*Chemistry and Ecology*
Vol. 26, Supplement, June 2010, 219–240

# The demersal faunal assemblage of the north-western Ionian Sea (central Mediterranean): current knowledge and perspectives

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(*Received 15 July 2009; final version received 19 January 2010*)



Data reported in this article were collected in the context of several trawl surveys carried out in the north-western Ionian Sea in the last 25 years. An overview of the available information on the demersal resources in the area and an historical analysis at population and community levels is reported with the aim of identifying eventual significant changes over time. During the study period 1985–2006, a total of 365 species (41 cephalopods, 76 crustaceans, 33 chondroichthyes and 215 osteichthyes) were collected in the investigated area from 10 to 4000 m, updating the faunal lists of this area with 18 new records and one alien species for the Mediterranean. An increase in the species richness was observed throughout the study period. The historical analysis showed a low abundance of chondroichthyes and significant increases over time for cephalopods, crustaceans and osteichthyes during the study period 1985–2006. An increasing trend in density over time was also detected for some target species (*Illex coindetii* and *Nephrops norvegicus*) and an inverse significant correlation with the fishing effort was also shown. Nevertheless, a significant decrease in the median lengths over time was depicted for *N. norvegicus* and *Parapenaeus longirostris*. A decreasing trend in the total mortality ($Z$) and exploitation rates ($E$) with time was only observed for *Mullus barbatus*. An overexploitation condition was shown by *P. longirostris* and *Merluccius merluccius* during time while a moderate overexploitation was detected for *M. barbatus* and *Aristaeomorpha foliacea* over time. A state of almost equilibrium and an optimal exploitation were observed for *N. norvegicus* and *Aristeus antennatus,* respectively. The authors give rise to discussion on the fishing effort-exploitation rate-recruitment process to explain the trends shown in the north-western Ionian Sea.

**Keywords:** demersal resources; biodiversity; distribution; abundance; population dynamics; Ionian Sea

## 1. Introduction

The start of a systematic investigation into knowledge on the demersal resources in the north-western Ionian Sea dates back to the late 1980s with the start of the National Program on the Assessment of Demersal Resources in the Italian Seas (GRUND; Italian National Law 41/82; UE Reg. 1543/2000, 1639/2001, 1581/2004) [1], and further information was later provided by the International Research project on the Mediterranean Bottom Trawl Surveys (MEDITS) funded by the European Union and also included in the UE Reg. 1543/2000, 1639/2001, 1581/2004 from 2001 [2].

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ISSN 0275-7540 print/ISSN 1029-0370 online

DOI: 10.1080/02757541003693987
http://www.informaworld.com

In the first years, the distribution and abundance of the most common resources in the north-western Ionian Sea were explored [3,4], and research on the spatio-temporal distribution and population dynamics for many commercial species was carried out focusing on the most valuable stocks [5–10].

Starting from the fully or over-exploited status for many demersal stocks, several studies on the life cycles and exploitation condition of marketable species were also carried out [11–14] according to the priority of a stock-oriented fishery management. Moreover, throughout selectivity experiments on the employed trawl net in the Ionian areas, further information on the commercial and discarded fractions of the exploited resources was also collected [15–19]. All the results provided useful suggestions to the Italian government for defining the best management policy and taking up adequate regulation measures [3,4]. In particular, starting from 1987, a fishery regulation measure was first planned as a 'closed season' in different Italian areas according to the local conditions (D.L. July 1987) and then a weekend closure was also added (D.L. 31 May 1999) to reduce the fishing effort. Moreover, the adoption of a legal mesh size in the trawl net and definition of the minimum legal size for the most important commercial species (CE N° 1626/94, 27/6/1994) were also introduced. Most recently, the institution of 'no-take zones' (Zone di Tutela Biologica, ZTB) was defined along the Italian coast but this is not still performed in the north-western Ionian area.

Taking into account the habitat heterogeneity and high biodiversity of marine communities in the Mediterranean Sea [20], this basin has been considered a priority area for nature conservation (Barcelona Convention, 1976). Thus, increasing interest in biodiversity led to the development of innovative and wider approaches to assess marine ecosystems both for conservation and fisheries management objectives, providing further studies focusing on biodiversity of the demersal communities for the Ionian area [21–23]. In this way, the multi-species nature of Mediterranean fisheries, together with the systematic collection of a large amount of data, gave an opportunity to improve knowledge on the composition of demersal assemblages and update the faunal lists previously reported for the north-western Ionian Sea within the bathymetric range (10–800 m) where biological resources are generally exploited in this area [24–27].

Moreover, new information on the life-history traits of many bathyal species was also provided, extending studies on low or non-marketable species [28–33].

In recent years, the increasing exploitation of deep-sea resources (down to 800 m) in the Mediterranean Sea has promoted some investigations into the bathyal environment of the Ionian Sea, improving knowledge on the deepest almost 'virgin' ecosystems where fishing activity does not occur [34–38].

To date, the large amount of data collected in the context of all the performed research, represents a good opportunity to better investigate on a wide temporal scale possible changes that have occurred in the demersal resources of the north-western Ionian Sea. In particular, the availability of historical data, collected in the Ionian basin using the same methodology and sampling plans throughout the investigated period of 1985–2008 as part of the national GRUND project, represents a powerful opportunity to detect potential significant changes over time in the availability of demersal resources, also related to environmental conditions and in particular to global warming. Moreover, observations on species diversity over two decades by means of spring (MEDITS) and autumn (GRUND) surveys could be an efficient method for monitoring the eventual change in biodiversity due to fishing or the incoming of new species in the Mediterranean.

Although the MEDITS time series is too short to identify eventual temporal trends in the abundance of demersal resources, it has given further insight into the spatio-temporal distribution of these species in the north-western Ionian Sea, as already reported on a large scale in the Mediterranean basin ([39] and references therein).

The new demand from both the scientific and political communities is focused on the development of an ecosystem approach to fisheries management through the implementation of indicators related to marine environmental pressures, both natural and anthropogenic.

Thus, an overview of the available information on demersal resources of the north-western Ionian Sea for the last 25 years, as well as an historical analysis on the demersal faunal assemblage, are reported in this article with the aim of identifying eventual significant changes over time.

The analysis, over a long period, of abundance, size and mortality of the most abundant commercial species is examined with respect to changes in fishing effort in the study area as a first step towards a wider approach on the study of environmental phenomena and their influence on marine resources.

## 2. Materials and methods

### 2.1. *Study area*

The Ionian Sea is the deepest sea in the Mediterranean basin and is characterised by a complex geomorphology and oceanography. The north-western Ionian Sea corresponds to Geographical Sub Area (GSA) n. 19. The studied area is between Cape Otranto (40° 06′N 18° 31′E) and Cape Passero (36° 41′N 15° 10′E). This area has a coastline ∼1000 km long and covers, between 10 and 800 m in depth, a surface of ∼16,500 $km^2$ (Figure 1).

The north-western Ionian is divided by the Taranto Valley into an eastern sector represented by a broad continental shelf and a south-western sector where the shelf is generally very limited and many submarine canyons are located along the coasts [40].

The Ionian Sea receives Modified Atlantic Water (MAW) from the western Mediterranean through the Sicilian Channel, with salinity increasing from 37.5 psu in the Sicilian Channel to 38.6 psu near the Cretan Passage [41]. The Levantine Intermediate Water (LIW) is characterised by variable salinity and temperature values between the southern and northern Ionian. Hydrographic observations and current measurements conducted in the 1990s revealed strong modifications in the dynamics of the entire water column termed as 'transient' [42]. Highly saline (>39.0 psu), warmer (around 15 °C) and well-oxygenated intermediate waters were found to be flowing out of the Aegean through the western Cretan Arc Straits. They interrupted the traditional path of the LIW, spread northwards into the Ionian Sea and eastwards into the Levantine basin and also affected the water properties of the bottom layer. This interruption caused a greatest input of MAW into the Ionian Sea with a change in circulation of water masses from cyclonic to anticyclonic, now re-established [43].

#### 2.1.1. *Fisheries data*

The mean annual catch from the three main fisheries of the north-west Ionian Sea (Crotone, Taranto and Gallipoli) is ∼3% of the whole Italian production [3]. In the north-western Ionian Sea, fishing occurs from coastal waters to 700–750 m [3,4]. The most important demersal resources in the north-western Ionian Sea are represented by the red mullet (*Mullus barbatus*) on the continental shelf, hake (*Merluccius merluccius*), rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*) over a wide bathymetric range and the deep-water red shrimps (*Aristeus antennatus* and *Aristaeomorpha foliacea*) on the slope [4].

Gallipoli, Taranto, Crotone and Reggio Calabria represent the most important fisheries in the north-west Ionian Sea, although with a different distribution of the fishing effort. Official national statistics (IREPA, 2008) report the highest percentage of big gross tonnage vessels (≥10 GRT) in the Crotone (44%) and Reggio Calabria (21%) fisheries, whereas a lower percentage of trawlers operates in the Gallipoli (24%) and Taranto (11%) districts (Table 1) where fisheries are mainly made up of small vessels. Considering the low reliability of official statistics of fishing effort data

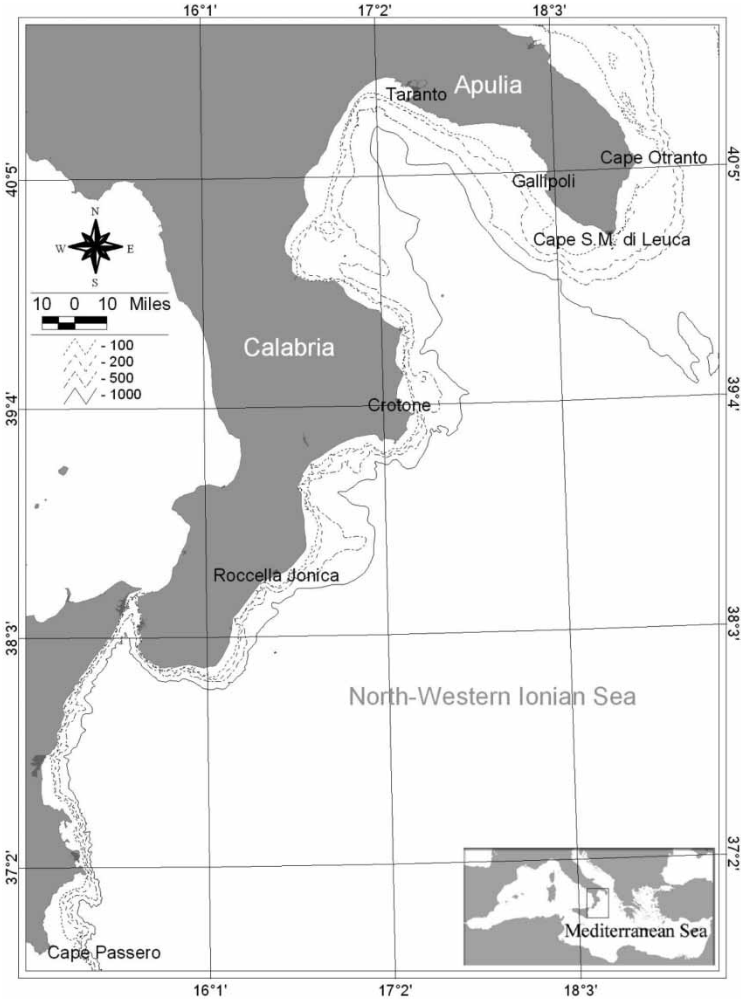


Figure 1. Map of the area investigated in the north-western Ionian Sea from 1985 to 2008.

Table 1. Recorded trawlers in the principal harbours of the north-western Ionian Sea with an indication of the total number for gross tonnage (GRT), engine power (PKW) and vessels (N) (IREPA, 2008).

| | GRT | PKW | N |
|---|---|---|---|
| Crotone | 1676 | 13384 | 86 |
| Gallipoli | 923 | 10863 | 80 |
| Reggio Calabria | 789 | 7184 | 38 |
| Taranto | 439 | 7225 | 44 |
| Total area | 3827 | 38656 | 248 |

for the whole investigated area, the potential fishing effort in the north-western Ionian Sea was computed taking account of all available working days per year, starting from 1985. In particular, all holidays and closed season days were subtracted from the total. Moreover, assuming that a wind speed $\geq 15$ knots did not allow fishing, all these days were also deleted from the total. The residual days were considered as potential working days and thus as a measure of the potential

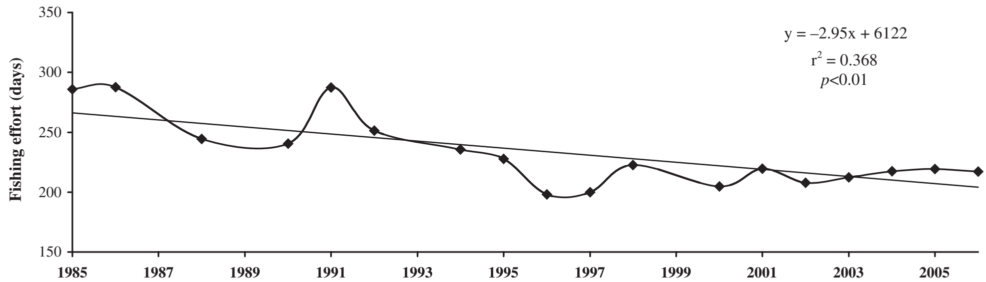


Figure 2. Potential fishing effort per year computed for the north-western Ionian Sea from 1985 to 2006.

fishing effort. Thus, a significant decrease in the fishing effort in the north-western Ionian Sea was detected from 1985 to 2006 (Figure 2).

