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Ecological distribution of semi-demersal fishes in space and time on the shelf of Antalya Gulf

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ABSTRACT

In this study we provide a baseline data on semidemersal fish assemblages and biology in a heterogeneous and yet less studied portion of the shelf of Antalya Gulf. The distribution of fish abundance in three transects subjected to different fisheries regulations (fishery vs non fishery areas), and including depths of 10, 25, 75, 125, 200 m, was studied between May 2014 and February 2015 in representative months of winter, spring, summer and autumn seasons. A total of 76 fish species belonging to 40 families was collected and semidemersal species distribution was analyzed in comparison with the whole community. Spatial distribution of fish was driven mainly by depth and two main assemblages were observed: shallow waters (10-25; 75 m) and deep waters (125-200 m). Significant differences among transects were found for the whole community but not for the semidemersal species. Analysis showed that this was due to a strong relation of these species with local environmental characteristics rather than to a different fishing pressure over transects. Firstly all species distribute according to the bathymetrical gradient and secondly to the bottom type structure. Semidemersal species were then found more related to zooplankton and suspended matter availability. The main morphological characteristics, sex and size distribution of the target semidemersal species *Spicara smaris* (Linnaeus, 1758), *Saurida undosquamis* (Richardson, 1848), *Pagellus acarne (*Risso, 1827) were also investigated.

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1. INTRODUCTION

1.1. The ecological framework

Marine ecosystems provide key services which are essential for maintaining life on our planet. Marine services are provided both at a global scale with oxygen production, nutrient cycles or carbon fixation and at regional and local scales with bioremediation of waste and pollutants or stabilizing coastlines, to name a few examples. These services also include important economic benefits for humans such as food provision and tourism (Atkins et al., 2011; Balmford et al., 2010).

Ecosystem dynamics are an integrated response of the various ecosystem components to the several drivers that act independently but that can have synergistic or antagonistic effects. Living marine resources are affected by three main drivers: anthropogenic, trophodynamic and environmental processes (Fu et al., 2012). The interaction of these drivers is not easy to be disentangled, making it difficult to determine precisely which changes are results of direct human influence. It is clear, however, that deteriorating biodiversity impairs the marine ecosystem's capacity to maintain the services working properly (Worm et al., 2006).

Among anthropogenic drivers, over-exploitation of marine resources through fisheries activities is the most important in many marine ecosystems. The world's oceans are at or near maximum sustainable fishery yields. United Nations Food and Agriculture Organization's estimation that "75% of the world's fisheries are fully- or over-exploited" has been widely quoted (UN FAO 2000). While the consequences of overharvesting are expressed in social, economic, cultural and ecological changes, the ecological consequences of overfishing often are undocumented and may be poorly known or overlooked. Geographical distribution, biomass and abundance, reproduction, recruitment, growth, and energy allocation of fish populations may respond differently due to these changes (Jørgensen et al., 2008). At the population level, impacts of fishing are direct and indirect.

First of all fisheries remove the oldest, largest individuals from the exploited populations. In this way sex ratio can be modified since many species are hermaphrodites and can change sex once they reach a certain size. As a result, the reproductive potential of a species can be altered, following in a negative outcome for recruitment (Hamilton et al., 2007). Indirect effects include genetic selection affecting growth rates and reproductive output through a decreasing in age and size at maturation (Enberg et al., 2012). There are potential indirect effects driven by overexploitation also at the community level. Fishing is typically a size-selective agent of mortality and, therefore, it is unlikely to be the natural cause of mortality. Most of the fish removed by fishing activities are in the middle or near the top of food webs in their habitats and thus fishing can be considered as the removal of a keystone predator. Depletion of the largest species tends to release predation pressure which can result in a better survival rate of the smallest species with the modification of the food web propagation (Stevens et al., 2000). When a species is less abundant because of overexploitation, ecological niche doesn’t remain free but is occupied by other species, often resulting in competition and then accentuating even more the effects due to fishing. In addition this circumstance can be intensified by exotic introductions which often take opportunistic advantage replacing native species. The ecological effects of fishing are therefore substantially greater and more complex than simply the removal of biomass.
Furthermore, the trawl net has a very low selectivity and studies available show that 26% of the world's catch is discarded annually (Alverson et al., 1998). Discarding is usually caused by economic or regulatory constraints because the fish are too small to be retained or the species are unmarketable. This phenomenon can then be a substantial component of fishing mortality and may aggravate overfishing (Hilborn et al., 2003). In addition bottom trawling often reduces hard substrate and simplifies the ground topography determining consistent and persistent alterations of the benthic habitats (Jennings et Kaiser, 1998).

As previously introduced, for a full comprehension of the dynamics that underlie marine communities, it would be necessary to consider, in addition to the disturbance caused by human activities, also the potential effects on the ecosystem determined by changes in certain environmental and climatic variables. Fishing through the removal of biomass from a complex of species that feed one other is certain to have an impact on the ecosystem. Likewise, changes in primary production can affect the amount of available food that is propagated towards the higher trophic levels, leading to changes in the flux of energy that are noticeable throughout the food-web. Primary producers, the phytoplanktonic organisms, depend on sunlight in the upper pelagic layers of the ocean and absorb nutrients from water in order to reproduce and grow. The phytoplankton provides the primary food source for the zooplankton and together they form the first step of the oceanic food chain. Indeed fish rely on the density and distribution of zooplankton which is the initial prey item for almost all fish larvae (Pershing et al., 2005).

Temperature, salinity, currents, river inputs, storm runoff have an effect on marine communities that could interact with the influence exerted by fishing (Kennish et al., 2002; Lloret et al., 2001). The natural factors can affect a population during various stages of the life cycle: the recruiting (Abella et al., 2008), the development of eggs (Horne and Smith, 1997; Alvarez et al., 2001), the larval stage (Sebatés et al., 2007). The temperature definitely plays a significant importance in the life cycle of ectothermic organisms, unable to maintain a body temperature different from the external one. Numerous studies suggest that surface temperature of water may have some effects on the population dynamics of fish stocks and even small changes at deeper waters are, however, related to what happens at the surface (Palomera et al., 2007; Nunn et al., 2010). Moreover, the phases of the biological cycle most sensitive to temperature are the larval development, growth, sexual development and the production of eggs (Hidalgo et al., 2011), steps that in the majority of cases occur in the vicinity of the coastline, area showing wide variations in chemical and physical parameters. The wind, currents and storms are fundamental factors for water column mixing and especially in lifting of deep waters, which is often associated with an increase in the content of dissolved nutrients. In addition water mixing turns out to be very important also for the movement and the spatial distribution of the planktonic organisms, which can in turn strongly affect larval dispersal and therefore breeding success and fish survival (Palomera et al., 2007; Lloret et al., 2001).

Local habitat structure and its related abiotic and biotic parameters play also an important role in determining fish assemblage and abundance. Structural characteristics like sediment grain size, rocky reliefs, presence of vegetation or connectivity, can affect many behavioral strategies such as search for suitable recruitment zones, shelter from predators, day-time distribution, competition, predation, feeding habits (Robertson and Lenanton, 1984; Orth et al., 1984; Edgar and Shaw, 1995).

Finally, studies at global scale illustrate the wide range in nutrients availability fuelling fisheries production. Nutrients availability, under different conditions of enrichment and irrespectively of the sources, has a differential effect on local pelagic, and on demersal-benthic stocks (Caddy and Bakun, 1994). Under extreme oligotrophic conditions, local populations of small pelagic fish on the continental shelf are food-limited and generally small or migratory, and demersal or benthic forms tend to predominate in the landings. Moderate enrichment increases the productivity of both resident populations of small planktivorous and of demersal fishes. However if nutrient inputs to the photic zone exceed then extra production is exported to the benthic habitat and can lead to hypoxia close to the bottom, which negatively impacts demersal community. This may still, however, promote growth of resident small pelagic stocks that continue to profit from nutrient- induced blooms of planktonic organisms. The pelagic/demersal ratio (the ratio of small pelagic fish to demersal fish plus benthic landings) from fisheries landing data has been used in many studies as proxy reflecting the impact of differential nutrient enrichment levels on marine systems (de Leiva et al., 2000; Caddy et al., 2000).

Hence the importance of understanding the ecological dynamics and how they respond to the various external pressures in order to ensure the sustainability of marine resources.

1.2. The study area

1.2.1. Environmental characteristics

Fig. 1.1: Physical map of the Gulf of Antalya.

The Gulf of Antalya locates in the North-eastern Levantine Sea, one of the major basins of the Eastern Mediterranean (Fig. 1.1). The Antalya Gulf has a coastline of about 680 km in length, with an average depth exceeding 1000 m and reaching a maximum of 2500 m. The western and the eastern parts of the gulf differ by their bathymetric and oceanographic characteristics. The width of the continental shelf ranges from less than 1 to 8 km, being wider in the east and steeper in the western part. In many places mountains rise up immediately behind the coasts to form the Western Taurus Mountain belt, reaching heights up to 3070 m. Numerous rivers reach the sea providing a large fresh water supply. The main streams and Managavat River reach the sea in the eastern part of the shelf causing lower salinity comparing to the western part.

The variability of meteorological conditions is one of the distinguishing characteristics of the Eastern Mediterranean. This is because the region is a pathway for extratropical cyclones during winter and spring (Bingel et al., 1993). Circulation and current patterns off the coast of the gulf of Antalya can be related to wind-stress, thermoaline flux and barotropical components. As a result surface currents flow in different direction throughout the year (Vigo et al., 2005). The water formed in Aegean Sea sinks into the deepest parts of the basin. This sinking water transports all nutrients down in the deeper layers. In addition high temperature and salinity, geophysical, arid climatic conditions and low nutrient supply from external sources, make Levantine Sea extremely depleted and one of the most oligotrophic seas (Bingel et al., 1993).

The productivity of the study area is thus strongly influenced by local processes resulting in a local seasonal production. The majority of the streams which drain coastal hinterland to supply sediment into the gulf are of ephemeral nature and flow unsteadily throughout the year. Observations of high nitrate and phosphate levels in the surface waters are observed during late winter and spring due to the heavy rainfall and intense river input. Moreover large amounts of terrigenous material may be transported to the coast especially after snowmelt.

In addition to low nutrients concentrations, the eastern Mediterranean has low plankton biomass and production. Phytoplankton production is principally dominated by the extent and duration of winter mixing of the water column due to due to storms and turbulence, providing transportations of nutrients from the deeper layer. Chlorophyll concentrations previously recorded in the Levantine basin are low, not exceeding 1 µg/L. The Chl-a concentrations vary seasonally occurring with higher values during late winter, with the onset of mixing of the upper layers (Bingel et al., 1993). Also zooplankton distribution is affected by environmental variables. The species are evenly distributed in the water column due to mixing process during winter and they aggregate in the surface water down to 25 m depth where optimum temperature is present in spring and autumn.

At last Antalya gulf is under the influence of pollution due to the intense tourism activities, commercial and tourist boat traffic, residential areas with dense population. Antalya region, with a resident population of 1.98 million, in 2010 hosted the 32% of overall tourism activity of Turkey with more than 8.5 million visitors occurring especially during summer along the coastline. This causes an increase of land-based pollutants and river discharges to the sea (Güven et al., 2013).

1.2.2. The Demersal Fishery

Turkey, with its favorable geographic position, has a great access to the fish resources. The entire coastline spans more than 8,400 km in length and borders four distinct sea basins: the Mediterranean to the south, the Aegean to the west, the Sea of Marmara in the north-west between the European and Asian lands, and the Black Sea to the north. The total national catch between 1991 and 2008 averaged 474,000 tons per year, fluctuating between 317,000 and 589,000 tons (SUBIS, http://www.ulakbim.gov.tr). Fisheries resources are disparate and vary substantially between the basins. Black Sea landings represent 75% of total national landings. Here fisheries are largely dominated by the abundant occurrence of small pelagics, the most important species of which are the anchovy and the horse mackerel (FAO, 2011). In Mediterranean and Aegean Seas important demersal and semi-pelagic stocks of fish and shrimps dominate. Tuna and other large pelagics such as bonito, bluefish and mullet are also important in the Mediterranean.

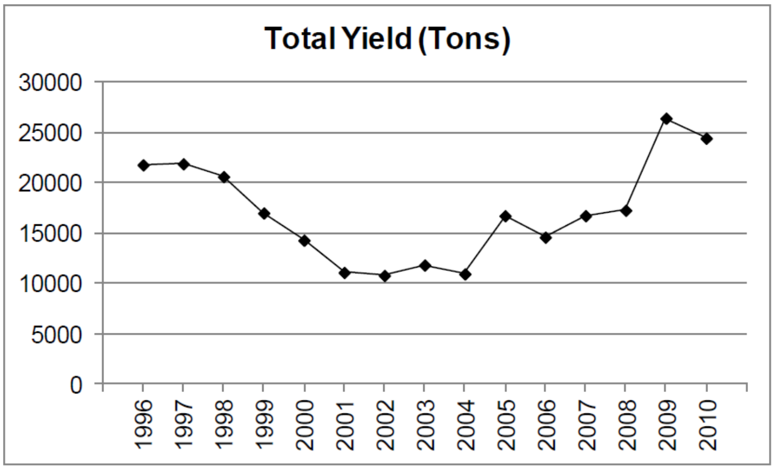


Fig. 1.2: Yields of Turkish Mediterranean fishing fleet for the years 1996-2010 (DIE,1996-2010)

Fishery in the Turkish Mediterranean is mainly coastal and artisanal, with relatively high number of small professional fishing boats whose operations are limited to coastal shallow zone and do not expand to the continental shelf. It operates in biologically poor waters and landing of relatively high price (Bingel et al., 1993). Annual yields of the Turkish fleet in the Mediterranean are given in Figure 1.2. However it should also be taken into account that since the collection of the fisheries statistics are based on fishermen's questionnaires, it could not be strictly reliable and the values could not always reflect the real catch data (Bingel et al., 1993). On the basis of the fish data set of the years 1978-1991, a maximum sustainable yield (MSY) (only for trawl fishery) of 7,770 tons was found (Gücü and Bingel, 1994).

The gulf of Antalya due to sudden increase in depth of the shelf is very limited for trawling. A total of 4509 tons is the annual fisheries production of the region, with 3094 tons belonging to aquaculture, which is a rapidly developing sector, and an amount of 1415 tons of products obtained by hunting. Small scale fishery has an important role as for the rest of the southern coast of Turkey. There are 690 fishing vessels and 97% are smaller than 12 m length. Gill and trammel nets with different combinations of gear characteristics and mesh sizes are traditionally used (Olguner et al., 2013). Fisheries activities are forbidden during the whole year within 2 miles from the coast. Moreover the gulf comprises two different regions, an area opened to fisheries activity and a protected area. The first area comprises the coast between Lara district and the city of Side, the latter goes from Side to Gazipașa. Here bottom trawling activity is forbidden from 9 Years within the R.G. 26.02.2005/ 25739.

Studies on the fish assemblages in the Gulf of Antalya are extremely limited. Few studies concerning the demersal fish community of the shallow continental shelf area of the North-eastern Levant Sea are available. Predominant catches are bottom-dwelling species of high diversity including Red Sea emigrants (Bingel et al., 1993). The faunal composition of the Turkish Mediterranean coast has been changed dramatically due to the construction of Suez Channel in 1869 which allowed the introduction of numerous Indo-Pacific species from the

Red Sea (Galil 2009). The impacts of Lessepsian species in the Levantine basin of the Mediterranean have proven to be considerably high, where they are replacing native species. In total 62 species of non-native marine fishes arrived to NE Mediterranean by natural dispersal via the Suez Canal (Goren and Galil, 2005). Invasive species have become a major component of commercial catches and study conducted between 1980 and 1984 in the North-eastern Turkish coasts showed that Lessepsian fishes constituted up to 74.5% of fish landings during the study period (Gücü and Bingel, 1994b).

Bingel et al., (1993) listed economically important and locally marketed species in the Levantine Sea as follows: Brushtooth lizardfish (*Saurida undosquamis*), Red mullet (*Mullus barbatus*), Goldband goatfish (*Upeneus moluccensis*), Common sole (*Solea solea*), Common pandora (*Pagellus erythrinus*), European hake (*Merluccius merluccius*), the Common shrimp (*Penaeus sp.)* and the Common cuttlefish (*Sepia officinalis*). Species with the highest percentage in main catch was *Saurida undosquamis*. In addition, when applying the yield per recruit (Y/R) model to the stocks whose population parameter were estimated, showed that except *Saurida undosquamis* all other stocks were overfished in the region.

1.3. Target species

1.3.1. *Spicara smaris* (Linnaeus, 1758)

Fig. 1.3: Adult specimen of *Spicara smaris* (Linnaeus, 1758)

Spicara smaris (Linnaeus, 1758), commonly known as picarel, is a bony fish of the Centracanthidae family. This species is distributed in the eastern Atlantic from Portugal to Marocco and throughout the Mediterranean Sea and the Black Sea. The picarel is a sociable fish, forming large schools over seagrass beds and sandy or muddy bottoms and can be generally found at a depth range from 15 to 170 m. It grows to a max length of 20 cm but a more common length is 14 cm (FISHBASE, http.//www.fishbase.org). It is a more slender fish than the congener *Spicara maena* and can be distinguished by the related species by having lower scale number (75-81) along the lateral line, vomerin teeth usually absent and a linear snout shape. Its back is grey-brown and it has a silvery flank with a distinctive large black spot. Males are usually larger than female and become brighter at the breeding time. It is a *protogynous* sequential hermaphrodite, individuals maturing as females and turning into males later. All individuals over about TL = 17 cm are males. Reproduction takes place once per year from February to May (WoRMS, www.marinespecies.org). *Spicara smaris* is a zooplanktivorous fish. Copepoda are the most important food item and it can also occasionally prey upon fish larvae (Karachle et al., 2014). The Picarel is a species with minor but increasing commercial fisheries importance and among the ten most abundant fish species caught in Turkey (Harlioğlu 2011).

1.3.2. *Saurida undosquamis* (Richardson, 1848)

Fig. 1.3: Adult spiecemen of *Saurida undosquamis* (Richardson, 1848)

The brushtooth lizardfish, *Saurida undosquamis* (Richardson, 1848), is a Lessepsian fish. The natural distribution range of *S. undosquamis* includes the Indo-West Pacific Ocean from the Red Sea and Eastern Africa to southern Japan and Australia. In Mediterranean it was recorded first in Israel (Ben-Tuvia, 1953), becoming one of the most successful invaders throughout the Levant basin. The brushtooth lizardfish is currently the most exploited alien fish in Turkey, comprising almost one-third of the commercial trawl catch in the north-eastern Levant (Cinar et al., 2005). Common lengths range from TL = 20-30 cm although individuals up to 50 cm were reported (FISHBASE http.//www.fishbase.org). The body is slender and cylindrical. The head is slightly depressed with a large mouth and long jaws from which stick out numerous needle-like teeth. It appears brown-beige on the back with silvery white belly and a series of dark spots along the lateral line. It is found in zones above 100 m over sand or mud bottoms of coastal waters and feeds mainly on pelagic fishes (anchovy) and, to a lesser extent, on crustaceans and other invertebrates. Spawning season lasts from March to December (WoRMS, www.marinespecies.org)

1.3.3. *Pagellus acarne (*Risso*, 1827)*

Fig. 1.4: Adult specimen of *Pagellus acarne* (Risso, 1827)

The Axillary Seabream is a widely distributed species along the northern and eastern Atlantic coasts from Norway to Senegal and the Mediterranean Sea. It can be found on various types of sea bottoms, especially seagrass beds and sand, down to a depth of 500 m, but more common between 40 and 100 m with the young found nearer to the shore. This species is omnivorous, with preference for a carnivorous diet based on fishes (Morato *et al.,* 2003). Reproduction occur between September and November in the eastern Mediterranean Sea. It is a *protandric* hermaphrodite (most individuals are first males, then become females at 2-7 years. It is typically a schooling species. The maximum TL is 36 cm (FISHBASE, http.//www.fishbase.org). *Pagellus acarne* is a highly-valued commercial species along the eastern Atlantic coasts and the Mediterranean Sea, targeted main by bottom-trawl and artisanal fleets (IUNC, www.iuncredlist.org).

1.4. Objectives of the study

This study was designed to investigate the ecology of semidemersal fish species on the shelf of Antalya gulf in space and time. For this purpose fish distribution was analyzed at different strata, for two distinct areas (one opened and one closed to fishery) and during different seasons over a year. For an exhaustive comprehension of the dynamics that determine the fish assemblages pattern it was necessary a comparison of semidemersal species with all those fishes that coexist in the study area sharing the same resources and subjected to the same environmental conditions and external pressures.

Summing up, the aims of this study were to explore:

- Fish species composition and abundance
- Seasonal changes in distribution
- Different pattern along a bathymetrical gradient
- Semidemersal species in relation to the whole community
- Main morphological characteristics and sex distribution of target species
- Distributional difference due to the prohibition of hunting
- Definition of the main environmental parameters affecting the community

2. MATERIAL AND METHODS

Data used in this study were collected within the framework of the Project n. 2014.01.0111.001 supported by Scientific Research Coordination Unit of Akdeniz University.

