MARINE LIVING RESOURCES – WITH SPECIAL EMPHASIS ON THE ADRIATIC SEA

Jakov Dulčić

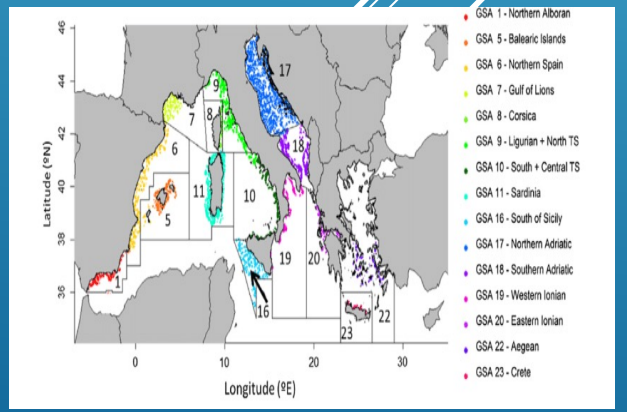
Institute of Oceanography and Fisheries, Split, CROATIA

The Northern and Central Adriatic (Geographical sub area - GSA 17) is one of the largest and best defined areas of occurrence of demersal and small pelagic shared stocks in the Mediterranean

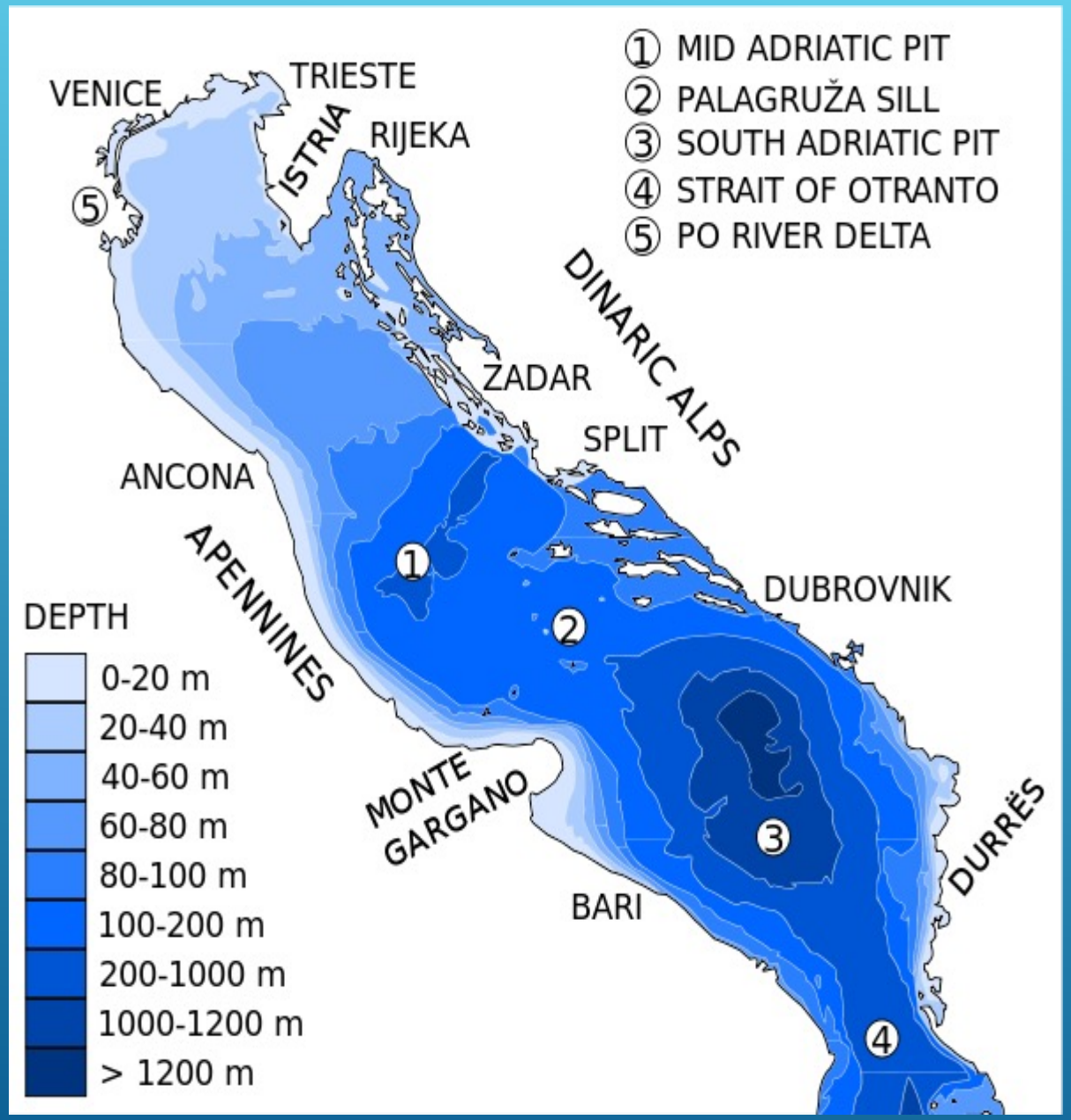
In this area bottom trawl fishing is a well-developed acivity since the beginning of 20th century along the whole basin.

