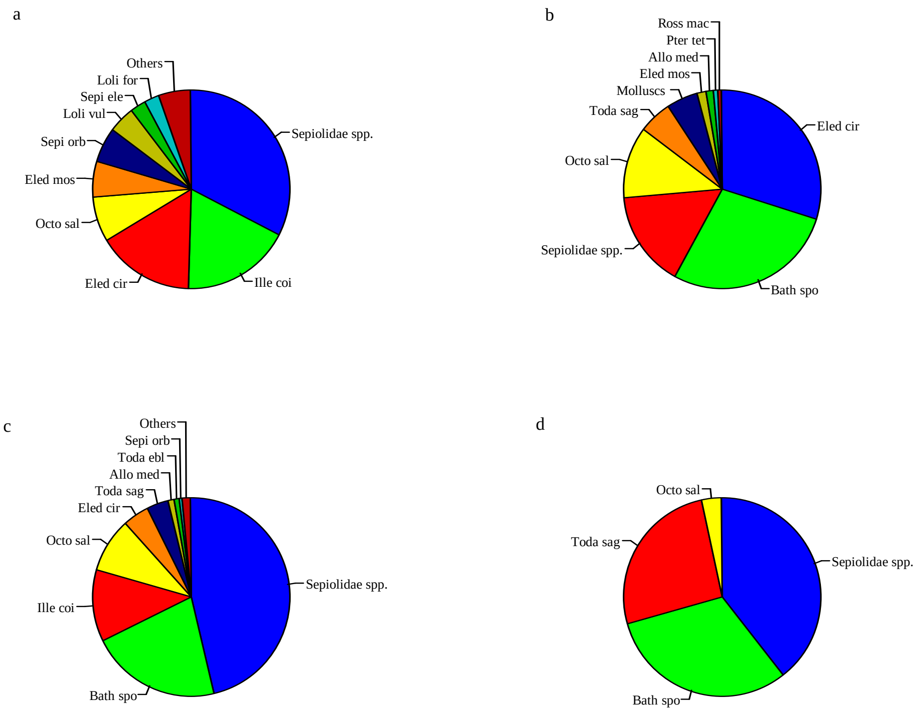
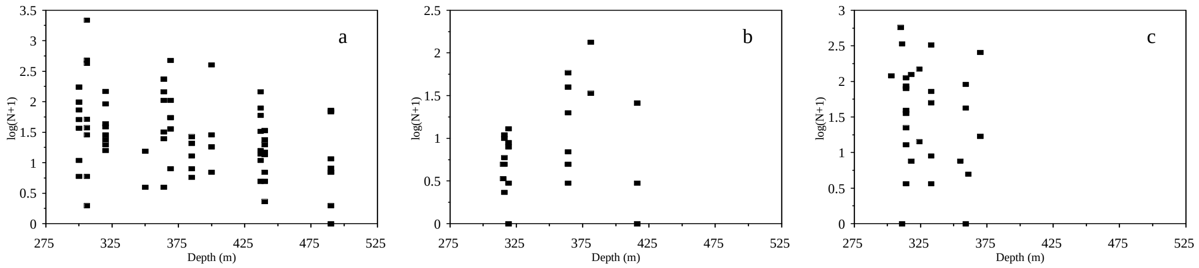
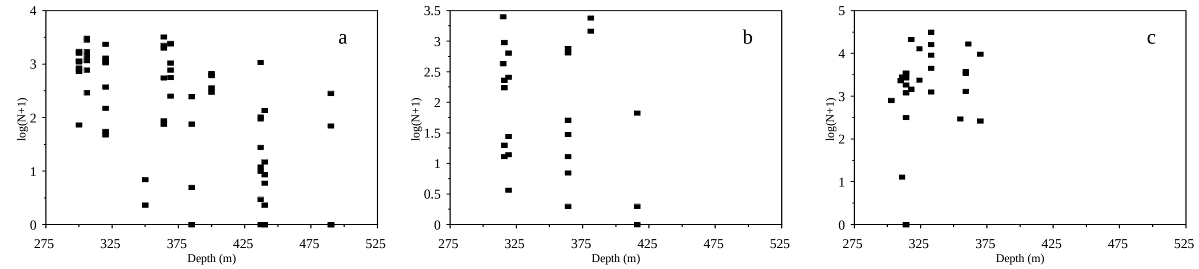


Fig. 4. Cephalopods catch composition by number per depth in the areas: North Aegean Sea (a=300-400 m, b>400 m)and Thracian Sea (a=300-400 m, b>400 m). (Ross *mac*=*Rossia macrosoma*, Pter tet=*Pterocopus tetracirus*, Allo med=*Alloteuthis media*, Eled mos=*Eledone moschata*, Toda sag=*Todarodes sagittatus*, Octo sal=*Octopus salutii*, Bath spo=*Bathypolypus sponsalis*, Eled cir=*Eledone cirrhosa*, Loli for=*Loligo forbesii*, Sepi ele=*Sepia elegans*, Loli vul=*Loligo vulgaris*, Sepi orb=*Sepia orbignyana*, Ille coi=*Illex coindetii*, Toda ebl=*Todaropsis eblanae*).

Merluccius merluccius



Gadiculus argenteus argenteus



Micromesistius poutassou poutassou

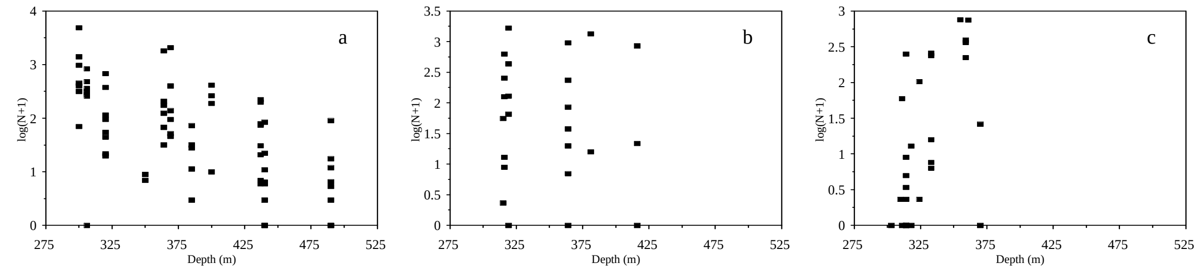


Fig. 5. Bathymetrical distribution of the most abundant species. (a=North Aegean Sea, b=Thracian Sea and c=Ionina Sea).

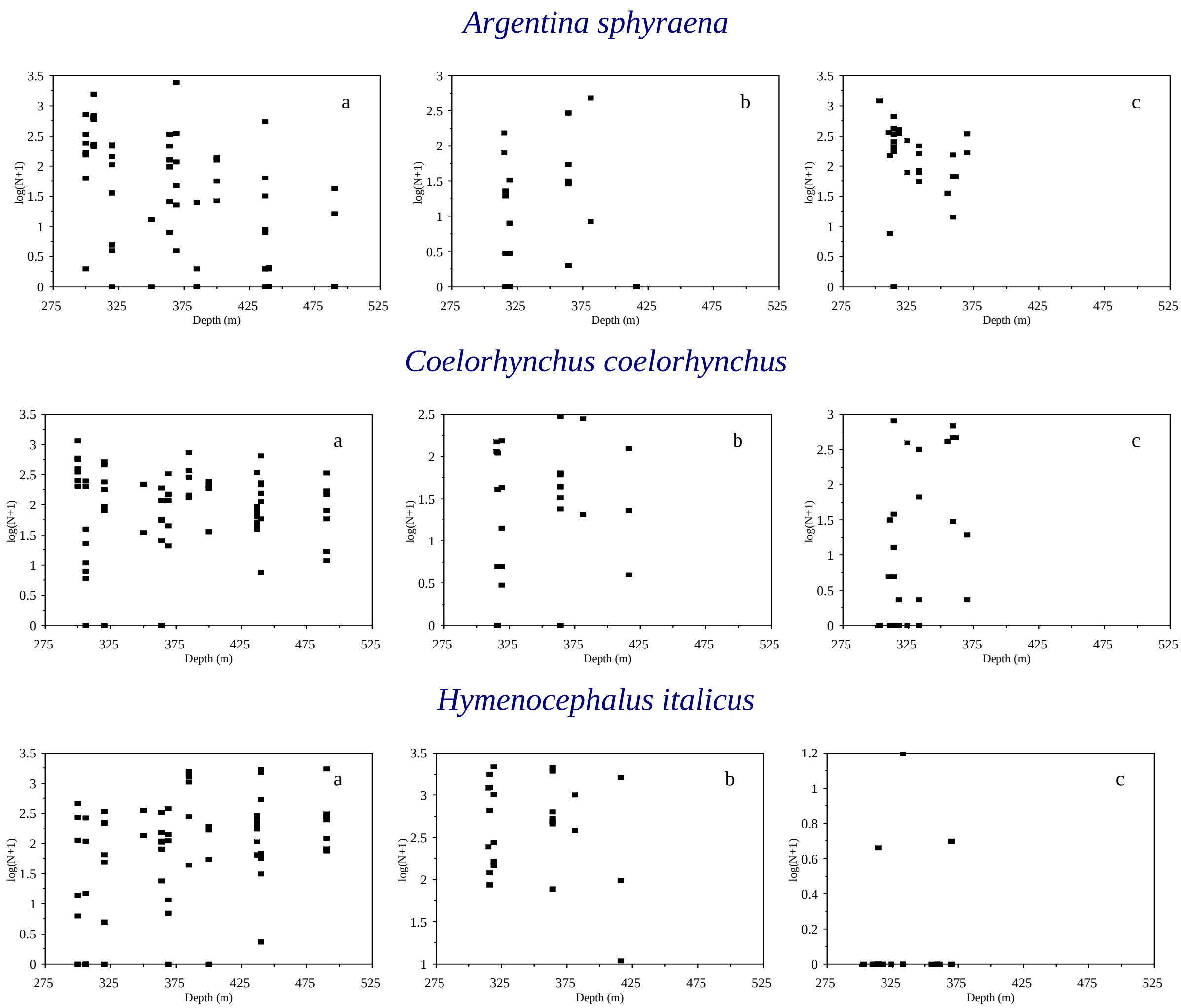


Fig. 6. Bathymetrical distribution of the most abundant species. (a=North Aegean Sea, b=Thracian Sea and c=Ionina Sea).

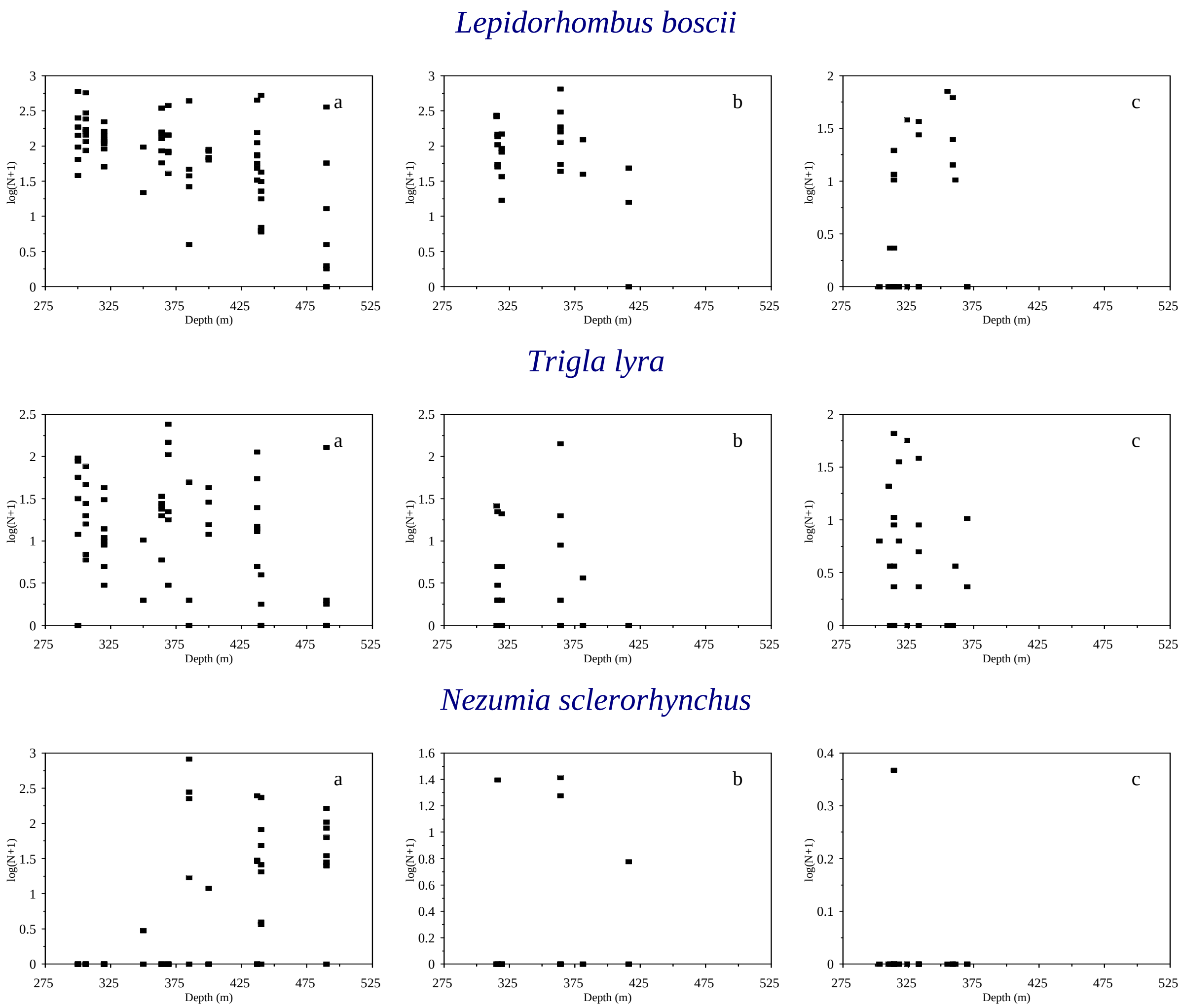


Fig. 7. Bathymetrical distribution of the most abundant species. (a=North Aegean Sea, b=Thracian Sea and c=Ionina Sea).

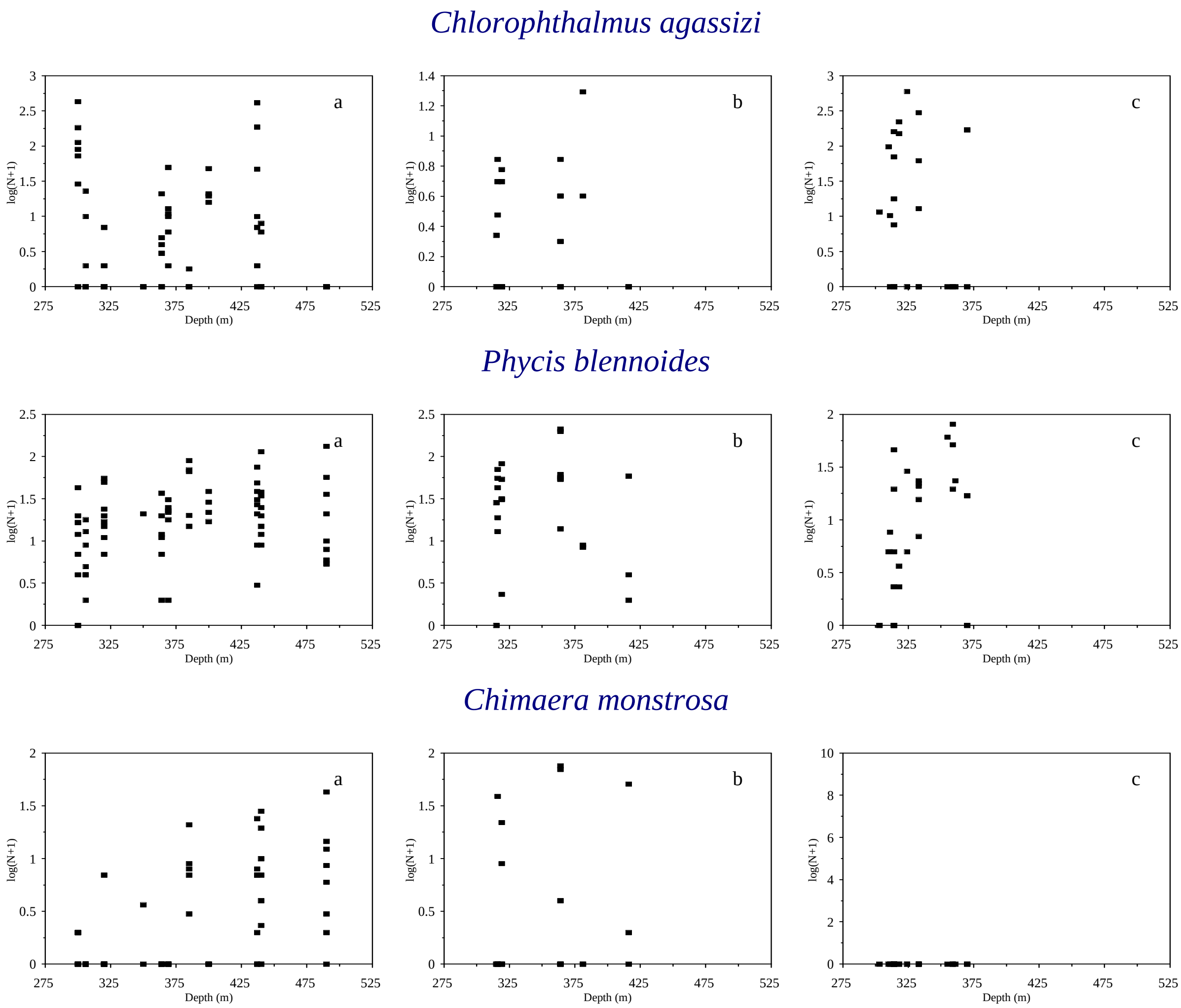


Fig. 8. Bathymetrical distribution of the most abundant species. (a=North Aegean Sea, b=Thracian Sea and c=Ionina Sea).

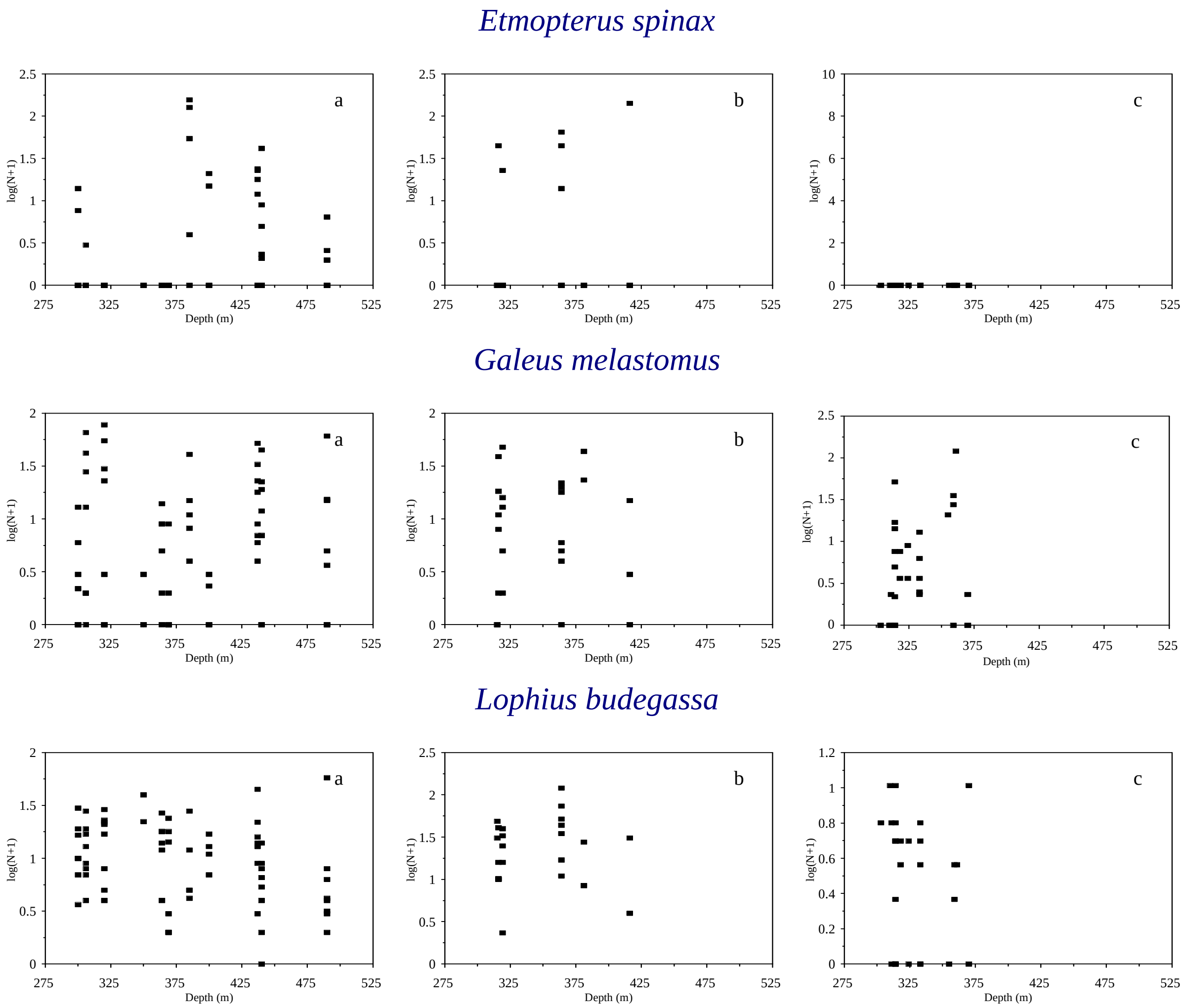


Fig. 9. Bathymetrical distribution of the most abundant species. (a=North Aegean Sea, b=Thracian Sea and c=Ionina Sea).