It should be noted that since 1988 a 45-day ‘closed season’ for trawling has been carried out in late summer–early autumn, as a management measure adopted by the Italian Government.



### 2.2. *Biological data collection*

The information reported in this article comes mostly from the scientific literature and experimental bottom trawl surveys carried out by the authors in the north-western Ionian Sea from 1985 to 2008 within the framework of several national and international projects funded by the Italian Government and EU. In particular, the national project ‘Assessment of Italian Demersal Resources’ (GRUND) [1], from 1985 to 2008, and the international ‘MEDiterranean International Trawl Survey’ (MEDITS) [2] from 1994 until 2008, were performed seasonally during autumn and spring–summer, respectively. The area examined was from Cape Otranto (LE) to Cape Passero (SR), covering a depth range of 10 to 800 m. Moreover, other experimental trawl surveys were carried out in the Ionian area in different depth ranges and seasons throughout the investigated period, as reported in Table 2.

A professional motor-powered vessel was hired during all cruises, with the exception of the DESEAS project which was carried out using the research vessel *García del Cid* [35]. Commercial and experimental trawl nets were differently adopted in the cruises as reported in Table 2.

The sampling design adopted in each project was random-stratified. The horizontal and vertical openings of all the types of nets were measured using the SCANMAR acoustic system [44].

All specimens sampled by trawl during the study period 1985–2008 were identified at the species level according to the nomenclature reported in CEPHBASE (2006) for cephalopods, in d’Udekem d’Acoz [45] for crustaceans and in FISHBASE [46] for bony fish and Serena [47] for elasmobranchs.

For each individual, the following data were taken: length, according to species, to the nearest mm, body weight to the nearest 0.1 g, sex and maturity stage of gonads.

Moreover, for growth analysis both *sagittae* were collected during the trawl surveys carried out from 1985 to 2007. These otoliths, extracted from fishes, were placed in a black dish with glycerine (30%) and alcohol (70%); an opaque and translucent (hyaline) zone deposition pattern was considered as an annual event. The translucent zones were considered as *annuli* and counted under a stereoscope using reflected light [30].

### 2.3. *Data processing*

Data collected in all surveys were differently processed according to the various goals of this article. In particular, in order to produce a full description of the north-western Ionian community and

Table 2. List of the surveys repoted in the article, with an indication of the investigated period, the study area, the depth range and the sampling gear employed with relative stretched mesh size in the codend.

| Project | Date | Study area | Depth (m) | Sampling gear | Mesh size (mm) |
|---|---|---|---|---|---|
| GRUND | 1985–2008 | North-western Ionian Sea, Cape Otranto–Cape Passero (GSA 19) | 10–800 | Commercial trawl net | 40 |
| MEDITS | 1994–2008 | North-western Ionian Sea, Cape Otranto-Cape Passero (GSA 19) | 10–800 | Experimental trawl net | 20 |
| RED SHRIMPS | 1993–1996 | North-western Ionian Sea, Cape Otranto–Cape Passero (GSA 19) | 200–800 | Commercial trawl net | 40 |
| DEEP FISHERIES | 1995–1999 | North-western Ionian Sea, Calabrian area | 200–800 | Commercial trawl net | 40 |
| INTERREG Italy–Greece | 1999–2001 | North-western Ionian Sea, Apulian area | 300–1200 | Commercial trawl net | 40 |
| DESEAS | 2001–2002 | North-western Ionian Sea, Calabrian area | 600–4000 | Experimental otter trawl Maireta net | 20 |
| APLABES | 2002–2006 | North-western Ionian Sea, Apulian area | 300–800 | Commercial trawl net | 40 |
| RIME | 2003–2004 | North-western Ionian Sea, Apulian area | 300–1200 | Commercial trawl net | 40 |
| GAVIS | 2006–2007 | North-western Ionian Sea, Apulian area | 400–1200 | Experimental otter trawl Maireta net | 20 |



to update the list of species collected in the study area during the overall study period (1985–2008), data from all the surveys carried out by trawling were considered and the relative depth range of occurrence was also reported.

The frequency of occurrence (Foc) of each species was computed as the percentage of the positive hauls on the total hauls carried out in the depth range 10–800 m from 1985 to 2008. Taking into account the stratified sampling design adopted throughout the study period, only data collected systematically during the GRUND and MEDITS trawl surveys were considered. Thus, the Foc was only reported for the species collected in the context of these two projects.

Data collected from all the surveys carried out in the north-western Ionian Sea allowed the recording of new species for the area as well as the increasing occurrence of tropical and sub-tropical species such as *Sphoeroides pachygaster* [48]. In order to detect any temporal trend in the catch of this species, a cumulative sums technique was computed on its abundance ($N \cdot km^{-2}$). The cumulative sums method was useful to highlight potential changes in a time series and an assessment of the intensity and duration of these changes [49]. Each value of the series was subtracted from a reference value (the mean of the time series), resulting in a new time series of residuals, which were used to calculate the cumulative sum (each value was summed to the previous) [50]. Finally, changes in density sums with time from 1991 (first record) to 2008 (last finding) were evaluated using the regression analysis.

In order to evaluate the biodiversity of the demersal communities in the area, only the data collected systematically during spring (MEDITS) and autumn (GRUND) surveys from 1994 to 2007 and standardised to the swept area ($N \cdot km^{-2}$) were considered. Univariate ecological indices (Margaleff richness $d$, Shannon–Wiener diversity index $H'$, Pielou's evenness $J$) [51] were computed using data collected for only demersal species in the investigated depth range 10–800 m and their changes over time (from 1994 to 2007) were evaluated using the regression analysis.

Abundance data were standardised to the 'swept surface unit' [52]. Thus, biomass ($kg \cdot km^{-2}$) and density ($N \cdot km^{-2}$) indices were computed by survey for each faunal category (cephalopods, crustaceans, chondrichthyes and osteichthyes) and species for the depth range 10–800 m and by depth stratum (10–200 and 200–800 m) [53]. Taking into account both the abundance and the commercial interest, six target species were selected for the analysis of abundance over time: *Illex coindetii* for cephalopods, *Nephrops norvegicus* and *Parapenaeus longirostris* for crustaceans and *Galeus melastomus*, *Merluccius merluccius* and *Mullus barbatus* for fish.

In order to detect any temporal trend during the investigated period (1985–2006), the longest time series of the autumn GRUND surveys was considered and the trend in abundance indices was tested using linear regression analysis. For these analyses, the log transformation of the abundance was adopted to normalise the variables.

Given that changes both in abundance and size may be indicators of fishing effects [54,55], the median values of the Length Frequency Distribution (LFD) for the six selected species were computed by season and thus both the MEDITS (spring) and GRUND (autumn) surveys were considered for the study period 1994–2007; the changes in median values over time were also evaluated by Spearman rank correlation and linear regression [56,57].

In order to highlight the fishing effect on these exploited populations, the temporal changes in abundance were correlated (by Pearson correlation and Spearman rank correlation) with the trend in the fishing effort detected in the studied area over the same period. All the regression analyses computed on time series data have been checked for autocorrelation by means of the Durbin–Watson test [58,59]. When autcorrelations were identified, autoregressive models were applied using the Cochrane–Orcutt procedure [60].

Concerning growth, a review of the growth parameters computed for several fish and crustacean species in the last 25 years is also reported here. Age and growth were studied by reading otoliths and length frequency analysis for fish and crustaceans, respectively. The length frequency analysis was carried out to estimate crustacean age and compare the direct readings of otoliths for some fishes. The length distributions were calculated by sex and for sexes combined and the main modal components were separated by means of the Bhattacharya's methods. The Age–Length Keys (ALKs) from the two different methods were employed to calculate the growth parameters. The Von Bertalanffy Growth Function (VBGF) was adopted using the 'Length at Age' routine in the FISAT II program [61].

Finally, in order to detect the exploitation condition of the most important commercial species, the total mortality rates ($Z$) and exploitation rates ($E$) were considered as reference points [62].

The total mortality rates ($Z$) computed by year from 1994 to 2004, for the whole sampled population during autumn season of *N. norvegicus*, *P. longirostris*, *A. foliacea*, *A. antennatus*, *M. merluccius* and *M. barbatus*, are considered here. Two different approaches were followed for the computation of the total mortality rate ($Z$): the 'Length-Converted Catch Curve' (LCCC) method was applied for all species, as reported in FISAT II [61] and the Hoenig method was only utilised for *A. foliacea* because recruitment of this species can be considered almost discrete in the north-western Ionian Sea [8]. In order to detect any temporal trend, changes in $Z$ per year values with time and their correlation with fishing effort (as independent variable) were tested by Spearman rank correlation. For each species, the fishing mortality ($F$) was obtained as the difference between total mortality ($Z$) and natural mortality ($M$). Thus, the exploitation rate ($E = F/Z$) was also estimated by year and the changes of $E$ and $Z$ over time were also evaluated by Spearman rank correlation. An average $E$ value with relative confidence interval (95%) was computed for the study period (1994–2004).

## 3. Results

### 3.1. *Faunal assemblage*

The large amount of trawl surveys carried out in the last 25 years in the north-western Ionian Sea has provided new information on the faunal composition in the area and allowed the updating of

Table 3. List of the species recorded for the first time in the north-western Ionian Sea from 1985 to 2008, with indication of depth range of finding.

| Species | Depth (m) Min. | Max. |
|---|---|---|
| **Cephalopods (41 species collected)** | | |
| *Ancistrocheirus lesueurii* (D'Orbigny, 1842) | 508 | 563 |
| *Brachioteuthis riisei* (Steenstrup, 1882) | 314 | 606 |
| *Chiroteuthis veranii* (Férussac, 1835) | 345 | 670 |
| *Ctenopteryx sicula* (Verany, 1851) | 501 | 501 |
| *Galiteuthis armata* Joubin, 1898 | 1123 | 1123 |
| *Neorossia caroli* (Joubin, 1902) | 131 | 779 |
| *Octopoteuthis sicula* Rüppell, 1844 | 501 | 618 |
| *Octopus defilippi* Verany, 1851 | 25 | 40 |
| **Crustaceans (76 species collected)** | | |
| *Chaceon mediterraneus* Manning & Holthuis, 1989 | 3300 | 3300 |
| *Ebalia nux* A. Milne-Edwards, 1883 | 736 | 736 |
| *Gennadas elegans* (S.I. Smith, 1882) | 800 | 1500 |
| *Munida rutllanti (iris)* Zariquiey Alvarez, 1952 | 101 | 800 |
| *Nematocarcinus exilis* Bate, 1888 | 190 | 4000 |
| *Philocheras echinulatus* (M. Sars, 1861)[a] | 161 | 595 |
| *Plesionika acanthonotus* (S.I. Smith, 1882) | 284 | 1239 |
| *Scyllarus pygmaeus* (Bate, 1888)[a] | 96 | 564 |
| **Chondrichthyes (33 species collected)** | | |
| *Dipturus oxyrinchus* (Linnaeus, 1758) | 429 | 1218 |
| *Heptranchias perlo* (Bonnaterre, 1788) | 322 | 345 |
| *Myliobatis aquila* (Linnaeus, 1758) | 16 | 85 |
| *Oxynotus centrina* (Linnaeus, 1758) | 495 | 800 |
| *Raja clavata* Linnaeus, 1758 | 149 | 560 |
| *Raja montagui* Fowler, 1910 | 31 | 314 |
| *Rostroraja alba* (Lacépède, 1803) | 532 | 532 |
| **Osteichthyes (215 species collected)** | | |
| *Cataetyx laticeps* Koefoed, 1927[a] | 2000 | 3300 |
| *Coelorinchus mediterraneus* Iwamoto & Ungaro, 2002[a] | 917 | 1500 |
| *Coryphaenoides guentheri* (Vaillant, 1888)[a] | 1500 | 1700 |
| *Coryphaenoides mediterraneus* (Giglioli, 1893)[a] | 1054 | 4000 |
| *Deltentosteus collonianus* (Risso, 1820)[a] | 153 | 153 |
| *Diaphus metopoclampus* (Cocco, 1829)[a] | 312 | 662 |
| *Dysomma brevirostre* (Facciolà, 1887)[a] | 264 | 504 |
| *Elates ransonnetii* (Steindachner, 1876)[b] | 20 | 20 |
| *Gobius geniporus* Valenciennes, 1837[a] | 34 | 165 |
| *Grammonus ater* (Risso, 1810)[a] | 654 | 654 |
| *Hygophum hygomii* (Lütken, 1892)[a] | 316 | 1142 |
| *Lepidion lepidion* (Risso, 1810)[a] | 504 | 1700 |
| *Lobianchia gemellarii* (Cocco, 1838)[a] | 528 | 528 |
| *Sphoeroides pachygaster* (Müller & Troschel, 1848) | 66 | 400 |
| *Synapturichthys kleinii* (Risso, 1827)[a] | 16 | 171 |
| *Syngnathus taenionotus* Canestrini, 1871[a] | 101 | 101 |
| *Syngnathus tenuirostris* Rathke, 1837[a] | 60 | 60 |
| *Tetragonurus cuvieri* (Risso, 1810) | 300 | 300 |
| *Vinciguerria attenuata* (Cocco, 1838)[a] | 73 | 569 |