Demersal resources are expolited by Italian, Croatian and Slovenian fishing fleets which often operate on the same stocks and fishing grounds.

It is a semi closed elongated basin of the Central Mediterrannean, and because of its deep penetration into mainland and shallowness it may be described as a continental sea. It extends about 800 km from NW to SE between 40 and 46 N of latitude and between 12 and 20 E of longitude.



For the purpose of fisheries management the fisheries of the Adriatic basin are divided in two Geographical Sub-Areas (GSA): the GSA 17 (North and Central Adriatic) and the GSA 18 (Southern Adriatic). Croatia, Bosnia-Herzegovina, Italy and Slovenia border the GSA 17 (North and Central Adriatic), Albania, Italy (South-Eastern coast) and Montenegro are included in the GSA 18



-The Adriatic – shallow sea – estimated mean depth 252 m

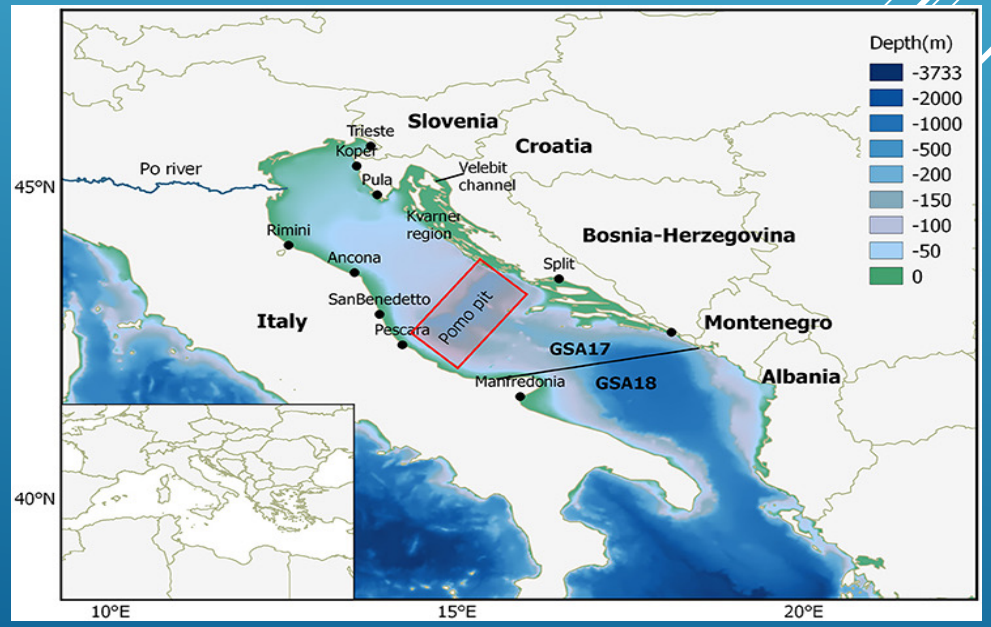
-About 74% of the bottom is less than 200 m deep

-Depth gradually increases from north to south

N and C Adriatic – characterised by an extended continental shelf, N part has shallow wates and depth that gently decreases southwards reaching 70 m at max depth