2.1. Study area and field sampling

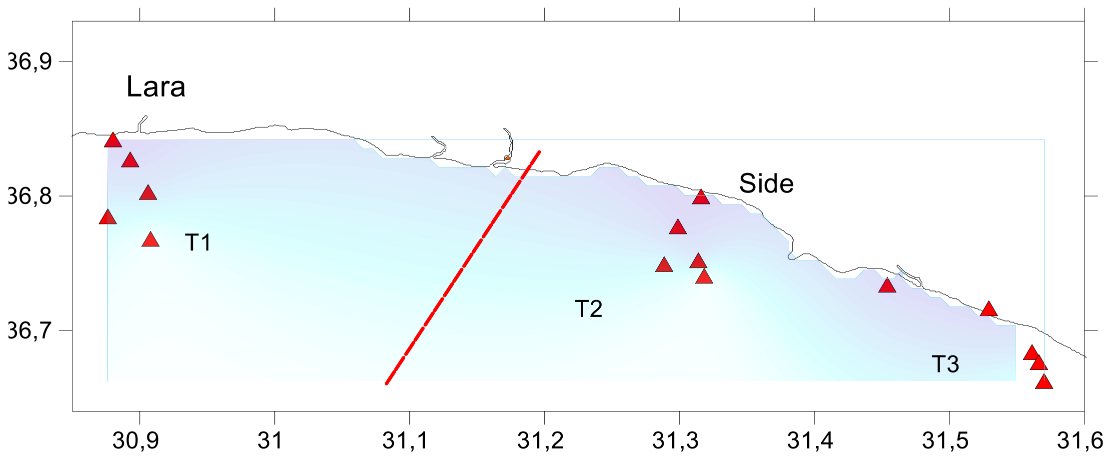


Fig. 2.1: The study area showing the stations and transects over the basic sampling scheme (Surfer 12-Golden software).

The study area encompassed a strip of coast in the north-eastern part of Antalya Gulf. Sampling stations were located along a range of depth extending from 10 to 200 m over the inner portion of the continental shelf. Samples were collected over 6-10 consecutive days in four different seasons covering a period of a year: May, August, October 2014 and February 2015. For each cruise three transects have been considered over two different regions: one transect was located in the Lara-Side region opened to fisheries while two were in the Gaşipasa-Side protected area (Fig. 2.1). There were 5 fixed trawling stations for each transect, located at 10-25-75-125-200 m depth. All sampling was conducted during daylight hours between sunrise and sunset. Effort was equally distributed among seasons and all stations were visited during every cruise. A total amount of 79 hauls were performed over all the study.

2.2. Trawling

Resources were sampled on board R/V "Akdeniz Su", 26,5m length, of the Fisheries Faculty of Akdeniz University. In all the fish samplings the same gear was used: a polyethylene bottom trawl net with 44 mm mesh size.

During the hauls, towing speed varied around 2.5 knots, and towing duration was limited to 30 minutes. The starting time and coordinates of the haul were recorded as the moment when the warp was tightened and towing started. The end of the haul was registered as the moment of the beginning of warp hauling. The exact location of sampling hauls for the starting of the operation was found when the desired depth was observed from the echo sounder.

Fig. 2.2: The head rope of the trawl net visible at the end of a hauling operation.

2.3. Deck work

2.3.1. Environmental parameters

The environmental parameters considered in this study (Tab. 2.1) include the collection of physical, chemical, biological and geological data. All the parameters have been generally collected just before the sampling or at the end of the trawl operation.

Tab. 2.1: List of the environmental parameters considered in the study with their respective unit measure and abbreviations used in the analysis. Surface water: SSx, Subsurface water: SuSx, Near Bottom water: NBx.

Physical-chemical parameters	**Biological parameters**
Secchi disk depth (m); Secchi	Seston - 1 mm (g); Se1
Oxygen (mg/L); SSOx, SuOx, NBOx	Seston - 0,5 mm (g); S2
Temperature (°C); SST, SuT, NBT	Seston - 0,063 mm (g); S3
Salinity (PSU); SSS, SuSS, NBS	Bioseston - 1 mm (g); Bi1
pH; SSpH, SuSpH, NBpH	Bioseston - 0,5 mm (g); Bi2
Conductivity (S/m); SSC, SuSC, NBC	Bioseston - 0,063 mm (g); Bi3
Density, sigma-t; SSD, SuSD, NBD	Tripton - 1mm (g); Tr1
Total Suspended Matter (mg/mL); STSM, SuTSM, NBTSM	Tripton - 0,5mm (g); Tr2
Chl-a (mg/mL); SSChl, SuSChl, NBChl	Tripton - 0,063mm (g); Tr3

2.3.1.1. Physical parameters

Secchi disk depth: The Secchi disk is a plain white circular disk of 30 cm in diameter used to measure the transparency of the water. The disk is slowly lowered by hand into the water column until the reflectance equals the intensity of light backscattered from the water and it is no longer visible. The distance at which the disk disappears from the sight, called the Secchi depth, is taken as a measure of transparency. It is related to water turbidity and can be affected by the colour of the water, algae, and suspended sediments.

Water temperature, salinity, density, dissolved oxygen, pH: the values of water temperature, salinity, dissolved oxygen, pH, and conductivity have been recorded for each station at the surface, subsurface and bottom depth. The water samples have been sampled through a polyethylene Nansen bottle lowered on a cable to the appropriate depth. Once collected, seawater was immediately analyzed through a portable multi-parameter probe provided with three sensors: a pH electrode, a dissolved oxygen sensor and a conductivity cell.

2.3.1.2. Chemical parameters

Total suspended material: Seawater collected through the Nansen bottle was used to determine the suspended material at surface, subsurface and bottom depth. One litre of water was filtered onto GF/D 25 mm glass fibre filters through a vacuum pump and stored in the freezer for laboratory analysis.

Chlorophyll a: Samples were taken from three different depths from each station trough a Nansen bottle: at 1 meter depth, at the maximum depth where the Secchi disk disappears from sight, and near the bottom for the shallow depth stations or until 75 m for the deepest ones. One litre of seawater was filtered through Whatman GF/F filters (with a 0.7 mm pore size and 47 mm diameter) using a vacuum of less than 0.5 atm. The filters were stored in a freezer until laboratory analysis.

2.3.1.3. Biological parameters

Zooplankton samples were collected by means of a Nansen Closing Net (100 μm mesh size and $(0.57/2)^2\pi$ mouth opening area) with messenger-operated closing mechanism. The open net was brought to the greatest scheduled depth and the sample was concentrated inside a metal collecting bucket with side window covered with sieve gauze. At the end of the tow, the outer side of the net was sprayed down with surface seawater to concentrate the organisms in the collecting bucket. The sample was size-fractionated through a sieve series (1, 0.5, 0.063 mm) and each size fraction was filtered on board onto GF/D 25 mm glass fibre filters through a vacuum pump (Fig. 2.3). Samples were frozen until laboratory processing.

Fig. 2.3: Organisms and non-living matter obtained after seawater filtration on board.

2.3.2. Fish collection

For each trawl the material caught was separated: fish, benthic organisms, no-living organic and inorganic materials such litters and garbage. The fishes were sorted and identified to species or occasionally to higher taxonomic level. Then the total weight was measured for each species. Very large samples were subsampled by weight for some abundant species according to the fish size (1/3 for large size and 1/6 for small size). Total number amount of fish was then estimated from the abundance of subsample. For cartilaginous fishes morphometric parameters, weight and sex were determined individually on board before being thrown back into the sea. The remaining fish was preserved with 5% formaldehyde and stored for laboratory analysis.

Litter was sorted and weighted according to the material properties (metal, nylon, plastic, etc.) and then stored to be disposed ashore.

2.4. Laboratory work

2.4.1. Environmental parameters

2.4.1.1. Chemical parameters

Total suspended material: In laboratory samples were defrosted at room temperature. Each filter was dried in an oven at 60 °C for 24 hours and weighted on an analytical balance (Radawak A220) for determination of the dry weight.

Chlorophyll a: Chlorophyll measurements were made with acetone extraction method. Filters were homogenized in 10 mL of 90% acetone solution and maintained in the dark and cold. After 24 h, samples were centrifuged and absorbance was subsequently measured at 665 645 630 nm wavelength at spectrophotometer. The filtered samples were bleached with a solution of 90 % acetone at 750 nm. Final Chl-a (mg/mL) value was calculated dividing by the volume of the filtered seawater according to the equation:

$$Chla\ (mg/mL) = (11{,}85\ A665 - 1{,}54\ A645 - 0{,}08\ A630) * V * I^{-1} * V^{7}$$

Where: V=aceton volume (mL), V= filtered water (mL), I= cell length cm, A= absorbance

2.4.1.2. Biological parameters

Samples were defrosted at room temperature. Each filter (which represents a single size-fraction of the tow) was dried in an oven at 60 °C for 24 hours and weighted on the analytical balance Radwak AS220 for determination of the dry weight. The filters then were ashed in a muffle furnace at 500 °C for 5-6 hours, and reweighed for ash. Three aliquots of filtered seawater were treated as above for blanks determination. The mean dry weight blank was subtracted from the measured dry weights for determination of the total organic and non-living matter (Seston). The ash weight, which represents the inorganic fraction (Tripton), was subtracted from the dry weight for determination of the organic fraction (Bioseston).

2.4.1.2. Geological parameters

The information about bottom types, bottom sediments and aquatic plants is encoded in the echo signal of the echosounder, stored and acquired simultaneously with GPS data. During surveys different echoes can be observed on the oscilloscope and echogram of the echosounder when sampling hard or soft bottom. Hard bottom will produce a sharp bottom echo with high amplitude while a soft bottom will produce an elongated echo with lower amplitude. In order to classify the different bottom types the Fractal dimension method implemented in BioSonics Bottom Classifier VBT was used in this study. In the VBT software, the Fractal Dimension is a measure of the irregularity of an echo envelope obtained from the bottom. By classifying the echo envelope in terms of its fractal dimension, we define the shape of the envelope by associating it with a FD number. Since the echo envelopes associated with different bottom types show regularities in shape, one can expect that we can classify the bottom echo in terms of FD. Different bottom categories are colour coded at the same time and displayed on the map with the location of each VBT report acquired with GPS data.

2.4.2. Fish analysis

In the laboratory species identification was checked by the *Mediterranee et mer Noire* Volume II (Fischer, 1973) and for Lessepsian species by the *Atlas of Exotic Species in the Mediterranean* on the CIESM website. For each specimen total length (TL, ± 0.01 cm) was recorded and after being dried with paper total weight was measured with the digital balance Precisa XB620M (W, ± 0.01 g). For each individual sex was determined according to dimension and macroscopic aspects (vascularization, eggs or sperm visibility, color) of gonads. Specimens whose sex determination was not possible because badly decomposed or deformed were classified as “not identified”.

2.5. Statistical analysis

2.5.1. Preliminary work

Raw data values of abundance and biomass from the field work were standardized according to the swept area of the different stations. The swept area was estimated from:

A=D*hr*X2

where D is the distance covered by the trawl over the ground when trawling, calculated from acoustic lines, and X2 is the fraction of the head-rope length, hr, which is equal to the width of the path swept by the trawl, the wing spread hr*X2. A value of 0.5 was chosen for X2 according to the model of the trawl as suggested by Pauly (1980). The catch per unit area (CPUA) was then estimated by dividing the catch by the swept area (in squared km) obtaining abundance per unit area (N / km2) and biomass per unit area (kg / Km2).

Standardized data have been organized over two different matrices for abundance and biomass with the list of the fish species as first column and the sampling stations as first row.

Information used to classify the diet of adults for each species was obtained from FAO species identification sheets (Fisher et al., 1987) and from FISHBASE (ICLARM. http.//www.fishbase.org), to broaden our fish species codification to be consistent with trophic considerations. First of all, flatfishes and bottom dwellers whose habits depend entirely on the ground were excluded. “Semidemersal” fishes were classified as those species, mainly zooplanktivorous, living above the seafloor. These species can play a crucial role in the flux of energy from low to high trophic levels of benthic and pelagic food webs being preyed by larger demersal and pelagic fishes. “SD” abbreviation was used to group all those fish species which are generally considered demersal in habits but that can tear away from the bottom in some part of the day or can feed on the same resources of semidemersals. Some pelagic species have been also found. In this study a comparison was made between the semidemersal species and the whole community constituted by the all SD and semidemersal fishes.

2.5.2. Numerical indices

The qualitative and comparative descriptions among the species in the whole area were based on the following three numerical indices (Holden and Raitt 1974):

- Dominance (D%): occurrence percentage of each species among stations;
- Frequency of occurrence (FO%): occurrence percentage of each species among the total frequency of occurrence of all species in the study area;
-Numerical occurrence (NO%): occurrence percentage of each species among the total abundance/biomass of all species in the whole study area.

According to the Soyer's Index and to the Dominance values the species were classified as follow over the study area: $D<25\%$ rare, $25\%<D<50\%$ common, $D>50\%$ constant.

2.5.3. Target species

Selection of the target species was made considering their ecological and economical importance and the order of numerical indices. The same analysis for the determination of the main morphometric relationships, sex ratio and length-frequency distribution were applied for each species.

The length-weight relationship for fishes is expressed by the equation $W=aL^b$ where W is the total weight, L is the total length, and a and b are parameters estimated by linear regression of logarithmically transformed length-weight data (Ricker, 1973). In general, a b value lower than 3.0 represents fish that become less rotund as length increases and a b value higher than 3.0 represents fish that become more rotund as length increases. When b is equal to 3.0, growth may be isometric meaning that the shape does not change as fish grows (Anderson and Neumann, 1996). The degree of association between the variables length and weight was computed by the determination coefficient, r^2. Student's t test was used to find out whether the coefficient b was significantly different from 3 ($H°$: b = 3). In this case growth can show negative allometry (*b* < 3) or positive allometry (*b* > 3). Regression curves were determined by IBM SPSS 21 software.

The sex ratio is expressed as the proportion of the different sexes from the pooled data. Statistical differences between changes in the number of females and males were determined using the chi-square test. The chi-square test shows if there is significant deviation from the expected ratio of 1:1.

The pooled length measures, standardized for each station according to subsample, were counted for length-frequencies. The length-frequency distributions were then separated into cohorts and an arbitrary age was assigned to each of those cohorts by means of Bhattacharya's Method in FISAT_II software (FAO-ICLARM *Fish Stock Assessment Tools*, VERSION 1.2.0). The optimal class interval was determined through the COST function.

2.5.4. Faunistic characteristics

The abundance and biomass values and the diversity indices were calculated for each station for both semidemersal and the combined species. The following diversity indices were considered:

- S: Species richness
- d: Margalef's index
- J': Pielou's evenness index
- H': Shannon-Winer diversity index

Three-way ANOVA was undertaken to test the differences in each number of species, abundance, biomass and the diversity indices among season, depth and the transects at p>0.05 by the IBM SPSS 21 software.

2.5.5. Assemblage structure: tests and ordinations

We used multivariate statistical tests to search for patterns of community structure in space and time for both the all fishes and the semidemersal species. PRIMER analytical software (vers. 6.1.6, PRIMER-E Ltd, Plymouth, U.K.) with PERMANOVA+ (Anderson et al., 2008) was used for all multivariate routines.

2.5.5.1. Permutational analysis of variance (PERMANOVA)

We first tested for differences among main effects (seasons, transects and depth) and interaction terms by using a type-III permutational multivariate analysis of variance (PERMANOVA) in a three-way crossed design. PERMANOVA is a semiparametric group difference test directly analogous to multivariate analysis of variance but with pseudo-F ratios and P-values generated by resampling (permutation) the resemblance measures of the data; thus it is less sensitive to assumptions of parametric tests that are frequently violated by community data sets (Anderson et al., 2008). For all biotic data we used the Bray-Curtis coefficient to construct resemblance matrices. Transects and depths were treated as fixed effects: the examination and testing of variations in community structure between transects and depths was the *a priori* objective of the study. Seasons were treated as random effects because there was no *a priori* reason for the timing of the study. After this global test, pairwise comparisons were made between the levels of each significant factor.

2.5.5.2. Species clustering and ordination

Cluster analysis and non-metric multidimensional scaling (MDS), were applied to create graphical summaries of relationships among samples and to highlight geographical patterns in fish assemblage composition. MDS constructs a map of the samples in a specified number of dimensions and operates on the rank orders of the elements in the resemblance matrix, rather than on the resemblance matrix itself. A stress value ranging from 0 to 1.0 is used to measure the reliability of the ordination, with zero indicating a perfect fit and with values >0.3 indicating that points are close to being arbitrarily placed in the graph.

2.5.5.3. Representative species

Where group differences in community structure were found, we used another exploratory method to identify those species most responsible for the difference. For any two groups, SIMPER (similarity percentages) calculates the percent contribution each species makes to the total between group dissimilarity (Clarke and Warwick, 2001). SIMPER identifies a small subset of species that are more consistently present or more abundant in one group than another, thus helping to reveal the major contributors to each group's biotic identity and simplifying the interpretation of community patterns.

2.5.6. Relations between biotic and environmental variables

2.5.6.1. BIO-ENV analysis

The multivariate non-parametric technique BIO-ENV, implemented in the PRIMER analytical software (vers. 6.1.6, PRIMER-E Ltd, Plymouth, U.K.) with PERMANOVA+ (Anderson et al., 2008), was applied to assess the potential matches between environmental variables and the species composition of sampling sites. In this approach, a triangular resemblance matrix was first created for each group of fish using abundance and biomass normalized data and Euclidean distance. BIO-ENV attempts to find the best combination of environmental variables that maximize the match, measured using Spearman rank correlation (r) between sites in terms of their species composition and environmental gradient. Significance of the rank correlation was determined using permutation testing.

2.5.6.2. Canonical analysis

Multivariate analysis was also undertaken using the method of canonical correlation (CanCorr) in the Canoco for windows 4.5 statistical package. This approach seeks to find linear combinations of explanatory variables (the environmental parameters) and response variables (the various measures of abundance and biomass of fishes) along canonical axes. All fish abundance were log-transformed ($\log_{10}(B+1)$) prior to the analysis. A matrix of the explanatory variables was used to quantify variation in the matrix of response variables.

This method also provides some measures of statistical significance in terms of the canonical relationships among variables.

3. RESULTS

3.1. Environmental parameters

3.1.1 Physical, chemical, biological characteristics

Annual sea surface water temperature (SST) was found 22.79 ± 4.65 °C, with maximum values in August (29.72 ± 1.01 °C) followed by October and May months (24.26 ± 1.05 and 21.29 ± 1.00 °C respectively) and reaching the minimum values in February (16.7 ± 0.74 °C) as shown in Figure 3.1. At increasing depths seawater gets colder but the seasonal changes are still respected. The average subsurface water temperature (SSuT) and near bottom water temperature (NBT) were found 22.4 ± 4.16 °C and 21.06 ± 3.45 °C respectively. The only exception was February, with higher temperature for SSuT and NBT than the SST (17.34 ±0.48 °C and 17.29 ± 0.37 °C respectively). In general sea surface at 10 and 25 m was less salty than off-shore, with an annual average of 39.02 ± 3.00 PSU. May had the lowest SSS values (38.46 ± 1.52). To be noticed that at 25 meter, in proximities of the third transect, stations had the lowest salinity regardless of the sampling season, with values around 28.5 PSU (Fig.3.3). Down to greater depths salinity values increased and were found more stable: SSuS and NBS were found 39.87 ± 1.28 PSU and 39.91 ± 0.52 respectively.

Sea surface oxygen was found around 8.61 ± 0.73 mg/L concentration overall the year, with a slight increase nearing to the bottom. Annual chlorophyll surface concentration was found 1.51 ± 1.46 mg/mL, with the highest values off-shore at 125 and 200 m. This concentration decreases with depth, reaching near the bottom an annual concentration of 0.78 ± 1.22 mg/mL. All zooplanktonic fractions decreased with depth, especially the 0,063 mm size that was 0.0041 ± 0.0017 g at 10 m reaching a concentration of 0.0009 ± 0.0003 at 200 m (Fig. 3.2). February had the highest values in concentration, decreasing gradually during the year. Interesting that the highest concentration was found along the third transect. Total suspended matter had the maximum values at the sub-surface strata (0.270 ± 0.26) and highest concentrations were found in May and near the coast. Secchi disk revealed that the water was more transparent in August and October, especially at 125 and 200 m (Fig. 3.4).

Fig. 3.1: Average Surface seawater Temperature (SST) in the study area during the different seasons (Surfer 12 - Golden software).