Notes: The total number of the species collected by taxon is reported in bold and parentheses. [a]Species not included in the checklist of Italian Fauna. [b]Alien species.

the species list previously reported. Throughout the study period from 1985 to 2008 a total of 365 species (41 cephalopods, 76 crustaceans both stomatopoda and decapoda, 33 chondroichthyes and 215 osteichthyes) were collected in the whole investigated depth range, from 10 to 4000 m (Table S1 – online only) and some of them have represented new records for the study area (Table 3).

Concerning cephalopods, in the last 20 years, the species *Octopus defilippi* [63], *Neorossia caroli* [64], *Chiroteuthis veranyi* [65], *Octopoteuthis sicula* and *Brachioteuthis riisei* [66], *Ancistrocheirus lesueurii* [67] and *Chtenopteryx sicula* [68] have been recorded for the first time in the study area. The bathypelagic species *Galiteuthis armata* was recently collected in the north-western Ionian Sea during the GAVIS project. Previous findings of this species in the basin were only reported in the Strait of Messina [69] and on the eastern Greek side of the Ionian Sea [70]. At present, the total number of cephalopods collected in the north-western Ionian Sea represents 71% of the total species (58) reported in the checklist of the Italian seas [71]. No new records for the Mediterranean Sea have been reported.

With regard to crustaceans, study projects conducted on the bathyal grounds provided new information on deep-sea decapod crustaceans of the north-western Ionian Sea with the new findings for the study area of the species *Chaceon mediterraneus*, *Gennadas elegans*, *Plesionika acanthonotus*, *Nematocarcinus exilis* [72] and the presence of *Ebalia nux* in the Santa Maria di Leuca coral bank [73]. Moreover, the occurrence of *Munida rutllanti*, *Philocheras echinulatus* and *Scyllarus pygmaeus* recorded in recent years updated the list of decapod crustaceans in the north-western Ionian Sea. In fact, the first species did not appear on the previous checklist of Italian fauna [74] and it has been added to the last version [75], whereas the last two species have not yet been included (Table 3). The decapods reported in this article for the north-western Ionian Sea correspond to 34% of the species reported for all the Italian seas [75].

The research carried out to date has also deepened the knowledge on chondroichthyes distribution in the north-western Ionian Sea, with the first update of the previous available information provided by Matarrese et al. [25], reporting a total of 19 species recorded, and then by Sion et al. [27] reporting the occurrence of seven other species (*Dipturus oxyrinchus*, *Heptranchias perlo*, *Myliobatis aquila*, *Oxynotus centrina*, *Raja clavata*, *Raja montagui* and *Rostroraja alba*). At present, a total of 14 sharks, 18 batoids and 1 chimaera have been collected in the north-western Ionian Sea, representing 39% of chondroichthyes reported for the Mediterranean Sea [47].

Also for teleost fish, the research carried out in the area provided new findings in the Ionian basin (Table 3). In the first updating of the previous knowledge on ichthyofauna, a total of 140 species was reported in the north-western Ionian Sea [25], but a lot of other species were later collected in the area.

It is important to emphasise the occurrence of *Sphoeroides pachygaster* in the Ionian basin. During 1991, one specimens of this tropical species was collected for the first time in the north-western Ionian Sea [48] and since then it has almost always been present in the area with more individuals. The analysis of density indices after the application of the cumulated sums method computed in the time range of the species occurrence showed a significant increase over time as well as potential changes in the time series between 2001 and 2002 (Figure 3). Among fish, the occurrence of the bathypelagic species *Tetragonurus cuvieri* [76] was reported as a new finding in the north-western Ionian Sea. In recent years, it is also important to note the occurrence in the area of the subtropical benthopelagic species *Dysomma brevirostre* as the easternmost record in the Mediterranean Sea [77] as well as the first finding of the alien species *Elates ransonnetii* in the Mediterranean Sea [78]. Moreover, the bathyal species *Cataetyx laticeps*, *Coelorinchus mediterraneus*, *Coryphaenoides guentheri*, *Coryphaenoides mediterraneus* and *Lepidion lepidion* [79] have also been recorded for the first time in the area.

Therefore, the teleost fish species recorded here represent 49% of the total number of the osteichthyes reported in the checklist for all Italian areas [80]. However, it should be highlighted that, apart from the above-mentioned new records, another 10 species reported here (*Deltentosteus collonianus*, *Diaphus metopoclampus*, *Gobius geniporus*, *Grammonus ater*, *Hygophum hygomii*, *Lobianchia gemellarii*, *Synapturichthys kleinii*, *Syngnathus taenionotus*, *Syngnathus tenuirostris* and *Vinciguerria attenuata*) still have not been included in the checklist of Italian fauna for the Ionian area [79].

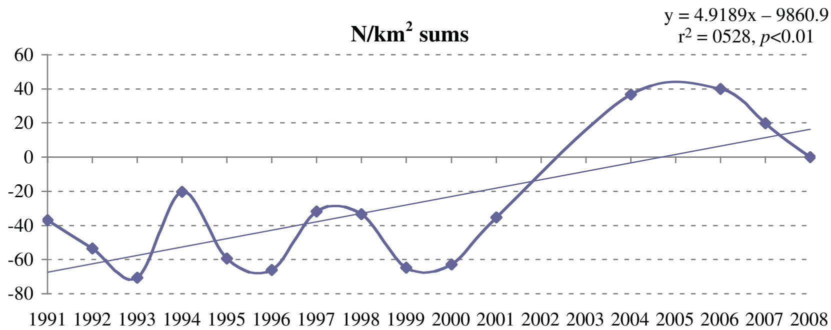


Figure 3. Density indices (N·km$^{-2}$) per year computed for *Sphoeroides pachygaster* caught in the north-western Ionian Sea from 1991 to 2008.



The depth range of occurrence was also reported for all species of the studied taxa (Table S1 – online only).

With regard to the frequency of occurrence (Foc) by trawl across the investigated depth range from 10–800 m, apart from selachians, the most common species were generally of commercial value. In particular, *Illex coindetii*, *Eledone cirrhosa*, *Sepietta oweniana* and *Todaropsis eblanae* were caught more frequently among cephalopods, whereas some species such as *Abraliopsis morisii*, *Argonauta argo*, *Ctenopteryx sicula* and *Galiteuthis armata* were collected only once in the area most probably in relation to their typical pelagic habit (Table S1 – online only).

Concerning crustaceans, *Parapenaeus longirostris*, *Plesionika martia*, *Polycheles typhlops*, *Nephrops norvegicus* and *Aristeus antennatus* were the most common species in the area with a Foc $>$30%, while some others (*Chaceon mediterraneus*, *Periclimenes granulatus* and *Sergestes arcticus*) were occasionally caught probably due to their very deep distribution (Table S1 – online only).

With regard to chondrichthyes, *Galeus melastomus* and *Etmopterus spinax* showed the highest Foc values. It is important to note the very low frequency of occurrence for this taxon ($<$6%) for all species, apart from the above-mentioned and *Chimaera monstrosa*, which was also frequently collected in the area. A low incidence of Rajiformes was also detected throughout the study period and only *Leucoraja circularis* (Foc = 1.58%) and *Raja miraletus* (Foc = 1.54%) were caught more frequently, although with a very low frequency (Table S1 – online only).

For teleost fish, *Merluccius merluccius*, *Phycis blennoides*, *Lophius budegassa* and *Helicolenus dactylopterus dactylopterus* were the most common species, but a high Foc ($>$34%) was also recorded for *Hymenocephalus italicus*, *Hoplostethus mediterraneus mediterraneus*, *Micromesistius poutassou* and *Nezumia sclerorhynchus* (Table S1 – online only). Also for this taxon, the single finding of some species could be related to the clear pelagic (*Auxis rochei rochei*, *Caranx crysos*, *Mola mola* and *Schedophilus ovalis*) or bathypelagic (*Ciclothone braueri* and *Lobianchia gemellarii*) habits that make these species less available to the trawl. The rare finding of other species such as *Coryphaenoides mediterraneus* is linked to their deeper distribution.

Concerning the univariate ecological indices computed in the depth range of 10–800 m for the spring and autumn seasons from 1994 to 2007, the richness index ($d$) increased significantly over time, whereas the Shannon–Wiener (H′) and eveness indices ($J$) fluctuated over time without any significant trend (Figure 4).

### 3.2. *Temporal trend in abundance and population structure*

Concerning the abundance of demersal resources in the north-western Ionian Sea, high variations were observed during the study period from 1985 to 2006. With regard to the faunal categories,

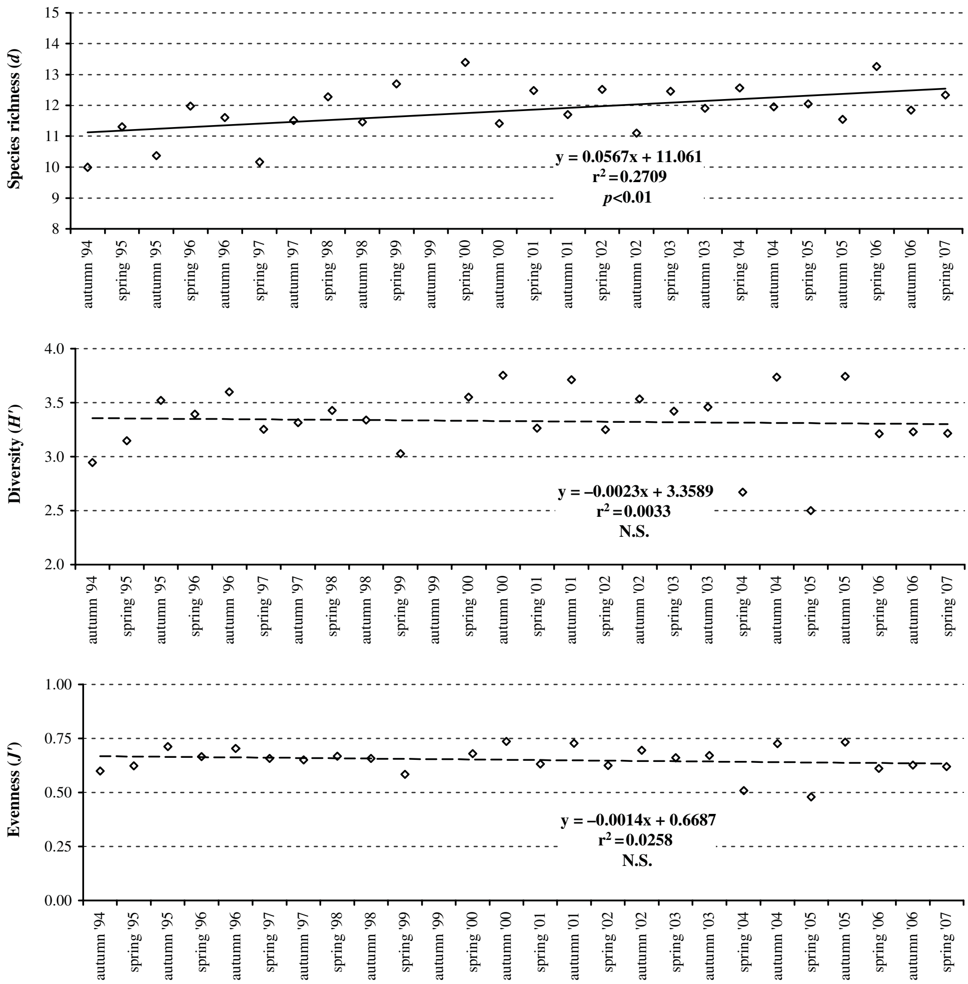


Figure 4. Species richness ($d$), diversity ($H'$), evenness ($J'$) by season of demersal species collected in the north-western Ionian Sea during MEDITS (spring) and GRUND (autumn) projects.

significant increases over time were observed in the log-transformed density indices ($N{\cdot}km^{-2}$) of cephalopods, crustaceans (linear regression corrected for autocorrelation) and osteichthyes, whereas no trend was detected for chondroichthyes in the depth range 10–800 m (Figure 5). Increasing values were also recorded in the biomass indices ($kg{\cdot}km^{-2}$) of all faunal categories, although they were not significant. The temporal trends obtained in the abundance indices were correlated with the decreasing fishing effort (linear regression corrected for autocorrelation) that occurred in the north-western Ionian Sea during the study period (Figure 2). Thus, highly significant negative correlations were observed for cephalopods (Pearson $= -0.585$; $p < 0.05$; linear regression corrected for autocorrelation) and osteichthyes (Pearson $= -0.843$; $p < 0,001$; linear regression corrected for autocorrelation).