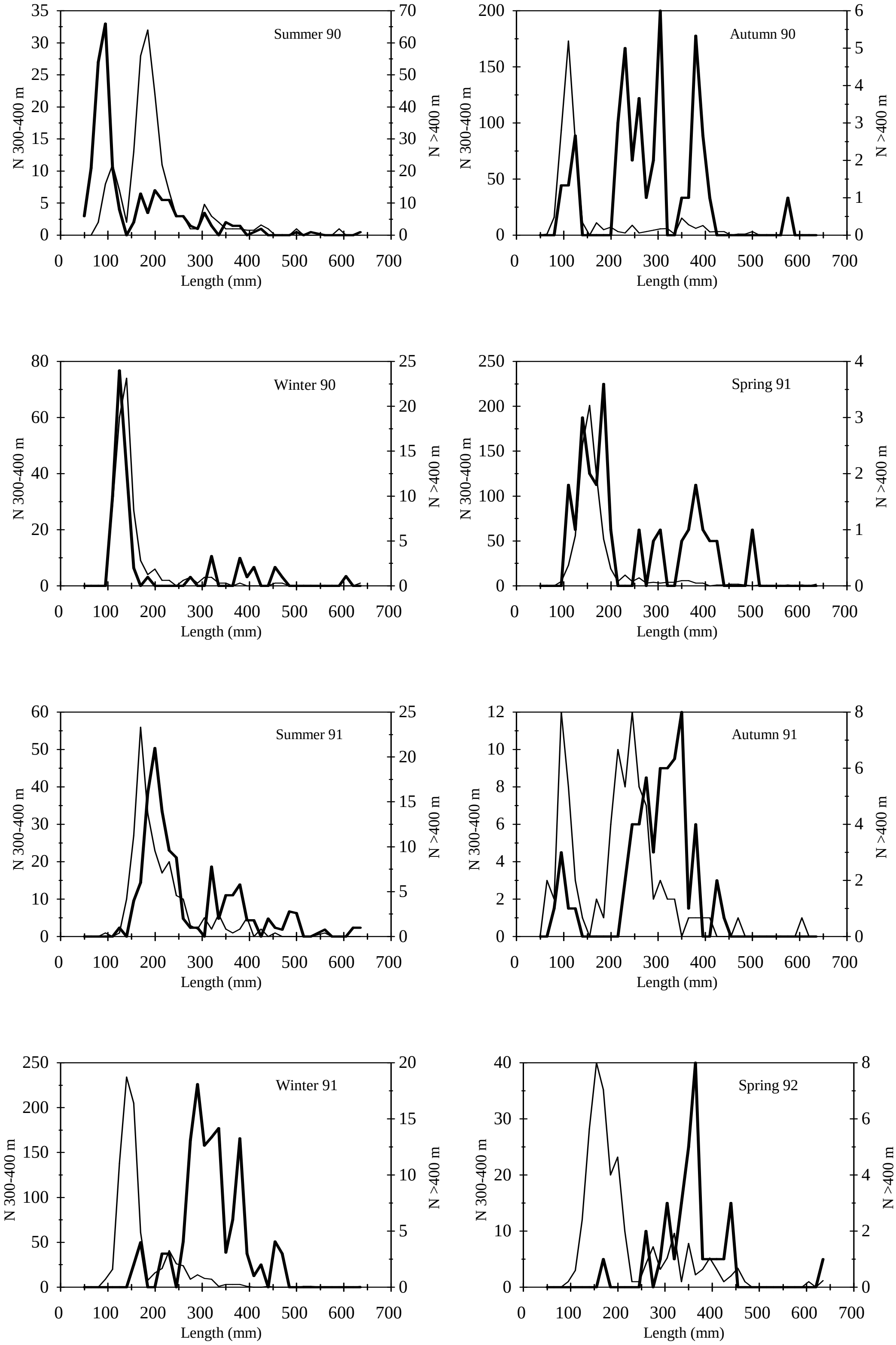


Fig. 10. Length frequency distribution of *M. merluccius* in the Northern Aegean sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

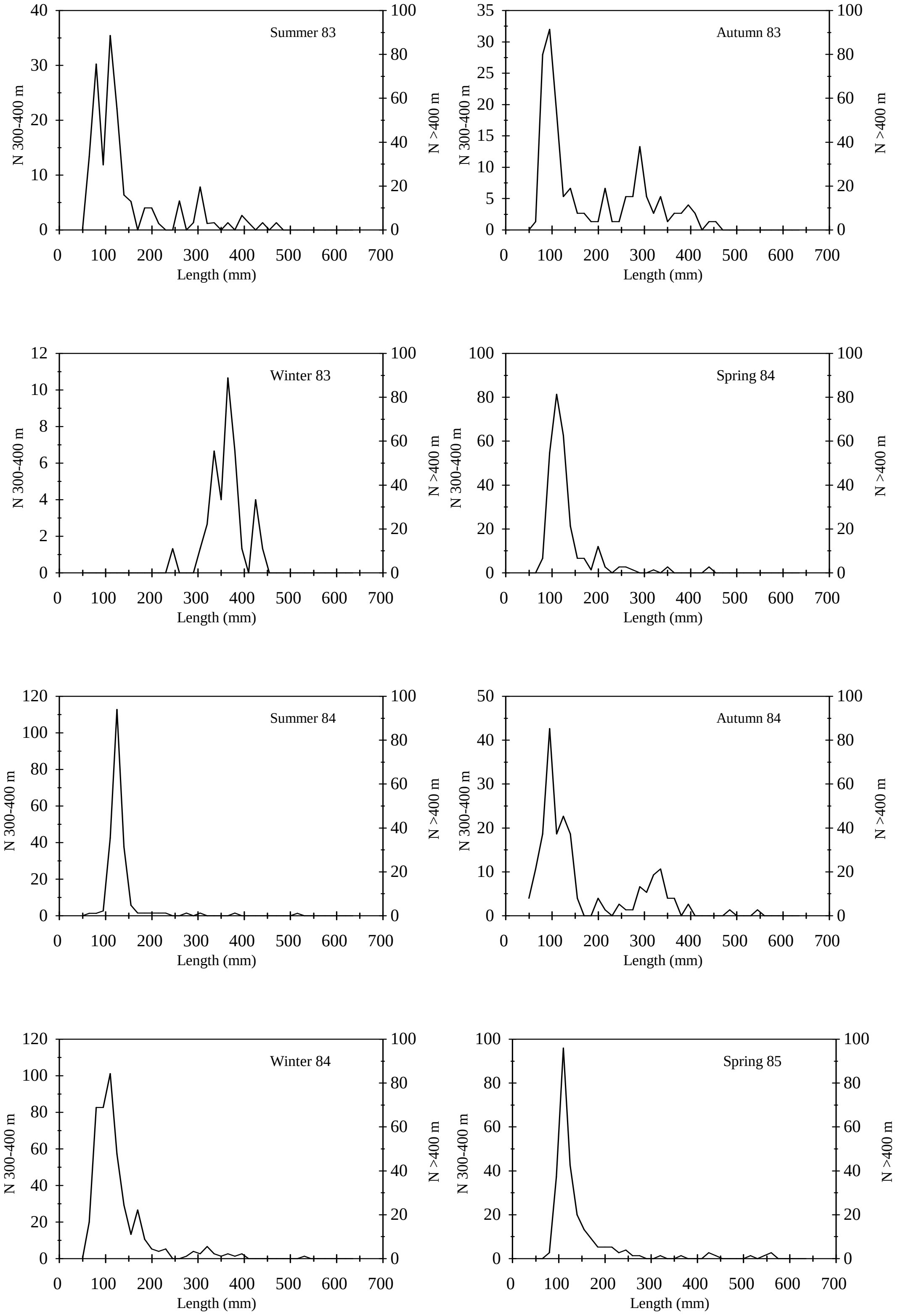


Fig. 11. Length frequency distribution of *M. merluccius* in the Ionian sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

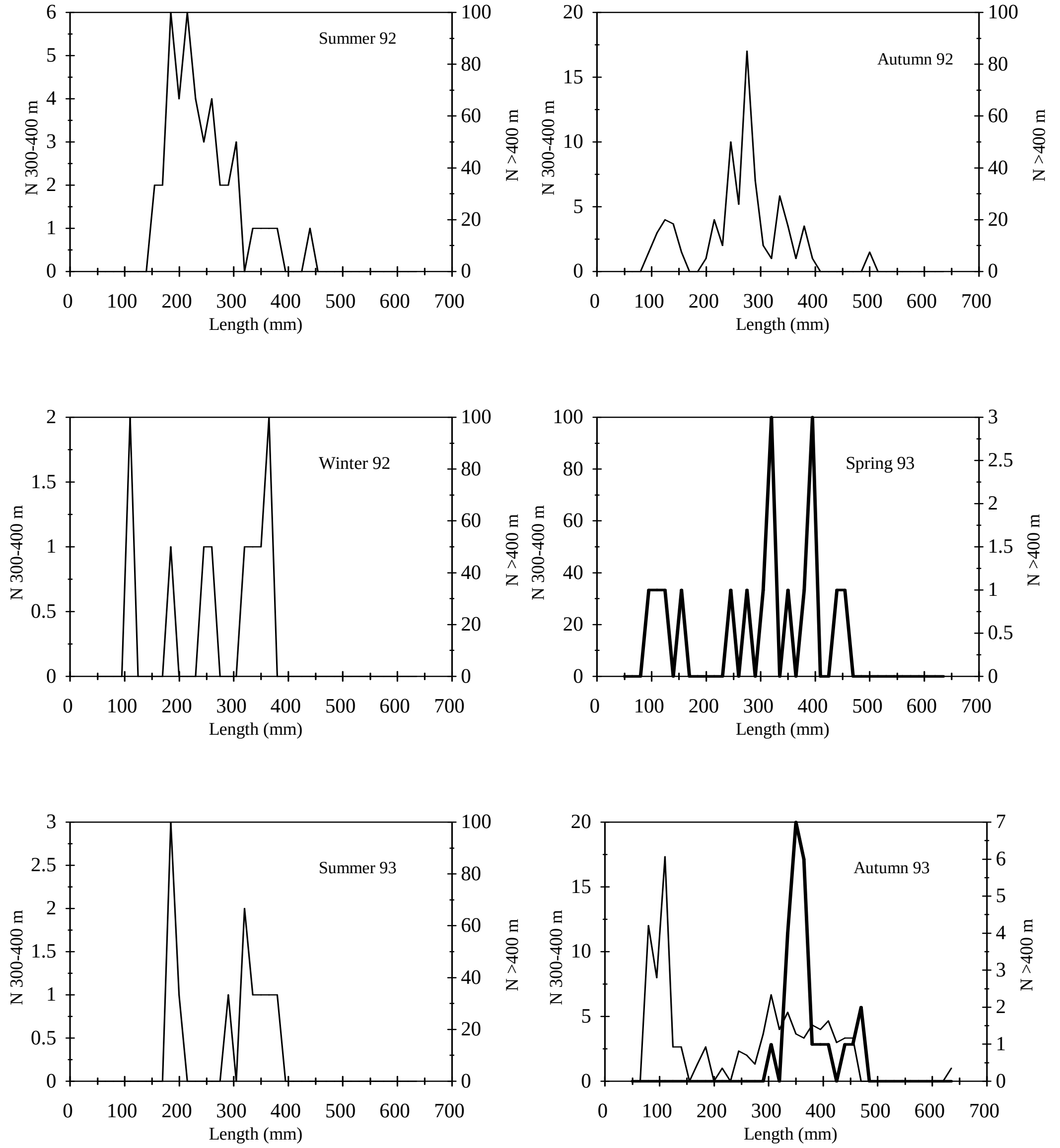


Fig. 12. Length frequency distribution of *M. merluccius* in the Thracian sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

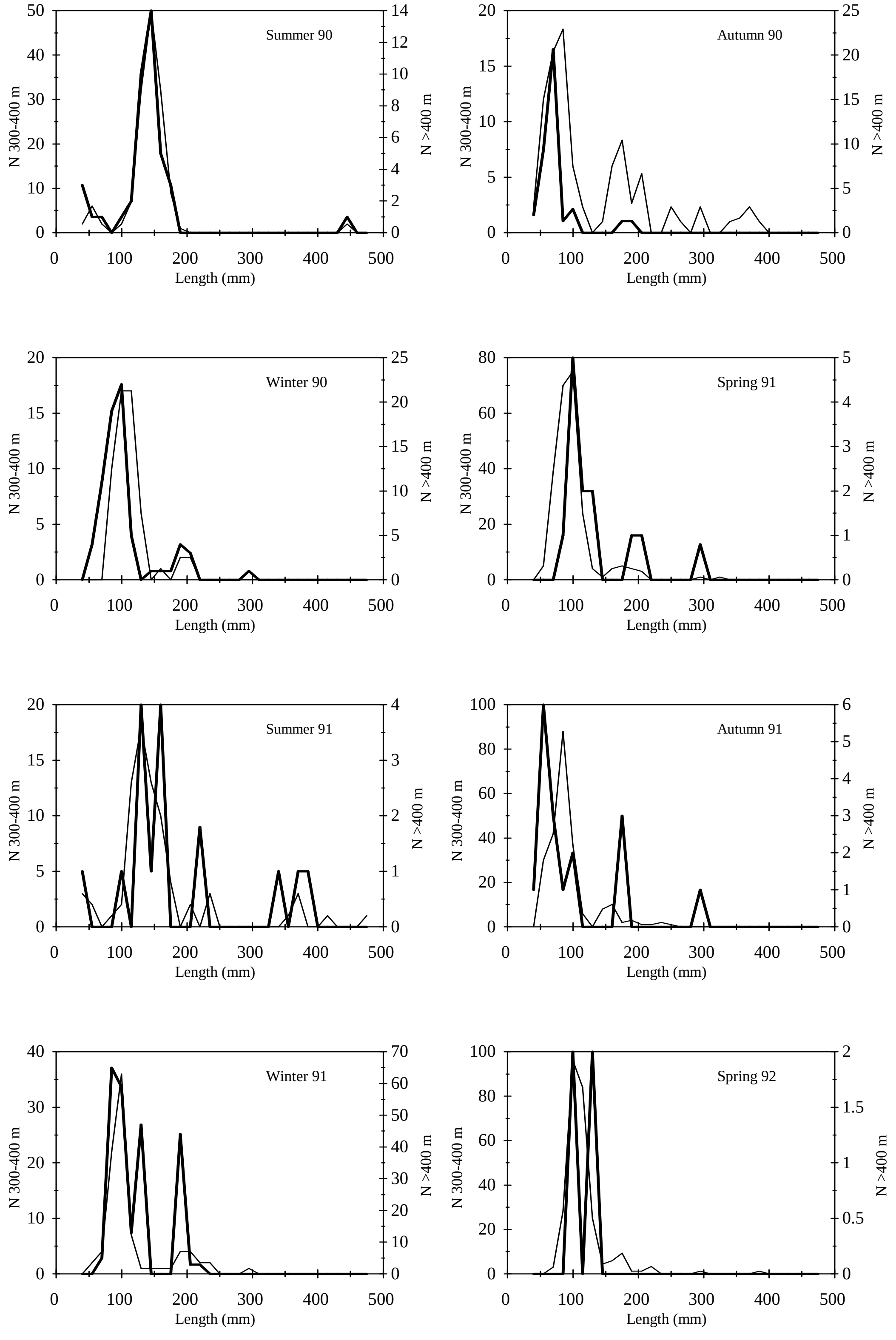


Fig. 13. Length frequency distribution of T. lyra in the Northern Aegean sea (Thin line: 300-400 m depth, Thick line: >400 m depth).

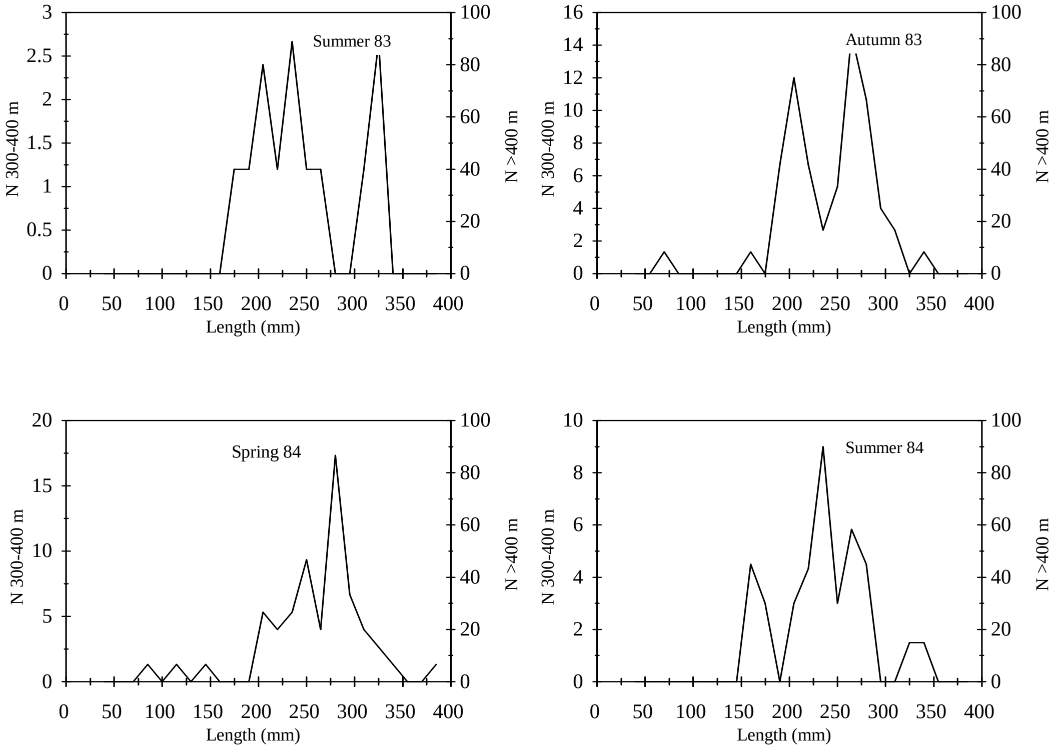


Fig.14. Lenght frequency distribution of T. lyra in the Ionian sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

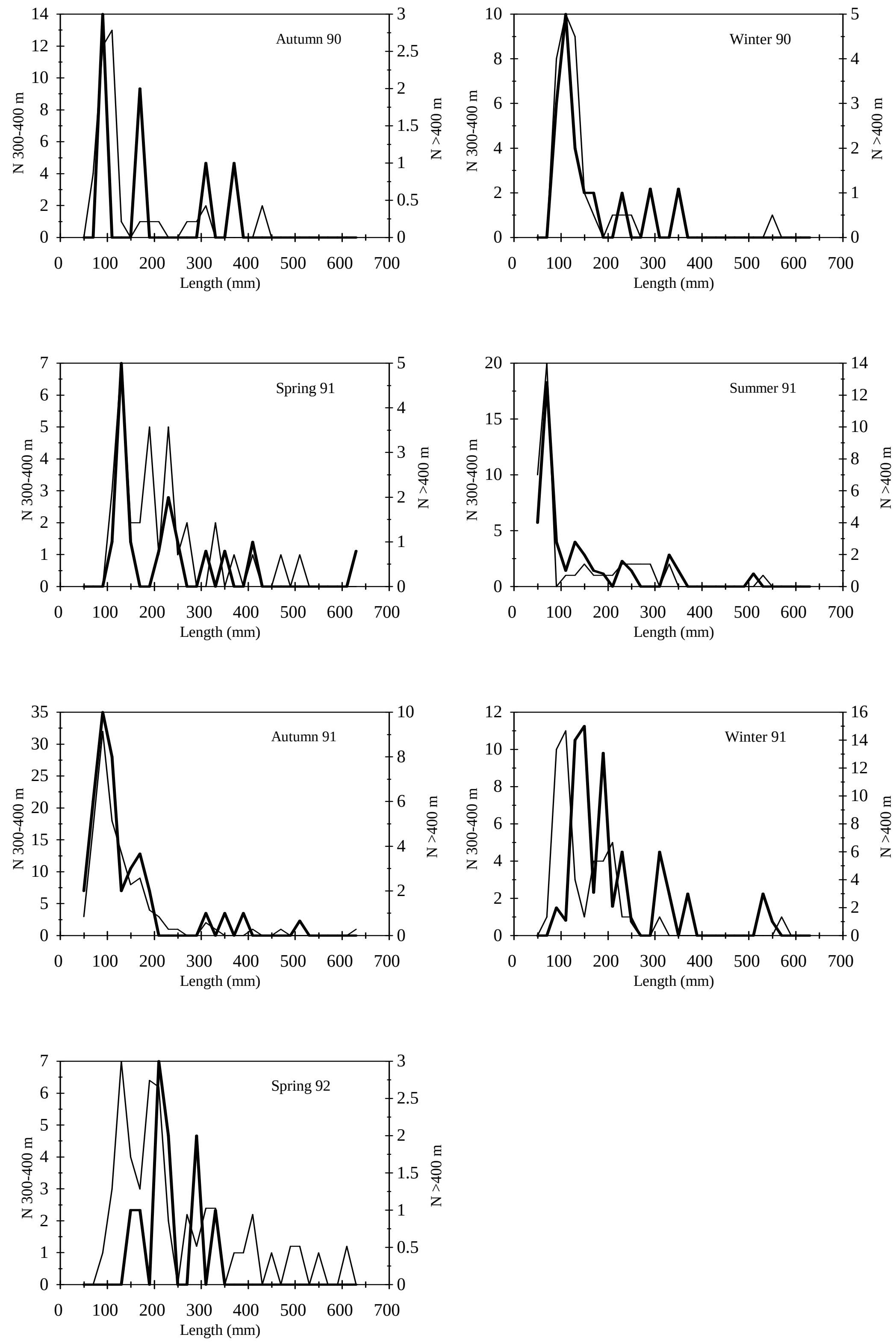


Fig. 15. Length frequency distribution of *L. budegassa* on the Northern Aegean sea .(Thin line: 300-400 m depth, Thick line: >400 m depth).