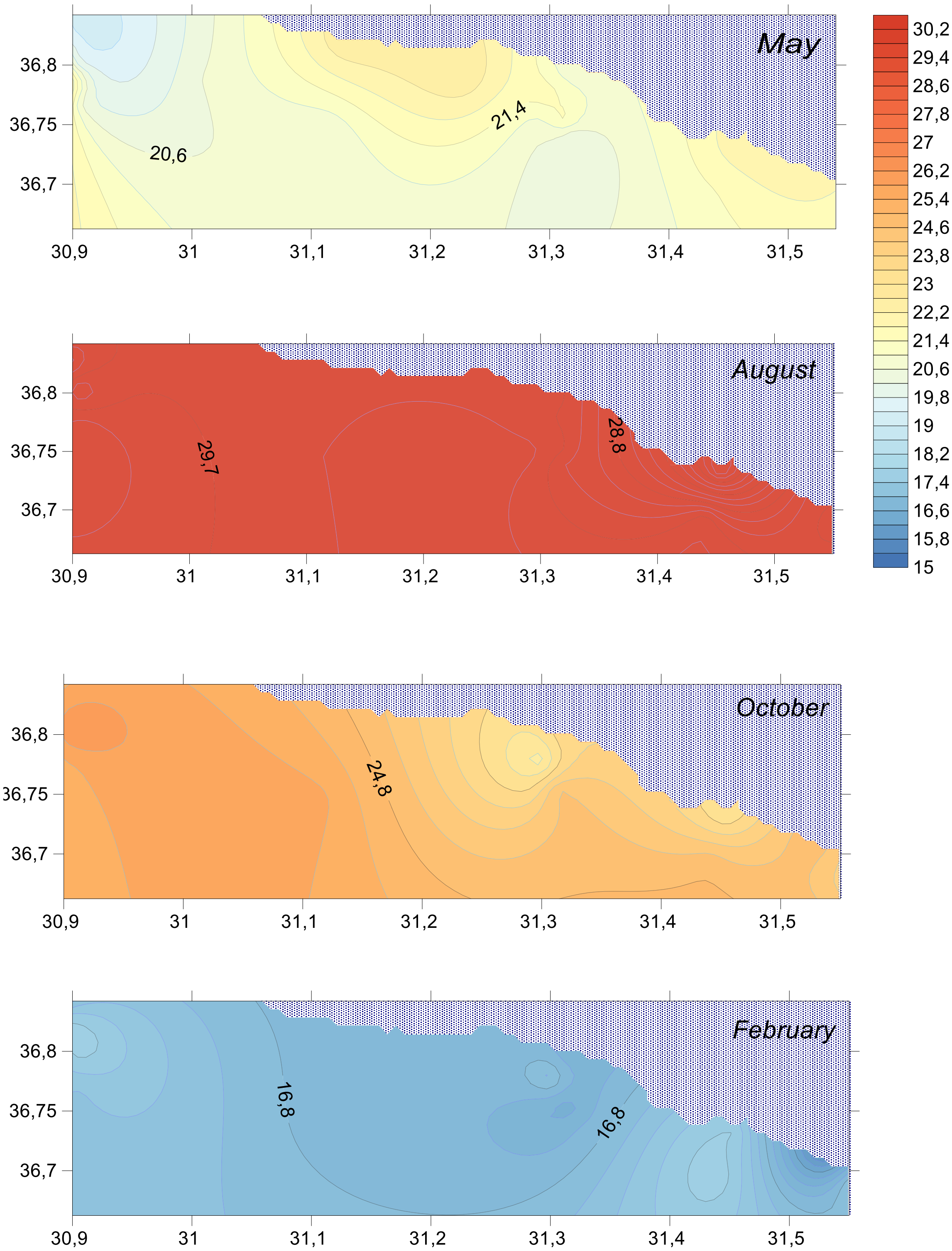


Fig. 3.2: Annual Bioseston (1, 0.5, 0.063 fractions) concentration over the study area (Surfer 12 - Golden software).

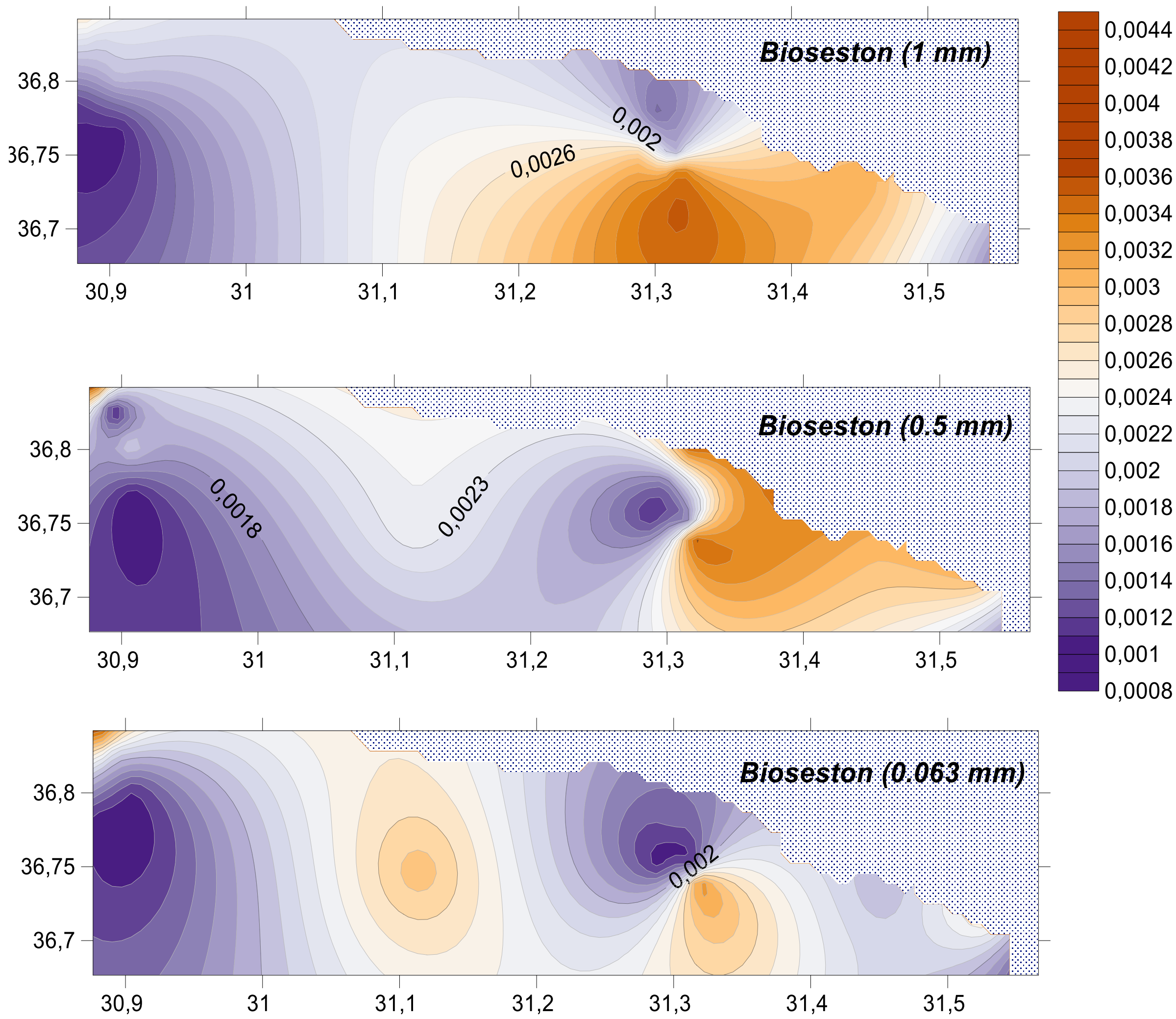


Fig. 3.3: Annual sea surface water salinity (SSS) in the study area (Surfer 12 - Golden software).

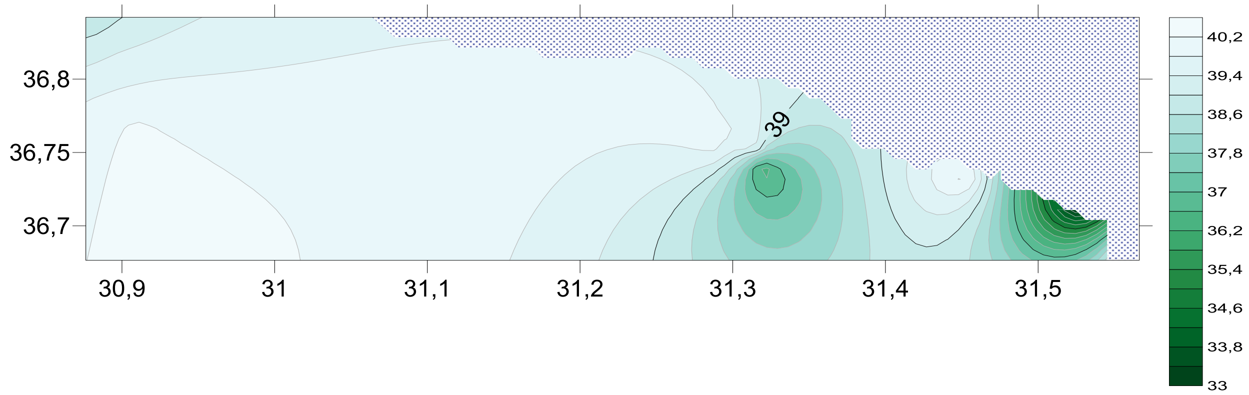
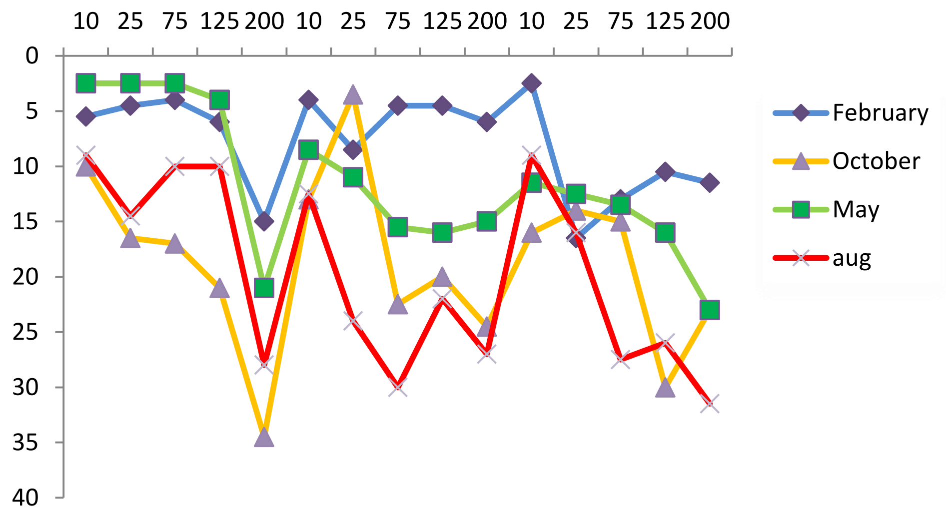


Fig. 3.4: Secchi depth measured over the different seasons (x-axis: sampling stations depths; y-axis: column water depth).



3.1.2. Seabed classification

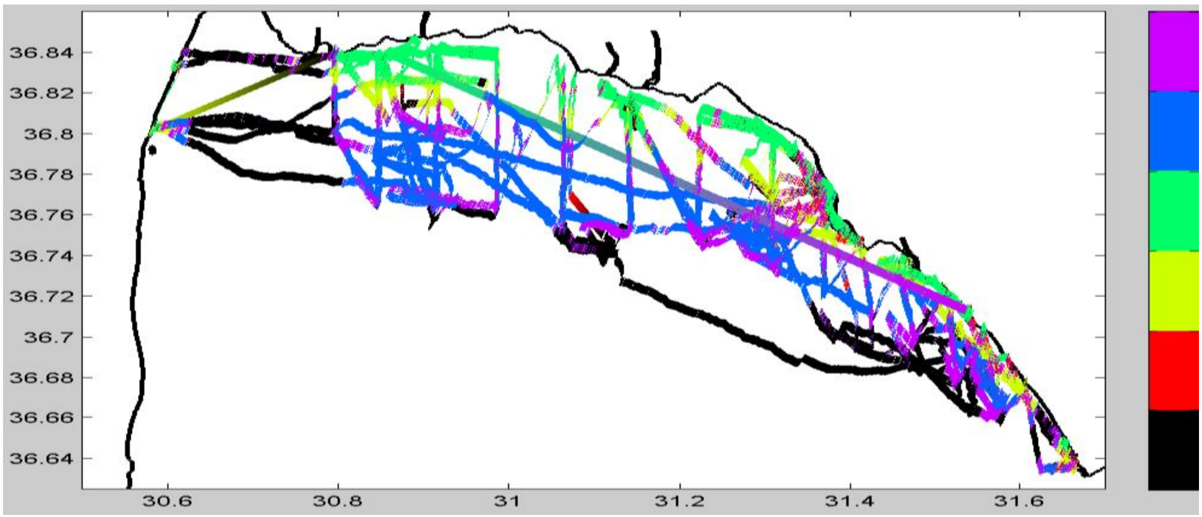


Fig. 3.5: The study area showing the different bottom types from the acoustic-survey lines, during all the cruises: Fine sandy mud; Mud; Sand; Coarse muddy sand; rocks covered by *Poseidonia;* Lost bottom.

According to the acoustic results, five main bottom classes were identified in the study area corresponding to the predominant sediment type: mud**,** fine sandy mud, sand, coarse muddy sand and rocks covered by *Posidonia* (Fig. *3.5*). The bottom type changes along the bathymetric gradient. At shallow depths, near the coast, a continuous strip of sand occurs, occasionally followed by some coarse muddy sand strata. In the eastern part, the superficial sediment pattern becomes more complex, due to the irregular presence of a rocky ground covered by vegetation. Down to greater depths a muddy bottom predominates, interrupt by fine sandy mud. In general the sea bed shows a quite constant pattern throughout the study period. Only fine sandy mud is unevenly distributed during the different seasons, probably because of the periodical water supply from the inland transporting terrigenous material.

3.2. Fish assemblages

3.2.1 Species composition

A total of 76 fish species belonging to 40 families were recorded in the study (Tab. 3.1). According to the feeding type 33 species (43%) were semidemersal, 33 species (43%) were semidemersal-demersal, 10 species (14%) were pelagic fish. Considering the different zoogeographical affinity of fishes, 48 species (63%) were Atlantic-Mediterranean, 22 species (30%) were Indo-Pacific, 4 species (5%) were cosmopolitan and 2 species (2%) were endemic of the Mediterranean.

Tab. 3.1: Fish species collected on the continental shelf of the study area. A-M: Atlantic-Mediterranean, C: Cosmopolitan, IP: Indo-Pacific, M: Mediterranean. SD: semidemersal-demersal.

Family	**Species**	**Feeding type**	**Origin**
Apogonidae	*Ostorhinchus fasciatus*	SEMIDEMERSAL	IP
Apogonidae	*Apogon queketti*	SEMIDEMERSAL	IP
Apogonidae	*Apogon smithii*	SEMIDEMERSAL	IP
Apogonidae	*Apogonichthyoides pharaonis*	SEMIDEMERSAL	IP
Argentinidae	*Argentina sphyraena*	SEMIDEMERSAL	A-M
Argentinidae	*Glossanodon leioglossus*	SEMIDEMERSAL	A-M
Atherinidae	*Atherina hepsetus*	SEMIDEMERSAL	A-M
Caproidae	*Capros aper*	SD	A-M
Carangidae	*Alepes djedaba*	SEMIDEMERSAL	IP
Carangidae	*Caranx crysos*	SEMIDEMERSAL	A-M
Carangidae	*Trachurus mediterraneus*	SEMIDEMERSAL	A-M
Carangidae	*Trachurus trachurus*	SEMIDEMERSAL	A-M
Carangidae	*Trichiurus lepturus*	SEMIDEMERSAL	C
Carapidae	*Carapus acus*	SD	M
Carcharhinidae	*Carcharhinus plumbeus*	SD	M
Centracanthidae	*Centracanthus cirrus*	SEMIDEMERSAL	A-M
Centracanthidae	*Spicara maena*	SEMIDEMERSAL	A-M
Centracanthidae	*Spicara smaris*	SEMIDEMERSAL	A-M
Centriscidae	*Macroramphosus scolopax*	SD	A-M
Cepolidae	*Cepola macrophthalma*	SD	A-M
Champsodontidae	*Champsodon capensis*	SEMIDEMERSAL	IP
Champsodontidae	*Champsodon nudivittis*	SEMIDEMERSAL	IP
Champsodontidae	*Champsodon vorax*	SD	IP
Chlorophthalmidae	*Chlorophthalmus agassizi*	SD	C
Clupeidae	*Alosa fallax*	PELAGIC	A-M
Clupeidae	*Herklotsichthys punctatus*	PELAGIC	IP
Clupeidae	*Sardina pilchardus*	PELAGIC	A-M
Clupeidae	*Sardinella aurita*	PELAGIC	A-M
Clupeidae	*Sardinella maderensis*	PELAGIC	A-M

Dasyatidae	*Dasyatis centroura*	SD	A-M
Dasyatidae	*Dasyatis pastinaca*	SD	A-M
Dussumieriidae	*Etrumeus teres*	SEMIDEMERSAL	A-M
Engraulidae	*Engraulis encrasicolus*	PELAGIC	A-M
Fistulariidae	*Fistularia commersonii*	SEMIDEMERSAL	IP
Haemulidae	*Pomadasys incisus*	SEMIDEMERSAL	A-M
Haemulidae	*Pomadasys stridens*	SEMIDEMERSAL	IP
Labridae	*Pteragogus pelycus*	SD	IP
Leiognathidae	*Equulites klunzingeri*	SD	IP
Macrouridae	*Coelorinchus caelorhincus*	SEMIDEMERSAL	A-M
Macrouridae	*Hymenocephalus italicus*	SEMIDEMERSAL	A-M
Merlucciidae	*Merluccius merluccius*	SD	A-M
Mugilidae	*Liza saliens*	SEMIDEMERSAL	A-M
Mullidae	*Mullus surmuletus*	SD	A-M
Mullidae	*Upeneus moluccensis*	SD	IP
Mullidae	*Upeneus pori*	SD	IP
Myliobatidae	*Pteromylaeus bovinus*	SD	A-M
Nemipteridae	*Nemipterus randalli*	SD	IP
Rajidae	*Raja asterias*	SD	A-M
Rajidae	*Raja clavata*	SD	A-M
Rajidae	*Raja miraletus*	SD	A-M
Rajidae	*Raja oxyrinchus*	SD	A-M
Scaridae	*Sparisoma cretense*	SD	A-M
Scombridae	*Scomber japonicus*	PELAGIC	IP
Sebastidae	*Helicolenus dactylopterus*	SD	A-M
Serranidae	*Anthias anthias*	SEMIDEMERSAL	A-M
Serranidae	*Epinephelus aeneus*	SD	A-M
Serranidae	*Epinephelus haifensis*	SD	A-M
Siganidae	*Siganus rivulatus*	SEMIDEMERSAL	IP
Sillaginidae	*Sillago suezensis*	SD	IP
Sparidae	*Dentex dentex*	SEMIDEMERSAL	A-M
Sparidae	*Dentex macrophthalmus*	SEMIDEMERSAL	A-M
Sparidae	*Dentex maroccanus*	SEMIDEMERSAL	A-M
Sparidae	*Diplodus annularis*	SD	A-M
Sparidae	*Diplodus vulgaris*	SD	A-M
Sparidae	*Lithognathus mormyrus*	SD	A-M
Sparidae	*Pagellus acarne*	SEMIDEMERSAL	A-M
Sparidae	*Sparus aurata*	SD	A-M
Sphyraenidae	*Sphyraena chrysotaenia*	PELAGIC	IP
Sphyraenidae	*Sphyraena sphyraena*	PELAGIC	A-M
Sphyraenidae	*Sphyraena viridensis*	PELAGIC	A-M
Synodontidae	*Saurida undosquamis*	SEMIDEMERSAL	IP
Synodontidae	*Synodus saurus*	SEMIDEMERSAL	A-M
Terapontidae	*Pelates quadrilineatus*	SD	IP
Trachichthyidae	*Hoplostethus mediterraneus*	SD	C
Trichiuridae	*Lepidopus caudatus*	SD	A-M
Zeidae	*Zeus faber*	SEMIDEMERSAL	C

3.2.2. Numerical indices

Constant and common fish species identified in the study area according to Soyer index (D%) are given in the table 3.2. The constant species, over 50% in Dominance, are *Upeneus moluccensis, Spicara smaris, Saurida undosquamis*. The first two species have high NO% for both biomass and abundance. S*aurida undosquamis* has NO% high for biomass and low for abundance which means occurrence of relatively few individuals but large in size. Among the common species ones with the highest dominance value are *Pagellus acarne, Macroramphosus scolopax* and *Spicara maena.*

Tab. 3.2: List of the dominant and common species according to numerical indices: Dominance D%, Frequency of Occurrence FO%, Numerical Occurrence for biomass NO%(B) and Numerical Occurrence for abundance NO%(A).