With regards to the target species, significant increases in density and biomass with time were detected for the cephalopod *Illex coindetii* (0.516 for biomass, corrected for autocorrelation) and the crustaceans *Nephrops norvegicus* (0.599 for biomass, corrected for autocorrelation), whereas a negative trend was shown in *Galeus melastomus* ($-0.585$ for biomass, corrected for

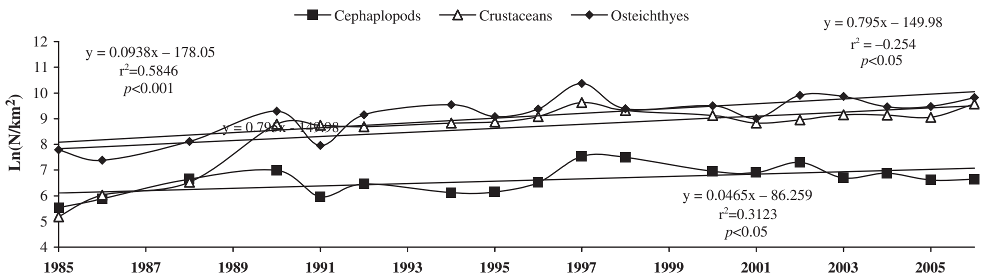


Figure 5. Log-transformed abundance indices per year by faunal categories collected in the north-western Ionian Sea from 1985 to 2006.

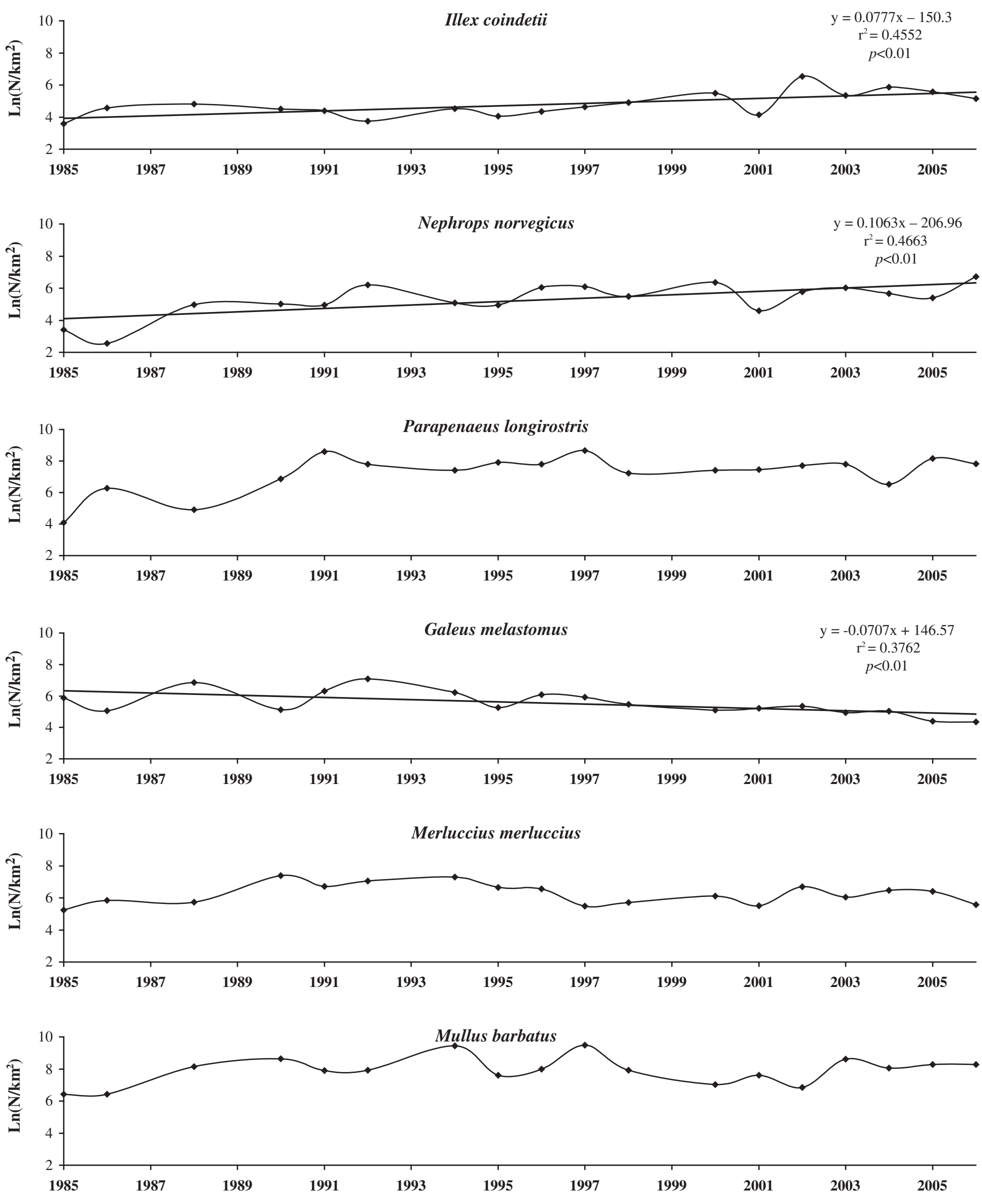


Figure 6. Log-transformed abundance indices per year by target species computed in the north-western Ionian Sea from 1985 to 2006.

Table 4. Changes of the median lengths by target species (*Illex coindetii*, *Nephrops norvegicus*, *Parapenaeus longirostris*, *Galeus melastomus*, *Merluccius merluccius* and *Mullus barbatus*) and season computed by Spearman rank correlation and linear regression, with indication of the statistic parameters and significance values.

| | Season | Spearman correlation | | Linear regression | |
|---|---|---|---|---|---|
| Species | (1994–2007) | $\rho$ | $p$ value | $R$ | $p$ value |
| *Illex coindetii* | Spring | n.s. | | n.s. | |
| | Autumn | n.s. | | n.s. | |
| *Nephrops norvegicus* | Spring | n.s. | | n.s. | |
| | Autumn | −0.659 | ** | −0.462 | * |
| *Parapenaeus longirostris* | Spring | −0.484 | * | −0.554 | * |
| | Autumn | −0.665 | ** | −0.604 | * |
| *Galeus melastomus* | Spring | 0.018 | ** | 0.011 | *** |
| | Autumn | 0.590 | ** | 0.495 | * |
| *Merluccius merluccius* | Spring | n.s. | | n.s. | |
| | Autumn | n.s. | | n.s. | |
| *Mullus barbatus* | Spring | n.s. | | n.s. | |
| | Autumn | n.s. | | n.s. | |

Notes: n.s., Not significant; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.



autocorrelation) (Figure 6). No significant trend was reported for *Parapenaeus longirostris*, *Merluccis merluccius* and *Mullus barbatus* and variable abundance indices over time were observed for these species (Figure 6). Moreover, significant negative correlations between the increasing density indices and decreasing fishing effort were detected for *I. coindetii* (Pearson = −0.520; $p < 0.05$), *P. longirostris* (Pearson = −0.471; $p < 0.05$) and *N. norvegicus* (Pearson = −0.673; $p < 0.01$ corrected for autocorrelation). No significant correlation was detected for the other considered species.

The analysis of LFDs for the six selected species showed different results depending on the species and the season. In particular, a significant decrease in the median length over time was detected for *N. norvegicus* in autumn and for *P. longirostris* in all investigated seasons (Table 4). By contrast, a significant increase in the median length over time was observed for *G. melastomus* and no significant trend was shown for *I. coindetii*, *M. merluccius* and *M. barbatus* (Table 4). All linear regression analyses were corrected for autocorrelation.

### 3.3. *Review on age and growth parameters*

As part of several projects carried out in the north-western Ionian Sea from 1985 to 2008, the age and growth of 6 crustaceans and 19 fish species were also studied. All the estimated parameters are reported in Table 5. Different life strategies were observed among the studied species. Concerning crustaceans, fast growth rates were generally exhibited and mostly in *P. longirostris*, whereas slower growth rates were observed for *A. antennatus* and *N. norvegicus* in both sexes. Apart from *P. martia*, faster growth rates were shown in females than in males (Table 5). With regard to fish, a moderate growth rate was almost always observed, apart from some species such as *L. caudatus* and *M. barbatus* that exhibited a fast growth with a $K$ value around 0.3. In some species for which growth parameters were estimated for both sexes, different growth rates were detected with a general faster growth in males than females as observed in *M. merluccius* and *P. blennoides* (Table 5).

Table 5. Growth parameters estimated (using the von Bertalanffy equation) in the north-western Ionian Sea by sex and/or sex combined, with indication of the different methodologies employed in age determination.

| Species | Sex | Methodology | $L^{\infty}$ (mm) | $K$ (year$^{-1}$) | $t_0$ (year) |
|---|---|---|---|---|---|
| **Crustaceans** | | | | | |
| *A. foliacea* | F | LFA | 69.78 | 0.45 | −0.18 |
| | M | LFA | 49.71 | 0.42 | −0.34 |
| *A. antennatus* | F | LFA | 79.39 | 0.22 | −0.23 |
| | F | LFA | 79.90 | 0.22 | −0.23 |
| *N. norvegicus* | F | LFA | 58.00 | 0.25 | −0.56 |
| | M | LFA | 79.70 | 0.20 | −0.64 |
| *P. longirostris* | F | LFA | 47.70 | 0.74 | −0.19 |
| | M | LFA | 35.50 | 0.54 | −0.29 |
| *P. martia* | F | LFA | 30.50 | 0.44 | −0.43 |
| | M | LFA | 28.00 | 0.50 | −0.48 |
| **Osteichthyes** | | | | | |
| *B. mediterraneus* | M+F | O | 194.30 | 0.15 | −0.92 |
| *C. agassizi* | M+F | O | 189.04 | 0.24 | −1.20 |
| | M+F | LFA | 218.33 | 0.16 | −1.69 |
| *C. coelorhincus* | F | O | 127.60 | 0.13 | −1.06 |
| | M | O | 114.90 | 0.15 | −1.05 |
| *H. dactylopterus* | M+F | O | 307.20 | 0.16 | −0.93 |
| *H. italicus* | F | O | 55.30 | 0.18 | −1.56 |
| | M | O | 54.90 | 0.18 | −1.57 |
| *H. mediterraneus* | F | O | 296.14 | 0.11 | −2.64 |
| | M | O | 270.48 | 0.13 | −2.47 |
| | M+F | O | 287.08 | 0.13 | −2.13 |
| | M+F | LFA | 270.03 | 0.23 | |
| *L. boscii* | F | O | 490.50 | 0.11 | −1.24 |
| | M | O | 480.00 | 0.11 | −1.34 |
| | M+F | O | 484.60 | 0.11 | −0.99 |
| *L. budegassa* | F | O | 684.50 | 0.11 | −1.18 |
| | M | O | 603.00 | 0.11 | −1.56 |
| | M+F | O | 683.90 | 0.10 | −1.43 |
| *L. caudatus* | F | O | 1824.60 | 0.30 | −0.50 |
| | M | O | 1742.70 | 0.31 | −0.53 |
| *M. barbatus* | F | O | 245.00 | 0.27 | −1.85 |
| | M | O | 224.00 | 0.28 | −1.98 |
| | M+F | O | 252.00 | 0.26 | −1.71 |
| *M. merluccius* | F | O | 695.57 | 0.14 | −0.73 |
| | M | O | 518.43 | 0.18 | −0.55 |
| *M. poutassou* | F | O | 442.70 | 0.22 | −1.32 |
| | M | O | 425.00 | 0.24 | −1.20 |
| | M+F | O | 432.00 | 0.23 | −1.23 |
| *N. sclerorhynchus* | F | O | 81.20 | 0.10 | −1.90 |
| | M | O | 77.00 | 0.11 | −1.75 |
| *P. blennoides* | F | O | 703.00 | 0.13 | −0.77 |
| | M | O | 410.00 | 0.21 | −1.24 |
| *T. scabrus* | M+F | O | 234.00 | 0.16 | −1.68 |
| *T. trachurus* | M+F | O | 473.00 | 0.17 | −0.91 |

Note: O, Otoliths; LFA, length–frequency analysis.