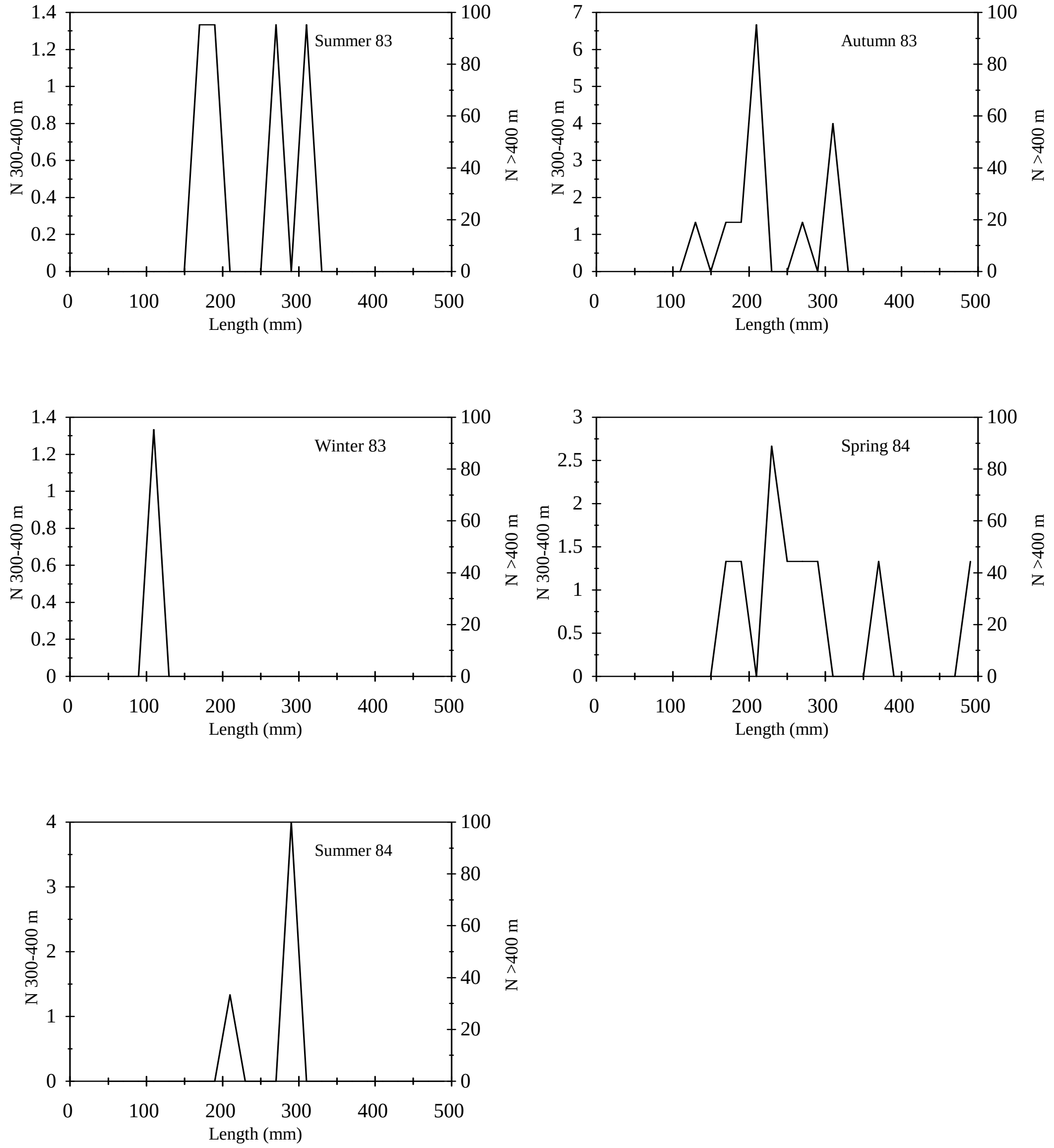


Fig. 16. Length frequency distribution of *L. budegassa* in the Ionian sea (Thin line: 300-400 m depth, Thick line: >400 m depth).

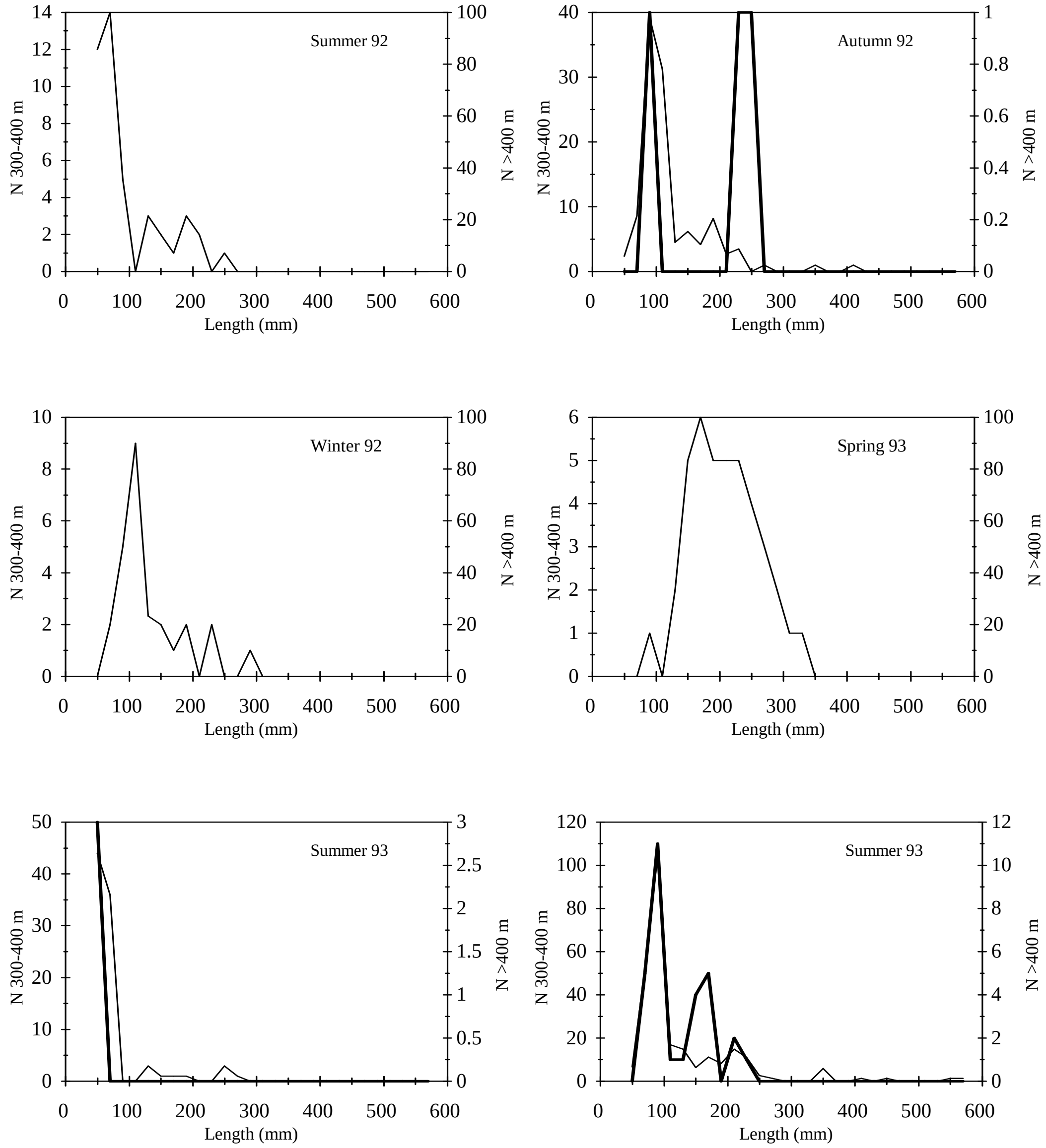


Fig. 17. Length frequency distribution of *L. budegassa* in the Thracian sea (Thin line: 300-400 m depth, Thick line: >400 m depth).

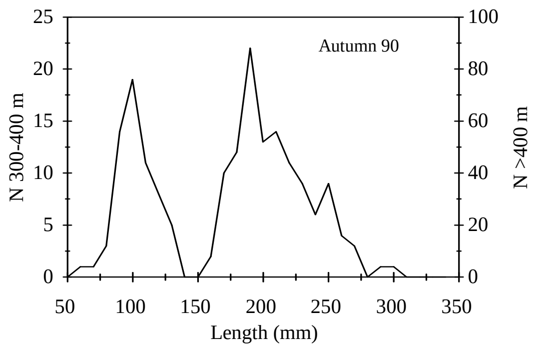


Fig. 18. Length frequency distribution of *M. poutassou* in the Northern Aegean sea (Thin line: 300-400 m depth, Thick line: >400 m depth).

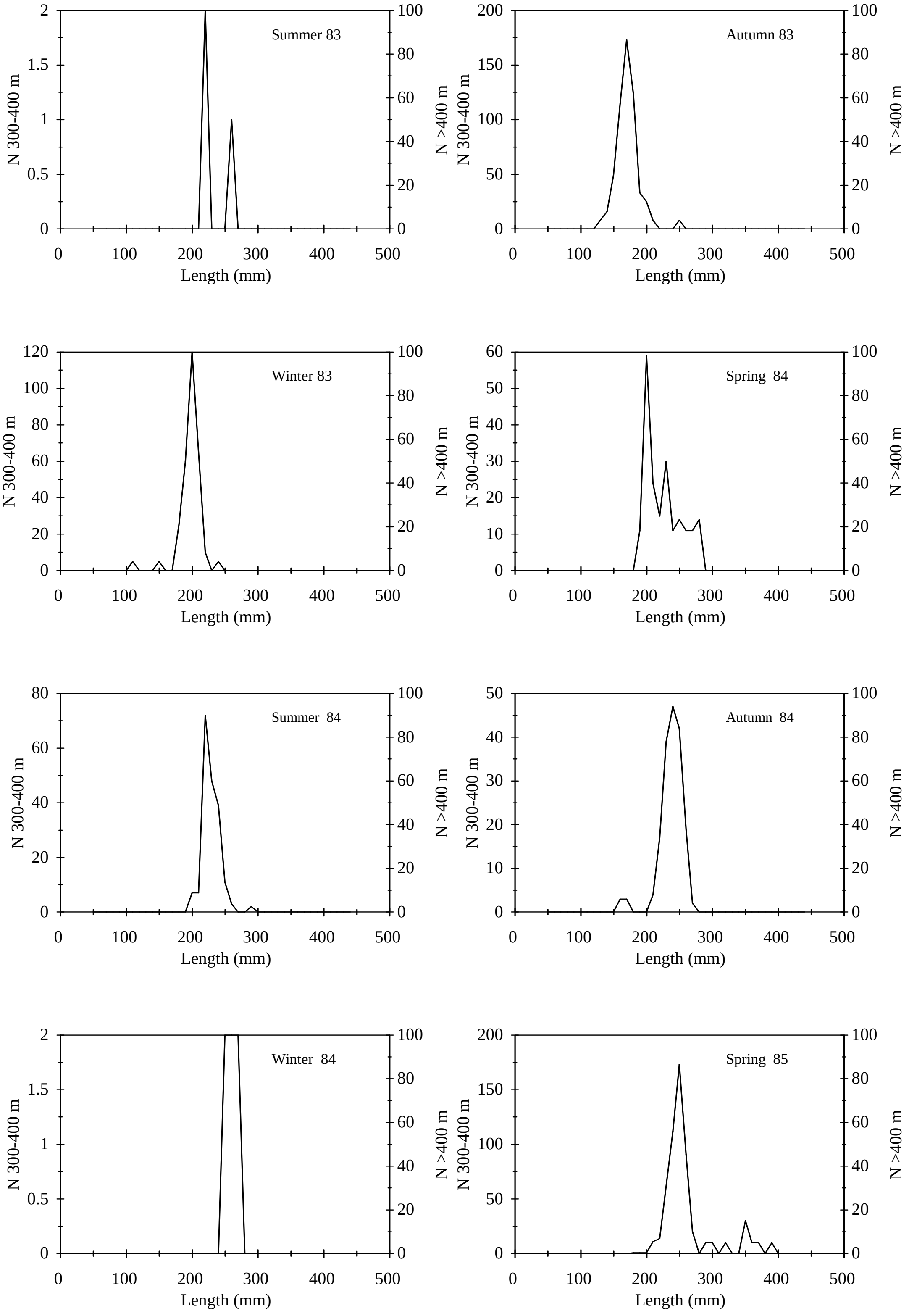


Fig. 19. Length frequency distribution of *M. poutassou* in the Ionian sea (Thin line: 300-400 m depth, Thick line: >400 m depth).

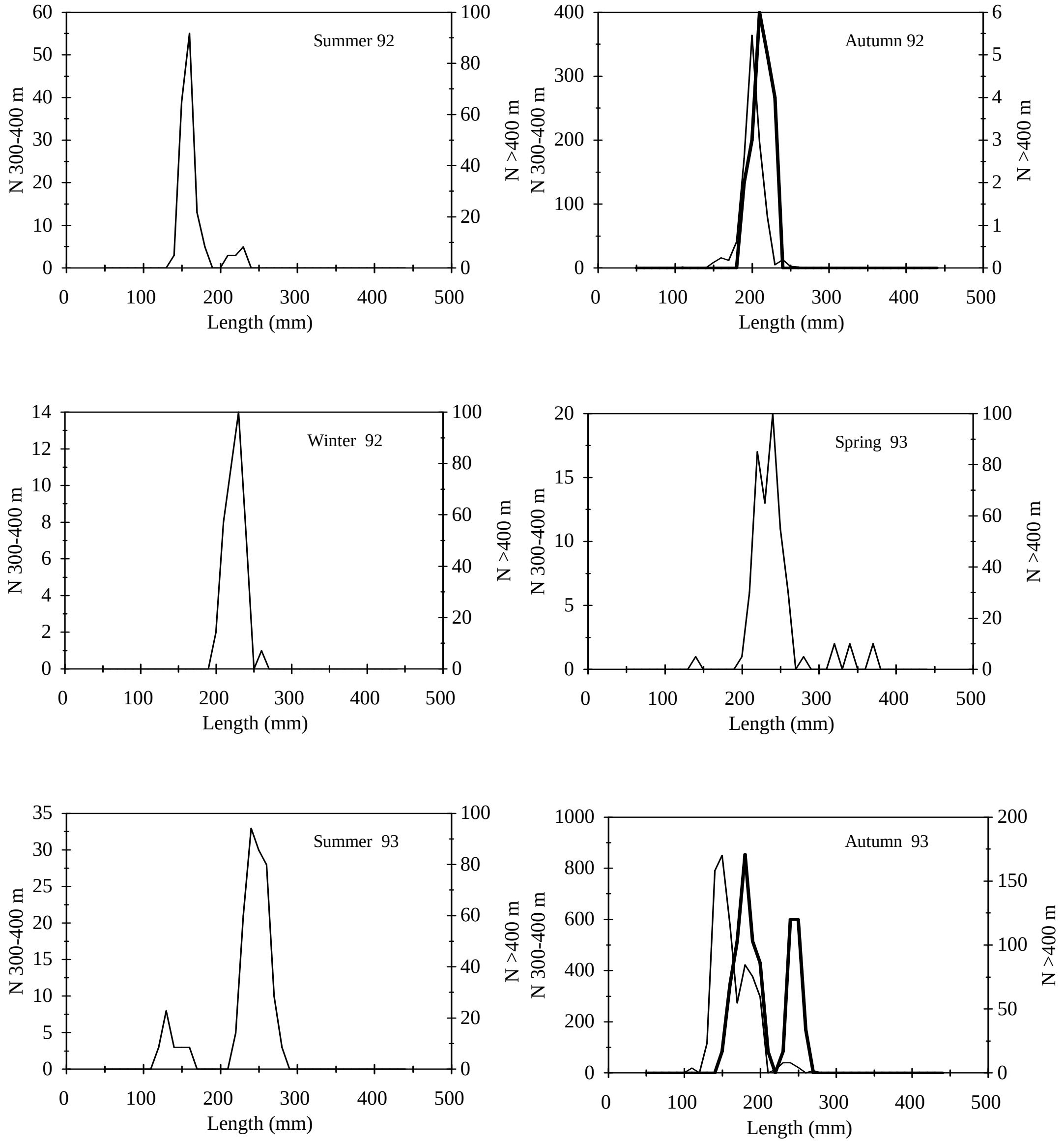


Fig. 20. Length frequency distribution of *M. poutassou* in the Thracian sea .(Thin line: 300-400 m depth, Thick line: >400 m depth).

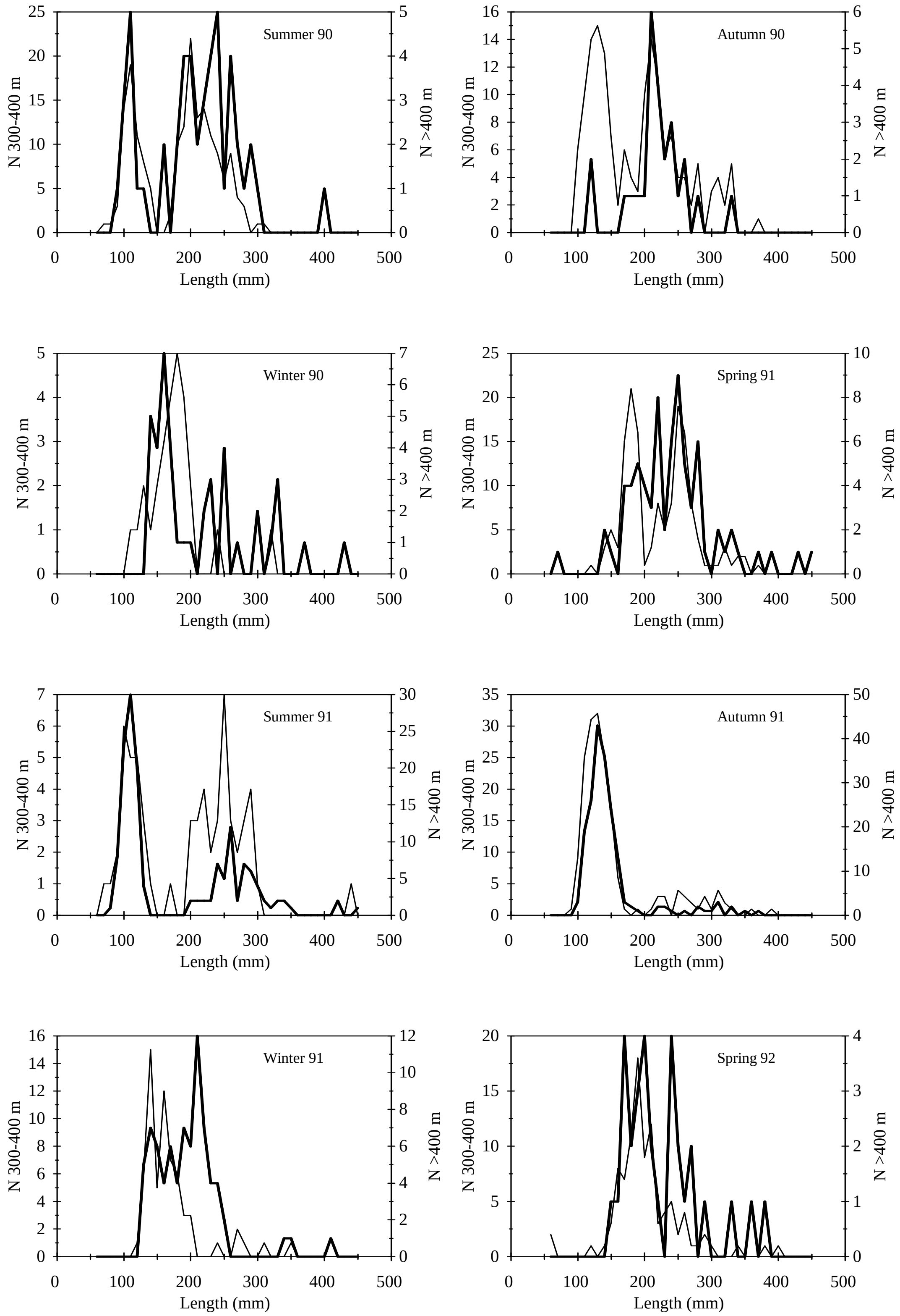


Fig. 21. Length frequency distribution of *P. blennoides* in the Northern Aegean sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

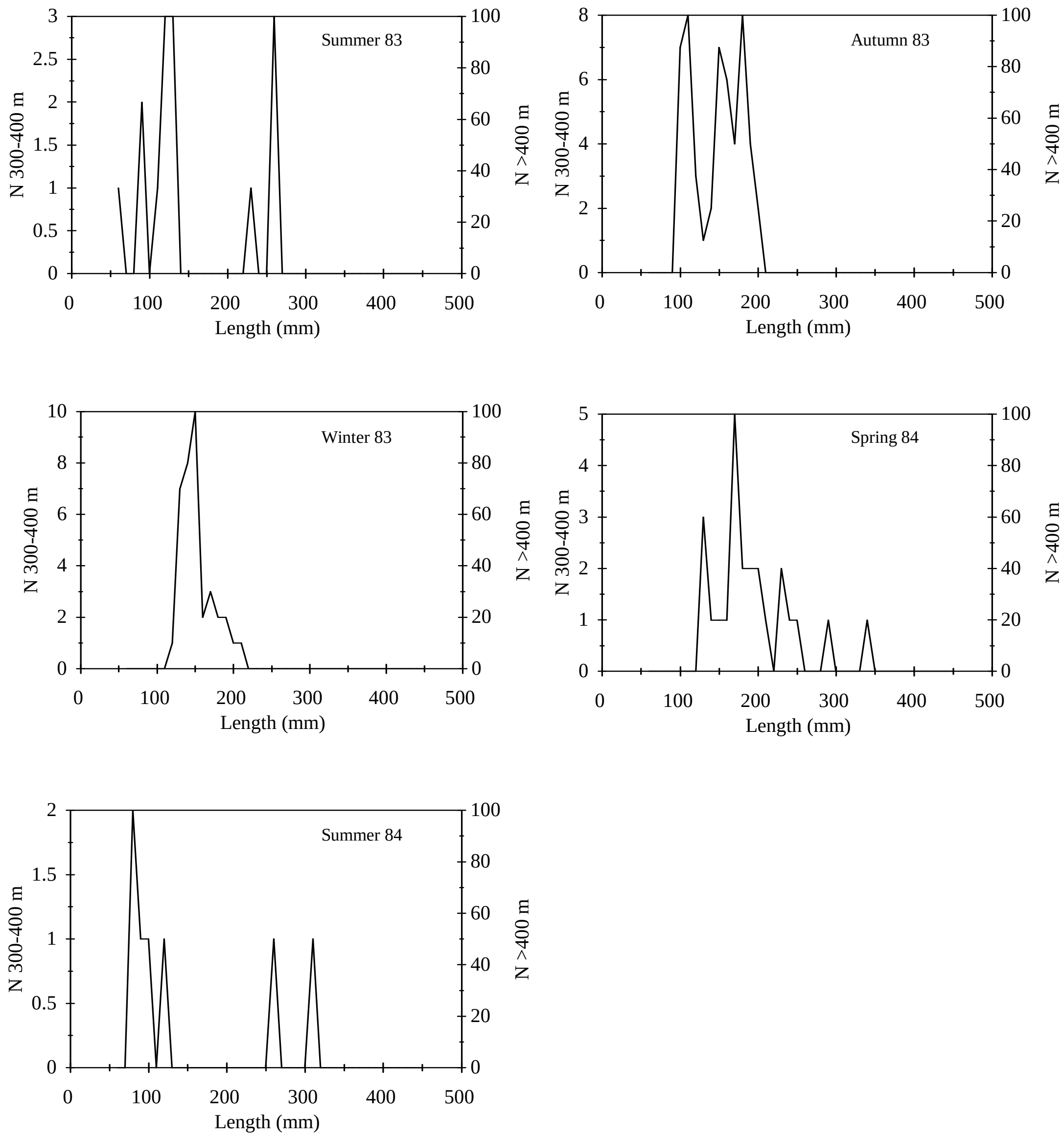


Fig. 22. Length frequency distribution of *P. blennoides* in the Ionian sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