Species	Feeding type	D%	FO%	NO%(B)	NO%(A)
Upeneus moluccensis	SD	67.09	6.02	4.87	5.62
Spicara smaris	SEMIDEMERSAL	60.76	5.45	7.25	5.33
Saurida undosquamis	SEMIDEMERSAL	53.16	4.77	3.97	0.93
Pagellus acarne	SEMIDEMERSAL	43.04	3.86	5.77	5.22
Macroramphosus scolopax	SD	40.51	3.63	0.85	5.18
Spicara maena	SEMIDEMERSAL	39.24	3.52	1.81	0.81
Merluccius merluccius	SD	35.44	3.18	1.96	0.52
Upeneus pori	SD	35.44	3.18	4.06	5.33
Trachurus mediterraneus	SEMIDEMERSAL	34.18	3.06	0.54	0.44
Dasyatis pastinaca	SD	32.91	2.95	12.14	0.19
Argentina sphyraena	SEMIDEMERSAL	31.65	2.84	3.29	8.84
Equulites kluzingeri	SD	31.65	2.84	2.27	7.69
Nemipterus randalli	SD	31.65	2.84	0.86	0.48
Fistularia commersonii	SEMIDEMERSAL	29.11	2.61	0.38	0.50
Dentex maroccanus	SEMIDEMERSAL	27.85	2.50	13.56	10.47
Epinephelus aeneus	SD	27.85	2.50	1.74	0.37
Diplodus annularis	SD	25.32	2.27	2.83	2.83
Lithognathus mormyrus	SD	25.32	2.27	2.88	1.79
Raja clavata	SD	25.32	2.27	4.32	0.32
Raja miraletus	SD	25.32	2.27	3.27	0.16

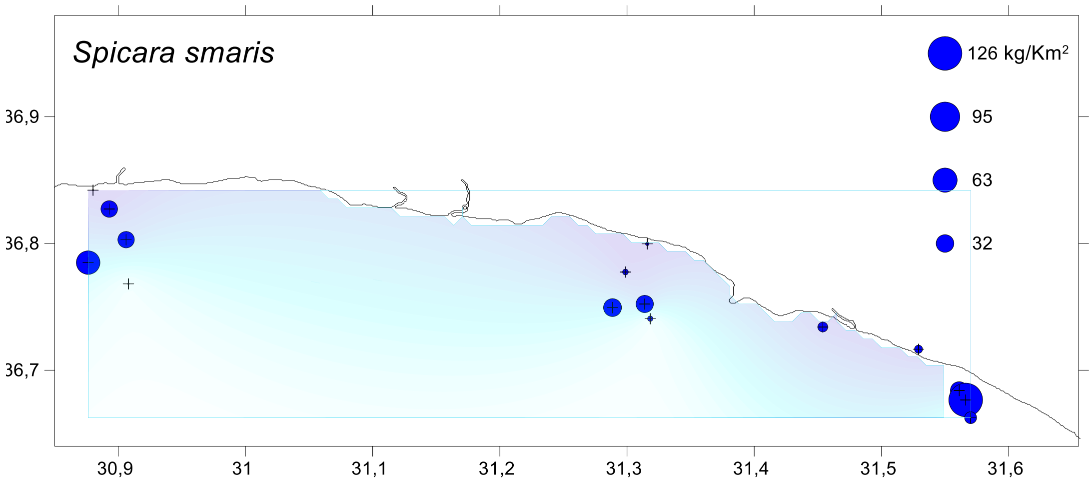
3.2.3. Target species

Selection of the following species was made according to their ecological and economical importance and to the order of dominance and frequency of occurrence over the study area.

3.2.3.1. *Spicara smaris* (Linnaeus, 1758)

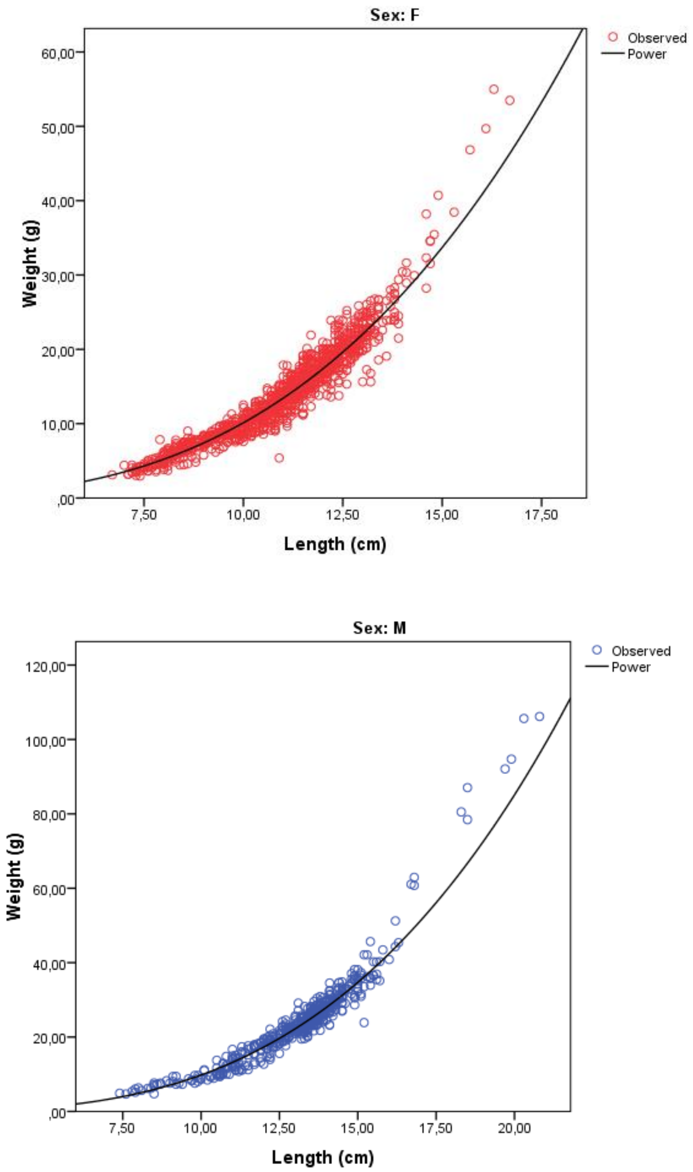
Spicara smaris was found all over the 10-200 m range depth, with the highest mean biomass values occurring at around 75 - 125 m depth (Fig. 3.6).

Fig.3.6: *Spicara smaris:* average biomass distribution (kg/Km²) at the different sampling stations over all the seasons (Surfer 12 - Golden software).



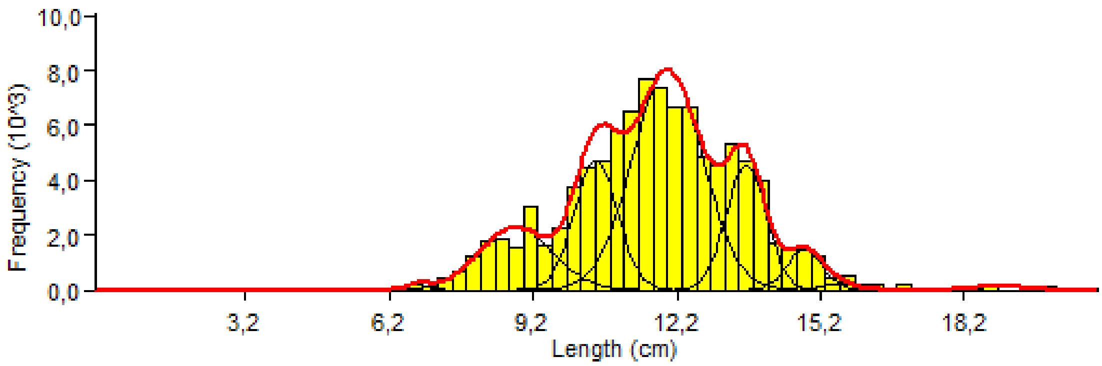
A total of 2,272 individuals ranging from about 6 to 16 cm total length were measured in laboratory. Among them 1,324 were females; 464 were males; 253 were hermaphrodites and 231 were not identified. The total length of males ranged from 8.0 to 20.8 cm, with a mean of 13.1 ± 1.9 cm, and females ranged from 7.0 to 16.7 cm with a mean of 10.9 ± 1.7 hermaphrodites ranged from 9.80 to 15.6 with a mean of 12.5 ± 1.2 cm. The exponent of the length-weight relationship calculated for females and males (Fig. 3.7) is significantly different from the 3 value ($P < 0.05$) for both sexes, showing allometric negative growth for females (b=2.97± 0.02) and allometric positive growth for males (b=3.12 ± 0.03).

Fig. 3.7: *Spicara smaris*: Regression curves for length-weight relationship estimation: $W=0.0076TL^{3.1377}$ for females (above) and $W=0.0063TL^{3.1886}$ for males (below) calculated by BM SPSS 21 software.



The sex-ratio of the samples was calculated as 1:2.85 in a strong favor of females and the chi-square ($p<0.05$) test shows that there is a significant deviation from the expected ratio 1:1. A few immature individuals, smaller than 7 cm; were classified as juveniles. The mean length of males is larger than females. Females were observed more frequently than males in the samples and no male was observed in the length classes smaller than 16.7 cm. Above this limit the contribution of males gradually increases while occurrence of females gets smaller. This trend reflects the *proterogynous* sexual behavior of this species, as also indicated by the mean total length of the hermaphrodite individuals collocating in between the transition phase from female to male. Seven different classes were found for frequency-length distribution analyzed through Bhattacharya's Method (Fig. 3.8). The optimal class interval of 0.3 cm was determined according to the COST function. The highest frequency values were found for the 2+ group at 11.5 cm mean total length. The lowest frequency was found for the last 6+ group with a mean total length of 18.9 cm. Separation index is high enough (S.I.>2) to show an appreciable distinction between the classes (Tab. 3.3).

Fig. 3.8: *Spicara smaris:* Length-frequency distribution for the total number of individuals as cumulated frequencies overall the sampling period (FISAT_II software).



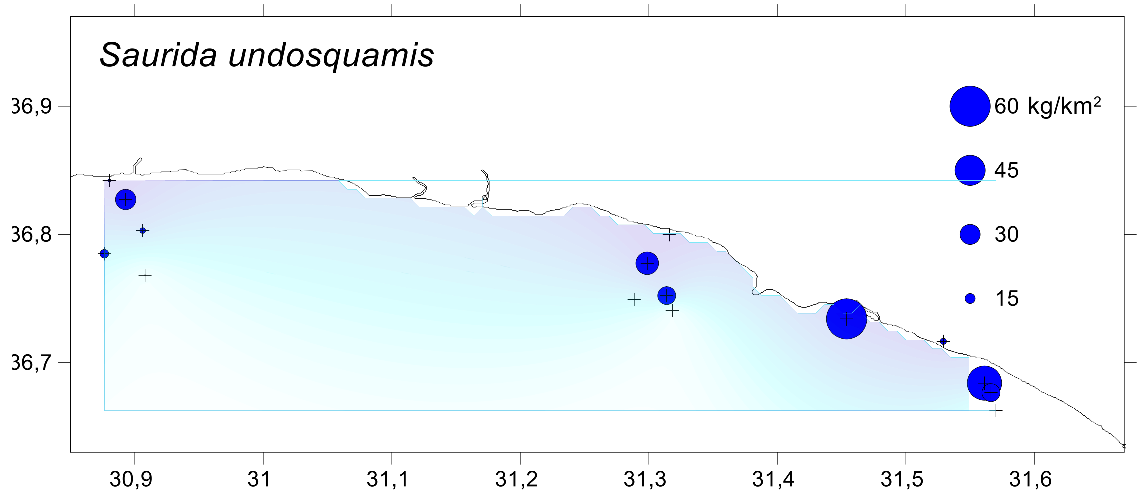
Tab. 3.3: *Spicara smaris*: Summary of results of the identification of the first seven main modal components for length-frequency distribution using the Battacharya's method (FISAT_II software).

Group	Comp.Mean	S.D.	Population	S.I.
0+	6.7	0.61	617	n.a
1+	8.8	0.82	15060	2.19
2+	11.5	0.89	58753	2.21
3+	13.5	0.53	19945	2.09
4+	14.9	0.35	4038	2.07
5+	15.6	0.32	664	2
6+	18.9	0.41	544	2.32

3.2.3.2. *Saurida undosquamis* (Richardson, 1848)

The brushtooth lizardfish was found between 10 and 125 m depths, with the highest mean biomass values occurring at around 25 m (Fig. 3.9).

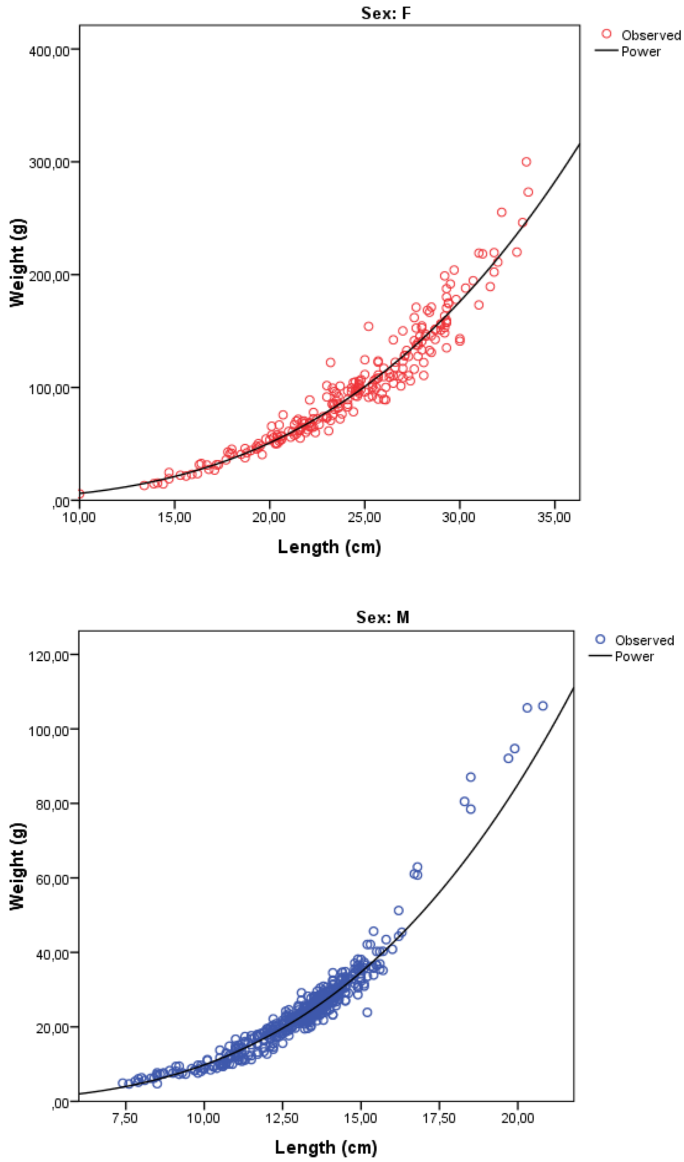
Fig.3.9: *Saurida undosquamis:* biomass distribution (kg/Km²) at the different sampling stations averaged over all the seasons (Surfer 12 - Golden software).



The length of the 370 individuals caught during the trawl operations ranged between 6 and 34 cm. Among them 231 were females; 111 were males; 4 were juveniles and 24 were not identified. Females ranged between 10.0 – 33.6 cm TL with an average of 24.21 ± 4.4 cm TL while males were between 9.5 and 30.7 cm TL, averaging 18.6 ± 4.1 cm TL.

The slope of the regression equation for length-weight relationship is significantly different from the 3 value ($P < 0.05$) indicating a positive allometric growth for males (b= 3.09±0.05) while it is not significant for females (b=3.06 ± 0.04) which show isometric growth (Fig. 3.10).

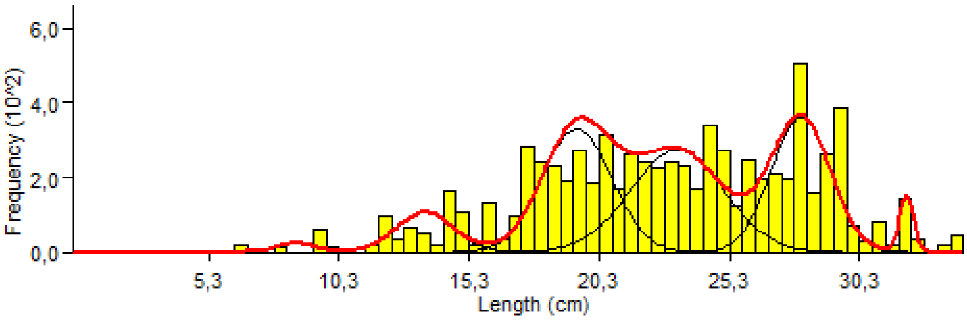
Fig. 3.10: *Saurida undosquamis*: Regression curves for length-weight relationship estimation: $W=0.0053TL^{3.062}$ for females (above) and $W=0.0049TL^{3.091}$ for males (below) calculated by the IBM SPSS 21 software.



The overall sex ratio was 1:2.9 in favor of females and the chi-square ($p<0.05$) test shows that there is a significant deviation from the expected ratio 1:1. The mean total length size of females seems larger than males one.

Frequency-length distribution for a class interval of 0.5 cm given by COST function displays six different groups (Fig. 3.11). The highest number of frequency values was found for the 3+ class at around 23.2 cm mean length (Tab. 3.4).

Fig. 3.11: *Saurida undosquamis:* Length-frequency distribution for the total number of individuals as cumulated frequencies overall the sampling period (FISAT_II software).



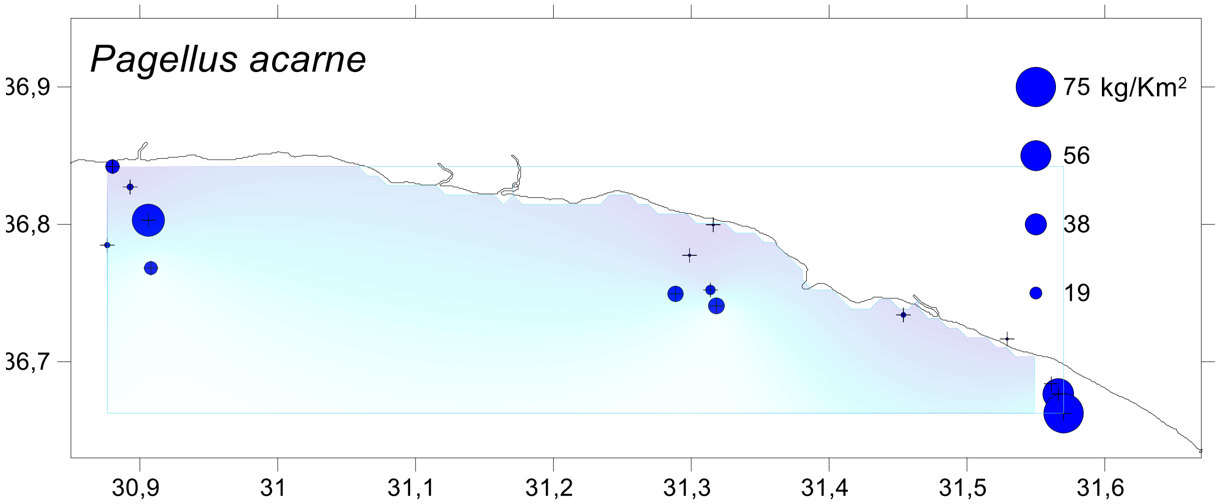
Tab. 3.4: *Saurida undosquamis*: Summary of results of the identification of the first six main modal components for length-frequency distribution using the Battacharya's method (FISAT_II software).

Group	Comp.Mean	S.D.	Population	S.I.
0+	8.6	0.72	86	n.a
1+	13.5	1.12	594	2.67
2+	19.4	1.33	2196	2.46
3+	23.2	1.78	2444	2.07
4+	28.0	1.14	2056	2.15
5+	32.1	0.26	202	2.18

3.2.3.3. ***Pagellus acarne*** **(Risso, 1827)**

Pagellus acarne was sampled from 10 to 200 meters throughout the study period (Fig. 3.12).

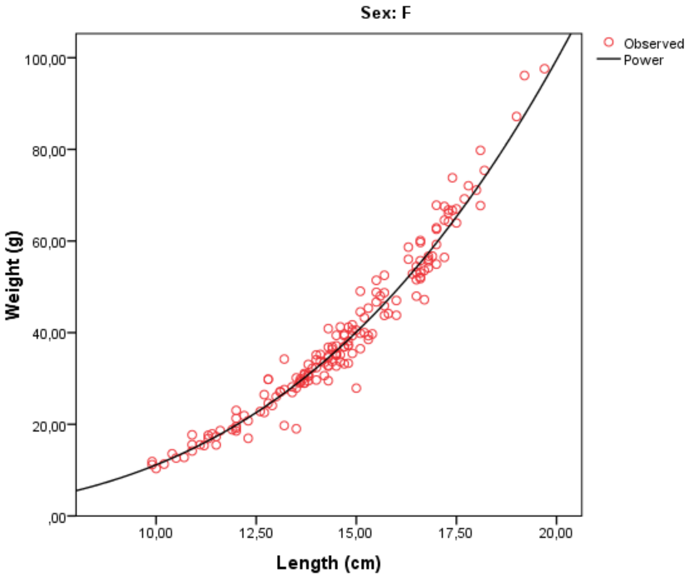
Fig. 3.12: *Pagellus acarne:* biomass distribution (kg/Km²) at the different sampling stations averaged over all the seasons (Surfer 12 - Golden software).