### 3.4. *Mortality and exploitation rates*

The total mortality rates by year computed for the target species fluctuated throughout the whole study period (Table 6). The highest $Z$ values were shown for *P. longirostris* between 4.22 per year (during 2001) and 5.84 per year (during 1994), whereas the lowest mortality rates ($0.60 < Z < 1.03$) were detected for *A. antennatus*.

Table 6. Total mortality rate (*Z*) and exploitation ratio (*E*) calculated by year and species in the north-western Ionian Sea during 1994–2004.

| | 1994 | | 1995 | | 1996 | | 1997 | | 1998 | | 2000 | | 2001 | | 2002 | | 2003 | | 2004 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Z* | *E* | *Z* | *E* | *Z* | *E* | *Z* | *E* | *Z* | *E* | *Z* | *E* | *Z* | *E* | *Z* | *E* | *Z* | *E* | *Z* | *E* |
| ***M. merluccius*** | 1.04 | 0.71 | 1.12 | 0.73 | 1.05 | 0.71 | 1.05 | 0.71 | 1.28 | 0.77 | 1.20 | 0.75 | 1.11 | 0.73 | 1.13 | 0.73 | 0.95 | 0.68 | 1.14 | 0.74 |
| ***M. barbatus*** | 1.77 | 0.66 | 2.28 | 0.74 | 1.63 | 0.63 | 1.55 | 0.61 | 1.40 | 0.57 | 1.22 | 0.51 | 1.04 | 0.42 | 1.15 | 0.48 | 1.19 | 0.50 | 1.12 | 0.46 |
| ***N. norvegicus*** | 0.94 | 0.47 | 0.90 | 0.44 | 0.93 | 0.46 | 0.97 | 0.48 | 1.05 | 0.52 | 1.05 | 0.52 | 0.82 | 0.39 | 1.12 | 0.55 | 1.16 | 0.57 | 1.17 | 0.57 |
| ***P. longirostris*** | 5.84 | 0.79 | 5.32 | 0.77 | 4.43 | 0.73 | 4.27 | 0.72 | 5.16 | 0.77 | 4.61 | 0.74 | 4.22 | 0.72 | 4.75 | 0.75 | 4.24 | 0.72 | 4.77 | 0.75 |
| ***A. foliacea**** | 0.87 | 0.43 | 1.56 | 0.68 | 1.23 | 0.59 | 1.56 | 0.68 | 0.83 | 0.40 | 1.44 | 0.65 | 1.30 | 0.62 | 1.53 | 0.67 | 1.45 | 0.66 | 1.38 | 0.64 |
| ***A. antennatus*** | 0.76 | 0.47 | 0.6 | 0.33 | 0.85 | 0.53 | 0.76 | 0.47 | 0.72 | 0.44 | 1.03 | 0.61 | 0.87 | 0.54 | 0.64 | 0.38 | 0.65 | 0.38 | 0.96 | 0.58 |

Note: **Z* values have been calculated with Hoenig method.

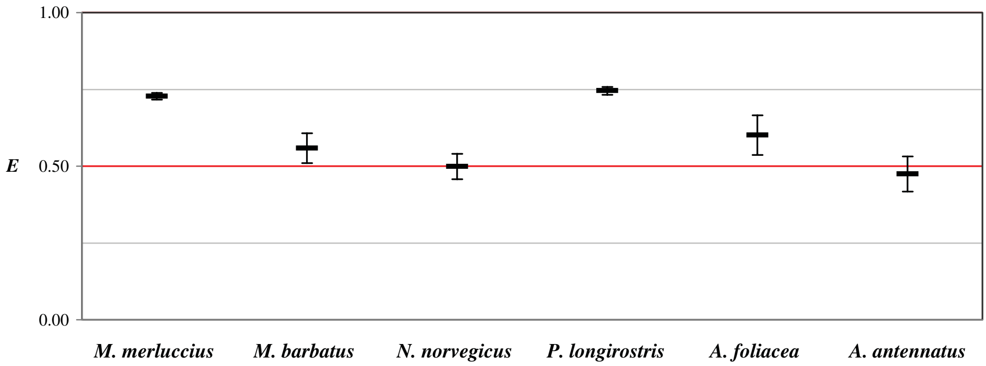


Figure 7. Average values of the exploitation rate ($E$), with relative confidence interval (95%), computed for the target species in the north-western Ionian Sea from 1994–2004.



Significant decreasing trends in the $Z$ (Spearman $= -0.707$; $p < 0.01$) and $E$ (Spearman $= -0.711$; $p < 0.01$) values with time were only observed for *M. barbatus*, although no significant trends were detected in other species.

The exploitation rate $E$ was generally higher than the critical threshold of 0.5 for the different species examined (Table 6). Because $E$ is the ratio between fishing mortality ($F$) and total mortality ($Z$), this means that >50% of mortality is due to the fishing pressure.

In particular, an overexploitation condition was shown in *P. longirostris* and *M. merluccius* with no variation over time, as enhanced by the narrow confidence limits (Figure 7). Moderate overexploitation was detected for *M. barbatus* and *A. foliacea*, more variable over time. Finally, *N. norvegicus* presented a near equilibrium state and a slightly underexploited condition was observed for *A. antennatus* stock.

## 4. Discussion

The particular geomorphology and oceanography of the north-western Ionian Sea determine the presence of different habitats that provide a complex system of environmental patches, reflected in the distribution and abundance of the demersal resources and in the biodiversity detected in this basin. The marine ecosystems are exposed to a strong increase in anthropogenic impact both directly through extension of the coastal fisheries to the slope, and indirectly due to the impact of global climatic change [81,82]. As a consequence, apart from areas where habitats and resources are naturally protected (irregular or unsuitable trawl bottoms), marine resources both living on the shelf and on the upper slope have also been subject to high trawl fishing pressure in recent decades in the north-western Ionian Sea.

The several surveys carried out systematically in the last 25 years on the demersal resources of this area have provided a large amount of standardised data useful for detecting the current status of these marine resources and investigating, over a wide time scale, any changes in their availability, as well as in the biodiversity of demersal faunal assemblages. Although two experimental and commercial trawl nets, with different catchability patterns, were adopted during the seasonal MEDITS and GRUND surveys, in this article, standardised data coming from both surveys were considered jointly for only biodiversity studies; moreover, in order to enhance any seasonal pattern related to the recruitment process in the population structure of the most commercially important species, data from both surveys were separately computed and consistent results were obtained. By contrast, only the longest time series of the autumn GRUND surveys (1985–2006) were considered for detecting abundance changes over time of both faunal categories and species. Finally, considering the importance to enlarge the knowledge on the species occurrence also to the deepest bottoms, data coming from all trawl surveys carried out in the study area from 10 to 4000 m were used.

The results reported in this study have updated the faunal lists reported for this area. In fact, through the finding of various species during the period 1985–2008, a high number of cephalopod, crustacean, cartilaginous and teleost fish species was recorded for the noth-western Ionian Sea, representing a high percentage of the species reported for the Italian seas. In addition, 18 records not included in the Italian checklist have been reported in this article, together with 1 alien species (*Elates ransonnetii*) for the Mediterranean Sea. These results reflect the increase in species richness observed throughout the study period. This knowledge may be used as a reference base to monitor the complexity of the biodiversity of the demersal faunal assemblage not only on the local Ionian scale, but also in the context of the whole Mediterranean basin. Moreover, it may also be useful to properly assess the response of these demersal assemblages to natural and anthropogenic pressures also acting in the recent years.

The tropical species *Sphoeroides pachygaster*, after its first occurrence in the Ionian basin in 1991 [48], showed a significant increase with time and there is now a steady population with the presence of spawning females. These data should document the effect of global warming in the Mediterranean [20] and the tropicalisation of this basin as already observed in other areas [83,84]. Moreover, the first finding of *Sphoeroides pachygaster* in the Ionian Sea was recorded shortly after the Eastern Mediterranean Transient (EMT) [42,43], whereas the increase in abundance after 2001–2002 could be most probably related to a more recent increase in the temperature and salinity recorded in this basin [85].

With regard to more direct anthropogenic forcing, the low contribution of the chondroichthyes in the species assemblage of the north-western Ionian Sea and particularly the low incidence of Rajiformes throughout the investigated period could be strictly linked to the fishing pressure as already documented in other Mediterranean areas [86,87]. According to Stevens et al. [88] chondroichthyes are particularly vulnerable to overexploitation because of their general k-selected life-history strategy. In fact, higher catches of Rajiformes and in particular of *D. oxyrinchus* and *R. clavata* have also been observed on the eastern side of the Ionian Sea (Greek waters) [89], where a lower fishing pressure is acting on the bathyal grounds [90]. In any case, a relevant presence of Rajiformes, such as *R. clavata* and *R. asterias* was also detected in neighbouring areas to the Ionian basin (South Adriatic and Sicily Channel), where the fishing activity is strong [87], also enhancing the role of environmental characteristics (edaphic conditions and physical–chemical parameters) in structuring the species assemblages.

The available time series showed high variations in the abundance of faunal categories and species during the study period. Apart from the general low abundance of chondroichthyes with no trend during the investigated period, significant increases over time were observed for the other faunal groups and they proved to be negatively correlated with the trend of fishing effort detected in the last decades in the area, enhancing the influence of a decreasing fishing effort on the increase in the experimental catch. Moreover, significant increases in abundance over time were also detected for the target species *Illex coindetii* and *Nephrops norvegicus* and an inverse significant correlation with fishing effort was also shown for these species. Nevertheless, a significant decrease in median length over time was depicted for *N. norvegicus* and *P. longirostris*, showing apparent conflicting results between abundance and this population parameter. Fluctuations in the marine populations have been generally supposed to be related to the biology of the species as well as fishing effort in the study areas. In the Mediterranean Sea, large changes in experimental catches and landings have been detected over time [91–93] and the effects of fishing on the dynamics of the marine biological resources and ecosystem have recently been documented [93]. High fluctuations in the catches also reflect large changes in the recruitment process that provides a remarkable contribution of juveniles to the catches by trawling in the area. Thus, the significant increase detected in abundance of the above-mentioned species could also be related to intense recruitment processes verified in the last years. In fact, some studies carried out in the north-western Ionian Sea described the remarkable contribution of recruitment to the abundance of many commercial species in this geographic area [4,15] that was recently confirmed as containing nursery areas for *P. longirostris*, *N. norvegicus*, *M. barbatus* and *M. merluccius* [94,95]. Thus, the intense recruitment documented for these species could explain both the increasing abundance and the decreasing median size throughout the study period. Moreover, the coastal distribution of nurseries of hake and deep-water rose shrimp and their consequent exposure to a high fishing activity could also explain their stable overexploitation conditions observed over such a long period of investigation in the north-western Ionian Sea. The significant decreasing trend in the $Z$ values with time, together with a moderate overexploitation observed in the red mullet, although variable over time, could be related to the regulation measures of the ‘closed season’ adopted in recent years, which has proved particularly efficient in protecting the summer–autumn recruitment of this species. The nearly equilibrium state and the optimal or slightly underexploited condition detected for *N. norvegicus* and *A. antennatus* respectively, could be related to the specific habit and life cycles of these two species. For *A. antennatus*, recruits and juveniles are distributed in deep waters and inside canyons [38,96,97] that represent ‘ecological refuges’ for this species, habitats unsuitable for trawling and providing some renewal of the stock. For *N. norvegicus*, the typical burial habit, particularly during the spawning phase, prevents the full exploitation of its stock [98].