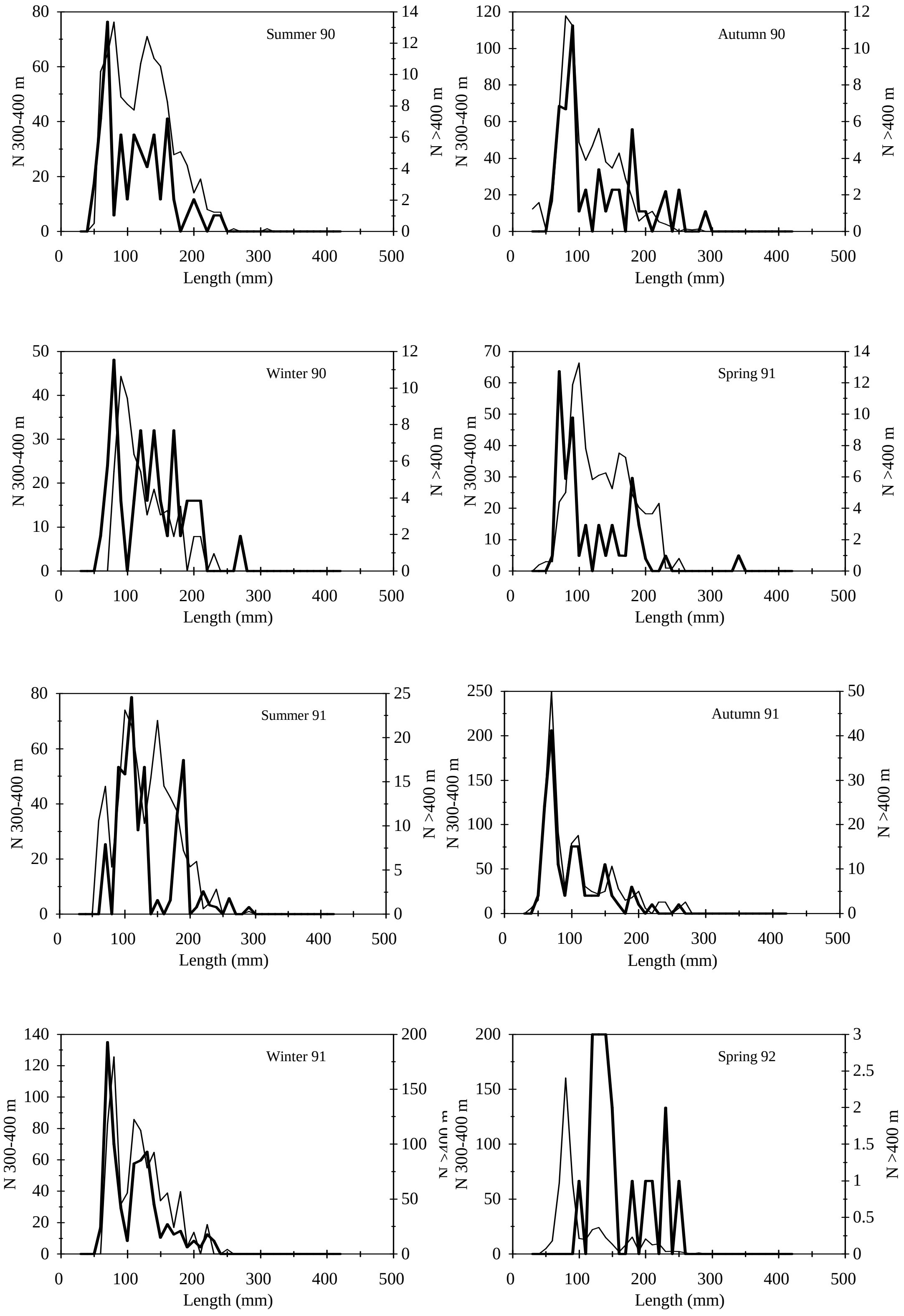


Fig. 23. Length frequency distribution of *L. boscii* in the Northern Aegean sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

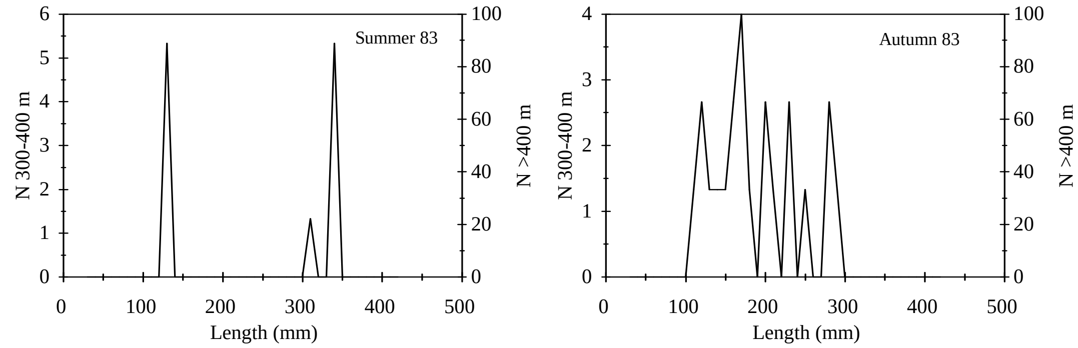


Fig. 24. Length frequency distribution of *L. boscii* in the Ionian sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

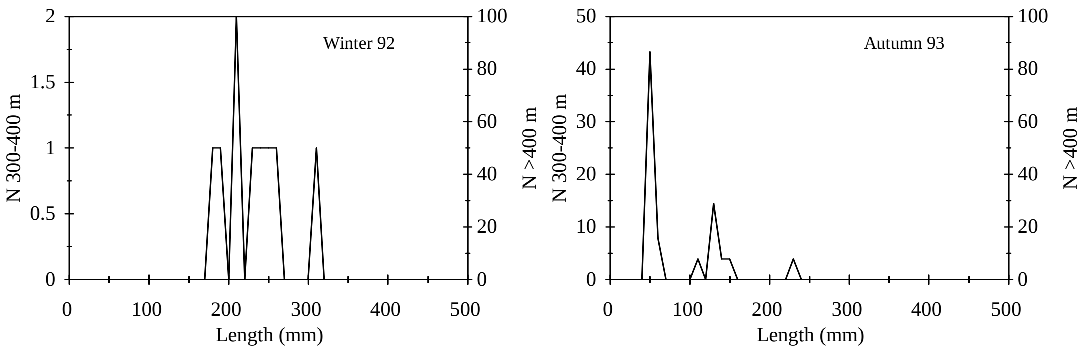


Fig. 25. Length frequency distribution of *L. boscii* in the Thracian Sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

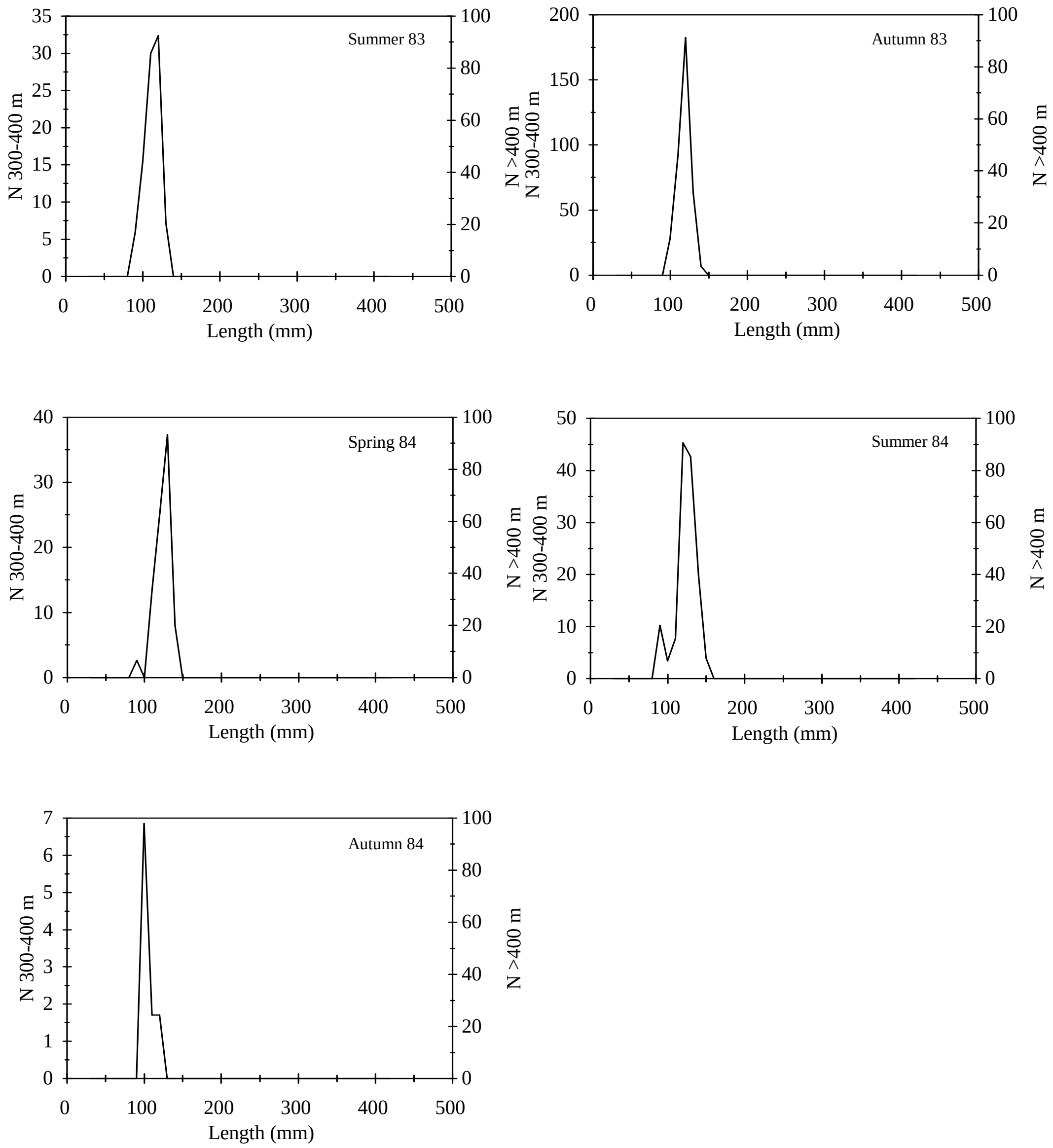


Fig. 26. Length frequency distribution of *P. bogaraveo* in the Ionian sea. (Thin line: 300-400 m depth, Thick line: >400 m depth).

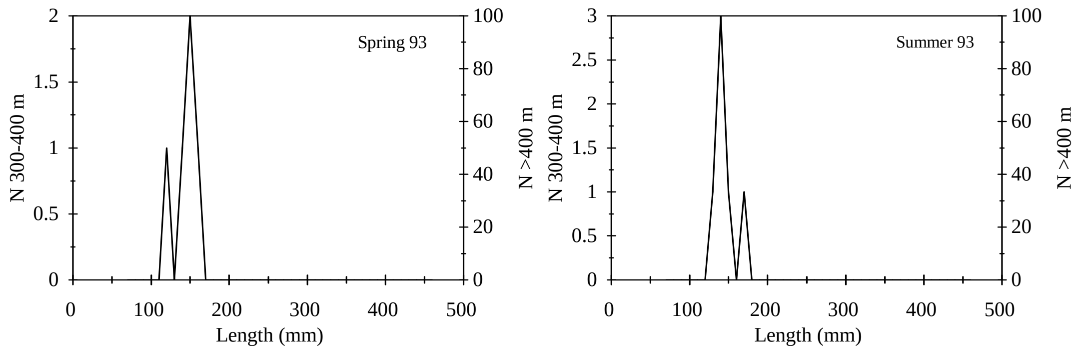


Fig. 27. Length frequency distribution of *P. bogaraveo* in the Thracian. (Thin line: 300-400 m depth, Thick line: >400 m depth).

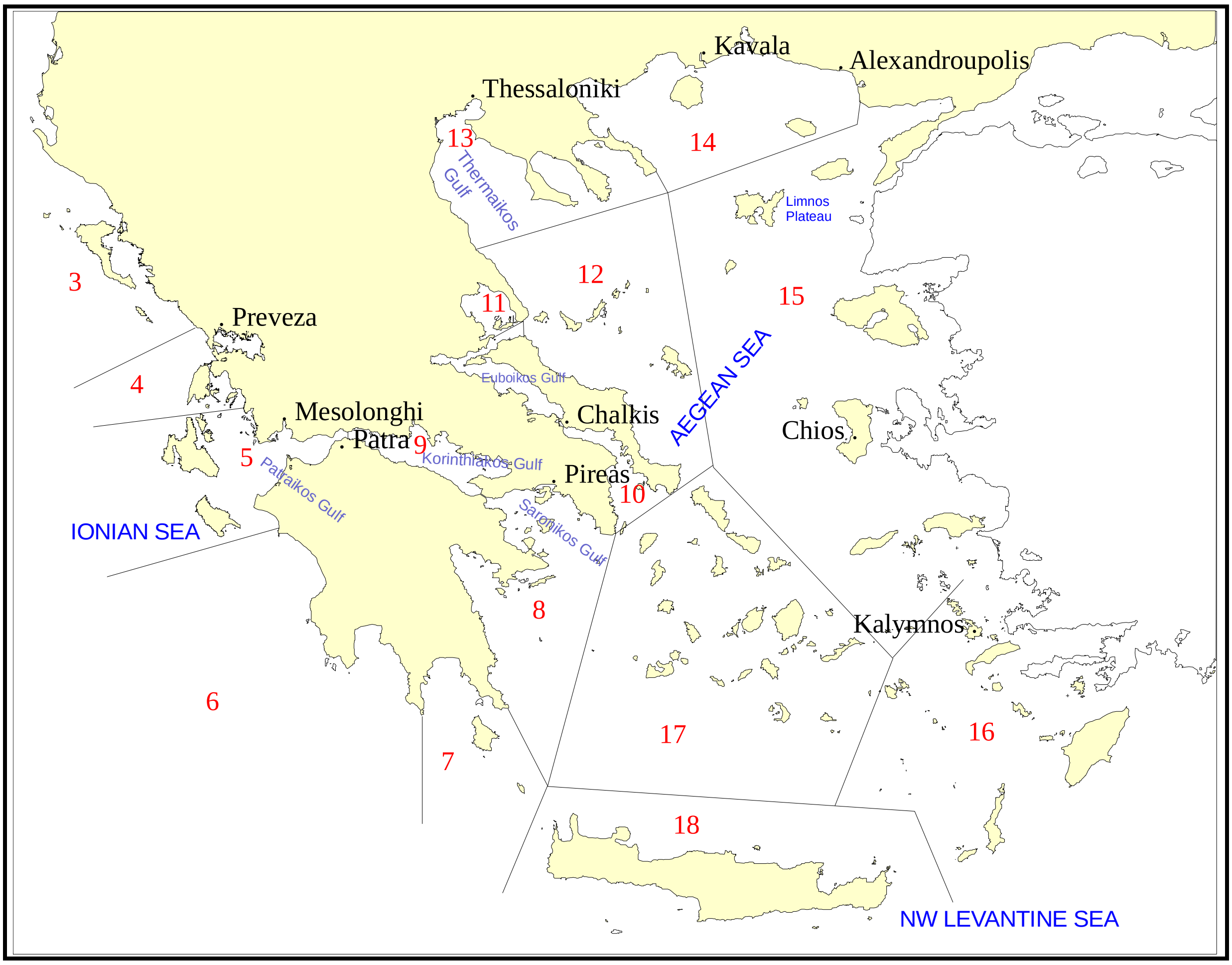


Fig. 28. Map of Greece with the National Statistic Service of Greece sub-areas and with the port-markets of ETANAL.

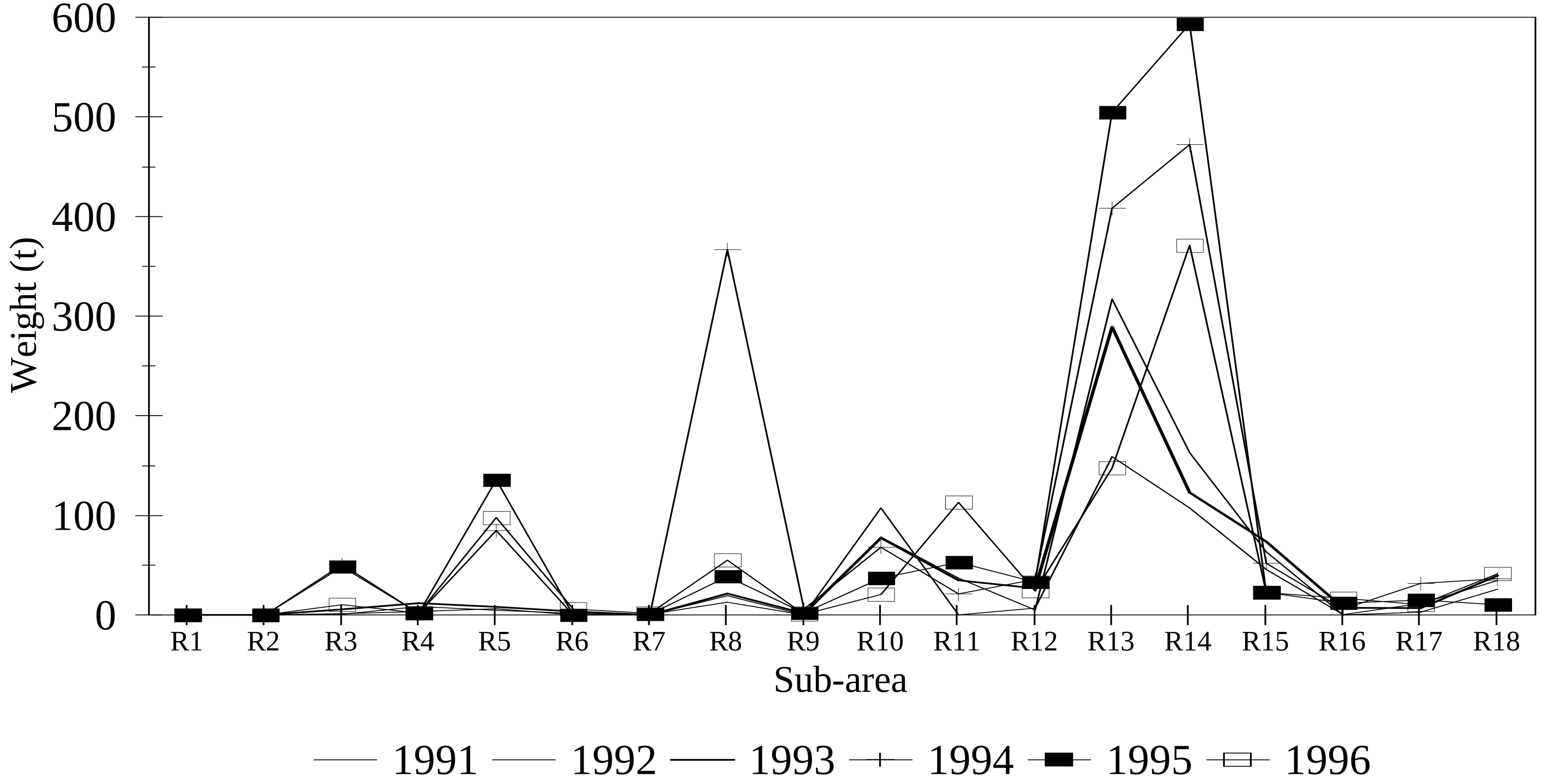


Fig. 29. Catch fluctuation of *L. budegassa* during 1991-1996 per sub-area. (R1-R18 sub-areas as in Fig. 28).