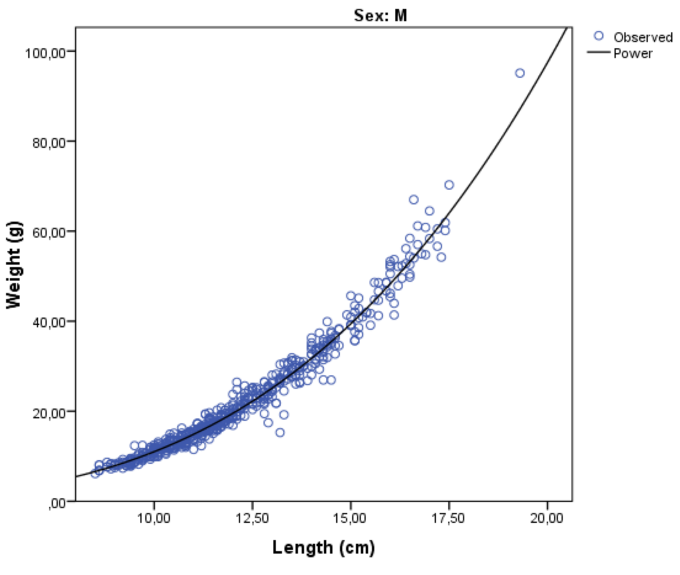


A number of 1074 individuals ranging from 5 to 20 cm TL was stored for laboratory analyses. Among them 2261 were females; 1914 were males; 54 were juveniles and 264 were not identified. Females of *P. acarne* ranged between 9.9 and 19.7 cm TL with an average of 14.6±2.1 cm TL. Males were between 8.5 and 19.3 cm TL, averaging 12.0±2.0 cm TL.

The exponent of the length-weight relationship is significantly different from 3 ($P < 0.05$) for both females and males with b: 3.16 ± 0.5 and b: 3.15 ± 0.2 respectively, indicating a positive allometric growth (Fig. 3.13).

Fig. 3.13: *Pagellus acarne*: Regression curves for length-weight relationship estimation: $W=0.008TL^{3.157}$ for females (above) and $W=0.008TL^{3.145}$ for males (below) calculated by IBM SPSS 21 software.



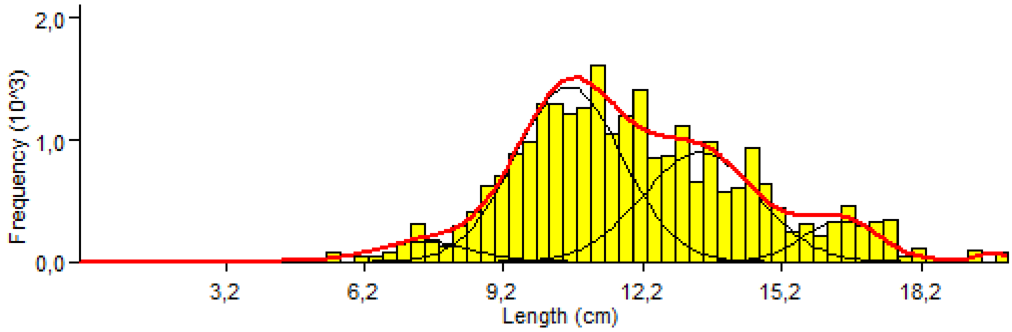


The sex-ratio of the samples was calculated as 1:0.29 in a strong favor to males. Immature individuals smaller than 8.5 cm could not be sexed, therefore they were classified as juveniles.

The mean length and the range of size the males were larger than females. Males were observed more frequently than females in the samples and the contribution of males gradually increases while occurrence of females gets smaller. Indeed this species shows *proterandric* sequential hermaphroditism.

Frequency-length distribution shows five different groups (Fig. 3.14). The class with the highest number of frequency values was 1+ with a mean total length of 10.6 cm; the lowest frequency value was found for the last group 4+ (Tab. 3.5). The interval class size of 0.3 cm was selected according to COST function.

Fig. 3.14: *Pagellus acarne:* Length-frequency distribution for the total number of individuals as cumulated frequencies overall the sampling period (FISAT_II software).



Tab. 3.5: *Pagellus acarne*: Summary of results of the identification of the first six main modal components for length-frequency distribution, using the Battacharya's method (FISAT_II software).

Group	Comp. Mean	S.D.	Population	S.I.
0+	7.4	1.03	1375	n.a
1+	10.6	1.15	13795	2.23
2+	13.4	1.23	9187	2.08
3+	16.5	0.82	2258	2.14
4+	19.7	0.33	184	2.24

3.2.4. Faunistic characteristics

The diversity indices and the total abundance and biomass, calculated separately for the combined and the semidemersal species are given respectively in Tables 3.8 and 3.9.

In both cases August season has the highest abundance and biomass values but diversity indices relatively lower than the other seasons. Considering the different areas, stations along the third transect have the highest biomass values respect to the first and the second, especially for semidemersal fishes. Looking at the factor depth the Species Richness, Margalef's index and Shannon index are higher at 25 m depth and at the deepest station, while the 75 m and especially 10 m stations have the lowest diversity values. Pielou's evenness seems to remain constant. Fishes were sampled in larger quantities at 125 m and 200 m stations.

Three-way ANOVA results for the significance of the faunistic characteristics between depth, transects and seasons and their interactions for the combined fish species are shown in Table 3.6. Species Richness index terms are all significant ($P<0.05$) except for the season and the interaction *transect*x*season*. Margalef's index, which takes in account the sample size also, shows the same results apart from the term transect. Abundance differs significantly for the depth only. Shannon-Winer index differs for depth and for *transect*x*depth* term. Pielou's evenness and biomass were all non significant. Regarding semidemersal species depth is the only significant term over Species Richness and Abundance. Shannon-Winer index differs significantly for depth again and for the interaction *transect*x*season.* Biomass also is significant over the transect (Tab. 3.7).

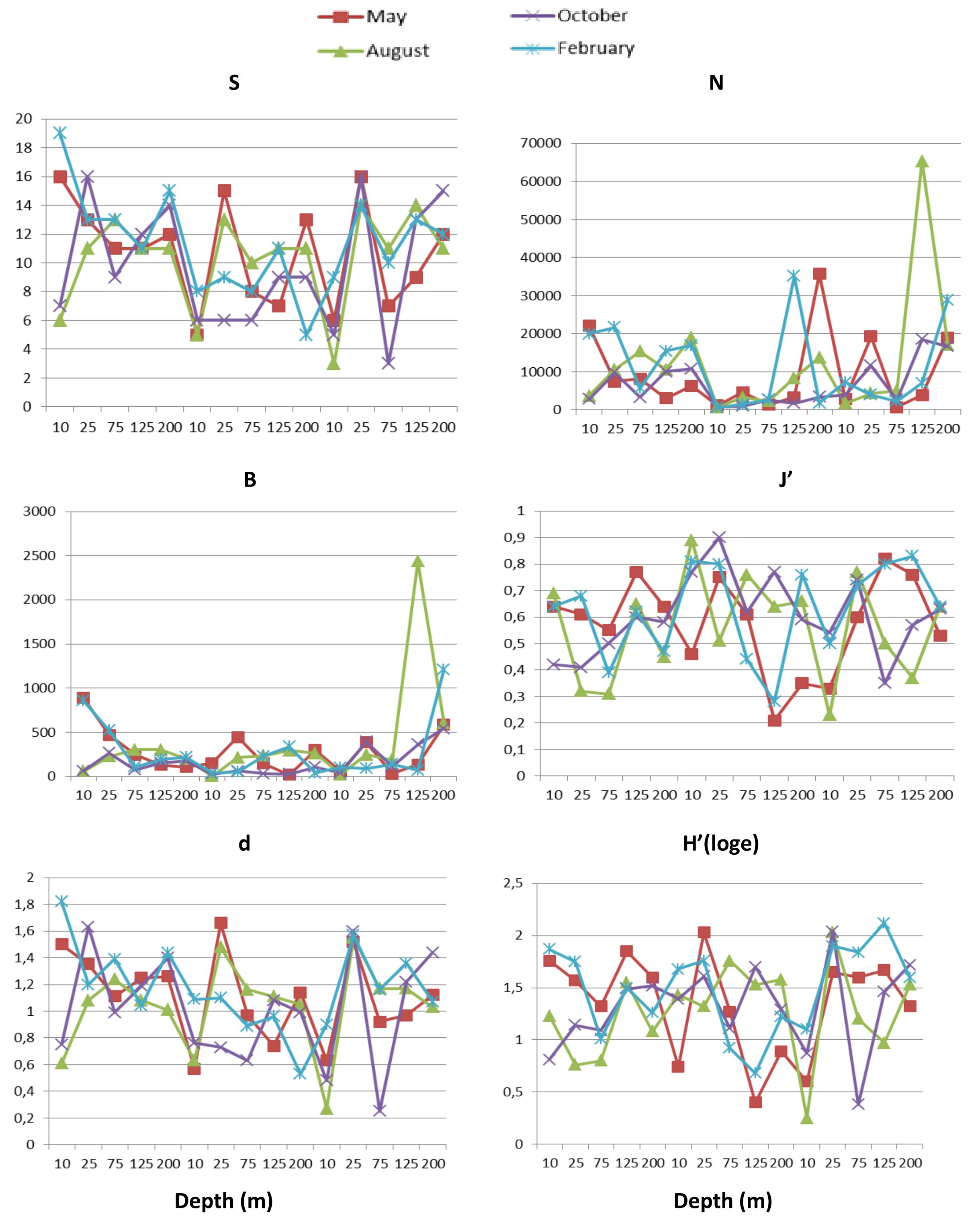
Tab. 3.6: Summary table of three-way ANOVA results of the faunistic characters for the combined species over all the stations: S=Species Richness, A=Abundance, d=Margalef's index, J'=Pielou's evenness index, H'(loge)=Shannon diversity index, B= Biomass.

	S	**N**	**d**	**J'**	**H'(loge)**	**B**
Factors	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Transect	*0.026	0.128	0.077	0.575	0.908	0.141
Depth	*0.036	*0.037	*0.044	0.369	*0.024	0.568
Season	0.753	0.562	0.729	0.832	0.731	0.566
Transect * Depth	*0.048	0.664	*0.051	0.058	*0.033	0.092
Transect * Season	0.176	0.794	0.173	0.078	0.067	0.466
Depth * Season	*0.020	0.701	*0.014	0.873	0.650	0.208

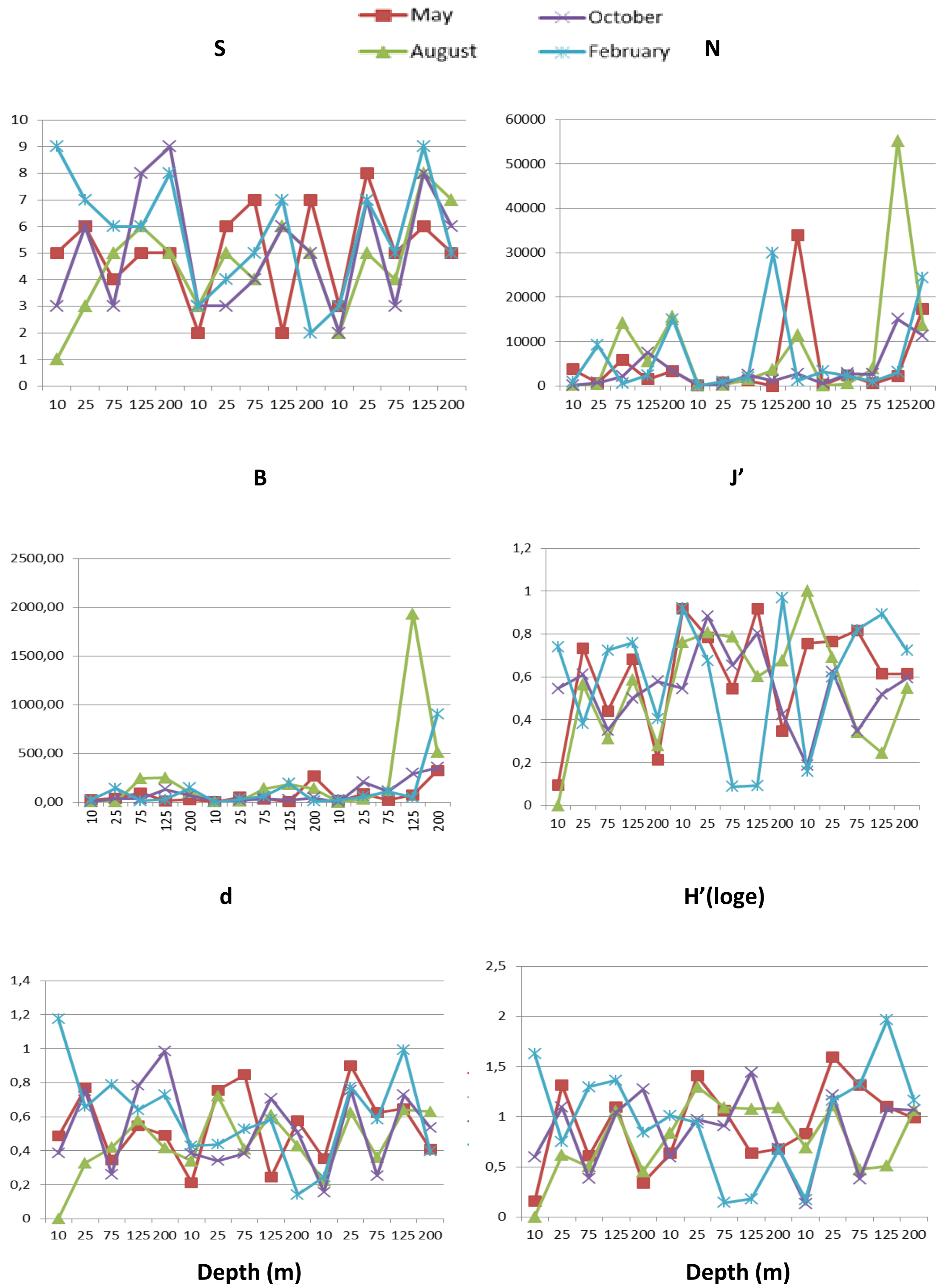
Tab. 3.7: Summary table of three-way ANOVA results of the faunistic characters for the semidemersal species over all the stations: S=Species Richness, A=Abundance, d=Margalef's index, J'=Pielou's evenness index, H'(loge)=Shannon diversity index, B= Biomass.

	S	**N**	**d**	**J'**	**H'(loge)**	**B**
Factors	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Transect	0.216	0.267	0.536	0.209	0.754	*0.034
Depth	*0.014	*0.008	0.065	0.357	*0.020	0.162
Season	0.613	0.738	0.603	0.751	0.848	0.347
Transect * Depth	0.129	0.788	0.200	0.891	0.688	0.280
Transect * Season	0.160	0.810	0.063	0.648	0.042	0.651
Depth * Season	0.086	0.785	0.086	0.852	0.650	0.251

Tab. 3.8: Faunistic characters for the combined species over all the stations and transects: S=Species Richness. A=Abundance (N/km²). d=Margalef's index. J'=Pielou's evenness index. H'(loge)=Shannon diversity index. B=Biomass (kg/km²).



Tab. 3.9: Faunistic characters for semidemersal species over all the stations and the transects: S=Species Richness. A=Abundance (N/km²). d=Margalef's index. J'=Pielou's evenness index. H'(loge)=Shannon diversity index. B=Biomass (kg/km²).



3.2.5. Multivariate biotic pattern

3.2.5.1. Permutational analysis of variance (PERMANOVA)

Considering the all semidemersal-demersal and semidemersal fish species all main effects and interactions in the three-way PERMANOVA are significant in both abundance and biomass (Tab. 3.10 and 3.12).

For the semidemersal species differences in community structure are significant for the main effects *season* and *depth* and for the interactions *season*x*depth* and *transect*x*depth* but are not significant for the factors *transect* and *season*x*transect* in both abundance (transect: pseudo-F=2.26. P=0.469; *season*x*transect*: pseudo-F=1.34; P=0.134) and biomass (transect: pseudo-F=1.64. P= 0.101; *season*x*transect*: pseudo-F=1.07; P= 0.335) (Tab. 3.11 and 3.13)

Subsequent pairwise comparisons for the term transect in the total community (Table 3.14) show differences between level 1 and 2 in both abundance (pseudo-t=1.85. P=0.045) and biomass (pseudo-t=1.96. P=0.03).

Tab. 3.10: Three-way PERMANOVA on log-transformed ($log_{10}(N+1)$) abundances values and Bray-Curtis dissimilarities for all semidemersal-demersal and semidemersal fishes. Asterisk (*) indicates P<0.5.

Factor	Df	SS	MS	Pseudo-F	P(perm)
Se	3	8000	2666.7	2.70	*0.001
Tr	2	6487.6	3243.8	2.26	*0.015
De	4	86726	21682	11.03	*0.001
SexTr	6	8607.7	1434.6	1.45	*0.049
SexDe	12	23589	1965.8	1.99	*0.002
TrxDe	8	13788	1723.6	1.75	*0.002
Res	24	23687	986.95		
Total	59	170890			

Tab. 3.11: Three-way PERMANOVA on log-transformed (log_{10}(N+1)) abundances values and Bray-Curtis dissimilarities for semidemersal fishes. Asterisk (*) indicates P<0.5.

Factor	df	SS	MS	Pseudo-F	P(perm)
Se	3	10848	3616	2.96	*0.001
Tr	2	3351	1675.5	1.02	0.469
De	4	82640	20660	9.60	*0.001
SexTr	6	9837.2	1639.5	1.34	0.134
SexDe	12	25834	2152.8	1.76	*0.006
TrxDe	8	18283	2285.4	1.87	*0.009
Res	24	29361	1223.4		
Total	59	180150			

Tab. 3.12: Three-way PERMANOVA on log-transformed(log_{10}(N+1)) biomass values and Bray-Curtis dissimilarities for all semidemersal-demersal and semidemersal fishes. Asterisk (*) indicates P<0.5.

Factor	df	SS	MS	Pseudo-F	P(perm)
Se	3	8466.3	2822.1	2.27	*0.001
Tr	2	8351	4175.5	2.40	*0.017
De	4	85723	21431	9.78	*0.001
SexTr	6	10443	1740.5	1.40	*0.053
SexDe	12	26323	2193.6	1.76	*0.001
TrxDe	8	15377	1922.2	1.55	*0.006
Res	24	29838	1243.2		
Total	59	184520			

Tab. 3.13: Three-way PERMANOVA on log-transformed (log_{10}(N+1)) biomass values and Bray-Curtis dissimilarities semidemersal fishes. Asterisk (*) indicates P<0.5.

Factor	df	SS	MS	Pseudo-F	P(perm)
Se	3	10851	3617.2	2.11	*0.008
Tr	2	6009.1	3004.6	1.64	0.101
De	4	79386	19847	7.99	*0.001
SexTr	6	10992	1832	1.07	0.355
SexDe	12	29804	2483.7	1.45	*0.015
TrxDe	8	20301	2537.6	1.48	*0.024
Res	24	41099	1712.5		
Total	59	1.98E+05			

Tab. 3.14**:** Results of PERMANOVA pairwise tests for differences in the all semidemersal-demersal and semidemersal fish assemblage. for both log-transformed (log_{10}(N+1)) abundance and biomass. between the transect levels. Asterisk (*) indicates P<0.05.

	Abundance		Biomass	
Pairs	Pseudo-t	P(perm)	Pseudo-t	P(perm)
1. 2	1.85	*0.045	1.96	*0.03
1. 3	1.51	0.092	1.49	0.159
2. 3	1.03	0.377	1.23	0.278

3.2.5.2 Species clustering and ordination

Cluster analysis of the species abundance and biomass data for semidemersal-demersal and Semidemersal species reveals three distinct species assemblage groups: 10-25 m. 75 m and 125-200 m. The MDS ordination also shows a clear distribution of the samples according to the depth gradient and confirms the grouping of the dendrogram (Fig. 3.10 and 3.12).

Considering the semidemersal species. the main factor contributing to the distribution of the samples is always the depth with the stations grouping almost in the same way for both abundance and biomass. For the same level of slicing (30%). samples in Cluster analysis are a little more unevenly distributed and MDS plots show the 125-200 m group collocating clearly apart while in the other group. composed of the shallower depths. stations lightly overlap (Fig. 3.11 and 3.13).

The factors transect and season do not seem to contribute in the distribution of the fish assemblages in these configurations.

Fig. 3.10: Dendrogram (above) and Multidimesional Scaling ordination (below) performed on log-transformed ($log_{10}(N+1)$) fish abundance of the semidemersal-demersal and Semidemersal species; resemblance was based on Bray-Curtis similarity. Labels show the depth and the season for each haul.