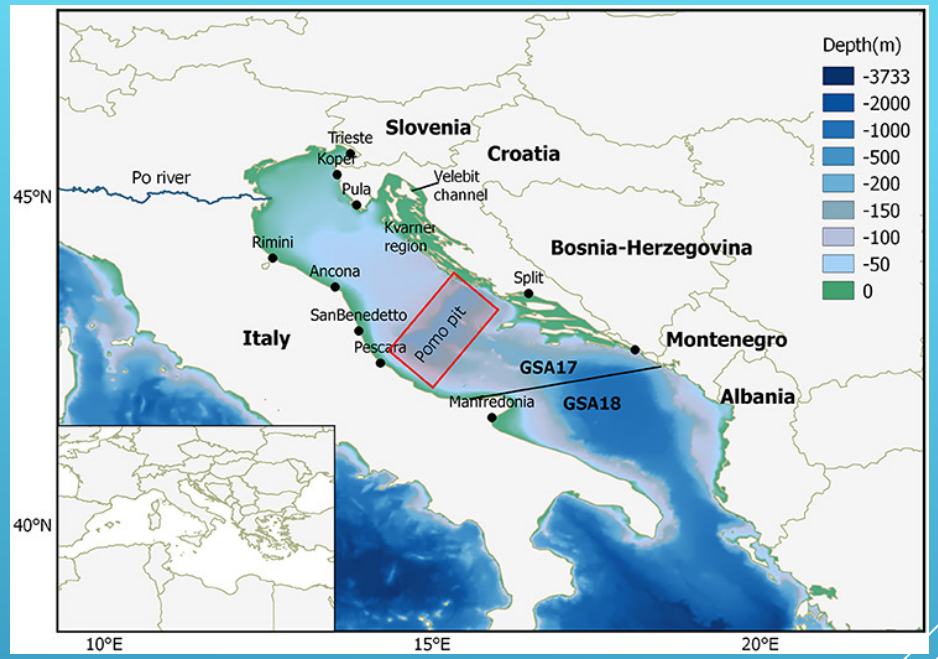
-Central part of basin reaches max depth in the Jabuka pit – 273 m

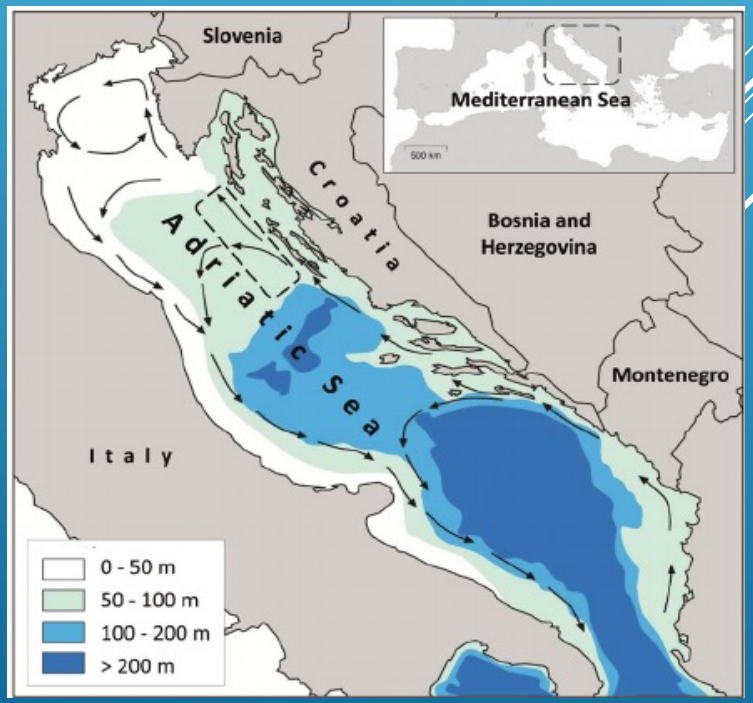
-In the southern part of GSA 17 Adriatic sea is deeper than 200 m, the maximum depth of 1223 m