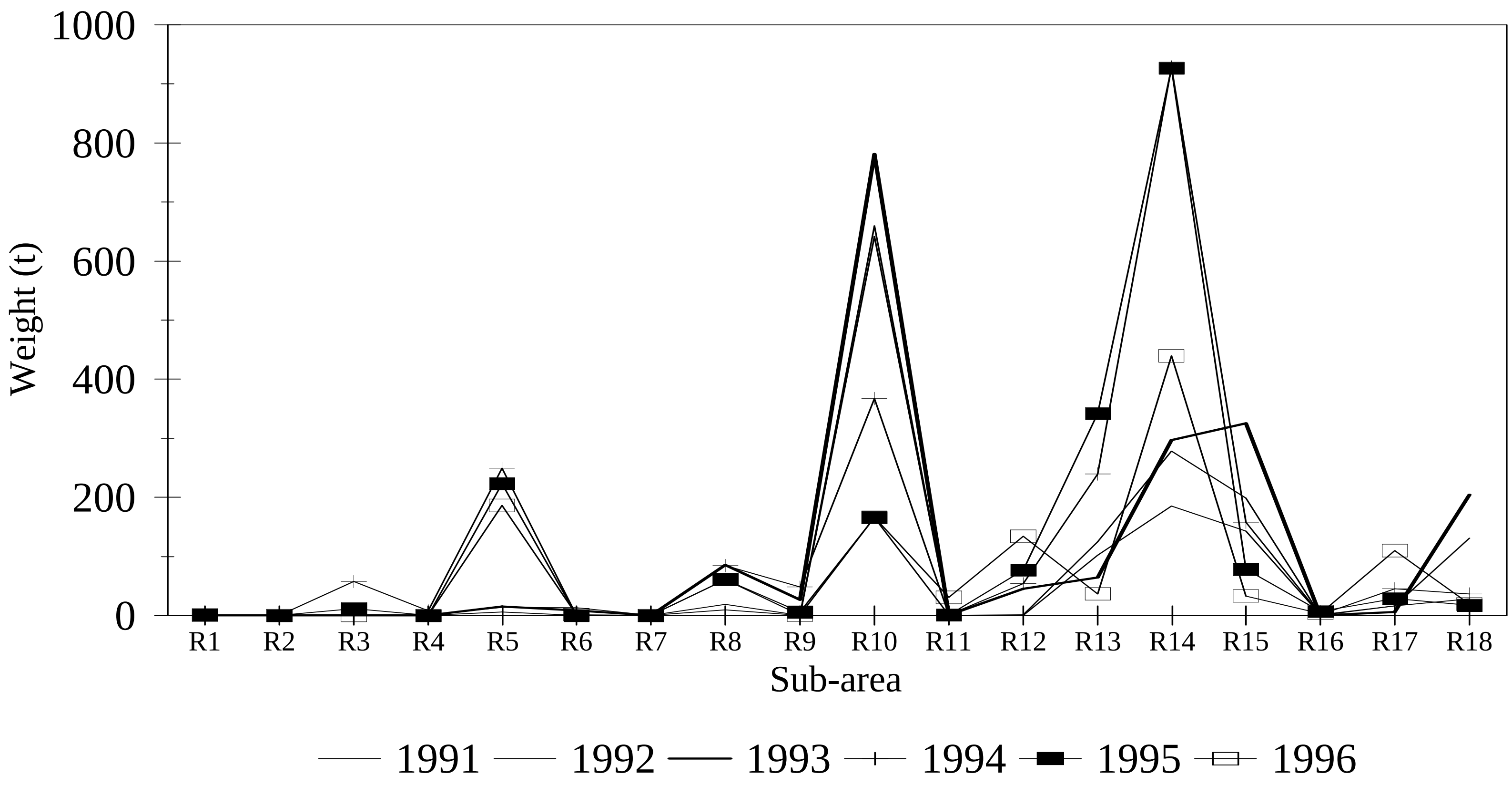


Fig. 30. Catch fluctuation of *M. poutassou* during 1991-1996 per sub-area. (R1-R18 sub-areas as in Fig. 28).

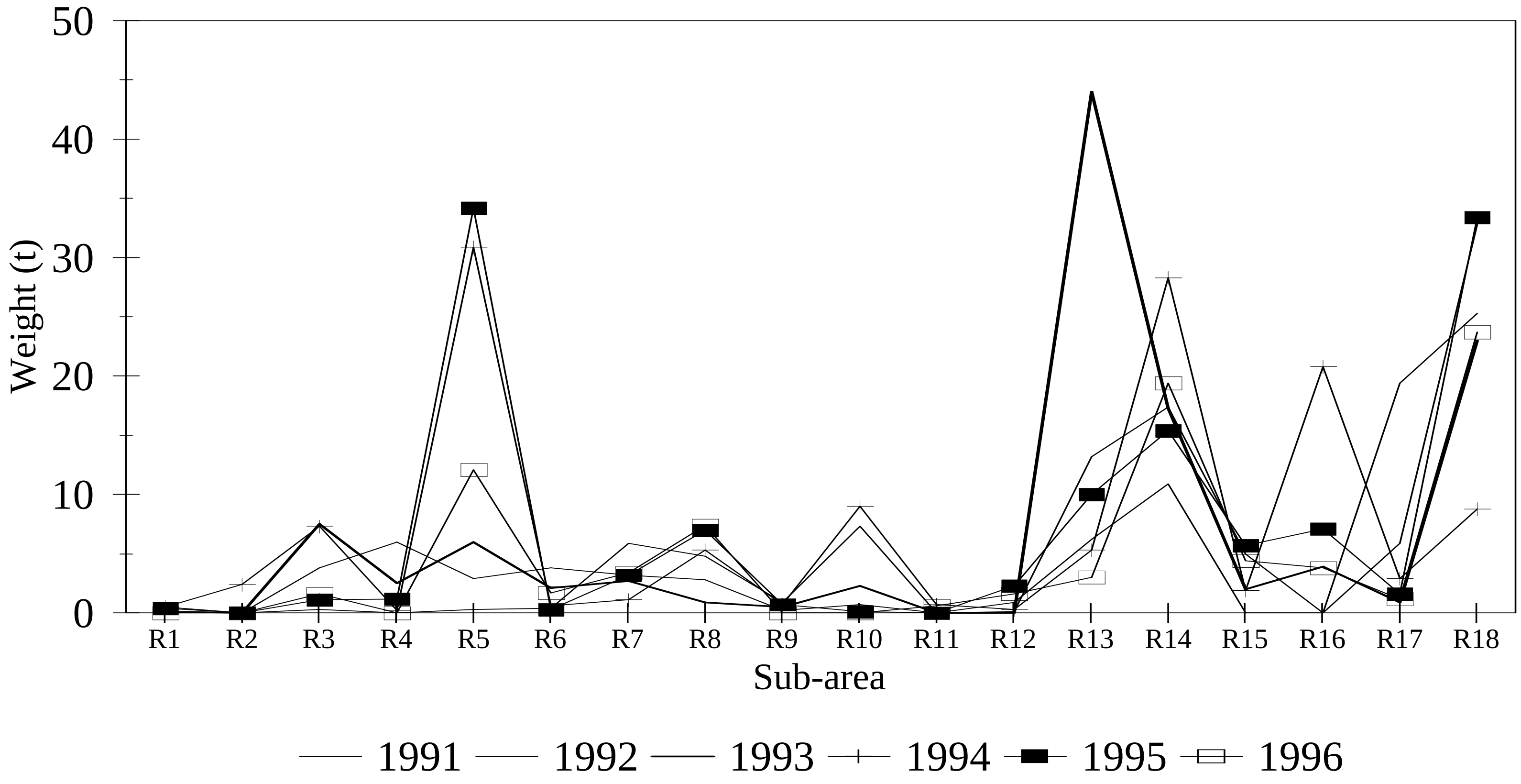


Fig. 31. Catch fluctuation of *P. americanus* during 1991-1996 per sub-area. (R1-R18 sub-areas as in Fig. 28).

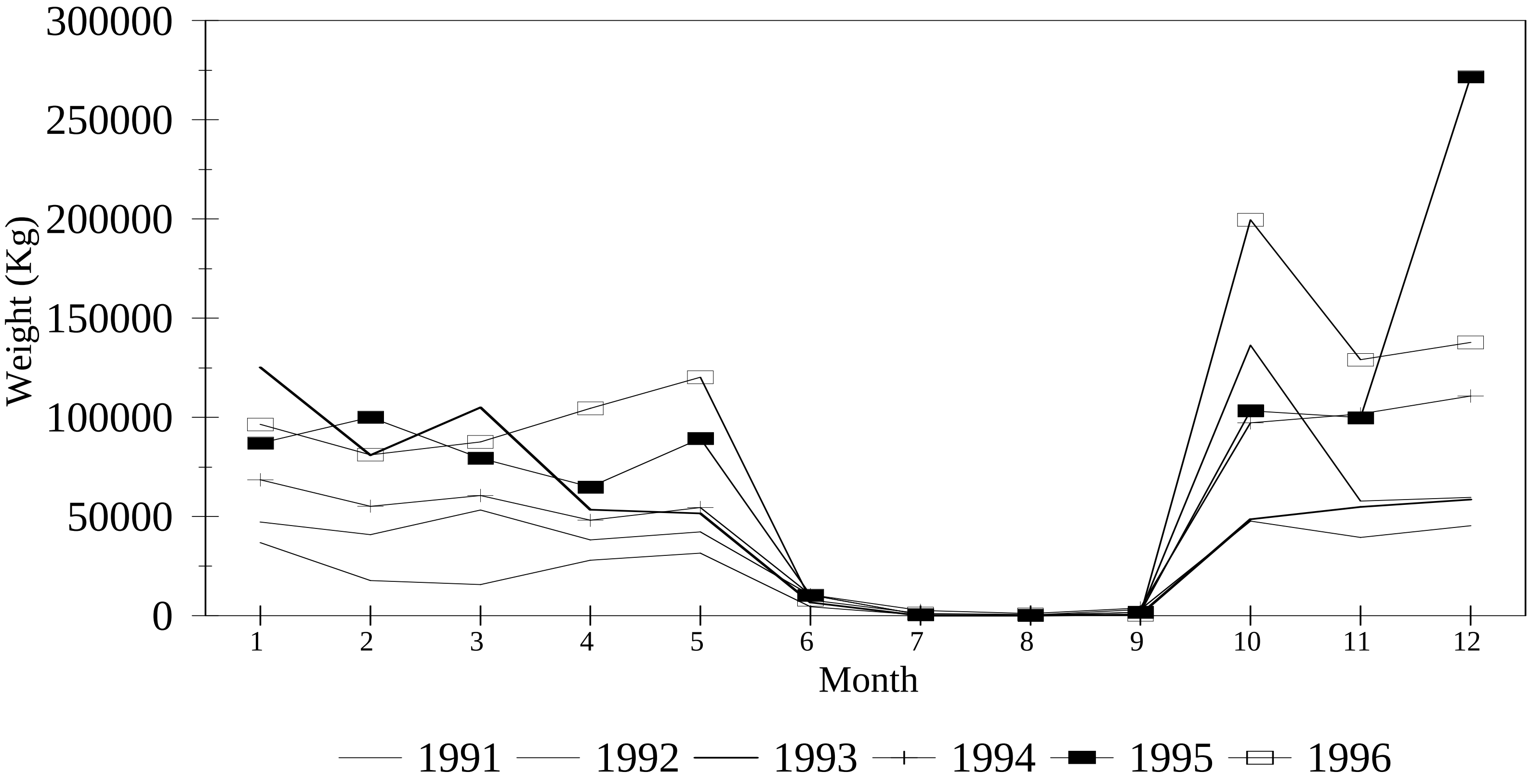


Fig. 32. Monthly catch fluctuation of *L. budegassa* during 1991-1996 according to the data of ETANAL.

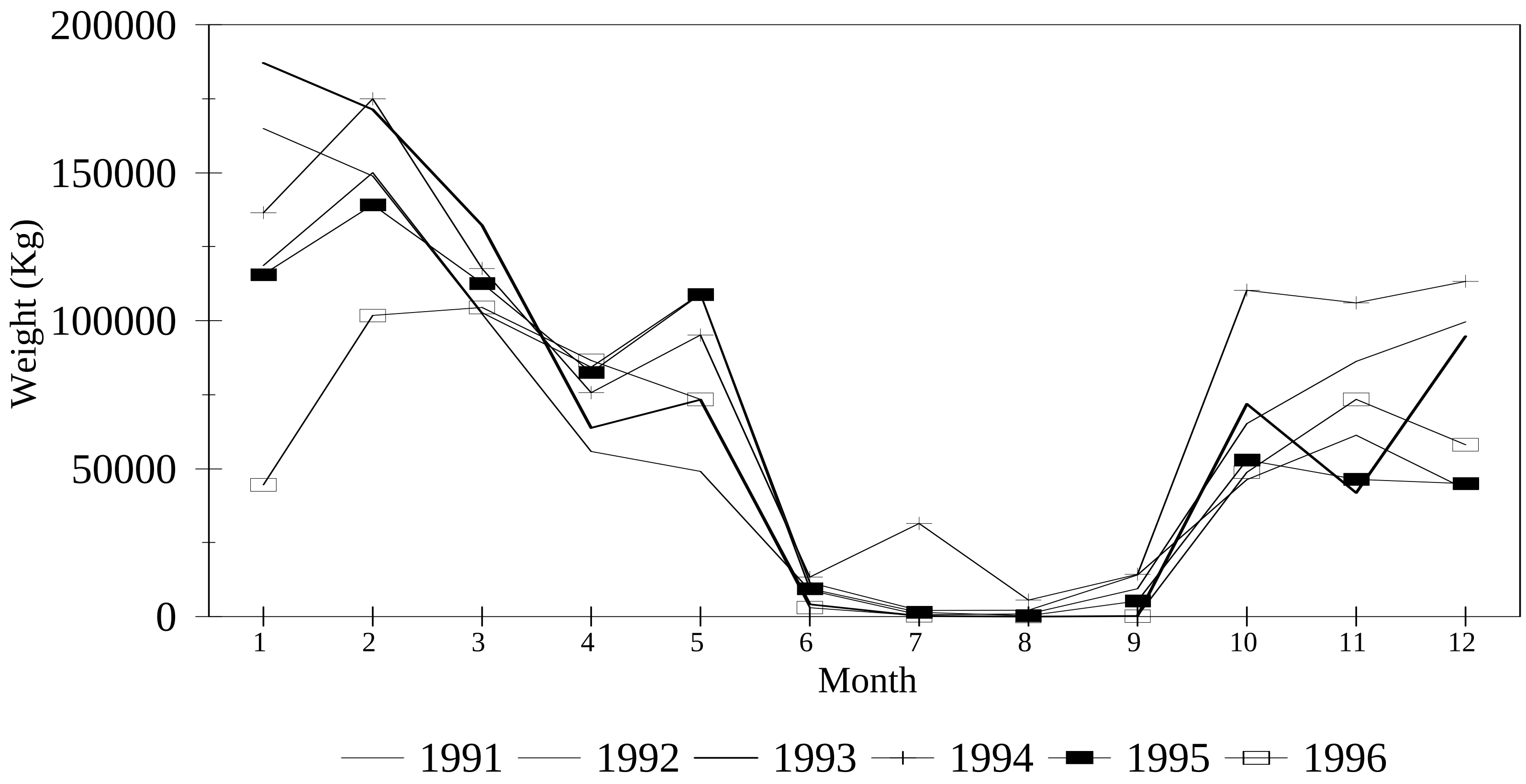


Fig. 33. Monthly catch fluctuation of *M. poutassou* during 1991-1996 according to the data of ETANAL.

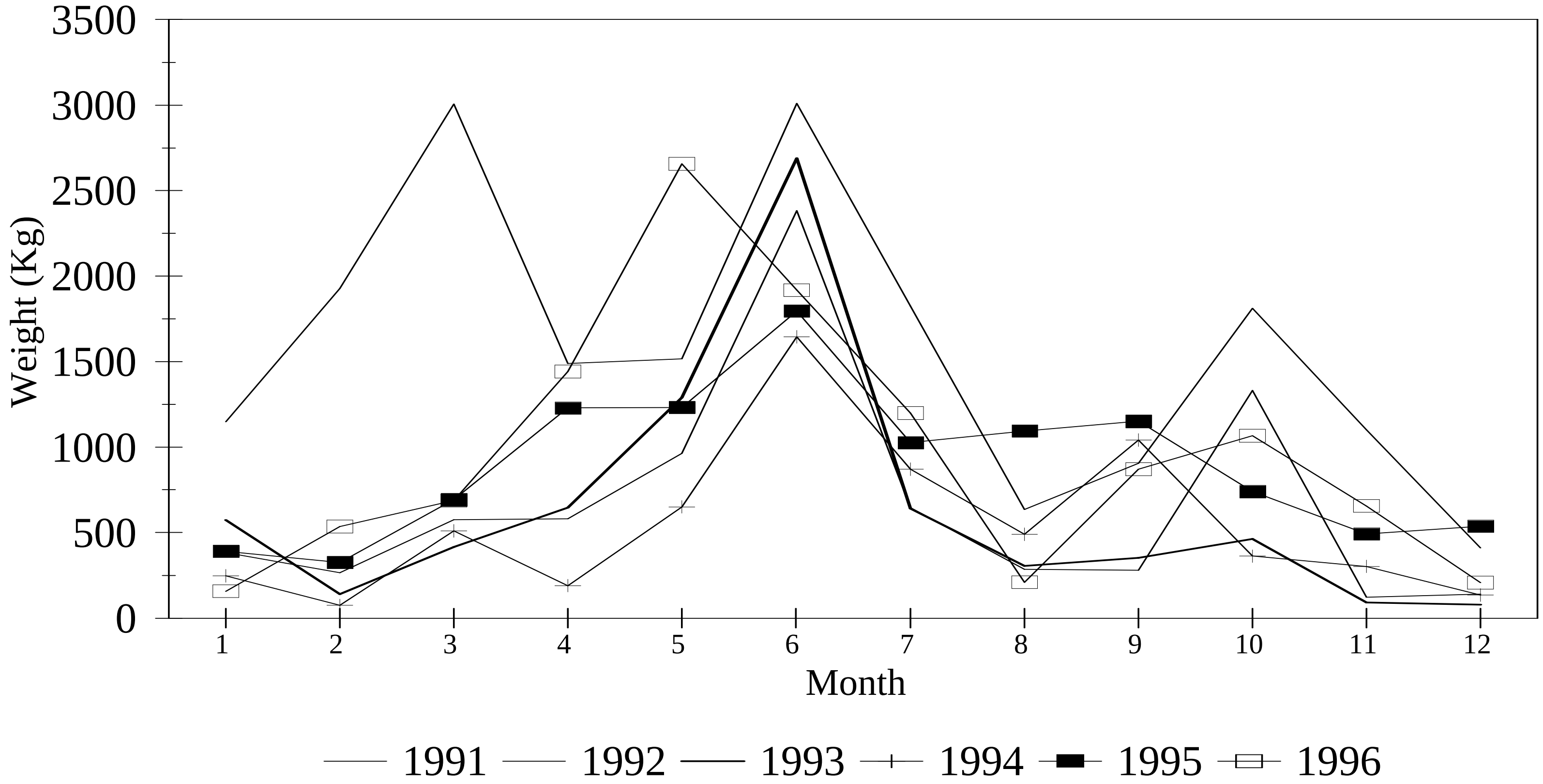


Fig. 34. Monthly catch fluctuation of *P. americanus* during 1991-1996 according to the data of ETANAL.

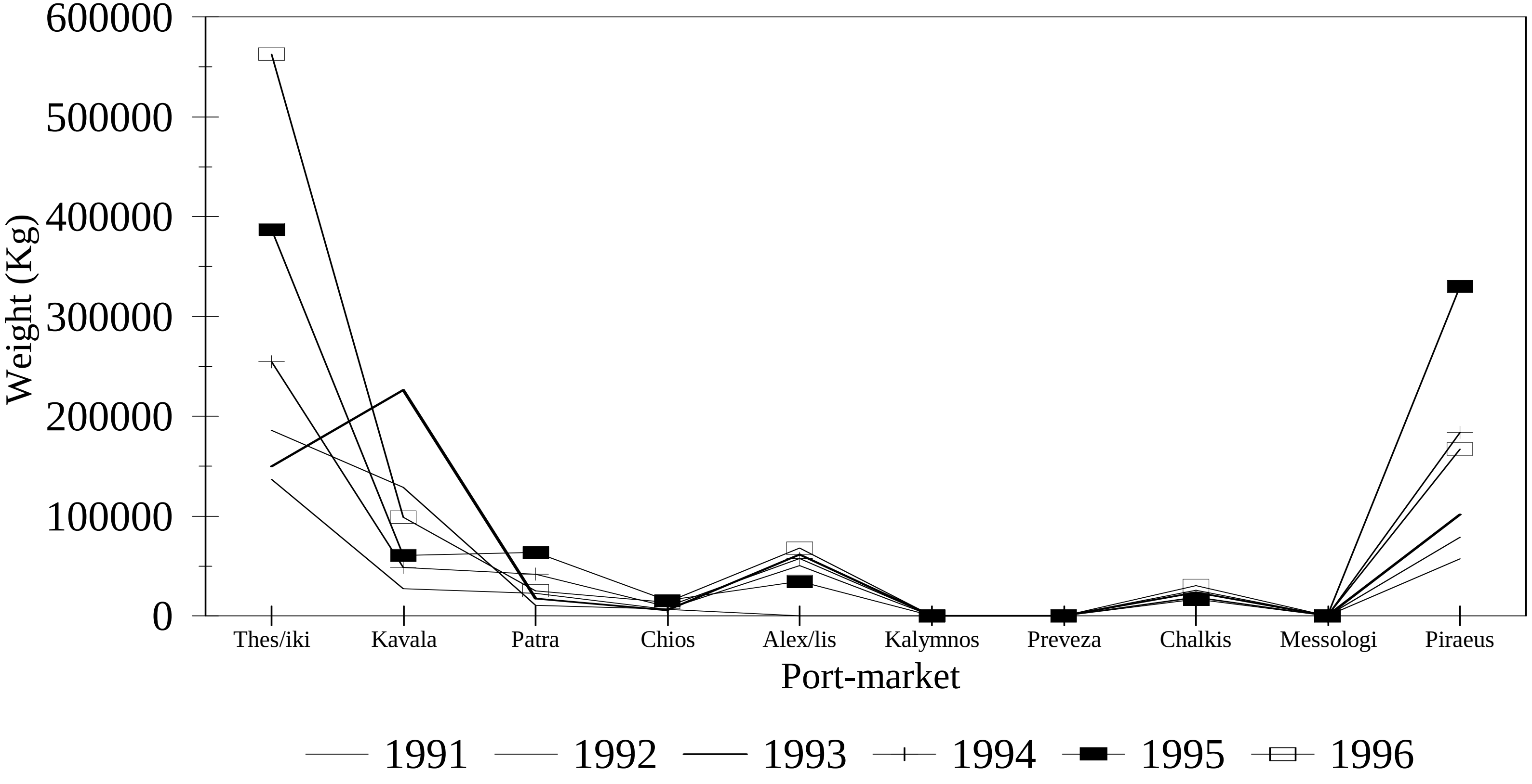


Fig. 35. Catch fluctuation of *L. budegassa* per port-market during 1991-1996 according to the data of ETANAL.