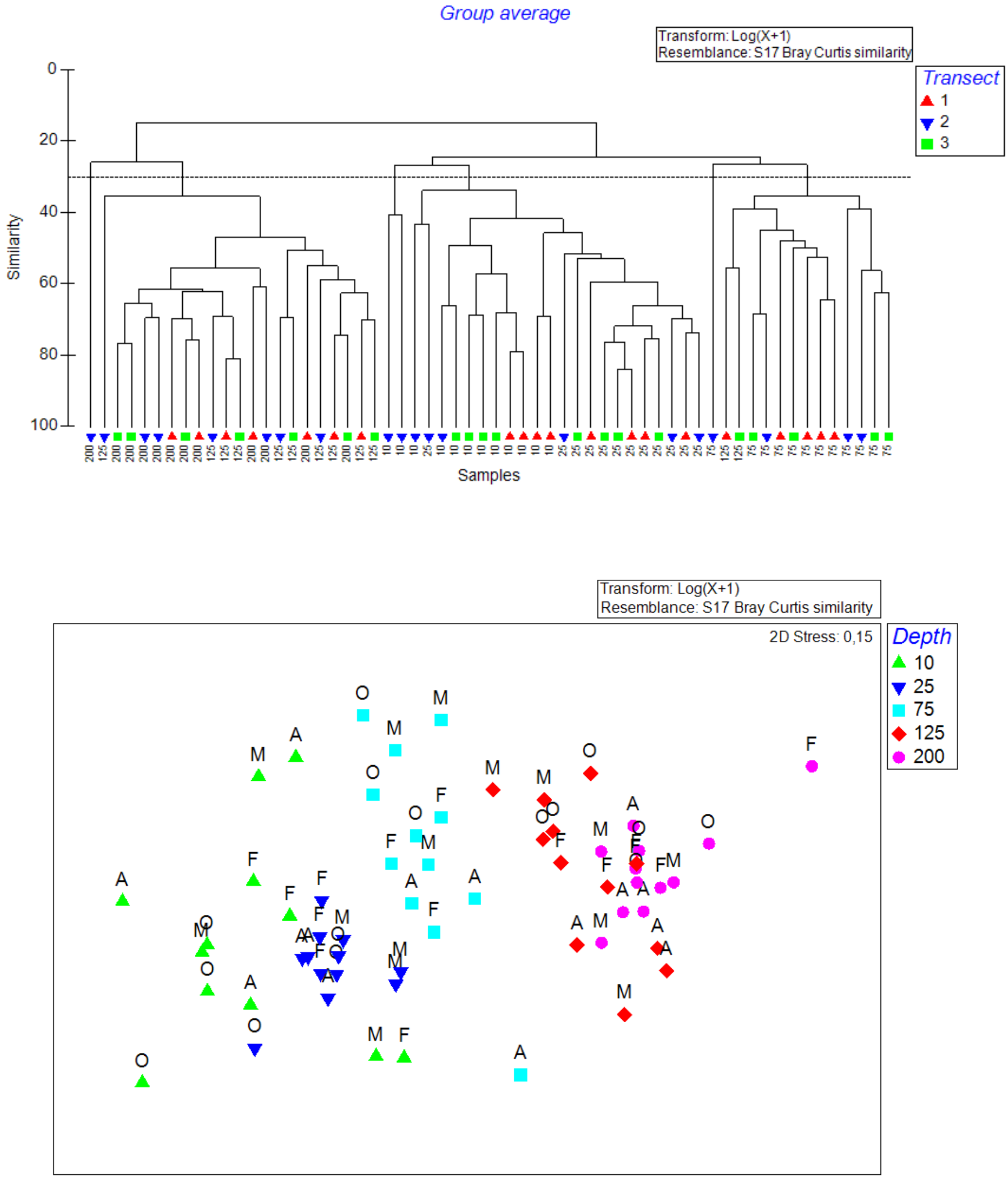


Fig. 3.11: Dendrogram (above) and Multidimensional Scaling ordination (below) performed on log-transformed ($log_{10}(N+1)$) fish abundance of the Semidemersal species; resemblance was based on Bray-Curtis similarity. Labels show the depth and the season for each haul.

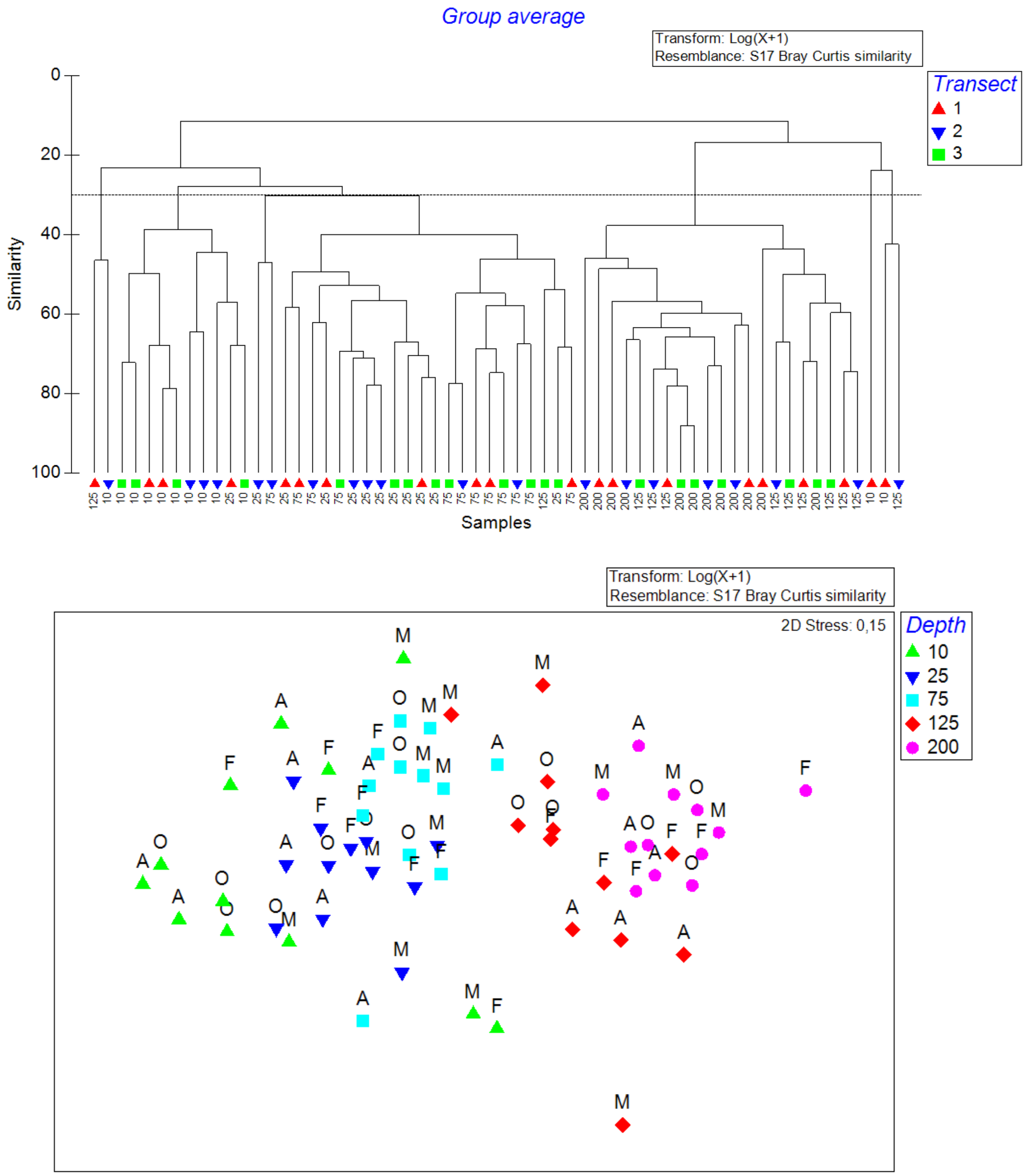


Fig. 3.12: Dendrogram (above) and Multidimensional Scaling ordination (below) performed on log-transformed ($log_{10}(N+1)$) fish biomass of the semidemersal-demersal and Semidemersal species; resemblance was based on Bray-Curtis similarity. Labels show the depth and the season for each haul.

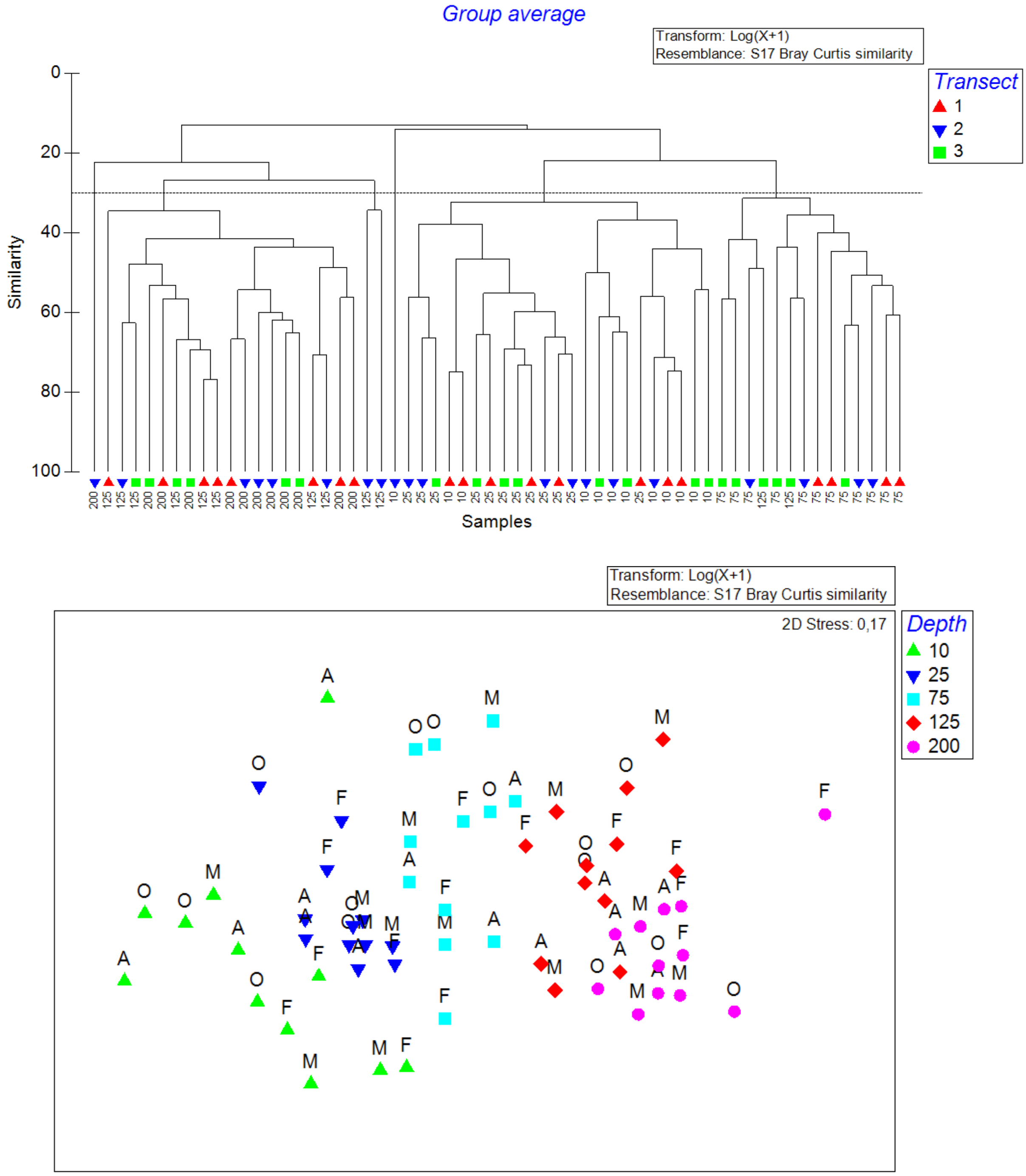
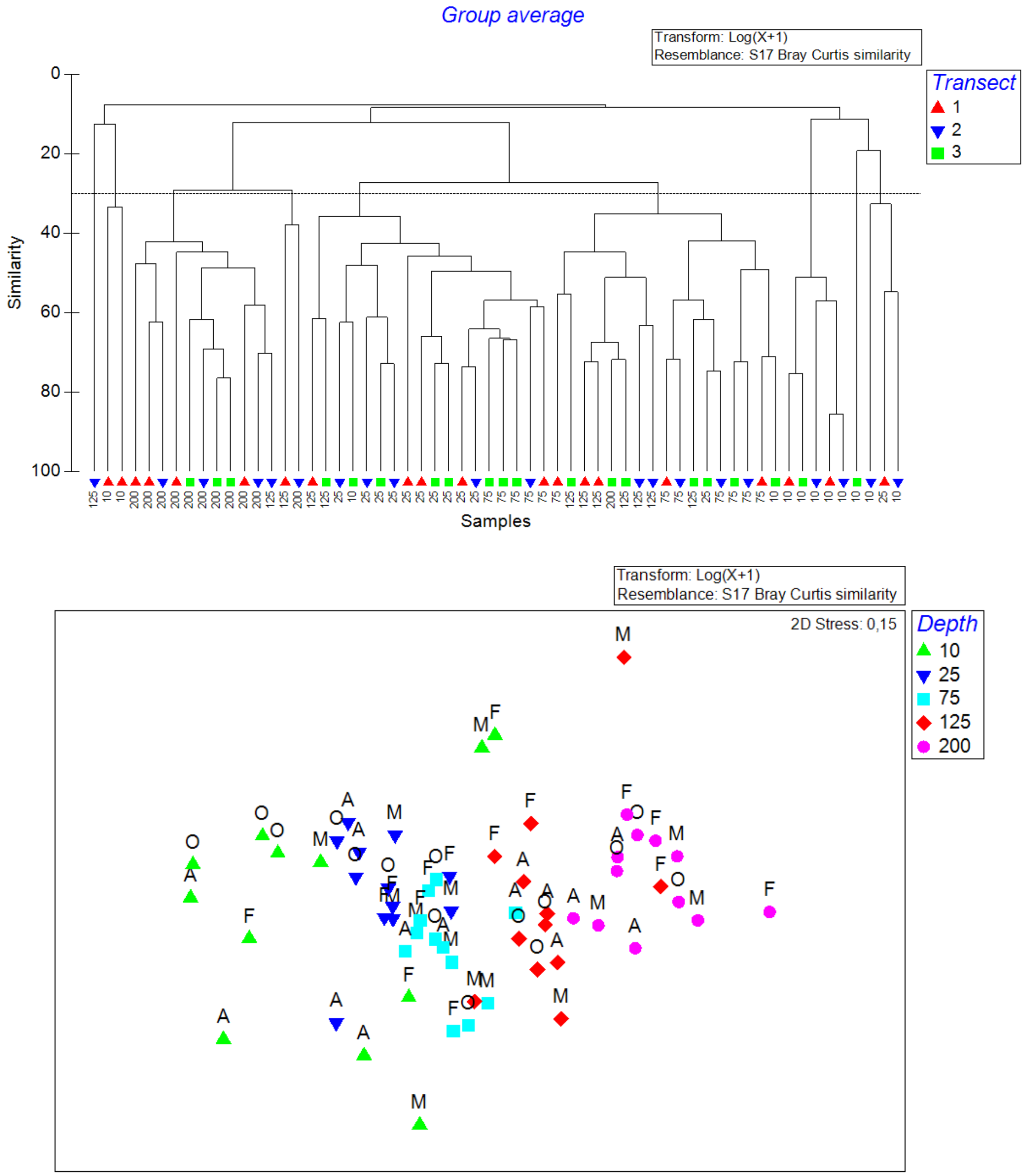


Fig. 3.13: Dendrogram (above) and Multidimensional Scaling ordination (below) performed on log-transformed ($log_{10}(N+1)$) fish biomass of the Semidemersal species; resemblance was based on Bray-Curtis similarity. Labels show the depth and the season for each haul.



3.2.5.3. Representative species

According to the bathymetric gradient. pair comparisons of the consecutive depth groups show the lowest dissimilarity in species contribution (Tab. 3.16). Overall the pair of depths. the lowest dissimilarity values corresponds to the 125-200 m group (Σ(dissimilarity)=55.78%) followed by the 10-25 m group (Σ(dissimilarity)=61.53%). Among the consecutive pair of groups the highest dissimilarity value is given by the 75-125 m (Σ(dissimilarity)=73%). These results reflect the grouping of sampling stations displayed by Cluster analysis and MDS plots.

Looking at the single species contribution to within depth groups similarity. this separation is present as well (Tab. 3.15). For instance *Upeneus pori* is the first species contributing to similarity (40.31%) for 10 .m group followed by *Fistularia commersoni* (20.68%). These species can be found at 25 m depth but with a lower contribution. disappearing at 75 m depth. *Saurida undosquamis* and *Equulites klunzingeri* have the highest contribution value (11.45% and 10.25% respectively) for the 25 m stations. *Spicara smaris* gives the highest contribution to the 75 m group (33.29%). followed by *S. undosquamis* (20.75%). but is also a constant species in the study area. occurring throughout the groups. New contributor species like *Macroramphosus scolopax* (27.99%). *Dentex maroccanu*s (11.4%). *Pagellus acarne*(9.26%) appear in the 125 m group. These species can be found with a lower contribution in the 200 m group too. Here the most important contributor is *Argentina sphyraena* (20.54%).

Tab. 3.15: species contribution to within depth groups similarity for the whole community. determined by using the SIMPER (similarity percentages) routine. Species are listed in order of decreasing percent similarity contribution with a 90% cumulative dissimilarity cut-off imposed.

Species	**Av.Abund**	**Av.Sim**	**Contribution%**
Group 10 Σ(similarity) = 39.45			
Upeneus pori	6.69	15.94	40.31
Fistularia commersonii	3.63	8.18	20.68
Lithognathus mormyrus	3.93	5	12.65
Equulites kluzingeri	3.67	3.58	9.04
Dasyatis pastinaca	2.04	1.66	4.2
Spicara smaris	1.75	1.27	3.21
Group 25 Σ(similarity) = 59.24			
Saurida undosquamis	5.16	6.79	11.45
Equulites kluzingeri	5.77	6.07	10.25
Upeneus pori	5.66	5.9	9.95
Nemipterus randalli	4.41	5.89	9.95
Epinephelus aeneus	4.41	5.79	9.78
Upeneus moluccensis	4.99	5.39	9.1
Diplodus annularis	4.83	4.83	8.15
Spicara smaris	4.36	3.85	6.51
Fistularia commersonii	3.75	3.69	6.23
Lithognathus mormyrus	3.68	2.72	4.6
Group 75 Σ(similarity) = 39.69			
Spicara smaris	6.32	13.21	33.29
Saurida undosquamis	4.18	8.24	20.75
Upeneus moluccensis	4.77	6.43	16.2
Spicara maena	2.84	2.83	7.12
Nemipterus randalli	2.65	2.03	5.1
Dasyatis pastinaca	2.11	1.84	4.64
Raja miraletus	1.21	0.65	1.64
Mullus surmuletus	1.27	0.63	1.58
Group 125 Σ(similarity) = 44.86			
Macroramphosus scolopax	7.73	12.56	27.99
Upeneus moluccensis	5.32	6.48	14.43
Dentex maroccanus	5.33	5.11	11.4
Pagellus acarne	4	4.15	9.26
Spicara smaris	3.4	2.33	5.19
Merluccius merluccius	2.71	2.08	4.65
Raja miraletus	2.15	1.94	4.33
Trachurus trachurus	2.4	1.56	3.47
Champsodon nudivittis	2.04	1.27	2.84
Centracanthus cirrus	2.58	1.24	2.77
Spicara maena	2.13	1.17	2.61
Argentina sphyraena	2.09	0.86	1.92
Group 200 Σ(similarity) = 56.60			
Argentina sphyraena	7.92	11.63	20.54
Macroramphosus scolopax	5.78	7.14	12.61

Upeneus moluccensis	5.79	6.25	11.03
Merluccius merluccius	4.77	6.1	10.78
Dentex maroccanus	5.85	5.8	10.25
Glossanodon leioglossus	4.75	3.87	6.83
Capros aper	3.81	3.45	6.1
Pagellus acarne	4.34	3.4	6
Trachurus trachurus	3.08	2.63	4.64
Raja clavata	2.24	1.72	3.04

Tab. 3.16: species contribution to between depth groups dissimilarity for the whole community. determined by using the SIMPER (similarity percentages) routine. Species are listed in order of decreasing percent dissimilarity contribution with a 90% cumulative dissimilarity cut-off imposed.

Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Contribution%**
10 vs. 25. Σ(dissimilarity) = 61.53	Group 10	Group 25		
Nemipterus randalli	0	4.41	4.68	7.6
Saurida undosquamis	1.02	5.16	4.42	7.18
Upeneus moluccensis	1.63	4.99	4.25	6.91
Equulites kluzingeri	3.67	5.77	4.15	6.74
Diplodus annularis	1.89	4.83	3.95	6.42
Spicara smaris	1.75	4.36	3.83	6.23
Epinephelus aeneus	1.1	4.41	3.73	6.07
Lithognathus mormyrus	3.93	3.68	3.25	5.28
Upeneus pori	6.69	5.66	3.06	4.97
10 vs. 75. Σ(dissimilarity) = 82.77	Group 10	Group 75		
Upeneus pori	6.69	0.3	8.58	10.37
Spicara smaris	1.75	6.32	6.91	8.34
Upeneus moluccensis	1.63	4.77	5.38	6.5
Saurida undosquamis	1.02	4.18	4.8	5.8
Fistularia commersonii	3.63	0.57	4.66	5.62
Lithognathus mormyrus	3.93	0.24	4.57	5.52
Equulites kluzingeri	3.67	1.16	4.23	5.11
Spicara maena	0.3	2.84	3.87	4.67
25 vs. 75. Σ(dissimilarity) = 65.8	Group 25	Group 75		
Upeneus pori	5.66	0.3	5.12	7.78
Equulites kluzingeri	5.77	1.16	4.77	7.25
Diplodus annularis	4.83	0.21	4.16	6.32
Epinephelus aeneus	4.41	0.32	4.1	6.23
Fistularia commersonii	3.75	0.57	3.37	5.13
Spicara smaris	4.36	6.32	3.22	4.89
Lithognathus mormyrus	3.68	0.24	3.19	4.84
Nemipterus randalli	4.41	2.65	3.02	4.59
Upeneus moluccensis	4.99	4.77	2.94	4.47
10 vs. 125. Σ(dissimilarity) = 91.29	Group 10	Group 125		
Macroramphosus scolopax	0.61	7.73	7.73	8.47
Upeneus pori	6.69	0	7.19	7.88

Dentex maroccanus	0	5.33	5.36	5.87
Upeneus moluccensis	1.63	5.32	5.01	5.48
Pagellus acarne	1.18	4	4.19	4.59
Fistularia commersonii	3.63	0	4.16	4.55
25 vs. 125. Σ(dissimilarity) = 83.93	Group 25	Group 125		
Macroramphosus scolopax	0.24	7.73	6.19	7.37
Equulites kluzingeri	5.77	0	4.63	5.52
Upeneus pori	5.66	0	4.57	5.44
Dentex maroccanus	0	5.33	4.13	4.92
Nemipterus randalli	4.41	0	3.73	4.45
75 vs. 125. Σ(dissimilarity) = 73.06	Group 75	Group 125		
Macroramphosus scolopax	1.13	7.73	6.74	9.23
Dentex maroccanus	0.26	5.33	4.95	6.77
Spicara smaris	6.32	3.4	4.21	5.76
Pagellus acarne	1.58	4	3.92	5.37
Saurida undosquamis	4.18	1.63	3.58	4.9
Upeneus moluccensis	4.77	5.32	3.28	4.49
10 vs. 200. Σ(dissimilarity) = 93.94	Group 10	Group 200		
Argentina sphyraena	0	7.92	8.26	8.79
Upeneus pori	6.69	0	6.83	7.27
Dentex maroccanus	0	5.85	5.71	6.08
Macroramphosus scolopax	0.61	5.78	5.21	5.54
Glossanodon leioglossus	0	4.75	4.93	5.25
Upeneus moluccensis	1.63	5.79	4.88	5.2
Merluccius merluccius	0	4.77	4.85	5.17
25 vs. 200. Σ(dissimilarity) = 89.59	Group 25	Group 200		
Argentina sphyraena	0	7.92	6.29	7.02
Dentex maroccanus	0	5.85	4.44	4.95
Upeneus pori	5.66	0	4.39	4.9
Macroramphosus scolopax	0.24	5.78	4.29	4.78
Equulites kluzingeri	5.77	0.54	4.23	4.72
75 vs. 200. Σ(dissimilarity) = 81.64	Group 25	Group 200		
Argentina sphyraena	0	7.92	7.74	9.48
Spicara smaris	6.32	0.74	5.7	6.98
Dentex maroccanus	0.26	5.85	5.26	6.45
Glossanodon leioglossus	0	4.75	4.62	5.65
Macroramphosus scolopax	1.13	5.78	4.58	5.61
Merluccius merluccius	0.55	4.77	4.2	5.14
Saurida undosquamis	4.18	0.24	4	4.89
Pagellus acarne	1.58	4.34	3.89	4.77
125 vs. 200. Σ(dissimilarity) = 55.78	Group 125	Group 200		
Argentina sphyraena	2.09	7.92	4.97	8.91
Glossanodon leioglossus	1.89	4.75	3.83	6.87
Dentex maroccanus	5.33	5.85	3.2	5.74
Capros aper	1.35	3.81	2.89	5.18
Spicara smaris	3.4	0.74	2.84	5.09
Pagellus acarne	4	4.34	2.75	4.93

3.3. Relations between biotic and environmental variables

3.3.1. BIO-ENV analysis

BIO-ENV procedure shows that depth is the variable matching the best results with biotic data overall the cases considered. with a slight higher correlation for the combined species than for the semidemersal species as shown table 3.17 and 3.18.

Immediately after the depth variable. for the combined species the best correlation is given by the combination depth/bottom type. and depth/near bottom suspended matter (Tab. 3.17).

For the semidemersal species the best combinations together with depth are tripton (1 mm; 0.5 mm; 0.063mm). near bottom suspended matter and bioseston (0.063 mm) as shown in Table 3.18.

Tab. 3.17: Results of BIOENV analysis showing the number of abiotic variables with best match the biotic matrix of the all semidemersal-demersal and semidemersal species and for abundance (left) and biomass (right): 1=Depth. 3=SuTSM. 4=NBTSM. 16=SspH. 24=Se1. 26=Se3. 29=Bi3. 30=Tr1. 31=Tr2. 32=Tr3. 33=Bottom type.

No.Vars	Correlation	Selections
1	0.747	1
2	0.66	1;4
2	0.657	1;33
2	0.628	1;30
2	0.622	1;31
2	0.621	1;29
3	0.612	1;29;33
2	0.61	1;24
2	0.607	1;3
3	0.605	1;4;33

No.Vars	Correlation	Selections
1	0.609	1
2	0.554	1;31
2	0.545	1;4
2	0.542	1;30
2	0.526	1;29
2	0.523	1;16
2	0.523	1;32
2	0.52	1;26
2	0.518	1;24
3	0.512	1;4;30

Tab. 3.18: Results of BIOENV analysis showing the number of abiotic variables witch best match the biotic matrix of the semidemersal species and for abundance (left) and biomass (right): 1=Depth. 3=SuTSM. 4=NBTSM. 16=SspH. 24=Se1. 26=Se3. 29=Bi3. 30=Tr1. 31=Tr2. 32=Tr3. 33=Bottom type.

No.Vars	Correlation	Selections
1	0.733	1
2	0.661	1;33
2	0.648	1;4
2	0.622	1;30
3	0.612	1;29;33
3	0.609	1;4;33
2	0.605	1;29
2	0.605	1;31
2	0.604	1;24
3	0.598	1;24;33

No.Vars	Correlation	Selections
1	0.591	1
2	0.538	1;30
2	0.534	1;31
2	0.532	1;4
2	0.524	1;29
2	0.523	1;24
2	0.52	1;33
3	0.515	1;4;30
2	0.513	1;32
2	0.513	1;26

3.3.2. Canonical analysis

The ordination diagrams CCA reveal the general relationship between faunal distribution and the set of environmental variables sampled in the study area.

Considering the CCA results for abundance values of the all semidemersal-demersal and semidemersal fishes. all four canonical axes together explained 47.8% of the variability and the first axes contributed 23.9%. Depth and bottom type explained the 35.8% in the total variation by a strong correlation with the first and the second axes respectively (Tab. 3.19). The rest of the variability associated with the fish assemblages was explained by STSM. NBS. NBChl and pH values on the third axes and by Secchi depth. oxygen and temperature values on the fourth axes. Sampling stations distribution in the diagrams reflects the depth gradient. The shallower depth stations. in the upper left part of the plot. were correlated with zooplankton (0.063 mm in particular) and near bottom Chlorophyll. The deepest stations were collocated in the lower part. with 200 m samples slightly correlated with

Secchi depth. SSS and SuS. The stations at 300 m form a separate group to the upper right part (Fig. 3.14). The validity of significance of both first canonical axis (F=4.390. p=0.0020) and all the axes (F=1.700. p=0.0020) was proved by the Monte Carlo test. Canonical analysis performed on biomass values for the all species reveals a similar correlation of the environmental parameters with the axes. All four axes explained 49.4% of the variability (F=2.044. p=0.0020) and the first contributed 24.2% (F=7.648. p=0.002) (Fig. 3.16; Tab. 3.21)

In the CCA plot performed on abundance values of semidemersal species all four axes explained 46.1% of the total variation with a contribution of the first axes of 19.9%. Depth and bottom type explained 31% of the variability on the first two axes. lower value compared to the total community. Oxygen. salinity and chlorophyll parameters were related to the third axes (Tab. 3.20). The validity of significance of both first canonical axis (F=5.788. p=0.0020) and all the axes (F=1.817. p=0.0020) was proved by the Monte Carlo test.

Considering canonical analysis performed on biomass values of semidemersal fishes. all four axes together explained 49.9% of the variability (Tab. 3.22). The first axes contributed 21.2% and was strongly correlated with depth as for the previous cases. The second axes (33.2%) had the strongest correlation with bottom type and a weaker correlation with zooplankton (0.063 mm). Looking at the sampling stations distribution on the plot (Fig. 3.17). the deepest stations (100-200 m) overlap. correlated with Secchi depth. SSS and SSuS. A more separate group of 10 m stations collocates in the upper part. The validity of significance of both first canonical axis (F=6.252. p=0.0020) and all the axes (F=1.850. p=0.0020) was proved by the Monte Carlo test.

Figure 3.14. Biplot of CCA (Plane 1-2) performed on log-transformed ($log_{10}(N+1)$) density values (N) of the all semidemersal-demersal and semidemersal fishes and environmental variables (arrows) at depth samples) on three transects (T1. T2. and T3) in four sampling months (May. August. October and February). Arrows refer to the direction and relative importance of environmental variables (see Table 2.1 for abbreviations of the parameters) in the ordination.

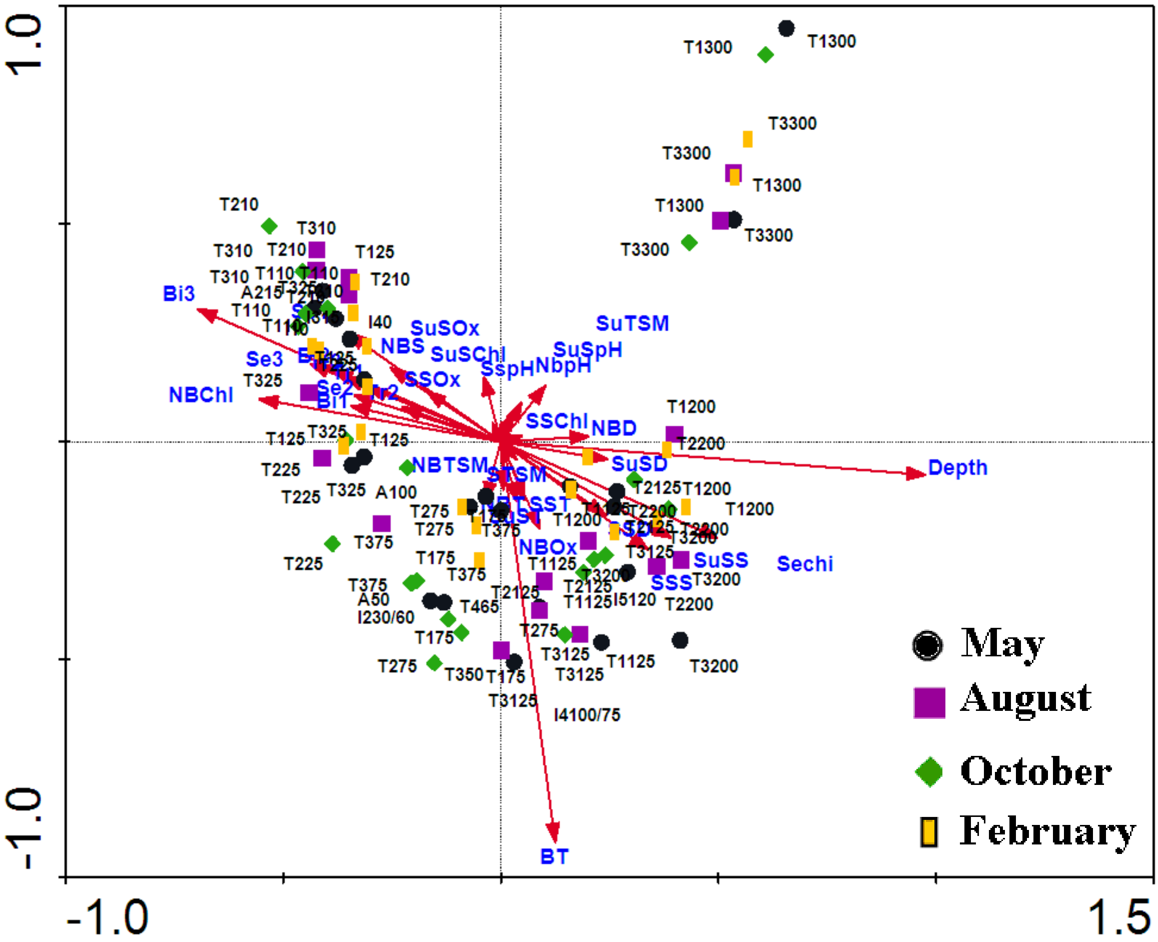


Table 3.19. Summary of statistical measures of the all semidemersal-demersal and semidemersal fish species characteristics and environmental variables for CCA (see Table 2.1 for abbreviations of the parameters).

Environmental variables	Species Axis 1	Species Axis 2	Species Axis 3	Species Axis 4
Depth	**0.962**	-0.070	-0.040	0.016
STSM	0.036	-0.038	**0.197**	0.070
SuTSM	0.101	0.118	-0.031	-0.115
NBTSM	-0.035	-0.124	0.027	-0.065
Sechi	0.491	-0.203	-0.004	**0.324**
SSOx	-0.168	0.106	0.026	**-0.442**
SuSOx	-0.038	0.137	0.107	**-0.486**
NBOx	0.089	-0.184	**0.258**	**-0.368**
SST	0.054	-0.123	-0.047	**0.398**
SuST	0.037	-0.126	-0.056	**0.405**
NBT	0.006	-0.101	-0.075	**0.396**
SSS	0.334	-0.227	-0.013	0.097
SuSS	0.386	-0.203	-0.140	0.081
NBS	-0.250	0.156	**-0.406**	-0.031
SspH	0.001	0.042	**-0.317**	0.093
SuSpH	0.048	0.082	**-0.373**	-0.139
NbpH	0.026	0.063	**-0.275**	0.126
SSD	0.238	-0.155	-0.032	-0.128
SuSD	0.242	-0.037	-0.087	**-0.276**
NBD	0.200	0.011	0.008	**-0.338**
SSChl	0.050	0.013	**0.268**	**-0.272**
SuSChl	-0.019	0.040	**0.277**	**-0.376**
NBChl	-0.547	0.090	**0.359**	**-0.190**
Se1	-0.348	0.230	-0.011	0.111
Se2	-0.332	0.098	-0.034	0.000
Se3	-0.431	0.164	0.128	0.157
Bi1	-0.340	0.076	-0.092	0.069
Bi2	-0.379	0.150	0.088	-0.029
Bi3	-0.686	0.280	0.004	**0.179**
Tr1	-0.301	0.114	0.034	0.039
Tr2	-0.224	0.072	-0.098	0.034
Tr3	-0.353	0.136	0.146	0.137
BT	0.124	**-0.844**	-0.093	0.012
Eigenvalues	0.698	0.349	0.184	0.166
Species-environment correlations	0.986	0.918	0.9	0.904
Cumulative percentage variance				
of species data	13.7	20.6	24.2	27.4
of species-environment relation	23.9	35.8	42.1	47.8

Figure 3.15. Biplot of CCA (Plane 1-2) performed on log-transformed ($\log_{10}(N+1)$) density values (N) of the all semidemersal-demersal and semidemersal fishes and environmental variables (arrows) at depth samples) on three transects (T1. T2. and T3) in four sampling months (May. August. October and February). Arrows refer to the direction and relative importance of environmental variables (see Table 2.1 for abbreviations of the parameters) in the ordination.

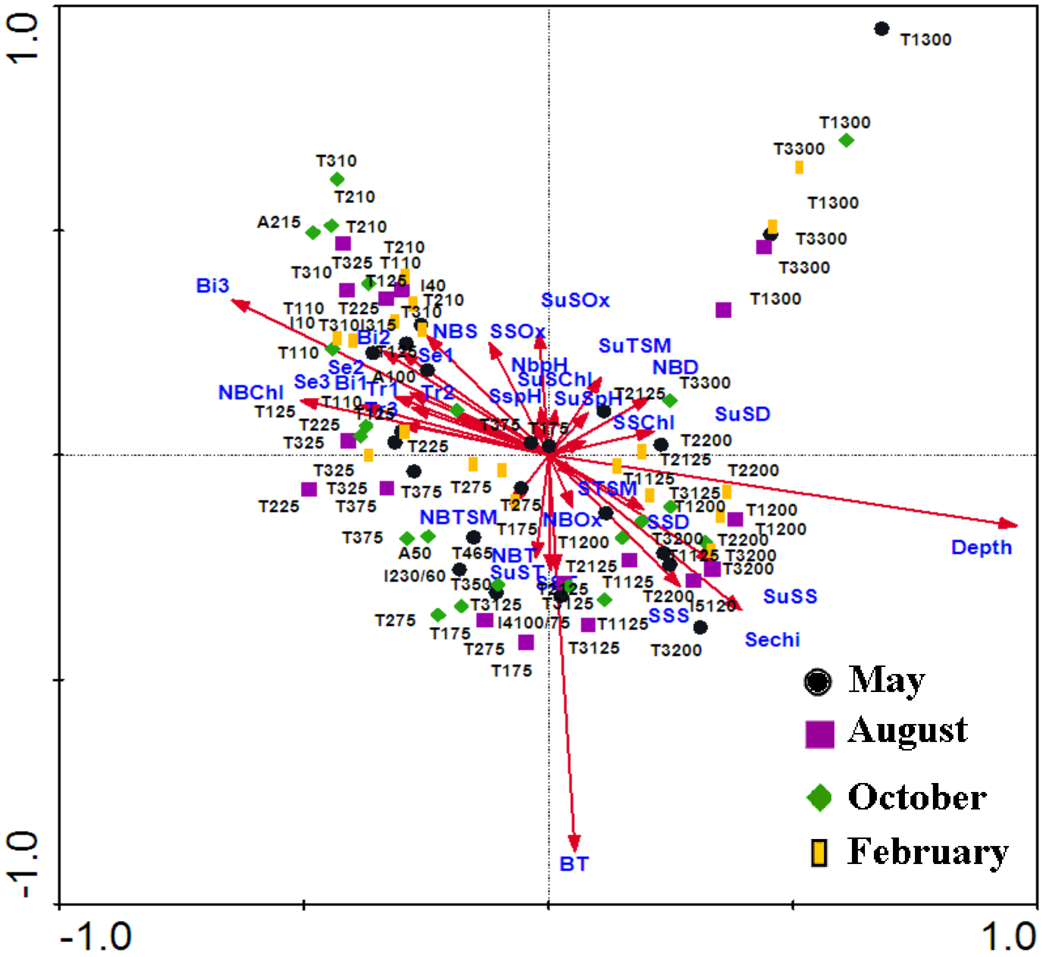


Table 3.20. Summary of statistical measures of semidemersal fish species characteristics and environmental variables for CCA (see Table 2.1 for abbreviations of the parameters).

Environmental variables	**Species Axis 1**	**Species Axis 2**	**Species Axis 3**	**Species Axis 4**
Depth	**0.927**	-0.139	0.067	-0.012
STSM	0.051	-0.041	-0.097	-0.249
SuTSM	0.105	0.153	-0.130	0.072
NBTSM	-0.075	-0.096	-0.124	0.065
Sechi	0.381	-0.305	0.176	-0.083
SSOx	-0.117	0.221	**-0.408**	0.140
SuSOx	-0.019	0.241	**-0.501**	0.106
NBOx	0.047	-0.102	**-0.495**	-0.037
SST	0.016	-0.227	**0.396**	-0.091
SuST	0.003	-0.227	**0.409**	-0.089
NBT	-0.026	-0.203	**0.418**	-0.067
SSS	0.260	-0.258	0.009	-0.113
SuSS	0.327	-0.210	0.079	-0.015
NBS	-0.242	0.235	0.141	**0.254**
SspH	-0.029	0.063	**0.294**	0.081
SuSpH	0.077	0.083	**0.254**	0.093
NbpH	-0.016	0.093	**0.309**	-0.013
SSD	0.188	-0.106	-0.191	-0.019
SuSD	0.208	0.047	**-0.280**	0.101
NBD	0.200	0.113	**-0.365**	0.051
SSChl	0.072	0.028	**-0.329**	0.086
SuSChl	0.013	0.090	**-0.427**	0.111
NBChl	-0.491	0.108	**-0.278**	-0.099
Se1	-0.292	0.203	0.051	-0.071
Se2	-0.274	0.123	-0.071	-0.034
Se3	-0.372	0.098	0.163	-0.083
Bi1	-0.304	0.116	0.100	0.103
Bi2	-0.329	0.205	-0.047	-0.199
Bi3	-0.627	0.305	0.196	-0.133
Tr1	-0.270	0.093	-0.041	-0.036
Tr2	-0.182	0.075	-0.012	0.046
Tr3	-0.292	0.062	0.145	-0.091
BT	0.052	**-0.779**	0.024	0.123
Eigenvalues	0.649	0.361	0.253	0.236
Species-environment correlations	0.969	0.883	0.902	0.826
Cumulative percentage variance				
of species data	11.4	17.7	22.2	26.3
of species-environment relation	19.9	31	38.8	46.1

Figure 3.16. Biplot of CCA (Plane 1-2) performed on log-transformed ($\log_{10}(B+1)$) biomass values (B) of the all SD and semidemersal fishes and environmental variables (arrows) at depth samples) on three transects (T1. T2. and T3) in four sampling months (May. August. October and February). Arrows refer to the direction and relative importance of environmental variables (see Appendix II for abbreviations of the parameters) in the ordination.