Finally, some significant correlations shown in this study could be simply correlative. Indeed, because fluctuations in the abundance of biological resources over time are related to manifold variables, further studies will be required to distinguish between relationships that are predictive and those that are simply correlative. The abundance increase of each demersal faunal group, apart from cartilaginous fish, seems to be a typical effect due to fishing effort decrease. This is less evident in each single species due to both the above-mentioned reason related to the recruitment phenomenon and to the fact that the fishing effort reported in this study probably does not explain efficaciously the real effort.

All the results reported here enhanced the role of environmental factors in the structure of demersal assemblages as well as the complexity of the management of marine biological resources. In the context of Mediterranean countries, several conservation and/or management plans have recently been proposed at an international level (e.g. the Marine Strategy Framework Directive of the European Union, MSFD 2008) and scientists are requested to provide comprehensive studies in order to support and orientate these plans. The influence of environmental factors and oceanographic conditions on the abundance and recruitment of commercial species has only recently been reported in the western Mediterranean [99,100].

Thus, taking into account the complexity of ecosystem processes coupled with human activities and climatic change affecting aquatic populations, the next objective is to deepen and explore potential relationships between marine resources and environmental conditions. Further projects on a wide geographic scale are also needed in order to apply an ecosystem based approach to the management of marine resources and human activities.

The results presented here point out the importance of systematic studies, which can allow monitoring biological resources subject to the exploitation. In particular, these studies should be integrated with knowledge of the environmental factors (climatic, oceanographic, etc.), which may influence their fluctuations as well as the knowledge of other ecosystem biological components, such as strictly benthic and pelagic fauna, with which demersal species interact within the complex marine food web.

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Table S1. List of the species caught in the Northern Ionian Sea (Eastern-Central Mediterranean) from 1985 to 2008 with indication of depth range of finding and frequency of occurrence (Foc). *Species not included in the checklist of Italian Fauna; **Alien species.

| **SPECIES** | **Depth (m)** | | **Foc (%)** |
|---|---|---|---|
| **Cephalopods** | **Min.** | **Max.** | |
| *Abralia verany* (Rüppell, 1844) | 62 | 746 | 8.43 |
| *Abraliopsis morisii (Vérany, 1839)* | 558 | 558 | 0.04 |
| *Alloteuthis media* (Linnaeus, 1758) | 12 | 478 | 15.19 |
| *Alloteuthis subulata* (Lamarck, 1798) | 12 | 539 | 1.93 |
| *Ancistrocheirus lesueurii* (D'Orbigny, 1842) | 508 | 563 | 0.17 |
| *Ancistroteuthis lichtensteinii* (Férussac, 1835) | 165 | 1123 | 1.93 |
| *Argonauta argo* Linneo 1758 | 362 | 362 | 0.04 |
| *Brachioteuthis riisei* (Steenstrup, 1882) | 314 | 606 | 0.21 |
| *Chiroteuthis veranii* (Férussac, 1835) | 345 | 670 | 0.47 |
| *Ctenopteryx sicula* (Verany, 1851) | 501 | 501 | 0.04 |
| *Eledone cirrhosa* (Lamarck, 1798) | 15 | 650 | 28.07 |
| *Eledone moschata* (Lamarck, 1798) | 12 | 363 | 16.73 |
| *Galiteuthis armata* Joubin, 1898 | 1123 | 1123 | - |
| *Heteroteuthis dispar* (Rüppell, 1844) | 143 | 1142 | 2.57 |
| *Histioteuthis bonnellii* (Férussac, 1835) | 254 | 763 | 4.15 |
| *Histioteuthis reversa* (Verrill, 1880) | 153 | 769 | 7.92 |
| *Illex coindetii* (Verany, 1839) | 14 | 767 | 38.90 |
| *Loligo forbesii* Steenstrup, 1856 | 20 | 425 | 1.41 |
| *Loligo vulgaris* Lamarck, 1798 | 12 | 560 | 8.94 |
| *Neorossia caroli* (Joubin, 1902) | 131 | 779 | 8.43 |
| *Octopoteuthis sicula* Rüppell, 1844 | 501 | 618 | 0.26 |
| *Octopus defilippi* Verany, 1851 | 25 | 40 | 0.26 |
| *Octopus macropus* Risso, 1826 | 17 | 350 | 0.77 |
| *Octopus salutii* Verany, 1839 | 31 | 778 | 15.92 |
| *Octopus vulgaris* Cuvier, 1797 | 11 | 290 | 18.23 |
| *Onychoteuthis banksii* (Leach, 1817) | 327 | 772 | 0.43 |
| *Pteroctopus tetracirrhus* (Delle Chiaje, 1830) | 55 | 714 | 10.65 |
| *Pyroteuthis margaritifera* (Rüppell, 1844) | 287 | 605 | 0.09 |
| *Rondeletiola minor* (Naef, 1912) | 12 | 585 | 9.88 |
| *Rossia macrosoma* (Delle Chiaje, 1830) | 68 | 772 | 12.49 |
| *Scaeurgus unicirrhus* (Delle Chiaje, 1841) | 23 | 625 | 21.05 |
| *Sepia elegans* Blainville, 1827 | 14 | 562 | 20.54 |
| *Sepia officinalis* Linnaeus, 1758 | 12 | 219 | 10.61 |
| *Sepia orbignyana* Férussac, 1826 | 12 | 562 | 7.62 |
| *Sepietta oweniana* (D'Orbigny, 1841) | 12 | 602 | 24.35 |
| *Sepiola intermedia* Naef, 1912 | 12 | 313 | 1.67 |
| *Sepiola ligulata* Naef, 1912 | 20 | 360 | 1.11 |
| *Sepiola robusta* Naef, 1912 | 25 | 334 | 0.81 |
| *Sepiola rondeletii* Leach, 1817 | 18 | 87 | 0.47 |
| *Todarodes sagittatus* (Lamarck, 1798) | 97 | 779 | 9.46 |
| *Todaropsis eblanae* (Ball, 1841) | 13 | 742 | 21.69 |
| **Crustaceans** | | | |
| **Decapoda** | | | |
| *Acanthephyra eximia* S.I. Smith, 1884 | 659 | 4000 | 0.56 |
| *Acanthephyra pelagica* (Risso, 1816) | 531 | 4000 | 0.43 |
| *Aegeon cataphractus* (Olivi, 1792) | 18 | 125 | 2.57 |
| *Aegeon lacazei* (Gourret, 1887) | 31 | 1054 | 16.77 |
| *Alpheus glaber* (Olivi, 1792) | 31 | 786 | 1.03 |
| *Aristaeomorpha foliacea* (Risso, 1827) | 127 | 1145 | 29.87 |
| *Aristeus antennatus* (Risso, 1816) | 108 | 3300 | 31.11 |
| *Atelecyclus rotundatus* (Olivi, 1792) | 24 | 50 | 0.21 |
| *Bathynectes maravigna* (Prestandrea, 1839) | 125 | 1500 | 8.90 |
| *Calappa granulata* (Linnaeus, 1758) | 18 | 665 | 6.16 |
| *Calappa rissoana* Pastore, 1995 | 25 | 165 | 0.26 |
| *Calappa tuerkayana* Pastore, 1995 | 24 | 140 | 0.26 |
| *Chaceon mediterraneus* Manning & Holthuis, 1989 | 3300 | 3300 | - |
| *Chlorotocus crassicornis* (A. Costa, 1871) | 52 | 736 | 19.73 |
| *Dromia personata* (Linnaeus, 1758) | 49 | 101 | 0.09 |
| *Ebalia nux* A. Milne-Edwards, 1883 | 736 | 736 | 0.04 |
| *Ethusa mascarone* (Herbst, 1785) | 18 | 18 | 0.04 |
| *Gennadas elegans* (S.I. Smith, 1882) | 800 | 1500 | - |
| *Geryon longipes* A. Milne-Edwards, 1882 | 140 | 1147 | 5.52 |
| *Goneplax rhomboides* (Linnaeus, 1758) | 12 | 917 | 7.79 |
| *Homola barbata* (J.C. Fabricius, 1793) | 29 | 665 | 1.20 |
| *Inachus communissimus* Rizza, 1839 | 12 | 130 | 0.94 |
| *Inachus dorsettensis* (Pennant, 1777) | 13 | 379 | 0.51 |
| *Latreillia elegans elegans* Roux, 1830 | 25 | 267 | 0.73 |
| *Ligur ensiferus* (Risso, 1816) | 320 | 1000 | 0.56 |
| *Liocarcinus depurator* (Linnaeus, 1758) | 12 | 698 | 21.69 |
| *Macropipus tuberculatus* (Roux, 1830) | 18 | 778 | 18.27 |
| *Macropodia tenuirostris* (Leach, 1814) | 27 | 651 | 1.28 |

| SPECIES | Depth (m) | | Foc (%) |
|---|---|---|---|
| **Crustaceans** | **Min.** | **Max.** | |
| *Macropodia rostrata* (Linnaeus, 1761) | 16 | 290 | 1.71 |
| *Maja crispata* Risso, 1827 | 24 | 60 | 0.09 |
| *Maja squinado* (Herbst, 1788) | 64 | 139 | 0.21 |
| *Medorippe lanata* (Linnaeus, 1767) | 18 | 778 | 3.68 |
| *Monodaeus couchii* (Couch, 1851) | 22 | 1123 | 8.64 |
| *Munida curvimana* A. Milne-Edwards&Bouvier, 1894 | 208 | 208 | 0.04 |
| *Munida intermedia* A. Milne-Edwards&Bouvier, 1899 | 255 | 725 | 9.20 |
| *Munida rutllanti (iris)* Zariquiey Alvarez, 1952 | 101 | 800 | 10.87 |
| *Munida tenuimana (perarmata)* G.O. Sars, 1872 | 142 | 1500 | 6.42 |
| *Nematocarcinus exilis* Bate, 1888 | 190 | 4000 | 0.17 |
| *Nephrops norvegicus* (Linnaeus, 1758) | 43 | 908 | 36.67 |
| *Palinurus elephas* (J.C. Fabricius, 1787) | 73 | 151 | 0.17 |
| *Parapenaeus longirostris* (Lucas, 1846) | 18 | 711 | 45.79 |
| *Paromola cuvieri* (Risso, 1816) | 91 | 1118 | 5.82 |
| *Parthenope angulifrons* Latreille, 1825 | 12 | 20 | 0.09 |
| *Parthenope macrochelos* (Herbst, 1790) | 18 | 885 | 2.57 |
| *Parthenope massena* (P. Roux, 1830) | 47 | 50 | 0.09 |
| *Pasiphaea multidentata* Esmark, 1866 | 132 | 1152 | 15.23 |
| *Pasiphaea sivado* (Risso, 1816) | 99 | 910 | 13.56 |
| *Penaeus (Melicertus) kerathurus* (Forssakal, 1775) | 12 | 316 | 0.39 |
| *Periclimenes granulatus* Holthuiis, 1950 | 800 | 800 | - |
| *Philocheras echinulatus* (M. Sars, 1861) * | 161 | 595 | 0.43 |
| *Pilumnus spinifer* H. Milne-Edwards, 1834 | 49 | 115 | 0.26 |
| *Pisa armata* (Latreille, 1803) | 47 | 108 | 0.26 |
| *Pisa nodipes* (Leach, 1815) | 50 | 151 | 0.13 |
| *Plesionika acanthonotus* (S.I. Smith, 1882) | 284 | 1239 | 9.20 |
| *Plesionika antigai* Zariquiey Alvarez, 1955 | 107 | 658 | 8.04 |
| *Plesionika edwardsii* (Brandt, 1851) | 53 | 669 | 9.11 |
| *Plesionika gigliolii* (Senna, 1903) | 113 | 673 | 15.06 |
| *Plesionika heterocarpus* (A. Costa, 1871) | 64 | 694 | 17.89 |
| *Plesionika martia* (A. Milne Edwards, 1883) | 103 | 1167 | 39.15 |
| *Plesionika narval* (J.C. Fabricius, 1787) | 101 | 557 | 1.97 |
| *Polycheles typhlops* Heller, 1862 | 113 | 2000 | 38.00 |
| *Pontophilus spinosus* (Leach, 1815) | 13 | 774 | 8.73 |
| *Pontophilus norvegicus* (M. Sars, 1861) | 365 | 1500 | 0.09 |
| *Processa canaliculata* Leach, 1815 | 111 | 713 | 9.76 |
| *Rochinia rissoana* (P. Roux, 1828) | 204 | 800 | 1.33 |
| *Scyllarides latus* (Latreille, 1803) | 40 | 77 | 0.13 |
| *Scyllarus pygmaeus* (Bate, 1888) * | 96 | 564 | 0.09 |
| *Sergestes arachnidopus* (Cocco, 1832) | 213 | 4000 | 2.91 |
| *Sergestes arcticus* Krøyer, 1855 | 570 | 1500 | 0.04 |
| *Sergia robusta* (S.I. Smith, 1882) | 222 | 4000 | 5.31 |
| *Sicyonia carinata* Brunnich, 1768 | 13 | 49 | 0.09 |
| *Solenocera membranacea* (Risso, 1816) | 18 | 741 | 27.56 |
| **Stomatopoda** | | | |
| *Pseudosquillopsis cerisii* (Roux, 1828) | 86 | 615 | 1.71 |
| *Rissoides desmaresti* (Risso, 1816) | 89 | 675 | 3.00 |
| *Rissoides pallidus* (Giesbrecht, 1910) | 92 | 605 | 3.94 |
| *Squilla mantis* (Linnaeus, 1758) | 12 | 253 | 8.86 |
| **Chondrichthyes** | | | |
| *Centrophorus granulosus* (Bloch and Schneider, 1801) | 300 | 1155 | 0.13 |
| *Centrophorus uyato* (Rafinesque, 1810) | 748 | 962 | 0.04 |
| *Chimaera monstrosa* Linnaeus, 1758 | 173 | 1239 | 10.10 |
| *Dalatias licha* (Bonnaterre, 1788) | 315 | 1239 | 5.99 |
| *Dasyatis centroura* (Mitchill, 1815) | 49 | 49 | 0.04 |
| *Dasyatis pastinaca* (Linnaeus, 1758) | 12 | 130 | 1.03 |
| *Dipturus batis* (Linnaeus, 1758) | 617 | 617 | 0.04 |
| *Dipturus oxyrinchus* (Linnaeus, 1758) | 429 | 1218 | 0.60 |
| *Etmopterus spinax* (Linnaeus, 1758) | 64 | 1500 | 32.09 |
| *Galeus melastomus* Rafinesque, 1810 | 140 | 1500 | 39.15 |
| *Gymnura altavela* (Linnaeus, 1758) | 345 | 345 | 0.04 |
| *Heptranchias perlo* (Bonnaterre, 1788) | 322 | 345 | 0.09 |
| *Hexanchus griseus* (Bonnaterre, 1788) | 219 | 1155 | 0.09 |
| *Leucoraja circularis* (Couch, 1838) | 18 | 1009 | 1.58 |
| *Leucoraja fullonica* Linnaeus, 1758 | 160 | 587 | 0.21 |
| *Mustelus mustelus* (Linnaeus, 1758) | 12 | 559 | 1.75 |
| *Myliobatis aquila* (Linnaeus, 1758) | 16 | 85 | 0.26 |
| *Oxynotus centrina* (Linnaeus, 1758) | 495 | 800 | 0.09 |
| *Pteromylaeus bovinus* (Geoffroy Saint-Hilaire, 1817) | 12 | 72 | 0.90 |
| *Raja asterias* Delaroche, 1809 | 18 | 541 | 1.45 |
| *Raja clavata* Linnaeus, 1758 | 149 | 560 | 0.09 |
| *Raja miraletus* Linnaeus, 1758 | 12 | 430 | 1.54 |
| *Raja montagui* Fowler, 1910 | 31 | 314 | 0.13 |
| *Raja radula* Delaroche, 1809 | 119 | 119 | 0.04 |
| *Rostroraja alba* (Lacépède, 1803) | 532 | 532 | 0.04 |