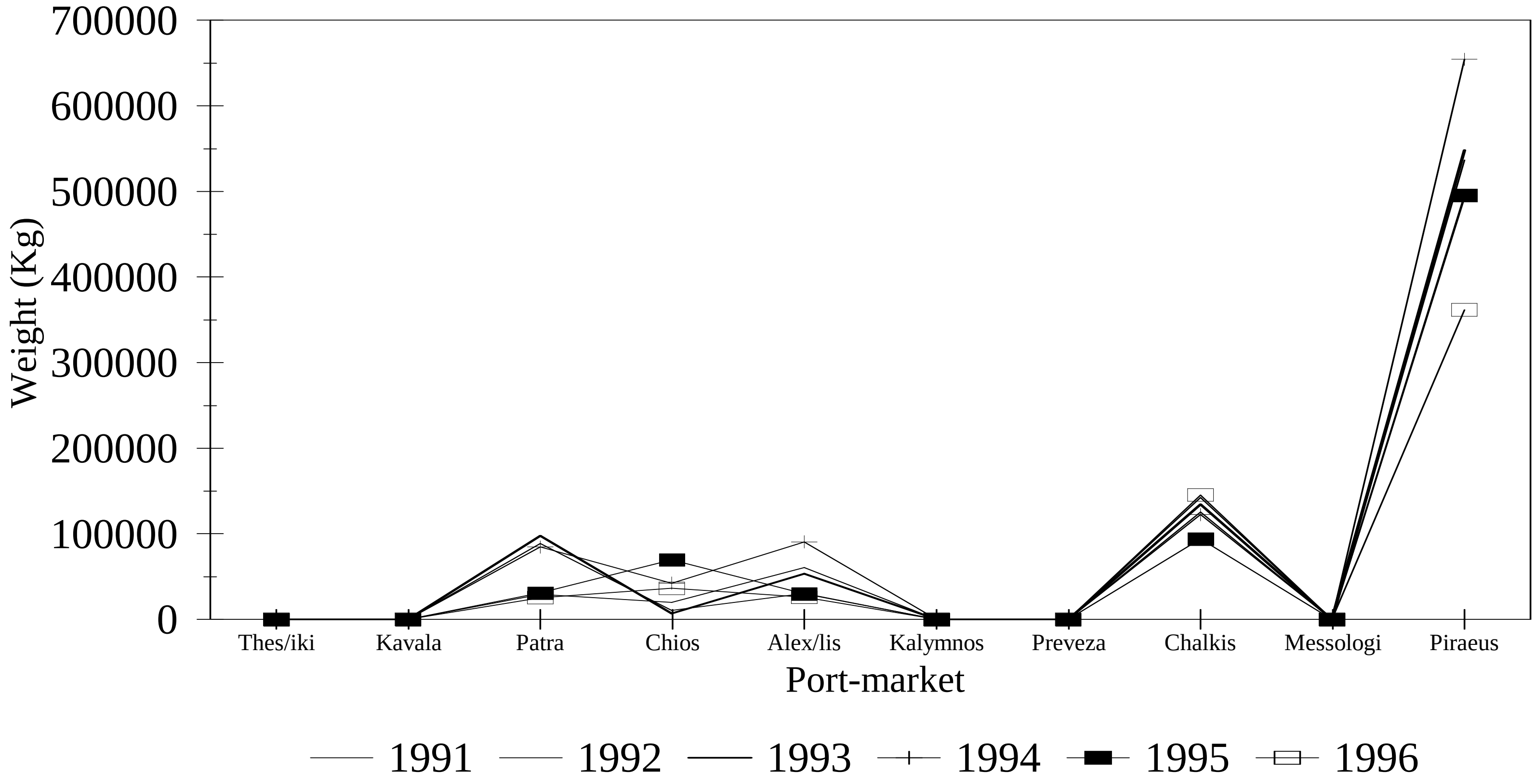


Fig. 36. Catch fluctuation of *M. poutassou* per port-market during 1991-1996 according to the data of ETANAL.

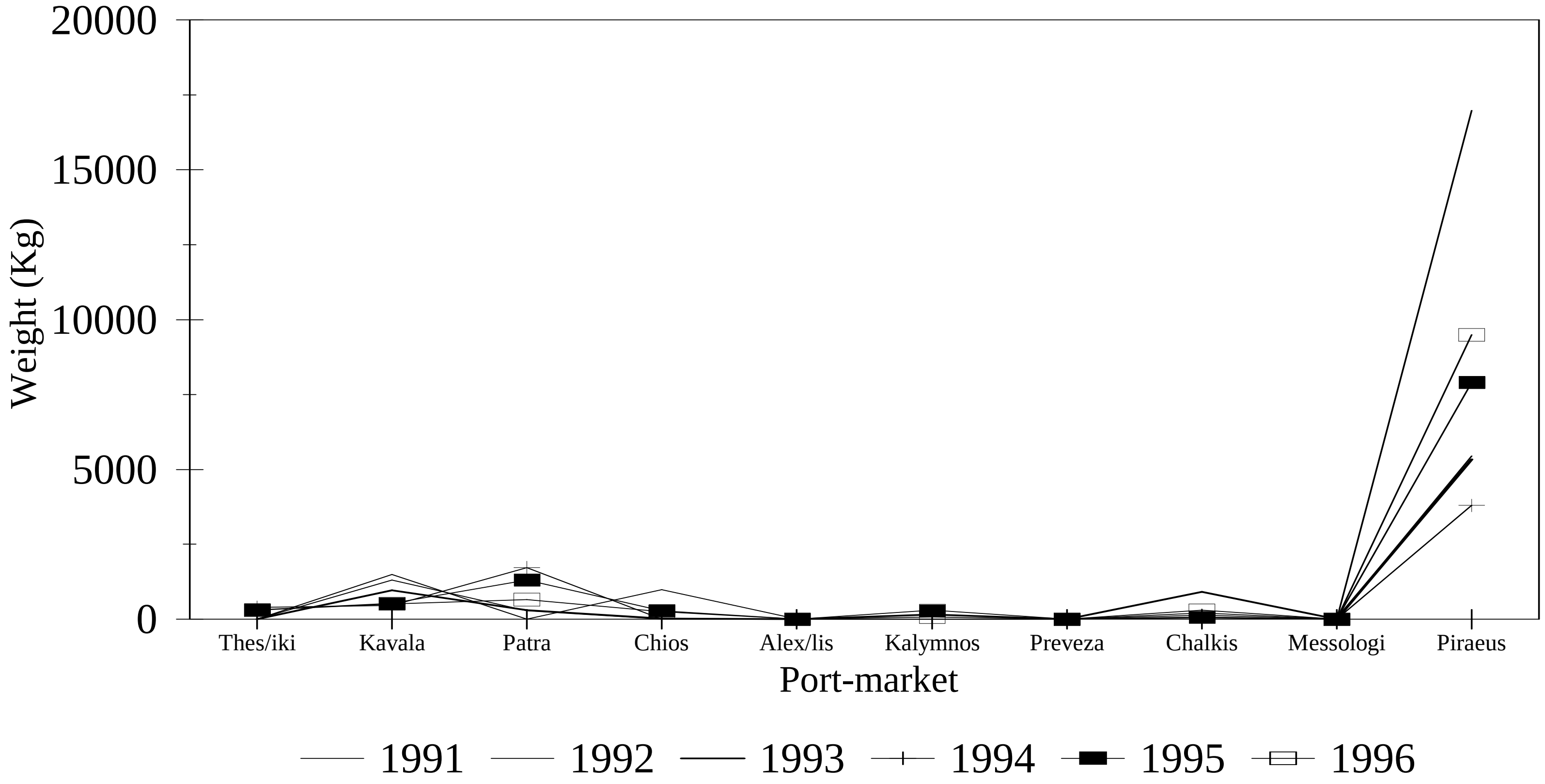


Fig. 37. Catch fluctuation of *P. americanus* per port-market during 1991-1996 according to the data of ETANAL.

Sub-task 1.2: Description of deep-water fisheries of Greece

By George Petrakis, Kostas Kapiris, Chrissi-Yianna Politou and Kostas Papaconstantinou.

The proposed program of the NCMR in this subtask had the following objectives.

1. Review of the oceanography of the deep Greek waters.
2. Description of the deep water fisheries (areas, seasons, etc.)
3. Description of the fishing vessels (type and specifications)
4. Description of the gears (static and mobile)

The first objective has been covered in the first interim report (working document No 12). The description of the present situation of the deep water fisheries in Greece (objectives 2,3 and 4) is included in the present report.

Introduction

The continental self of the Greek seas is generally limited. Only in the northern coasts, in the central Aegean and in Cyclades Islands there are quite extended fishing grounds with depths less than 400 m. The coast in the remaining are generally steep and the fishing activity is restricted mainly in a narrow zone along the coasts. A large proportion of the Greek sea area could be characterised as deep water (Fig. 1).

The information on the deep water fisheries in Greece, which could be extracted from the existing official data, is very limited, since the fishing vessels are not keeping log books and they do not record the area and the depth where they are fishing. The existing statistical data refer to the number, the horse power the tonnage of the fishing vessel and the catch per species per sub-area. However there is no information on the distribution of the fishing effort in the Greek Seas or of the depths where from the catches are coming. Furthermore, the small scale fisheries vessels (using fixed nets or long-lines) exploit different gears and fish in different fishing ground targeting to different species during the year. Thus for example, the same vessel during spring and summer is using long lines for sword fish fishery and during winter, when the sword fishery is closed, it uses bottom long lines for hake fishery in deep waters. The allocation of the effort of these vessels is completely unknown and estimations of the fishing effort for each target species are not possible.

In the framework of the “Deep water fisheries” project an attempt was done in order to collect the first information about the patterns and the degree of exploitation of the deep waters in Greece.

Material and Methods

In order to collect information and to describe the deep water fisheries in Greece (areas, seasons, gears, target species, etc.), interviews with fishermen and fishing administrators took place around the Greek coasts.

The Greek seas were divided in seven areas (Fig. 2) and interviews with fishermen and administrators took place in each one of them in one or more fishing ports. The questions were about the target species in waters deeper than 400 m, the seasons of the fishing activities per each target species, the gears and the vessels used for fishing and the fishing practice. Field observation has been done in the case of *Pagellus bogaraveo* fishery in the Ionian Sea.

Generally, the collaboration of the fishermen was good, but we faced a lot of difficulties. The identification of the species was not possible always because in different areas the fishermen use different common name for the same species. The quantity of the catches were considered not accurate because the fishermen trend to report less than the actual concerning the target species whereas concerning the by catch and the discards because they do not give attention. In order to obtain better information field observations and studies of each one metier are needed.

The distribution of the vessels that could have fishing activities in deep waters has been examined using the data of the census of the fishing fleet which contacted by the Ministry of Agriculture and the National Statistic Service of Greece (May 1998). Bottom trawl, bottom long line and static net vessels were considered to have this activity. The number, total GRT (gross tonnage), the total HP and the number of the crew members per category were estimated and a classification of the vessels according to their length was done per category. We defined three length classes for each category. For the bottom trawlers in the A category belong vessel with length less than 20 m, in the B category vessels with length 20-25 m and in the C category vessels with length more than 25 m. For the long-line and static net vessels the A category refers to vessels of length less than 10 m, the B category to vessels 10-15 m and C category to vessels more than 10 m.

Results

A description of the fishing activities in deep waters per each area will be given and the most important fisheries of each area will be presented.

Deep water fisheries in the Ionian Sea (area 1)

The Ionian Sea's continental shelf is restricted, fact resulting in limited fishing activities. Regions with the most important activity occur mainly off the northern Peloponnessus coasts in Patraikos Gulf and in the sea area between the islands of Zakynthos, Kefalonia and the mainland, the coasts of Etoloakarnania and the "plateau" determinated by Lefkada and Corfu island and the Preveza coast. The western coastlines of Peloponnessus and Zakynthos, Kefalonia and Ithaka islands are too steep so that the continental shelf is very limited (Fig. 3). Commercial fisheries in the deep waters of Ionian Sea are carried out by bottom trawlers, nets and long lines but generally they are not developed.

<u>Bottom trawl fishery</u>

The deep water bottom trawl fishing activity in the area is restricted. This is due mainly to the fact that the commercially important catches in these depths are not abundant and the fishing is not profitable. Another reason is that the fishermen not try to explore these areas because they wonder about the security of their gears and they do not want to loose time. Commercial trawl fishing is carried out in depths down to 300 m and sporadically down to 500 m mainly at the end of spring. Target species of this fishery are *Merluccius merluccius, Micromesistius poutassou* and *Trigla lyra*.

The presents of the deep water shrimps *Aristaeomorpha foliacea* and *Aristeus antennatus* was known to the skippers, but the species were unknown in the market and their price was very low. During the sampling of the deep water projects the skipper of the hired vessel realised that the quantities of these species are enough to support a fishery. Furthermore, he learned to distinguish the species. *A. antennatus* has now a good price in the local market and the consumers started to get used in these species. *Helicolenus dactylopterus*, *Merluccius*

merluccius, *Plesionika martia*, *Plesionika edwardsii* and *Nephrops norvegicus* are the most important by catch species in depths 300-750 m.

Gill net *Pagellus bogaraveo* fishery

Gill nets are used for *Pagellus bogaraveo* fishery in the area. This fishery is a new one, started in 1996-97. The fishery is carried out all the year round but it is more intensive during summer time, because the weather is better and the prices are higher. The depths are extended from 200 m to 600 m. The fish are concentrated mainly on rocky banks. The mesh size of the gill nets used is 80-100 mm (stretched length). Each net has length about 300 m and 6-10 pieces per day are used. They tie small bangs with bait on the foot rope of the net in a distance of 10 m. The bait is *Sardina pilchardus*, *Sardinella aurita* or *Scomber spp.*. The soaking time is about 4-5 hours. Considering the time that is needed for the nets to approach the bottom the nets fish about 3-4 hours. For each piece of nets, about 700 m of ropes are needed in order to connect the begging and the end of the net with buoy, and the space that is needed for storing the ropes is significant.

Each trip last for 1-3 days, depending on the distance of the fishing ground from the port. The vessels are equipped with freezer and ice in order to keep the fish fresh. They are also equipped with bythometer in order to detect the rocky banks and with hydraulic winch in order to haul the nets. Their length ranges from 12-16 m. The crew is consisted of 2-3 persons.

The catch is consisted almost exclusively of *P. bogaraveo*. The total catch per each peace of net varies and generally the fish are concentrated in one piece. According to our observations on a professional vessel the catch of *P. bogaraveo* ranged from 0-50 Kg per each peace of net (300 m). Daily catch range from 50-150 Kg. By catch species are *M. merluccius*, *Helicolenus dactylopterus* and *Squalus blainvillei*.

Long line *M. merluccius* fishery

Long lines are used in the area for *M. merluccius*, *P. bogaraveo* and *Polyprion americanus* fishery. Recently, the fishermen are targeting less and less to the *P. americanus* because the catches are very low. The fishermen observed that if they have good catches in one area for a small period (1-2 weeks) a long time (more than 3 years) is needed in order to obtain good catches again. They concluded that the regeneration of the *P. americanus* stock is very slow. This is a common opinion of the fishermen along the Greek coast.

The *M. merluccius* long line fishery is carried out in depths from 400-700 m on muddy bottoms. The total length of the long lines is 3000-6000 m, depending on the capacity of the vessel, and the number of the hooks is from 600-1200 (one hook in each 5 m). The size of the hooks is No 6. The bait is usual *S. pilchardus*. The fishery is carried out during all the year. Some vessel during summer are targeting on *Xiphias gladius*, so during winter when the *X. gladius* fishery is closed, the effort for *M. merluccius* is higher. The length of the vessels ranges from 9-16 m and they are equipped with bythometer and hydraulic winch. Each trip last 1-3 days. The time that is needed for shooting the long lines is about 1-2 hours and they start hauling 1-2 hours after the end of the shooting. The time needed for hauling is highly depended on the quantity of the catch and on possible problems when the long lines get stuck on the bottom.

The catch per day is about 100-200 Kg of *M. merluccius* and they are generally large specimens (>35 cm). Commercial by catch species are *P. americanus*, S. *blainvillei*, *H. dactylopterus* and *Raja sp.*. Non commercial by catch species are *G. melastomus*, *Lepidopus caudatus* and *Raja sp*. The catches of *L. caudatus* sometimes are very high and they destroy the long lines.

Long line *P. bogaraveo* fishery

The length of the long lines that are used in *P. bogaraveo* fishery are smaller 200-500 m than those used for *M. merluccius* fishery. The total length of long lines used per day is about 3500 m and the number of hooks is about 2500. The hooks are tied in smaller distance (about 1.2 m). The bait is usual *Scomber scombrus*. The practice is different, than in the hake fishery, since they fish on rocky banks and they shoot one or two pieces. After 0.5-1 hour the hauling starts and it is finished they shoot other pieces in the places where most fish were found in the first attempt. If the haul is successful, the long line is destroyed because the distance between the hooks is small and the long line is twisted. The catch per day is variable. A total catch of about 80-100 Kg per day is common. By catch species are S. *blainvillei* and *H. dactylopterus*.

Deep water fisheries in Saronikos, Argolikos and Lakonikos Gulf (area 2)

Saronikos Gulf is generally a shallow basin and the depth reaches 300 m only in a very restricted area so no deep water fisheries is existed there (Fig. 4);

The east and south coasts of Peloponnessus are steep and the continental shelf is very restricted. Even though there are suitable waters for deep water fisheries the activities are very restricted and the fisheries exploit mainly coastal stocks in depths less than 250 m.

The small scale fishery vessels in the area are mainly less than 10 m, and they are not suitable for trips more than one day. The sea is very exposed and during winter the weather is a strong restricting factor for long period. In addition, the *P. americanus* stock, one of the target species in deep waters, in the area, declined and it almost disappeared the last 7 years. Sporadically long lines are used targeting to *P. americanus,* but the use of them is more experimental in order to see the situation of the stock.

Even though there is a strong bottom trawler fleet in the area it mainly works in other areas of Greece, because the catches are very low. No one bottom trawler was fishing in the area during October 1998, when we interviewed fishermen of the area. The activity of bottom trawl fishery is scarcely extended in waters deeper than 300 m.

In the southern part of Peloponnessus, the only fishing activity in deep waters was a long line fishery that lasted from 1989-1991. The target species was a new species for the fishermen of the area and probably belonged to the family Centrolophidae. The catch was consisted from large specimens (up to 15 Kg) and the catch per day was up to 600 Kg. The depth was 250-650 m.

P. bogaraveo is fished in depths from 250-450 m on rocky banks with trammel nets during March to June but this fishery is not intense.

Long line *M. merluccius* fishery

This is the only deep water fishery that is taking place in quite high intensity in the area. Hake is fished in the area in depths down to 750 m on muddy bottoms in the eastern coast of Peloponnessus. The long lines have lengths of 300 to 600 m and the number of hooks varies between 500 and 1000 (one hook per 6 m). The bait is *Sardina pilchardus* or *Sardinella aurita*. Fishing takes place mainly from March to June. The weather is the main reason for the absence of fishing activity the other months. During July-August, strong northern winds blow in the area. The trips last usually one day. The fishing vessels are up to 10 m long and the crew is consisted of two persons. The vessels are equipped with bythometer and winch for hauling the nets. The horse power of the engines is about 90 HP.

The daily catches of hake range between 40-60 Kg. The main by catch species are *Helicolenus dactylopterus, Phycis blennoides, Raja sp. Galeus melastomus, Squalus blainvillei,* sharks and *Lepidopus caudatus.*

Deep water fisheries in Northern Aegean Sea (area 3)

The most extended fishing ground of the Greek seas is located in the Northern Aegean Sea (Fig. 5). The area is considered to be one of the more productive fishing areas of Greece. The ecosystem is characterized of rivers which carry fresh water and of the currents that come from the Black Sea with cold and low salinity and rich in nutrients water. Fishing activities take place mainly in shallow waters (less than 400 m).

Deep waters exist in the trough that extends from the eastern coast of Thessaly to south of the coast of Macedonia and Thracia. The small scale fishery vessels are from 5-15 m and the engines are 10-300 HP. Some of them are exploit the deep waters using mainly long lines for the *M. merluccius* fishery. Bottom trawlers are fishing in the area in depth down to 450 m.

<u>Long line *M. merluccius* fishery</u>

The fishery is carried out in depths down to 700 m. The crew of the vessels consisted from 1 to 3 persons and the duration of each trip is 1-3 days. The length of the long-lines is about 14000 m and the number of hooks about 2000. The distance between two hooks is about 7 m. The size of the hooks are No 10 to No 6. The bait is *Sardina pilchardus* or *Scomber spp.* The catch per trip is up to 200 Kg. Generally the quantities of the discarded fish are very low. The main discarded species is *G. melastomus.* The vessels are equipped with navigation equipments, bythometer, freezer and winch.

<u>Bottom trawl fishery</u>

The bottom trawl fishery in waters deeper than 400 m in the area could be characterised opportunistic since fishing takes place mainly in depth less than 200 m. Target species in the deep waters are *M. merluccius, Nephrops norvegicus* and a shrimp species which was not identified and belongs to the genous *Plesionika*. For both species, fishing takes place in depth down to 500 m. Main by catch species is *Micromesistius poutassou*. The duration of the tows in deep waters is up to 4 hours.

The catch of hake in the deep waters is up to 300 Kg per day, whereas the catch of the shrimps goes up to 250 Kg per day. This shrimp has no commercial value in Greece and is exported mainly in Spain and in Portugal. The quantity of the discarded fish is about 10% of the catch and it consists of no commercial species and of undersized specimens of commercial species.

Deep water fisheries in Central Aegean Sea (area 4)

The depth in the north-eastern part of the Central Aegean Sea is mainly less than 400 m, whereas in the south-western part the depth rounds mainly between 400 and 1000 m (Fig. 6). The north-eastern part is one of the most important fishing grounds for bottom trawl fishery in Greece. The bottom trawlers exploit the area in depths down to 500 m. In the deeper waters they are targeting mainly *M. merluccius* and *N. norvegicus*. The fishermen claim that the catches of *N. norvegicus* the last years are reduced and simultaneously the catches of *P. longirostris* increased.

The deep water fishery is carried out in the south-western part mainly with nets and long-lines. Target species are *P. bogaraveo, M. merluccius* and *P. americanus*. The fishery is mainly extended to depths down to 450 m and sporadically in deeper water (down to 1000 m).

The length of the vessels is about 12-15 m and the engines are of 100-150 HP. The duration of the trip is one day and they work approximately 15 days per month. During winter they work fewer days because of the weather conditions.

P. bogaraveo fishery

In this area, the fishermen use trammel instead of gill nets for the *P. bogaraveo* fishery. The mesh size of the inner net is 80 mm and of the outer net 360 cm. The height of the nets is about 1.5 m. The fishermen tie small bags with bait on the foot rope of the nets. The bait is *S. pilchardus* or *S. aurita*. Fishing is takes place in depths down to 550 m on rocky banks during the night. The most important by catch species is *H. dactylopterus.*

M. merluccius fishery

The fishermen in the area use long lines and trammel nets all year round. The trammel nets are similar with the nets that they use for *P. bogaraveo.* The difference is that they place these nets on muddy bottoms during the night. The catch is about 15-10 Kg per day.