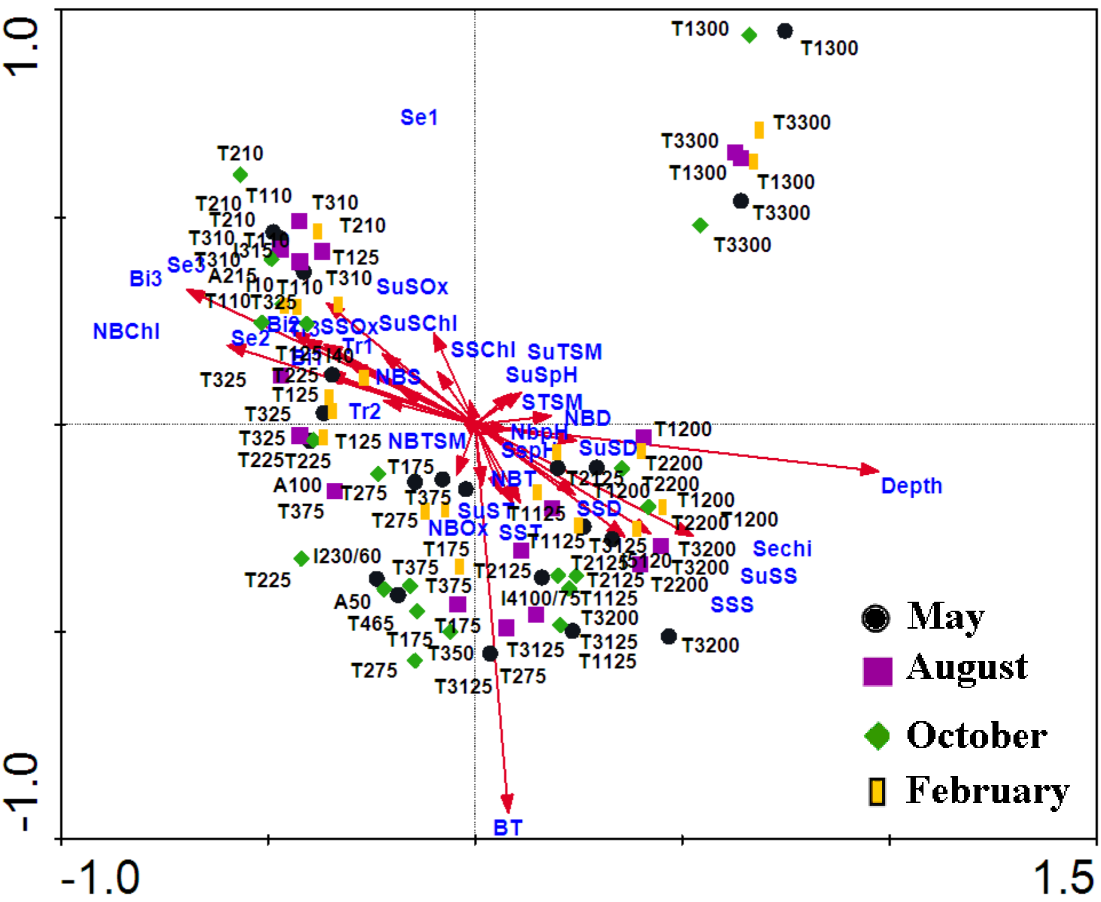


Table 3.21. Summary of statistical measures of the all semidemersal-demersal and semidemersal fish species characteristics and environmental variables for CCA (see Table 2.1 for abbreviations of the parameters).

Environmental variables	**Species Axis 1**	**Species Axis 2**	**Species Axis 3**	**Species Axis 4**
Depth	**0.962**	-0.107	-0.002	0.001
STSM	0.018	0.010	**0.269**	-0.101
SuTSM	0.110	0.073	-0.078	-0.001
NBTSM	-0.044	-0.114	0.023	-0.125
Sechi	0.520	-0.255	**-0.311**	-0.177
SSOx	-0.221	0.161	**0.312**	0.035
SuSOx	-0.099	0.209	**0.325**	-0.028
NBOx	0.017	-0.138	**0.374**	**-0.228**
SST	0.107	-0.177	**-0.283**	0.002
SuST	0.090	-0.181	**-0.284**	0.009
NBT	0.061	-0.156	**-0.297**	0.027
SSS	0.357	-0.256	-0.077	-0.043
SuSS	0.419	-0.249	-0.106	0.076
NBS	-0.174	0.074	-0.221	0.281
SspH	0.057	-0.025	**-0.343**	0.182
SuSpH	0.085	0.070	**-0.208**	**0.332**
NbpH	0.079	-0.013	**-0.324**	0.179
SSD	0.238	-0.160	0.067	0.013
SuSD	0.242	-0.037	0.119	0.093
NBD	0.181	0.020	**0.232**	0.019
SSChl	-0.013	0.054	**0.260**	-0.143
SuSChl	-0.090	0.120	**0.318**	-0.112
NBChl	-0.591	0.181	0.174	-0.219
Se1	-0.354	0.277	-0.043	-0.026
Se2	-0.358	0.117	-0.086	-0.011
Se3	-0.437	0.211	0.177	-0.043
Bi1	-0.353	0.118	-0.084	-0.003
Bi2	-0.409	0.195	0.019	-0.069
Bi3	-0.688	0.308	-0.043	0.027
Tr1	-0.302	0.140	0.020	-0.058
Tr2	-0.217	0.054	-0.116	0.073
Tr3	-0.361	0.183	0.202	-0.046
BT	0.080	**-0.886**	-0.027	-0.008
Eigenvalues	0.726	0.395	0.189	0.17
Species-environment correlations	0.988	0.945	0.867	0.887
Cumulative percentage variance				
of species data	14.5	22.4	26.2	29.6
of species-environment relation	24.2	37.4	43.7	49.4

Figure 3.17: Biplot of CCA (Plane 1-2) performed on log-transformed ($\log_{10}(B+1)$) biomass values (B) of semidemersal fishes and environmental variables (arrows) at depth samples) on three transects (T1. T2. and T3) in four sampling months (May. August. October and February). Arrows refer to the direction and relative importance of environmental variables (see Table 2.1 for abbreviations of the parameters) in the ordination.

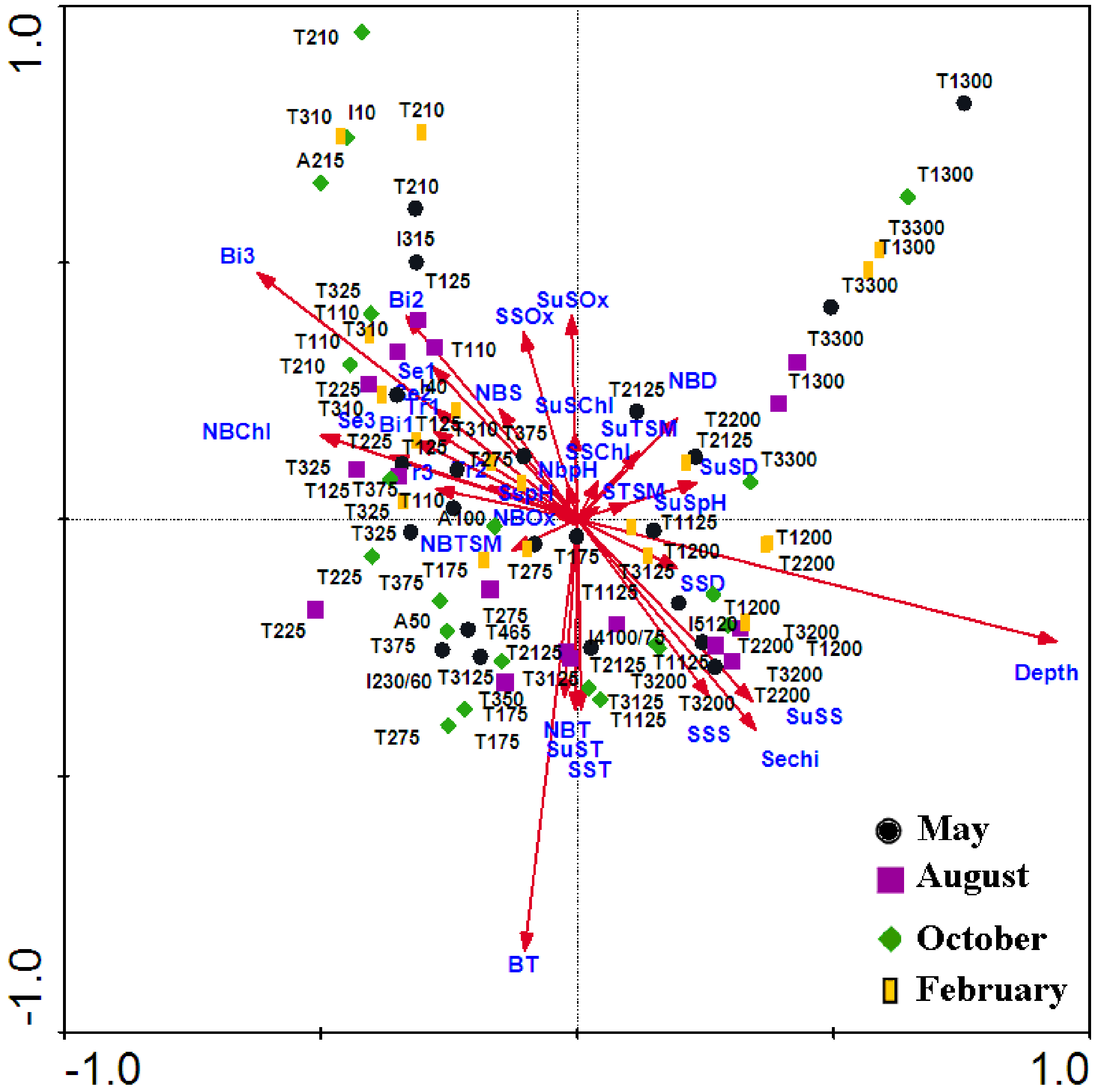


Table 3.22. Summary of statistical measures of semidemersal fish species characteristics and environmental variables for CCA (see Table 2.1 for abbreviations of the parameters).

Environmental variables	Species Axis 1	Species Axis 2	Species Axis 3	Species Axis 4
Depth	**0.9033**	-0.2153	0.0161	0.0978
STSM	0.0395	0.0213	-0.1991	0.1225
SuTSM	0.116	0.1185	-0.0501	-0.127
NBTSM	-0.1225	-0.0534	-0.1786	-0.2114
Sechi	0.3363	-0.3699	0.1104	0.0334
SSOx	-0.1016	0.3284	-0.1577	-0.0118
SuSOx	-0.0111	0.3577	-0.2221	-0.0414
NBOx	-0.0365	0.0037	-0.**4396**	0.0366
SST	0.0077	-0.3341	0.143	0.0128
SuST	-0.0041	-0.3351	0.1542	0.0181
NBT	-0.0242	-0.313	0.1749	0.0073
SSS	0.2475	-0.3113	-0.0689	0.1497
SuSS	0.3297	-0.3194	0.0135	0.1061
NBS	-0.1474	0.1941	**0.3375**	0.0343
SspH	-0.039	0.0174	**0.3425**	0.1657
SuSpH	0.096	0.0274	0.2603	**0.3151**
NbpH	-0.0168	0.0597	0.2863	**0.2688**
SSD	0.187	-0.0863	-0.1041	0.1435
SuSD	0.2251	0.0647	-0.0941	0.0546
NBD	0.1883	0.1766	-0.1434	0.0484
SSChl	0.0391	0.0666	-0.2416	**-0.3108**
SuSChl	-0.0052	0.1524	-0.2514	**-0.3343**
NBChl	-0.4826	0.1476	-0.2323	-0.2111
Se1	-0.2719	0.268	0.0089	0.0268
Se2	-0.2689	0.1942	-0.0403	0.0278
Se3	-0.3523	0.1115	0.1374	-0.0263
Bi1	-0.3035	0.1376	0.1252	-0.0795
Bi2	-0.3226	0.3569	-0.0852	**0.3624**
Bi3	-0.6026	**0.4335**	0.1978	0.2289
Tr1	-0.2703	0.1549	-0.0943	-0.0912
Tr2	-0.1651	0.0579	0.0822	-0.164
Tr3	-0.2664	0.0538	0.1137	-0.0427
BT	-0.099	**-0.759**	-0.0267	0.1109
Eigenvalues	0.677	0.385	0.296	0.235
Species-environment correlations	0.967	0.902	0.889	0.836
Cumulative percentage variance				
of species data	12.2	19.1	24.5	28.7
of species-environment relation	21.2	33.2	42.5	49.9

4. DISCUSSION

Abundance and biomass data from an annual survey of coastal marine fishes captured on the shelf of Antalya gulf revealed significant differences in semidemersal fish assemblages based on depth. different sampling areas. and seasons. These patterns were mirrored by changes in various oceanographic and geographic variables collected along with the fish samples. indicating that the fish communities were responding to seasonal and relatively small-scale spatial variability in environment.

Multivariate ordination placed samples with similar fish communities in arrangements that correspond mostly with the bathymetric gradient. Two groups were identified: a well-defined association formed by depth strata ranging from 125 to 200 m and another constituted by the shallower ones. slightly more dispersed among the 10 - 25 m and the 75 m in depth. Heterogeneity in communities was due primarily to difference in occurrence of a set of common species. most of which were regularly caught with different abundance in both transect and during both months of the study. Thus community patterns were not driven by sudden turnover of dominant taxa across different sampling areas or between seasons. but rather by gradients in local abundance along the depth. This spatial distribution was also confirmed by SIMPER routine. The dominant species *Spicara smaris* and *Upeneus moluccensis* occurred. with different abundance. at all depths. At 10 m depth a few species with low abundance were present: *Upeneus pori. Fistularia commersoni. Lithognatus Mormyrus. Equulites Klunzingeri. Spicara smaris* were the most important in contribution. At 25 m species richness increased: the previous species were still present. with a lower contribution. and new dominant ones were added (*Saurida Undosquamis. Nemipterus Randalli. Epinephelus Aeneus. Upeneus moluccensis and Diplodus annularis).* At 75 m species richness decreased again. some of the previous species disappeared and were replaced only by a few others. *Spicara smaris. Saurida undosquamis* and *Upeneus moluccensis* were found in order of importance. At the deeper stations the catches changed in quality and in quantity: some species were still shared with the shallower stations and the new ones had high abundance and biomass. *Macroramphosus scolopax. Upeneus moluccensis. Dentex maroccanus. Pagellus acarne. Spicara smaris. Merluccius merluccius* were the main species caught in order of importance at 100 m. At the deepest stations (125 – 200 m) the contribution of this species slightly decreased and *Argentina sphyraena. Glossanodon leioglossus. Capros aper* occurred more frequently.

Comparing the distribution of semidemersal fish assemblages and of the whole fish community (semidemersal-demersal. semidemersal and pelagic fish) an important difference can be found in regard to the term transect. PERMANOVA tests showed that the distribution of semidemersal fishes doesn't change significantly over the different sampling areas while considering the whole community this factor is significant. In particular Pairwise comparisons showed that the first transect (collocated in the area opened to fisheries activities) was significantly different from the second one (AREA). In general biomass and abundance seemed gradually increased going from the first to the third transect. with the second one in an intermediate position.

Anyway it is necessary to take into account the relation with the environmental variables. As expected. both the BIO-ENV and CCA analysis showed that the strongest correlation existed between the fish assemblages and the depth. The second most important factor affecting the distribution and diversity of the community was the bottom type. The different assemblages identified through SIMPER analysis strongly reflected the qualitative structure of the seabed. Fish assemblages of the shallower stations were sampled over a sandy/coarse muddy sand ground. Over 75 m there was an abrupt change and the fishes caught at 125 - 200 m inhabit a bottom mostly muddy. occasionally interrupted by fine sandy mud. Moreover it is important to note that the eastern part of the study area has a great heterogeneity: the second and the third transects in their shallower part presented a patchy ground. alternating sand and rocks covered by *Posidonia.* These plants provide food and shelter to several species and to a high number of juveniles (Hemminga and Duarte. 2000). The shallower stations near the coast are also directly exposed to fresh water supply.

particularly important in providing nutrients and thus in regulating the food chain especially in an oligotrophic sea. Indeed during spring. when the riverine input was greater. the lowest salinity values were recorded. together with higher chlorophyll-a concentration. Notably the lowest salinity values were recorded along the third transect. where a river flows.

BIO-ENV analysis revealed that the community depended not only on the bottom type but also on the availability of total suspended matter and zooplankton. Seston. bioseston. tripton and total suspended matter. maybe due to nutrient supplies from the inland. were found in higher concentration near the coast and CCA showed the correlation of these variables with the fish assemblages present at the shallower stations. Zooplankton is the most important food item of semidemersal fishes and both these analyses showed a stronger correlation of the smaller fraction of bioseston with the semidemersal species in comparison to the whole community. It is important to note that the biomass of semidemersal species is more related to zooplankton than abundance. Biomass of these fishes was found significantly different over the transects. with the highest values in the third one and zooplankton was also found in greater concentration in the same area.

Considering the strong correlation between the fish assemblages and the environmental characteristics. it's likely to assume that the changing distribution of semidemersal species and of the whole community over the transects is not due to a different fishery pressure but to the use of ecosystem's resources in a different way. It must be emphasized that a few studies have analyzed the biology and distribution of fish species on the shelf of Antalya gulf and time-series data are not available to detect a trend in catches and then to evaluate the possible level of overexploitation.

Analysis of target species in this study can't define exactly the state of exploitation of the stocks but give an indicative image of population compositions. *Spicara smaris*. as mentioned above. is a constant species in the habitat. with the greatest abundance between 75 and 125 m. Sex ratio was strongly shifted in favour of females and this was due to the fact that this species exhibits a *proteroginic* sexual behaviour and the most of the individuals were caught under the size of sexual inversion at 11.5 cm mean TL (+2). The last cohort (+6) was composed by a low number of males. The low presence of larger individuals and the modification of sex ratio are usually a signal of overexploitation with the alteration of the reproductive potential. especially for hermaphrodite species (Hamilton et al.. 2007). *Pagellus acarne* population showed a similar trend. This species is a *proterandric* hermaphrodite and the sex-ratio was in strong favor of males. with abundant small individuals of 10.6 cm TL (1+).

For *Saurida undosquamis* the situation was different: this species had a sex ratio shifted in favor of females but the length frequencies were more evenly distributed among the different cohorts. The common total length for these fishes ranges from 20 to 30 cm and individuals larger than 30 cm TL were caught. Indeed. as previously introduced. this invasive species is a successful alien species invader become a common sight in Turkish catches. The native confamiliar *Synodus saurus* was classified as a rare species in this study with a Dominance value of 20.25% and a Frequency of Occurrence of 1.82%.

The IUCN Red List of Threatened Species (www.iucnredlist.org) denotes that there are no major threats known for *Spicara smaris* but that the invasive fish *Fistularia commersonii*. which was found to prey on this species in the eastern Mediterranean. may constitute an upcoming threat since this fish is a successful colonizer of the Levantine Sea. In our study *F. commersonii* was found as one of the higher contributor for the shallower stations. Here *Spicara smaris* was less abundant probably limited by the presence of this species. Instead at intermediate stations the picarel was found dominant together with *Saurida undosquamis.* These semidemersal species could share the same habitat without competition because they have different food items: the picarel feeds on larvae and zooplankton (Karachle et al.. 2014) while the lizardfish preys are mainly anchovy (Golani 1993). Thus a decrease in abundance of this species in the study area could be due primarily to the presence of an active predator in addition to an eventual fish overexploitation. Moreover *Spicara smaris* is preyed both by larger native demersal/benthopelagic (e.g. *Conger conger. Merluccius merluccius*. *Muraena helena. Phycis phycis. Scorpaena scrofa*. *Uranoscopus scaber*. *Zeus faber*) and pelagic fishes (*Sarda sarda)* (Özbilgin et al.. 2007). Thus. given its relatively high abundance in Turkish waters. a depletion of this species in the habitat could modify the flux of energy from low to high trophic levels of the Levantine benthic and pelagic food webs.

5. CONCLUSIONS

In this study we provide a baseline data on semidemersal fish abundance in a highly heterogeneous and yet less studied portion of the shelf of Antalya gulf. This analysis reveals that the spatial distribution of fish assemblages is strongly dependent on the environmental characteristics. Seasonal changes are certainly important to ensure the basic processes on which the life cycle of these fishes depends. however species composition of semidemersal fishes remains constant overall the year. First of all species distribute according to the depth gradient and to the seabed structure. Ecological processes of the communities are then finer regulated by food availability and physical-chemical characteristics of the water column.

For a better comprehension of these processes. it would be interesting to investigate in future studies how other environmental parameters like nutrient level concentrations or photosynthetically active radiation could affect the ecology of the semidemersal assemblages.

Finally fishes seem to respond mostly to small scale changes in habitat gradient rather than to fishery pressure. Hence the importance of taking into account the ecological functions that structure these fish communities in order to evaluate the effects of future perturbations such as climate-induced oceanographic changes. variation in fishing pressure. enrichment of nutrients in an area increasingly subject to anthropogenic stress or establishment of new invasive species. In this framework single-species management strategies do not fully incorporate ecological interactions and environmental factors. Therefore an ecosystem based management is necessary to evaluate the effects of future perturbations. First of all it requires a more holistic approach. with a comprehensive understanding of the fundamental physical and biological dynamics and how they respond to human-induced changes. Secondly. it is fundamental the development of governance systems which have ecosystem health and sustainability. rather than short-term economic gain. as their primary goals (Large et al.. 2013; Link. 2002).

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