| SPECIES | Depth (m) | | Foc (%) |
|---|---|---|---|
| **Chondrichthyes** | **Min.** | **Max.** | |
| *Scyliorhinus canicula* (Linnaeus, 1758) | 20 | 634 | 4.54 |
| *Scyliorhinus stellaris* (Linnaeus, 1758) | 50 | 50 | 0.04 |
| *Somniosus (Rhinoscymnus) rostratus* (Risso,1810) | 590 | 590 | - |
| *Squalus acanthias* Linnaeus, 1758 | 20 | 20 | 0.04 |
| *Squalus blainvillei* (Risso, 1826) | 688 | 688 | 0.04 |
| *Torpedo (Torpedo) marmorata* Risso, 1758 | 12 | 525 | 3.47 |
| *Torpedo (Tetronarce) nobiliana* Bonaparte, 1835 | 18 | 675 | 1.58 |
| *Torpedo (Torpedo) torpedo* (Linnaeus, 1758) | 12 | 550 | 1.58 |
| **Osteichthyes** | | | |
| *Acantholabrus palloni* (Risso, 1810) | 142 | 297 | 0.26 |
| *Alosa alosa* (Linnaeus, 1758) | 33 | 56 | 0.13 |
| *Alosa fallax* (Lacepède, 1803) | 42 | 125 | 0.09 |
| *Anthias anthias* (Linnaeus, 1758) | 101 | 153 | 0.17 |
| *Argentina sphyraena* Linnaeus, 1758 | 18 | 675 | 12.45 |
| *Argyropelecus hemigymnus* Cocco, 1829 | 147 | 1219 | 4.15 |
| *Ariosoma balearicum* (Delaroche, 1809) | 24 | 340 | 0.73 |
| *Arnoglossus kessleri* Shmidt, 1915 | 124 | 124 | 0.04 |
| *Arnoglossus laterna* (Walbaum, 1792) | 12 | 637 | 23.92 |
| *Arnoglossus rueppelli* (Cocco, 1844) | 13 | 675 | 12.02 |
| *Arnoglossus thori* Kyle, 1913 | 15 | 363 | 5.73 |
| *Aspitrigla cuculus* (Linnaeus, 1758) | 17 | 478 | 12.28 |
| *Aulopus filamentosus* (Bloch, 1792) | 130 | 536 | 0.34 |
| *Auxis rochei rochei* (Risso, 1810) | 573 | 573 | - |
| *Balistes capriscus* Gmelin, 1789 | 13 | 48 | 0.34 |
| *Bathophilus nigerrimus* Giglioli, 1884 | 350 | 586 | 0.13 |
| *Bathypterois mediterraneus* Bauchot, 1962 | 659 | 3300 | 0.13 |
| *Benthocometes robustus* (Goode & Bean, 1886) | 85 | 767 | 1.93 |
| *Benthosema glaciale* (Reinhardt, 1837) | 161 | 769 | 6.80 |
| *Blennius ocellaris* Linnaeus, 1758 | 17 | 187 | 7.74 |
| *Boops boops* (Linnaeus, 1758) | 12 | 379 | 25.07 |
| *Bothus podas* (Delaroche, 1809) | 11 | 680 | 4.71 |
| *Buglossidium luteum* (Risso, 1810) | 16 | 520 | 0.34 |
| *Callanthias ruber* (Rafinesque, 1810) | 56 | 418 | 0.17 |
| *Callionymus lyra* Linnaeus, 1758 | 133 | 133 | 0.04 |
| *Callionymus maculatus* Rafinesque, 1810 | 12 | 594 | 11.51 |
| *Callionymus pusillus* Delaroche, 1809 | 20 | 20 | 0.04 |
| *Callionymus risso* Lesueur, 1814 | 12 | 370 | 0.17 |
| *Callyonimus fasciatus* Valenciennes, 1837 | 50 | 92 | 0.04 |
| *Campogramma glaycos* (Lacepède, 1801) | 25 | 25 | 0.04 |
| *Capros aper* (Linnaeus, 1758) | 14 | 673 | 18.01 |
| *Caranx crysos* (Mitchill, 1815) | 16 | 16 | 0.04 |
| *Caranx rhonchus* Geoffroy Saint-Hilaire, 1817 | 30 | 320 | 0.17 |
| *Carapus acus* (Brünnich, 1768) | 13 | 557 | 1.11 |
| *Cataetyx laticeps* Koefoed, 1927 * | 2000 | 3300 | - |
| *Centracanthus cirrus* Rafinesque, 1810 | 12 | 350 | 0.90 |
| *Centrolophus niger* (Gmelin, 1789) | 204 | 878 | 2.35 |
| *Cepola macrophthalma* Linnaeus, 1758 | 18 | 684 | 16.99 |
| *Ceratoscopelus maderensis* (Lowe, 1839) | 161 | 1038 | 4.62 |
| *Chauliodus sloani* Schneider, 1801 | 264 | 1152 | 8.30 |
| *Chelidonichthys lastoviza* (Brünnich, 1768) | 12 | 534 | 8.30 |
| *Chelidonichthys lucernus* Linnaeus, 1758 | 12 | 462 | 20.54 |
| *Chelidonichthys obscurus* (Linnaeus, 1764) | 23 | 299 | 0.68 |
| *Chlopsis bicolor* Rafinesque, 1810 | 97 | 629 | 0.47 |
| *Chlorophthalmus agassizi* Bonaparte, 1840 | 50 | 698 | 26.83 |
| *Cichlasoma bimaculatum* (Linnaeus, 1758) | 22 | 268 | 0.13 |
| *Ciclothone braueri* Jespersen & Tåning, 1926 | 1200 | 1200 | - |
| *Citharus linguatula* (Linnaeus, 1758) | 13 | 300 | 0.90 |
| *Coelorinchus caelorhincus* (Risso, 1810) | 127 | 1034 | 25.33 |
| *Coelorinchus mediterraneus* Iwamoto & Ungaro, 2002 * | 917 | 1500 | - |
| *Conger conger* (Linnaeus, 1758) | 12 | 1098 | 22.68 |
| *Coris julis* (Linnaeus, 1758) | 11 | 60 | 0.47 |
| *Coryphaena hippurus* Linnaeus, 1758 | 520 | 520 | - |
| *Coryphaenoides guentheri* (Vaillant, 1888) * | 1500 | 1700 | - |
| *Coryphaenoides mediterraneus* (Giglioli, 1893) * | 1054 | 4000 | - |
| *Cubiceps gracilis* (Lowe, 1843) | 508 | 667 | 0.09 |
| *Dactylopterus volitans* (Linnaeus, 1758) | 12 | 55 | 0.86 |
| *Dalophis imberbis* (Delaroche, 1809) | 25 | 429 | 0.98 |
| *Deltentosteus collonianus* (Risso, 1820) * | 153 | 153 | 0.04 |
| *Deltentosteus quadrimaculatus* (Valenciennes, 1837) | 12 | 543 | 12.84 |
| *Dentex dentex* (Linnaeus, 1758) | 15 | 258 | 0.30 |
| *Dentex gibbosus* (Rafinesque, 1810) | 15 | 15 | 0.04 |
| *Diaphus holti* Tåning, 1918 | 316 | 1054 | 0.17 |
| *Diaphus metopoclampus* (Cocco, 1829) * | 312 | 662 | 0.17 |
| *Diaphus rafinesqueii* (Cocco, 1838) | 330 | 676 | 0.17 |
| *Dicentrarchus labrax* (Linnaeus, 1758) | 15 | 18 | 0.13 |