The long-lines are of 5000 to 6000 m and the hooks are of No 10-6. The distance between two hooks is 6-9 m. They fish in depths down to 700 m. The bait is *Scomber spp.* By catch species are *Squalus spp.* and *P. americanum*. The hake catch is about 50-100 Kg per day.

Long line shark fishery

A long line fishery targeting to a shark species is developed even thought it is not intense. The identification of the species was not possible, but we thing that it belongs to the Hexanchidae family, and probably is *Hexanchus griseus*. The long lines are about 6000 m and the hooks are No 6. The distance between two hooks is 10 m. The snoods are of rope instead of nylon. The last part of the snoods, which is connected with the hooks, is of wire to avoid cutting by the teeth of the sharks. This fishery is extended in waters down to 1200 m. The price in the market is low, but the quantities are high, and the fishermen have a sufficient income.

Deep water fisheries in South Western Aegean Sea (area 5)

In this area the waters are mainly shallower than 400 m and there no deep water fisheries activities take place.

Deep water fisheries in South Eastern Aegean Sea (area 6)

The depth in the North-Eastern part of the area is less than 400 m but in the South-Western part the coasts are very steep and the deep waters compose a big proportion of the total sea area (Fig. 8). The substrate in the area is very rough and the bottom trawl fishing is restricted in small fishing grounds. Bottom trawl activities in the deep water of the area are rare deeper than 400 m.

The deep water stocks of the area are exploited mainly by the small scale fisheries vessels. Their length ranges from 12 to 20 m and they are equipped with 100-300 UP engines, navigation devices, bythometer, freezer and winch. The crew is consisted of 2-3 persons. The gears used are mainly long-lines and static nets. Target species in the deep waters are *M. merluccius, P. bogaraveo, P. americanus* and *Squalus spp.*

P. bogaraveo is one of the most important deep water species in the area and its fishery is carried out during all the year by long-lines and trammel nets. *M. merluccius* is fished with long lines during all the year. Of the other species, *P. americanus* is fished quite intense in the area (daily catches 20-25 Kg), and *Squalus spp., Raja spp.* appeared to be the most important by catch species.

Long line *P. bogaraveo* fishery

The long lines that are used for *P. bogaraveo* fishery are generally short (up to 300 m) and the distance between the hooks is about 2 m. The hooks are of No 10. The bait is usual *Scomber spp.* Fishing takes place on rocky banks during the day at depths from 350 to 700 m. The common practice is to shoot 2-3 pieces and to repeat the shooting where they catch more fish. If the fish are abundant in a place the long lines are destroyed because the distance between the snoods is small and the snoods twist to each other. The daily production ranges from 5-100 Kg. The length of the specimens ranges between 30 and 60 cm. By catch species are *Squalus spp., Raja spp., M. merluccius, H. dactylopterus* and *P. americanus.*

Trammel net *P. bogaraveo* fishery

Trammel nets are used when targeting to *P. bogaraveo.* The mesh size of the inner net is 40 mm and of the outer net 200 m. The length of each peace of net is about 300 m and the bait that is used is *S. pilchardus* or *S. aurita*. Some fishermen before shooting the nets they shoot a short long-line, and if the catch is good, they start shooting the nets. The depth ranges between 400-600 m.

Long line *M. merluccius* fishery

The length of the long-lines is up to 20000 and the number of hooks is about 2000 (one snood per 10 m). The hooks are of No 5-6. The fishery is extended in depths from 400 to 800 m. The bait is usual salted *S. pilchardus*. The daily catch is 100-150 Kg.

Deep water fisheries in Cretan Sea (area 7)

The continental shelf around Grete is very restricted. The south coasts are very steep and generally the fishing activity is very limited. More important fishing grounds exist in the North of the island, where considerable deep water fishing is carried out mainly with long lines, bottom trawlers, gill nets and trammel nets.

The exploitation of the deep water resources with long lines and nets in Grete started some years ago, and the fishermen have a good experience on these fisheries now. Due to the restricted continental self they were obliged to explore deeper water and to develop new fishing techniques which fishermen in other parts of Greece followed. A common opinion between them is that the target species in deep waters (*P. bogaraveo, P. americanum)* have a slow recovering rate. With the bythometers and the ploters, it is now easy to detect the banks and they can obtain very good catches in an unfished area for a short period but the catch declines rapidly. Two or three years are needed in order to have good catches again in the same area.

A shift of the long-liners of the sword fishery to deep water fisheries is quite common in the area. The sword fishery is considered to be more profitable so during February to September, they target to sword fish and during October to January, when the sword fishery is closed, they shift to deep water fisheries. Thus a vessel is working about 60 days per year in deep waters. All the vessels are equipment with bythometre and winch

Bottom trawl fishing is carried out in deep waters only in the northern coasts of the island. The waters down to 500 m are exploited quite intensely.

Long line *P. bogaraveo* fishery

The fishery is carried out at depths between 180-550 m on rocky banks. The length of the long lines that a vessel of 19 m uses per day is about 3500 m and the number of hooks is about 2500. The distance between two hooks is about 1.2 m. The hooks are of No 10. The long lines are composed of pieces of 200-400 m. The bait is mainly *Scomber scombrus*. They shoot two or three pieces, and they haul them after ½ hour. Fishing is takes place during daylight. The duration of each trip is one or two days.

The daily catches vary and depend mainly on the abundance of the stock. If the fishing is carried out in a new ground the catch is high (200 Kg per day) for some days but then it declines. Nowadays, due to the use of the bythometers and ploters, it is easy to detect the rocky banks and almost all of them are known and it is difficult to discover new, unfished banks. Main by catch species are *H. dactylopterus* and *Squalus spp.*. The fishery is carried out more intensively during winter when the sword fishery is closed.

Trammel net are used when targeting to *P. bogaraveo*. The mesh size of the inner net is 90 mm and of the outer net 450 mm. The nets are used in depths from 150-550 m during daylight. The nets are short (about 500 m each piece). Sometimes bait is tied on the nets (*Sardina pilchardus*). Each day about 5000 m of netting is used which is shot on rocky banks in pieces.

M. merluccius fisheries

The fishery is carried out at depths down to 600 m on muddy bottoms. The length of the long lines is 11000 m and the number of hooks is about 1800. The distance between two hooks is about 6 m and the hooks are of No 6. The bait is mainly *Sardina pilchardus*. The long lines are shot early in the morning and the hauling starts just after finishing shooting. The time that is need to shoot the long lines is 2-3 hours and time to haul them is about 10-12 hours. The duration of each trip is one or two days. The daily catch varies between 40-120 Kg. Main by catch species are *P. americanum, Raja spp. H. dactylopterus, Squalus spp.* and *G. melastomus*. The fishery is carried out mainly during winter.

Gill nets are used in the area for *M. merluccius* fishery. The mesh size is 80 mm. Fishing is carried out on muddy bottoms at depth down to 600 m. The nets are shot in the morning and they are hauled late in the afternoon. 8-10 pieces of netting (each one 300-400 m) are used, so the total length of the net is about 2500-4000 m per day. The daily catch is about 100-120 Kg.

P. americanus fisheries

The species was quite abundant some years ago but now the stock has declined. The fishermen target *P. americanus* very scarcely and more often it appears as by catch in other deep water long line fisheries. The fishermen claim that they do not catch any more small specimens during last years.

The long lines are about 6000 m long and there have about 500 hooks No 3. The bait is *Scomber scombrus*. The fishing is carried out during the daylight. The long lines are shot early in the morning and the hauling starts 2-3 hours after the end of shooting. Main by catch species are sharks, and *Squalus spp.*

The last 3 years a trammel net fishery started targeting *P. americanus* but it is still not developed. The mesh size of the inner net is 90 mm and of the outer net 450 mm. The nets are used in depths from 150 to550 m during daylight. The nets are short (about 500 m each piece). Sometimes baits are tied on the nets (*Scomber spp.* or *Sardina pilchardus*).

Long line *Hexanchus griseus* fishery

The fishery is carried out with long lines in the northern and in the southern coasts of the island in depths from 600 to1500 m. The species has a low commercial value, but the catch is quite high and the fishery is profitable. The length of the long lines is about 15-20 Km. The snood is about 2 m long. Half meter before the hook is made of wire to avoid cutting by the fish. The number of hooks is about 500. Not a special bait but whatever is found in the market is used. The long lines remain on the bottom about 12-20 hours. The duration of each trip is 1-5 days. The fishery is carried out during all the year. The catch consists of large specimens (100-200 Kg each one). The daily catch could be 1000 Kg. By catch species are mainly *Conger conger* and *Squalus spp*.

Bottom trawl fishery

In the northern coasts of the island, eleven bottom trawlers fish in depths down to 500 m. The bottom in the southern coasts is not suitable for bottom trawl fishing. The fishermen claim that in waters deeper than 500 m the catches are lower and the fishing is not profitable. The catch in depths 400-500 m consists mainly of *M. merluccius, M. poutassou, H. dactylopterus, Scorpaena spp., N. norvegicus, A. antennatus, A. foliacea* and *Plesionika spp.*. By catch species are *Phycis blennoides, Squalus spp., Lepidorhombus boscii* and *Lophius budegassa*. The fishermen observed that a lot of big females (4 Kg each one) of *L. budegassa* were mature. To find mature *L. budegassa* is not very common in bottom trawling in Greece at least in the areas where experimental surveys were carried out by the fisheries laboratory.

In deeper waters 700 m where some hauls were carried out the catch consisted of *M. merluccius, A. antennatus* and *H. dactylopterus* . The market for the red shrimps (*A. antennatus* and *A. foliacea*) is not very well developed. The deep water bottom trawl fishery will be more profitable, if the consumers get used to the red shrimp species.

Distribution of the fishing fleet

The number of vessels (bottom trawl, bottom long lines and static nets) per area is shown in the tables 1-7. The deep water fishery is carried out with vessels that belong mainly in these categories. During winter, some of the vessels working on sword fishery use bottom long lines and they work in deep waters. The fishing effort of each category in deep waters was not possible to be estimated in the framework of the project. A survey in much more ports is needed in order to obtain an estimation of the fishing effort in deep waters.

The number of bottom trawlers is higher in areas with big fishing ports independently of the size of fishing grounds (Fig. 10). Thus, the higher number of bottom trawlers recorded in area 2, where is the fishing port of Piraeus, and in area 3, where are the fishing ports of Thessaloniki, Kavala and Alexandroupolis. These vessels do not fish necessary in their home area, but they move in other areas according to the abundance of the fish. For example, in area 5 there are only 7 bottom trawlers, but the bottom trawl fishery in this area is carried out mainly with vessels from area 2.

The distribution of the fishing effort of the bottom trawlers around the Greek coasts is not known, since the skippers do not keep log-books, and consequently there is no estimation of the fishing effort in deep waters. From the interviews with the fishermen the effort seems to be very low.

The situation is different for the long-liners and the static net vessels. These vessels are generally small (less than 10 m) and they work usually on fishing grounds around the home port (Fig. 11, 12). Thus, the highest number of long-liners was recorded in the Central Aegean (area 4) and the highest number of static netters in the Ionian Sea (area 1). From the interviews with the fishermen, it appeared that the vessels involved in deep water fisheries are larger than 10 m. Thus, only 1296 out of 14979 vessels could carry out deep water fisheries. Part of them fish in deep waters for some periods of the year.

Discussion

The geomorphology of the Greek seas is favorable for the development of deep water fisheries, since the 0-400 m depth zone is large only in a part of the North Aegean Sea and around Kyklades Islands. The exploitation of the deep waters so far is not intense even thought the results of the sampling in the framework of the "Deep water project" showed that there are catches that could support a new fishery. The main reason is that the commercial important species in the deep waters (mainly shrimp species) are unknown in the market and the consumers are not used to their consumption.

The main target species in waters deeper than 400 m, as appeared from the interviews with the fishermen around the Greek coasts are *P. bogaraveo*, *M. merluccius*, *P. americanus* and *H. griseus*. *P. bogaraveo* is fished mainly in the western and southern Greece coasts with long lines, gill nets and trammel nets on rocky banks in depths from 250 to 600 m. *M. merluccius* is fished around all the Greek coasts with long lines in depths down to 700 m. In the Central Aegean Sea trammel nets are used for *M. merluccius* fishery. *P. americanus* is fished with long lines mainly in the western and southern part of Greece. The fishery declined the last years, because the abundance of this species is very low. The above fisheries are more intensive during winter, when some vessels which work on the sword fishery shift to other fisheries.

Bottom trawl fishing in waters deep than 400 m takes place mainly in the Northern coasts of Crete. In the other areas is more or less sporadic and opportunistic. Target species of the bottom trawl fishery in deep waters are M. merluccius, H. dactylopterus, Scorpaena spp., N. norvegicus, A. antennatus, A. foliacea and Plesionika spp..

The small scale fishery vessels which are working in deeper waters are generally longer than 12 m. They are equipped with navigation instruments, bythometer, hydraulic winch and usually with freezer, when they made trips longer than one day. The crew members of these vessels are 2 or 3 and each trip lasts 1-3 days.

The shrimps (*A. antennatus*, *A. foliacea* and *Plesionika spp*.), which could be the main catch of the bottom trawl fishery in waters deeper than 400 m, are known to the fishermen but the rate of exploitation of these stocks is so far low because they have low price in the market.

There is a common opinion between the fishermen that the regeneration of the deep water species is very slow. They base this opinion in their own experience. For example, when they discover a new bank, the catches of *P. bogaraveo* are very high for some days, but afterwards some years are needed in order to have good catches in the same area. Nowadays, with the use of bythometers and navigation devices the detection of the fishing grounds is easier and almost all the banks have been exploited.

There is no estimation about the stock size of the target species in deep waters. Furthermore, their biology is almost unknown and their distribution along the Greek coasts has not been defined yet. More research are needed in order to obtain knowledge of the distribution, the size of the stocks and the biology of the species, so that a management design can be planned and regulations about the exploitation of this ecosystem can be introduced.

The only regulations that exists so far in Greece and could be applied in the deep water fisheries are those established by the EU for the Common Fishery Policy concerning the minimum landing size of some species and the mesh size of the cod-end. According to these regulations the minimum mesh size of the cod-end must be 40 mm. The selectivity parameters of this mesh size on the deep water species are unknown. Possibly, a bigger mesh size or the use of a special device, which will allow the small shrimps to escape, in the cod-end will give much better results.

A minimum landing size is defined for *M. merluccius*, *P. bogaraveo*, *P. americanus* and *N. norvegicus* which are the main commercial deep water fisheries species. The catch of *M. merluccius* of the long line or the nets fisheries in deep waters consists of large specimens (larger than 20 cm which is the minimum landing size). Considering *P. bogaraveo*, the minimum landing size is common for all *Pagellus* species (12 cm). The catch in deep waters consists of fish larger than 16 cm. Individuals of lower size segregate in shallow waters and they are not commercial. A specific minimum landing size should be defined for *P. bogaraveo* taking into account the biology of the species (growth, first maturity). Anyhow, the established minimum landing size seems to be very small for this species since the all the specimens smaller than 16 mm were found to be immature.

A integrated management plan is needed to avoid negative results of the extension of the bottom trawl fishery in the deep waters in Greece. In Italy and Spain, where there are similar ecosystems, and where bottom trawl fishery in deep waters is carried out for many years the catch composition is different. Presently, in Greece *A. foliacea* is more abundant than *A. antennatus*, whereas in Italian and Spanish waters the opposite is true. Research in order to define the appropriate mesh size or minimum landing size for the shrimps is needed. Possibly other restrictions should also be applied (effort restriction or closed areas or seasons).

Finally, an attempt to introduce the deep water species (mainly shrimps and some fish species such as *Molva dipterygia macrophthalma*) in the Greek market should be done. The areas that can be exploited, if the new species realise a good price in the market, are considerable. Exploitation of these areas will result in an increase of the income of the fishermen, an increase of the quantity of high quality catches for the consumers and furthermore, in a relief of the fishing pressure on the coastal stocks, which now are overexploited, since fishing effort of the shallower fishing grounds will be transferred to deeper ones.

Dissemination

References

Table 1. Number of fishing vessels in Area 1. (Trawlers: A= less than 20 m, B=20-25 m and C= more than 25 m, Long-lines and static nets: A= less than 10 m, B=10-15 m and C= more than 15 m).

	Trawlers	Long Lines	Static Nets
Number	51	1172	1646
GRT	5072	2035	2498
HP	21446	25602	35379
Crew	346	1910	2411
A	18	1126	1598
B	23	43	434
C	10	3	5

Table 2. Number of fishing vessels in Area 2. (Trawlers: A= less than 20 m, B=20-25 m and C= more than 25 m, Long-lines and static nets: A= less than 10 m, B=10-15 m and C= more than 15 m).

	Trawlers	Long Lines	Static Nets
Number	124	1460	1278
GRT	20518	3536	3060
HP	65747	42878	33533
Crew	1606	2693	1904
A	18	1368	1200
B	28	88	73
C	78	4	5

Table 3. Number of fishing vessels in Area 3. (Trawlers: A= less than 20 m, B=20-25 m and C= more than 25 m, Long-lines and static nets: A= less than 10 m, B=10-15 m and C= more than 15 m).

	Trawlers	Long Lines	Static Nets
Number	126	1410	816
GRT	9519	3464	1899
HP	54683	60660	34632
Crew	972	2467	1473
A	14	1299	760
B	64	108	54
C	48	3	3

Table 4. Number of fishing vessels in Area 4. (Trawlers: A= less than 20 m, B=20-25 m and C= more than 25 m, Long-lines and static nets: A= less than 10 m, B=10-15 m and C= more than 15 m).

	Trawlers	Long Lines	Static Nets
Number	86	2692	1484
GRT	6509	4972	3025
HP	32171	65272	33224
Crew	535	4547	2436
A	36	2575	1400
B	24	113	81
C	26	4	3

Table 5. Number of fishing vessels in Area 5. (Trawlers: A= less than 20 m, B=20-25 m and C= more than 25 m, Long-lines and static nets: A= less than 10 m, B=10-15 m and C= more than 15 m).

	Trawlers	Long Lines	Static Nets
Number	7	511	492
GRT	581	1700	1391
HP	2461	16893	14201
Crew	43	1036	769
A	0	431	436
B	5	78	55
C	2	2	1

Table 6. Number of fishing vessels in Area 6. (Trawlers: A= less than 20 m, B=20-25 m and C= more than 25 m, Long-lines and static nets: A= less than 10 m, B=10-15 m and C= more than 15 m).

	Trawlers	Long Lines	Static Nets
Number	16	571	343
GRT	891	1664	843
HP	5937	17313	10177
Crew	118	886	510
A	7	506	315
B	7	61	25
C	2	4	3

Table 7. Number of fishing vessels in Area 7. (Trawlers: A= less than 20 m, B=20-25 m and C= more than 25 m, Long-lines and static nets: A= less than 10 m, B=10-15 m and C= more than 15 m).

	Trawlers	Long Lines	Static Nets
Number	15	536	176
GRT	1472	1190	468
HP	6328	11951	4526
Crew	119	1165	324
A	0	508	161
B	5	26	14
C	10	2	1

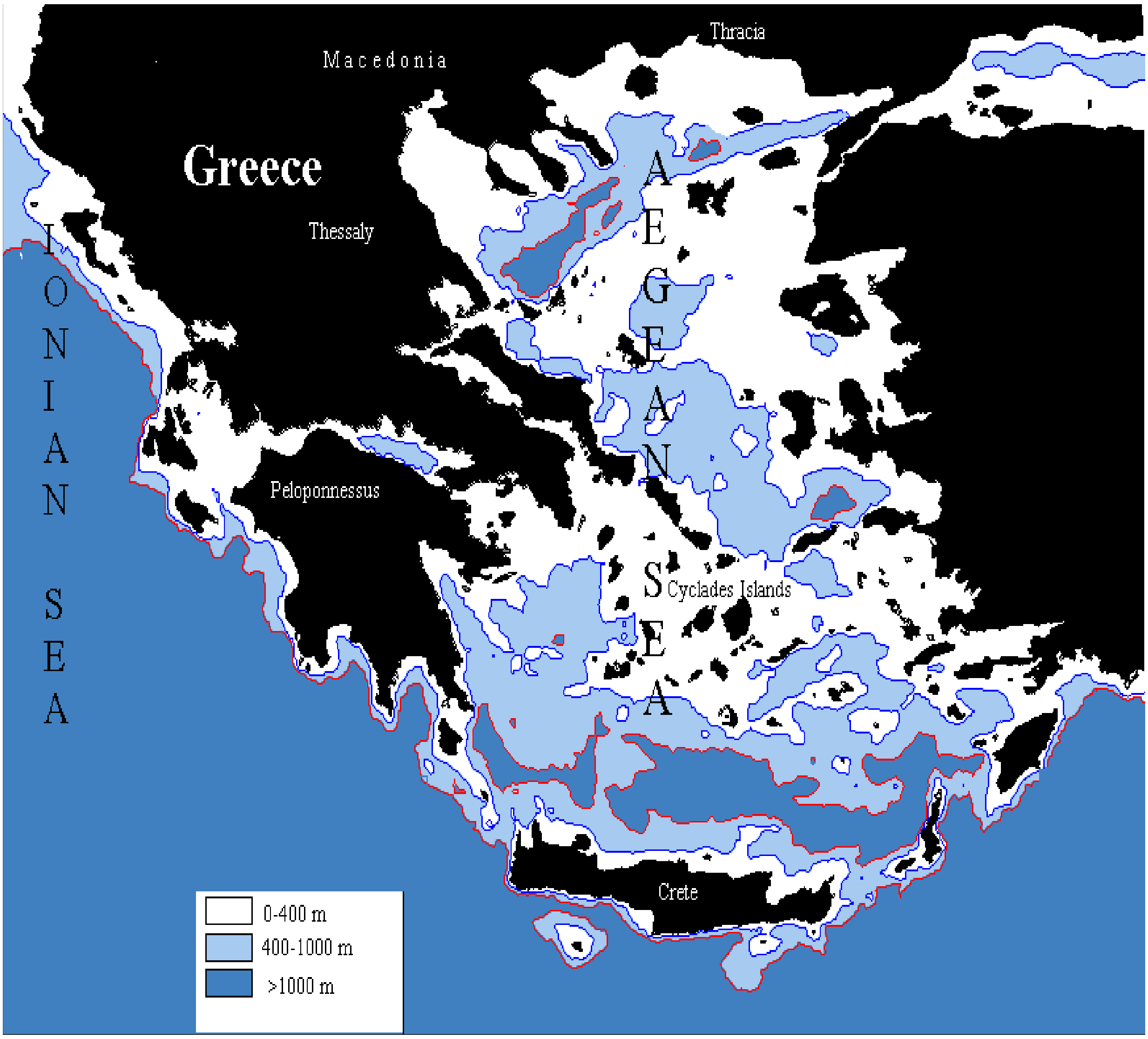


Fig. 1. Bathymetry of the Greek Seas.

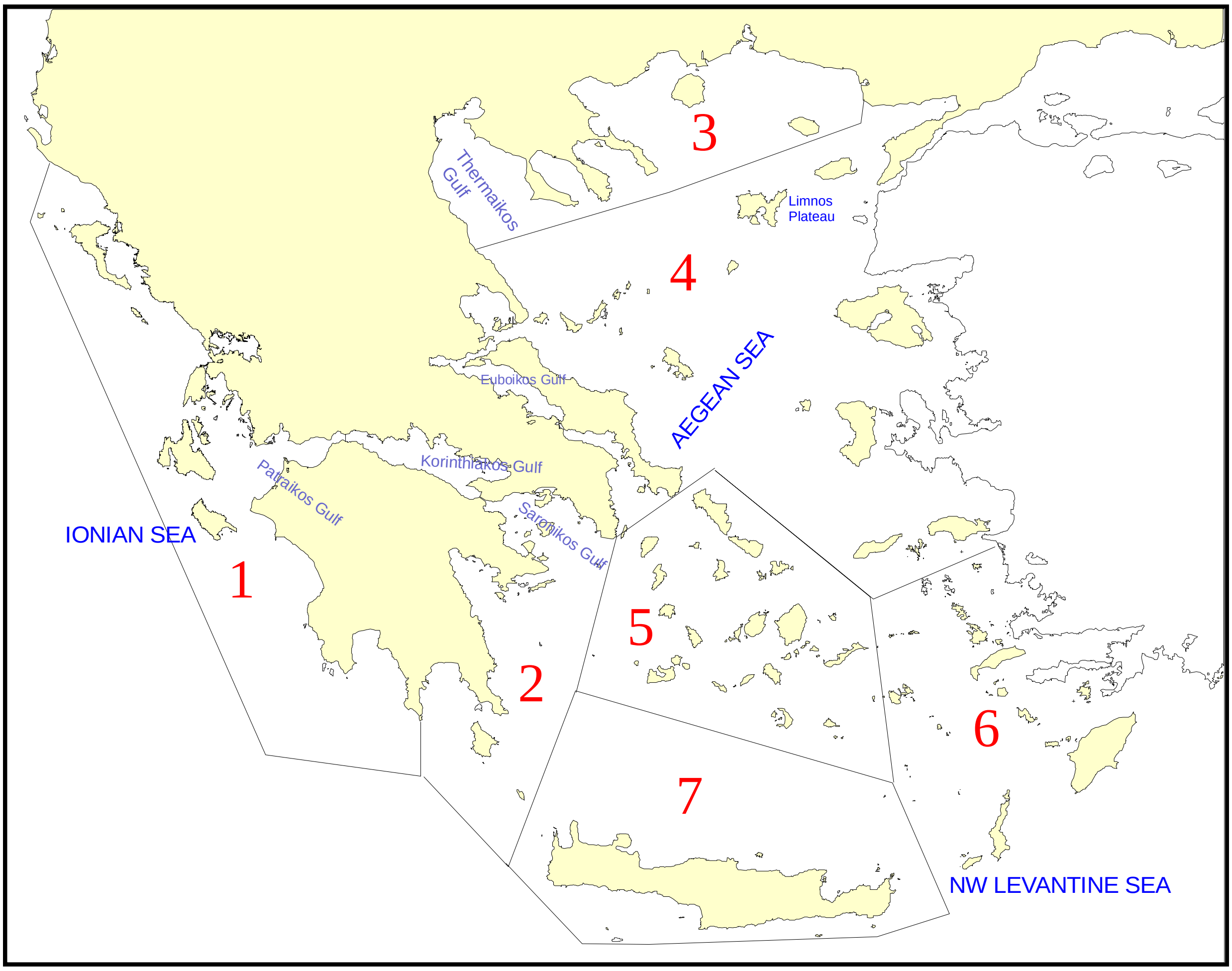


Fig. 2. Map of the Greece with the division per area.

Fig. 3. Map of area 1.

Fig. 4. Map of area 2.

Fig. 5. Map of area 3.

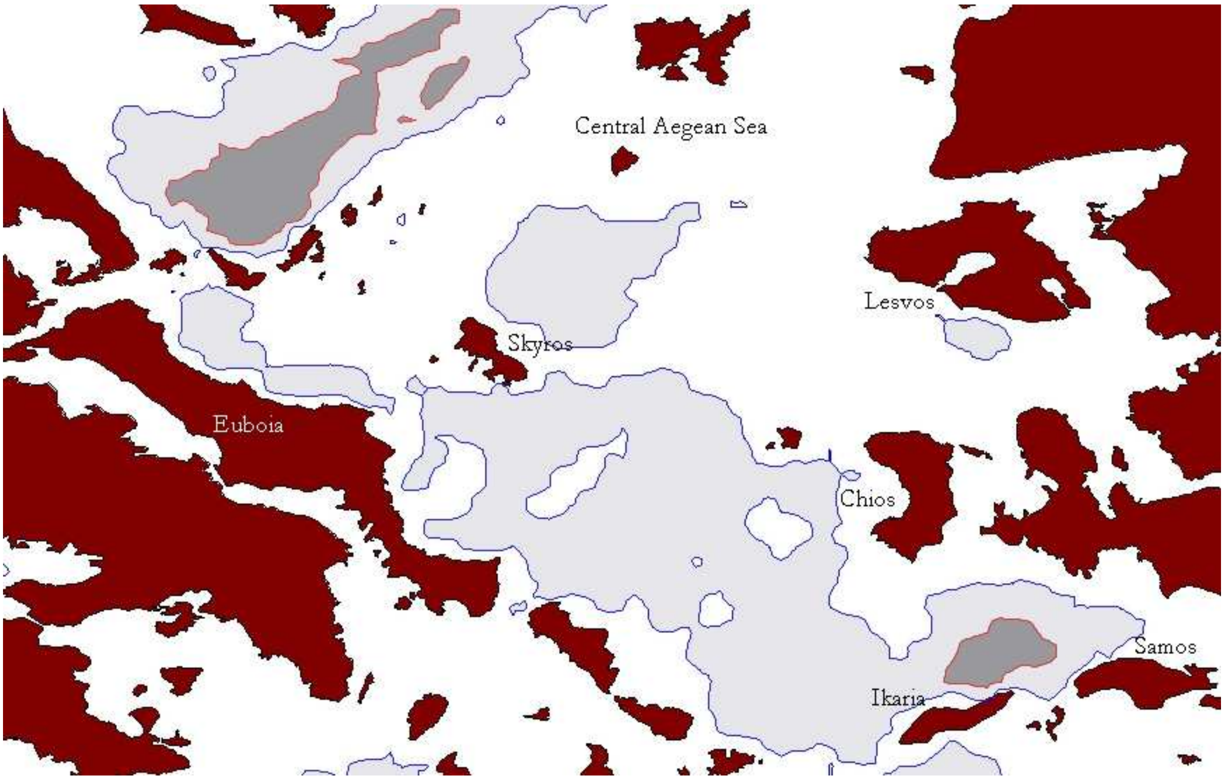


Fig. 6. Map of area 4.

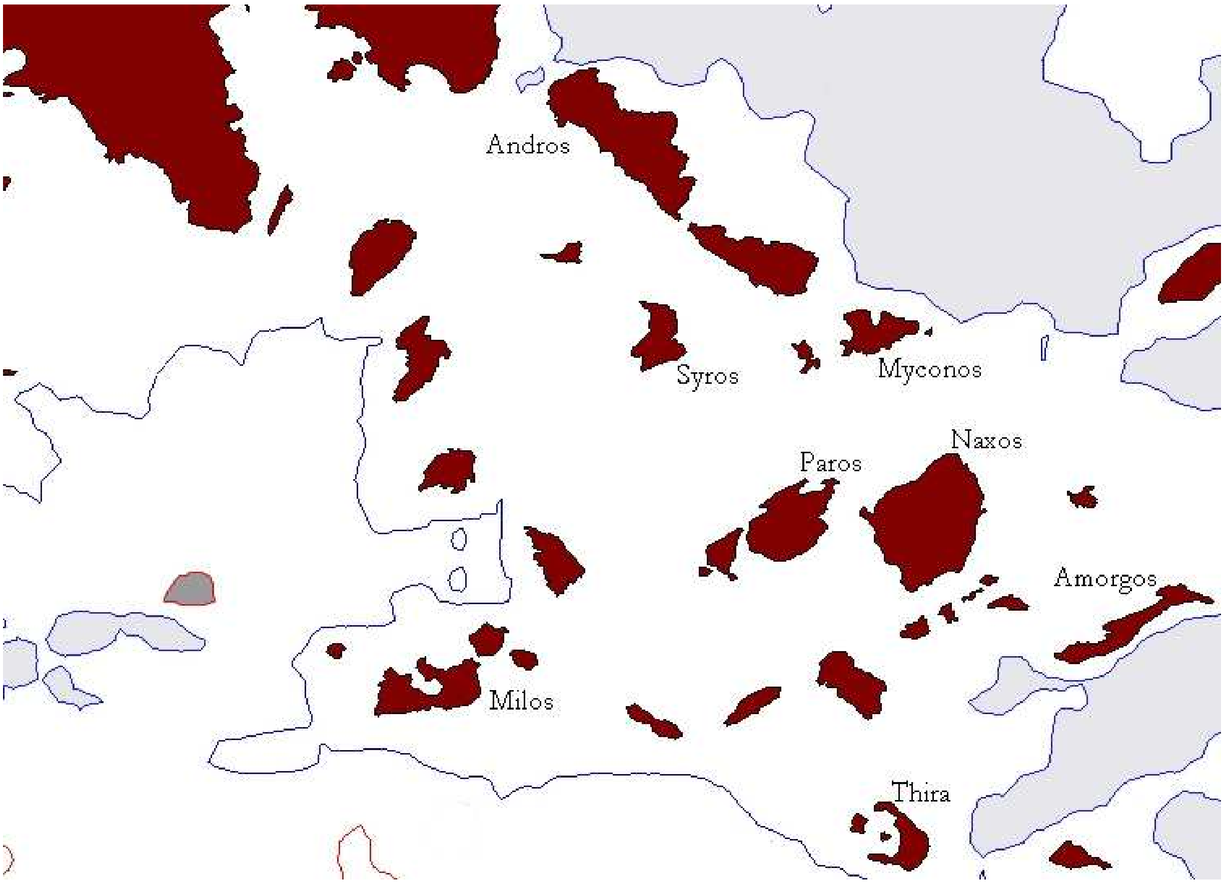


Fig. 7. Map of area 5.

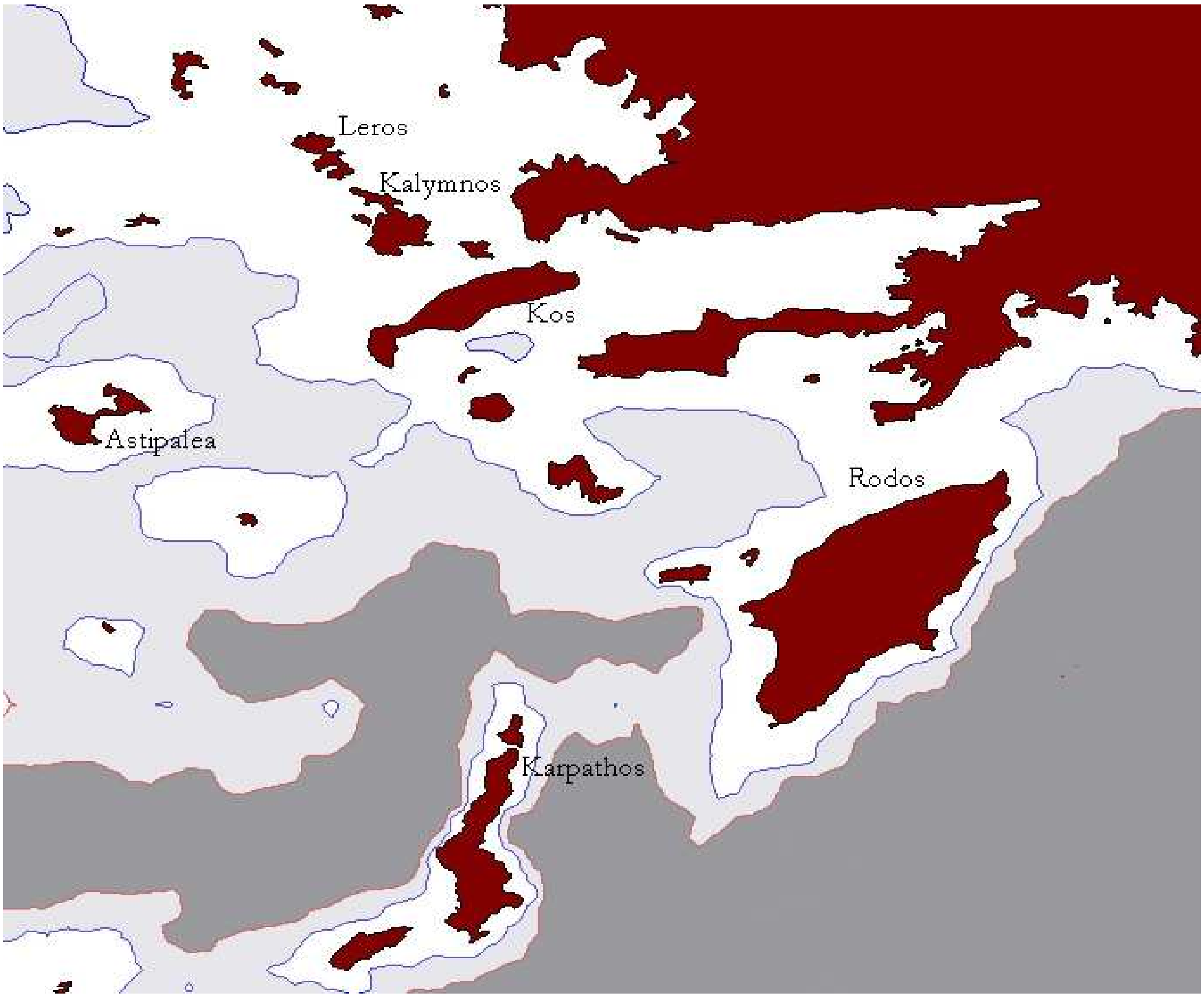


Fig. 8. Map of area 6.

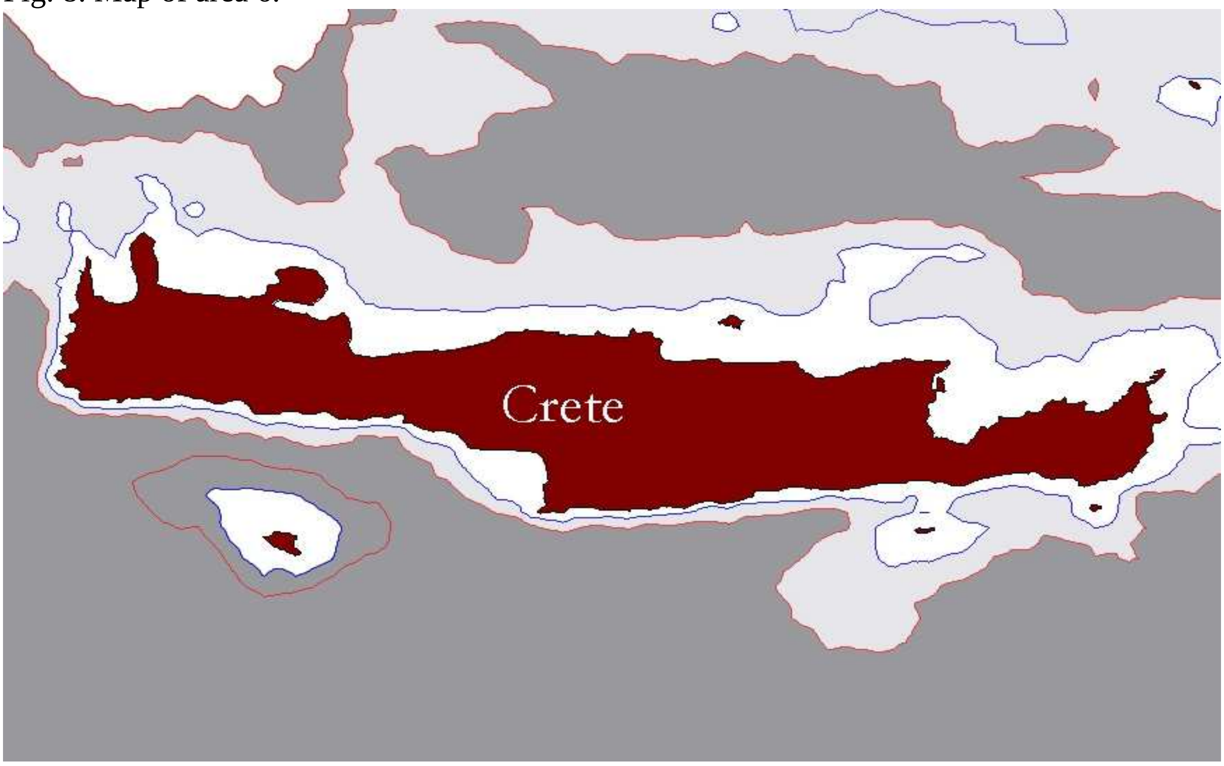


Fig. 9. Map of area 7.

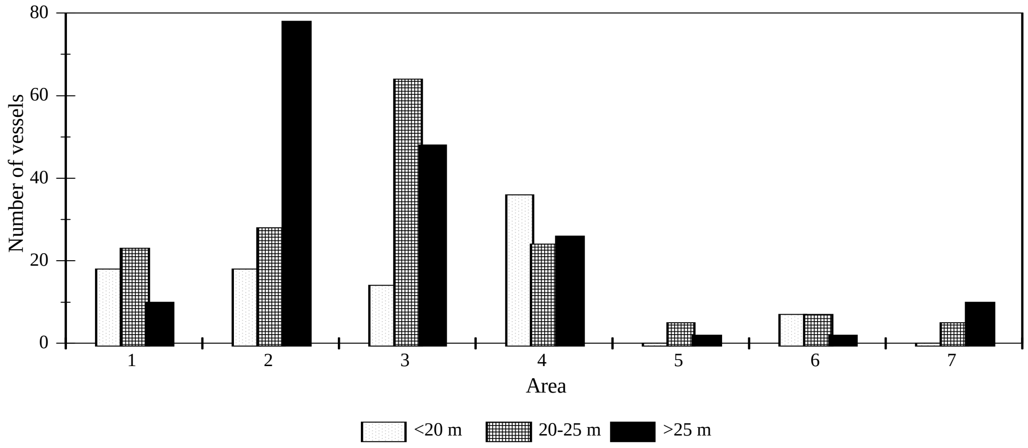


Fig. 10. Number of bottom trawlers per area.

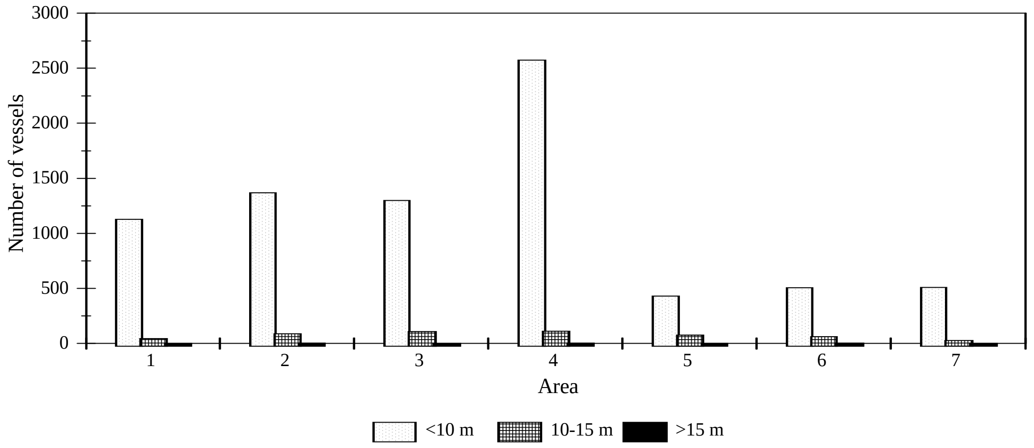


Fig. 11. Number of long liners per area.

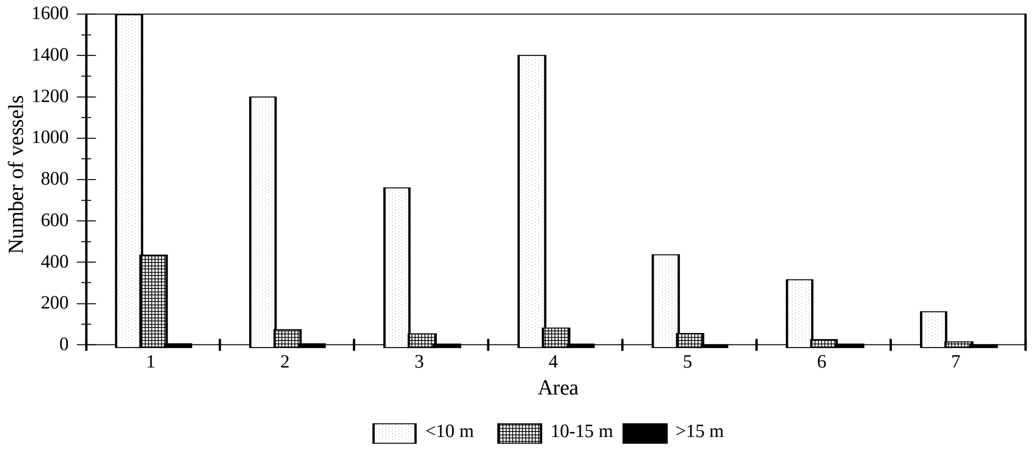


Fig. 12. Number of static netters per area.