| SPECIES | Depth (m) | | Foc (%) |
|---|---|---|---|
| **Osteichthyes** | **Min.** | **Max.** | |
| *Diplodus annularis* (Linnaeus, 1758) | 11 | 144 | 5.22 |
| *Diplodus puntazzo* (Cetti, 1777) | 11 | 11 | 0.04 |
| *Diplodus sargus sargus* (Linnaeus, 1758) | 17 | 29 | 0.21 |
| *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) | 12 | 114 | 0.64 |
| *Dysomma brevirostre* (Facciolà, 1887) * | 264 | 504 | 0.09 |
| *Echelus myrus* (Linnaeus, 1758) | 29 | 575 | 1.93 |
| *Echiichthys vipera* (Cuvier, 1829) | 18 | 30 | 0.13 |
| *Echiodon dentatus* (Cuvier, 1829) | 19 | 775 | 1.07 |
| *Elates ransonnetii* (Steindachner, 1876) ** | 20 | 20 | - |
| *Electrona risso* (Cocco, 1829) | 272 | 1007 | 0.51 |
| *Engraulis encrasicolus* (Linnaeus, 1758) | 12 | 346 | 9.63 |
| *Epigonus constanciae* (Giglioli, 1880) | 258 | 739 | 1.93 |
| *Epigonus denticulatus* Dieuzeide, 1950 | 91 | 738 | 17.20 |
| *Epigonus telescopus* (Risso, 1810) | 287 | 1000 | 3.47 |
| *Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817) | 12 | 130 | 1.28 |
| *Eutrigla gurnardus* (Linnaeus, 1758) | 12 | 531 | 8.09 |
| *Evermannella balbo* (Risso, 1820) | 501 | 607 | 0.47 |
| *Gadella maraldi* (Risso, 1810) | 118 | 774 | 9.37 |
| *Gadiculus argenteus argenteus* Guichenot, 1850 | 51 | 690 | 20.33 |
| *Gaidropsarus biscayensis* (Collett, 1890) | 18 | 1142 | 20.58 |
| *Gaidropsarus mediterraneus* (Linnaeus, 1758) | 60 | 567 | 0.13 |
| *Glossanodon leioglossus* (Valenciennes, 1848) | 33 | 675 | 10.48 |
| *Gnathophis mystax* (Delaroche, 1809) | 12 | 598 | 10.31 |
| *Gobius geniporus* Valenciennes, 1837 * | 34 | 165 | 0.09 |
| *Gobius niger* Linnaeus, 1758 | 12 | 565 | 8.34 |
| *Gonichthys cocco* Cocco, 1829 | 121 | 531 | 0.13 |
| *Gonostoma denudatum* Rafinesque, 1810 | 349 | 917 | 0.56 |
| *Grammonus ater* (Risso, 1810) * | 654 | 654 | - |
| *Gymnammodytes cicerelus* (Rafinesque, 1810) | 49 | 107 | 0.09 |
| *Helicolenus dactylopterus dactylopterus* (Delaroche, 1809) | 50 | 775 | 43.60 |
| *Hippocampus hippocampus* (Linnaeus, 1758) | 13 | 50 | 0.17 |
| *Hoplostethus mediterraneus mediterraneus* Cuvier, 1829 | 136 | 919 | 36.24 |
| *Hygophum benoiti* (Cocco, 1838) | 287 | 908 | 2.82 |
| *Hygophum hygomii* (Lütken, 1892) * | 316 | 1142 | 0.98 |
| *Hymenocephalus italicus* Giglioli, 1884 | 114 | 1130 | 37.66 |
| *Ichthyococcus ovatus* Cocco, 1838 | 204 | 523 | 0.21 |
| *Lampanyctus crocodilus* (Risso, 1810) | 165 | 3300 | 23.53 |
| *Lepidion lepidion* (Risso, 1810) * | 504 | 1700 | 0.04 |
| *Lepidopus caudatus* (Euphrasen, 1788) | 34 | 687 | 21.31 |
| *Lepidorhombus boscii* (Risso, 1810) | 15 | 745 | 28.71 |
| *Lepidorhombus whiffiagonis* (Walbaum, 1792) | 16 | 552 | 5.09 |
| *Lepidotrigla cavillone* (Lacepède, 1801) | 12 | 501 | 14.38 |
| *Lesueurigobius suerii* (Risso, 1810) | 15 | 530 | 3.08 |
| *Leusueurigobius friesii* (Malm, 1874) | 12 | 549 | 12.20 |
| *Lichia amia* (Linnaeus, 1758) | 39 | 39 | 0.04 |
| *Lithognathus mormyrus* (Linnaeus, 1758) | 11 | 120 | 2.05 |
| *Liza aurata* (Risso, 1810) | 15 | 15 | 0.04 |
| *Liza ramada* (Risso, 1826) | 12 | 77 | 0.21 |
| *Lobianchia dofleini* (Zugmayer, 1911) | 16 | 1130 | 1.58 |
| *Lobianchia gemellarii* (Cocco, 1838) * | 528 | 528 | 0.04 |
| *Lophius budegassa* Spinola, 1807 | 13 | 745 | 43.82 |
| *Lophius piscatorius* Linnaeus, 1758 | 16 | 672 | 13.86 |
| *Macroramphosus scolopax* (Linnaeus, 1758) | 12 | 674 | 21.31 |
| *Maurolicus muelleri* (Gmelin, 1789) | 170 | 339 | 0.30 |
| *Merlangius merlangus* (Linnaeus, 1758) | 60 | 412 | 0.09 |
| *Merluccius merluccius* (Linnaeus, 1758) | 14 | 828 | 60.63 |
| *Microchirus ocellatus* (Linnaeus, 1758) | 16 | 50 | 0.86 |
| *Microchirus variegatus* (Donovan, 1808) | 12 | 181 | 0.94 |
| *Micromesistius poutassou* (Risso, 1827) | 49 | 815 | 35.43 |
| *Mola mola* (Linnaeus, 1758) | 151 | 151 | - |
| *Molva dipterygia* (Pennant, 1784) | 20 | 800 | 20.45 |
| *Monochirus hispidus* Rafinesque, 1814 | 12 | 520 | 0.34 |
| *Mora moro* (Risso, 1810) | 148 | 1239 | 16.65 |
| *Mugil cephalus* Linnaeus, 1758 | 12 | 18 | 0.13 |
| *Mullus barbatus barbatus* Linnaeus, 1758 | 11 | 379 | 30.51 |
| *Mullus surmuletus* Linnaeus, 1758 | 11 | 635 | 17.67 |
| *Muraena helena* Linnaeus, 1758 | 58 | 153 | 0.13 |
| *Myctophum punctatum* Rafinesque, 1810 | 253 | 1014 | 4.45 |
| *Nansenia oblita* (Facciolà, 1887) | 461 | 535 | 0.04 |
| *Nemichthys scolopaceus* Richardson, 1848 | 123 | 859 | 0.94 |
| *Nettastoma melanurum* Rafinesque, 1810 | 63 | 1500 | 21.01 |
| *Nezumia sclerorhynchus* (Valenciennes, 1838) | 128 | 1500 | 35.30 |
| *Notacanthus bonaparte* Risso, 1840 | 83 | 1500 | 18.74 |
| *Notoscopelus elongatus* (Costa, 1844) | 133 | 878 | 5.48 |
| *Ophichthus rufus* (Rafinesque, 1810) | 12 | 508 | 2.82 |

| SPECIES | Depth (m) | | Foc (%) |
|---|---|---|---|
| **Osteichthyes** | **Min.** | **Max.** | |
| *Ophidion barbatum* Linnaeus, 1758 | 18 | 687 | 5.18 |
| *Ophidion rochei* Müller, 1845 | 655 | 655 | - |
| *Ophisurus serpens* (Linnaeus, 1758) | 50 | 346 | 0.47 |
| *Pagellus acarne* (Risso, 1827) | 12 | 575 | 14.25 |
| *Pagellus bogaraveo* (Brünnich, 1768) | 12 | 1000 | 14.46 |
| *Pagellus erythrinus* (Linnaeus, 1758) | 11 | 535 | 17.29 |
| *Pagrus pagrus* (Linnaeus, 1758) | 12 | 183 | 4.49 |
| *Parablennius tentacularis* (Brünnich, 1768) | 27 | 27 | - |
| *Paralepis speciosa* Bellotti, 1878 | 18 | 926 | 1.67 |
| *Peristedion cataphractum* (Linnaeus, 1758) | 14 | 570 | 4.79 |
| *Phycis blennoides* (Brünnich, 1768) | 34 | 1155 | 58.92 |
| *Phycis phycis* (Linnaeus, 1766) | 23 | 672 | 0.56 |
| *Polyprion americanus* (Bloch & Schneider, 1801) | 18 | 712 | 0.21 |
| *Pomatomus saltatrix* (Linnaeus, 1766) | 22 | 26 | 0.09 |
| *Psetta maxima* (Linnaeus, 1758) | 13 | 13 | 0.04 |
| *Sardina pilchardus* (Walbaum, 1792) | 12 | 470 | 13.61 |
| *Sardinella aurita* Valenciennes, 1847 | 12 | 171 | 3.59 |
| *Sarpa salpa* (Linnaeus, 1758) | 17 | 17 | 0.04 |
| *Schedophilus ovalis* (Cuvier, 1833) | 510 | 510 | 0.04 |
| *Sciaena umbra* Linnaeus, 1758 | 32 | 32 | 0.04 |
| *Scomber japonicus* Houttuyn, 1782 | 25 | 401 | 0.68 |
| *Scomber scombrus* Linnaeus, 1758 | 15 | 260 | 4.28 |
| *Scophthalmus rhombus* (Linnaeus, 1758) | 61 | 61 | 0.04 |
| *Scorpaena elongata* Cadenat, 1943 | 16 | 383 | 0.98 |
| *Scorpaena loppei* Cadenat, 1943 | 30 | 30 | - |
| *Scorpaena notata* Rafinesque, 1810 | 18 | 555 | 2.10 |
| *Scorpaena porcus* Linnaeus, 1758 | 11 | 525 | 1.88 |
| *Scorpaena scrofa* Linnaeus, 1758 | 11 | 400 | 1.71 |
| *Seriola dumerili* (Risso, 1810) | 12 | 292 | 0.34 |
| *Serranus cabrilla* (Linnaeus, 1758) | 11 | 330 | 12.24 |
| *Serranus hepatus* (Linnaeus, 1758) | 12 | 502 | 21.44 |
| *Serranus scriba* (Linnaeus, 1758) | 15 | 125 | 0.26 |
| *Solea solea* (Linnaeus, 1758) | 12 | 401 | 1.16 |
| *Sparisoma cretense* (Linnaeus, 1758) | 14 | 14 | 0.04 |
| *Sparus aurata* Linnaeus, 1758 | 15 | 57 | 0.39 |
| *Sphoeroides pachygaster* (Müller & Troschel, 1848) | 66 | 400 | 1.20 |
| *Sphyraena sphyraena* (Linnaeus, 1758) | 12 | 209 | 1.24 |
| *Spicara maena* (Linnaeus, 1758) | 12 | 585 | 20.84 |
| *Spicara smaris* (Linnaeus, 1758) | 11 | 380 | 17.54 |
| *Spondyliosoma cantharus* (Linnaeus, 1758) | 38 | 63 | 0.09 |
| *Sprattus sprattus sprattus* (Linnaeus, 1758) | 20 | 255 | 0.56 |
| *Stomias boa boa* (Risso, 1810) | 34 | 1039 | 10.91 |
| *Stromateus fiatola* Linnaeus, 1758 | 20 | 20 | 0.04 |
| *Sudis hyalina* Rafinesque, 1810 | 31 | 1132 | 0.47 |
| *Symbolophorus veranyi* (Moreau, 1888) | 189 | 1007 | 3.12 |
| *Symphodus cinereus* (Bonnaterre, 1788) | 12 | 40 | 0.39 |
| *Symphodus mediterraneus* (Linnaeus, 1758) | 27 | 40 | 0.04 |
| *Symphodus melops* (Linnaeus, 1758) | 27 | 27 | - |
| *Symphodus roissali* (Risso, 1810) | 27 | 27 | - |
| *Symphodus rostratus* (Bloch, 1791) | 13 | 120 | 0.04 |
| *Symphodus tinca* (Linnaeus, 1758) | 18 | 18 | - |
| *Symphurus ligulatus* (Cocco, 1844) | 18 | 1118 | 10.10 |
| *Symphurus nigrescens* Rafinesque, 1810 | 12 | 1130 | 34.10 |
| *Synapturichthys kleinii* (Risso, 1827) * | 16 | 171 | 0.21 |
| *Synchiropus phaeton* (Günther, 1861) | 12 | 673 | 3.94 |
| *Syngnathus acus* Linnaeus, 1758 | 12 | 125 | 1.50 |
| *Syngnathus taenionotus* Canestrini, 1871 * | 101 | 101 | 0.04 |
| *Syngnathus tenuirostris* Rathke, 1837 * | 60 | 60 | 0.04 |
| *Syngnathus typhle* Linnaeus, 1758 | 15 | 598 | 0.17 |
| *Synodus saurus* (Linnaeus, 1758) | 11 | 335 | 2.70 |
| *Tetragonurus cuvieri* (Risso, 1810) | 300 | 300 | - |
| *Trachinus draco* Linnaeus, 1758 | 12 | 375 | 9.41 |
| *Trachinus radiatus* Cuvier, 1829 | 16 | 300 | 0.21 |
| *Trachurus mediterraneus* (Steindachner, 1868) | 12 | 661 | 14.55 |
| *Trachurus picturatus* (Bowdich, 1825) | 12 | 763 | 10.44 |
| *Trachurus trachurus* (Linnaeus, 1758) | 12 | 763 | 33.46 |
| *Trachyrincus scabrus* (Risso, 1810) | 289 | 1239 | 7.83 |
| *Trigla lyra* Linnaeus, 1758 | 12 | 673 | 11.60 |
| *Trisopterus minutus* (Linnaeus, 1758) | 25 | 528 | 9.97 |
| *Uranoscopus scaber* Linnaeus, 1758 | 11 | 425 | 13.44 |
| *Vinciguerria attenuata* (Cocco, 1838) * | 73 | 569 | 1.20 |
| *Xyrichthys novacula* (Linnaeus, 1758) | 11 | 105 | 2.91 |
| *Zeus faber* Linnaeus, 1758 | 16 | 429 | 10.65 |
| *Zosterisessor ophiocephalus* (Pallas, 1814) | 91 | 91 | 0.04 |