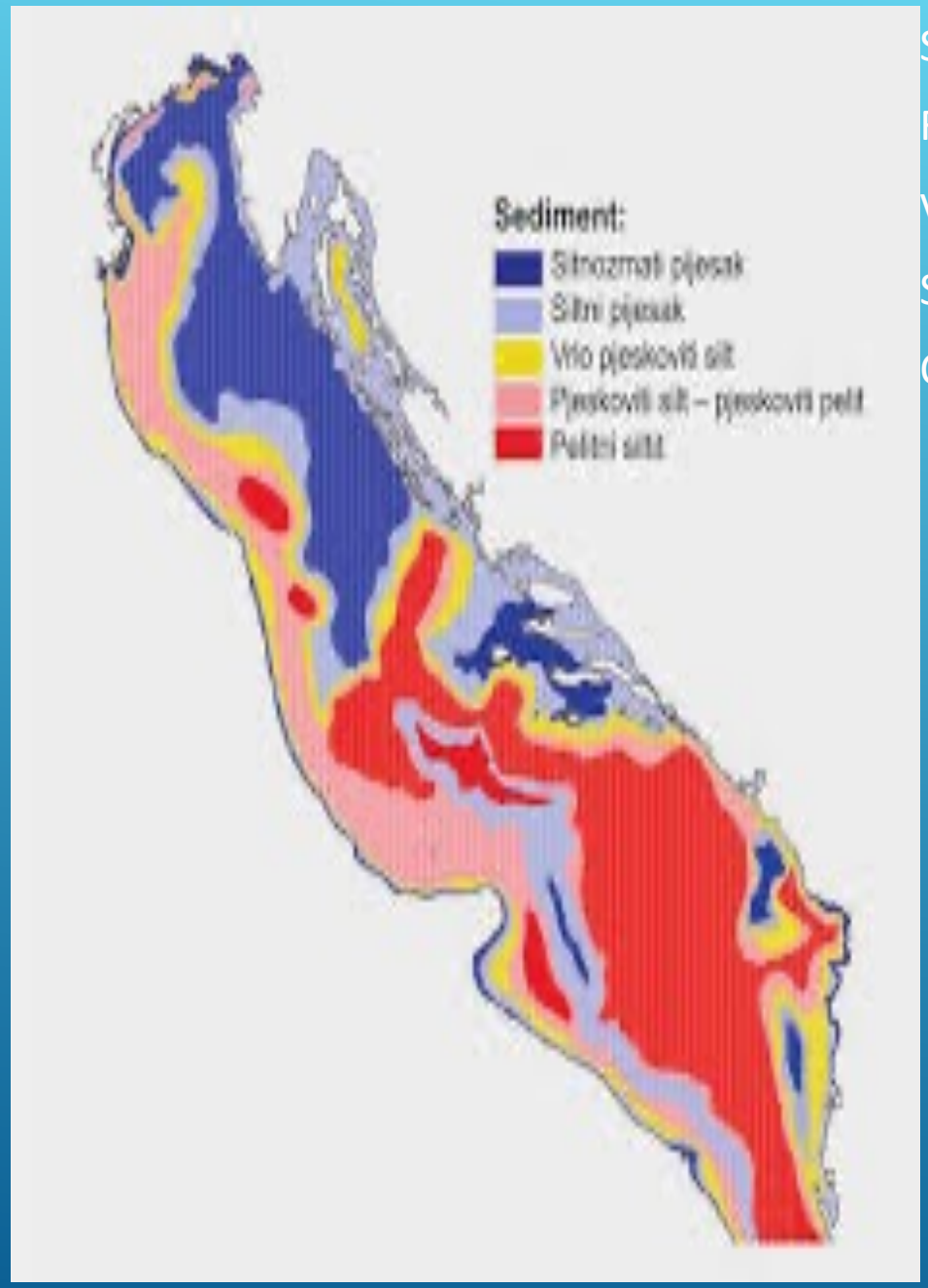


The Adriatic Sea is part of the Mediterranean Sea, occupying only 5.5% of its surface area. This semi-enclosed sea is the northernmost part of the Mediterranean, which influences some important physical properties of the Adriatic Sea. Together with the Gulf of Lion, the Adriatic Sea is the coldest part of the Mediterranean with winter temperatures below 10 ◦C in its northern part.

The Adriatic Sea is also a shallow sea compared to the rest of the Mediterranean. Three quarters of the sea bottom, about 102,415 km2 , is less than 200 m deep. The depth gradually decreases from south to north. The Jabuka/Pomo pit (280 m) and the South Adriatic pit (1330 m) are the only areas deeper than 200 m. Therefore, most of the bottoms are on the continental shelf and a significantly smaller part is on the continental slope (>200 m deep). In the south, the Adriatic Sea is separated from the Ionian Sea by the 72 km wide Strait of Otranto.







Bottom sediments

Mostly covered with recent muddy and sandy sediments of various mineral-petrographic compositions and granulometry, whose transport highly depends on marine currents

The wide cyclonic circulation of watres favours the longitudinal dispersion of the sediments in the basincoming from coast towards offshore there is a narrow belt of coastal sand up 5-7 m depth; then a mud belt 30-40 km wide extensions south-eastward along the Italian coasts, up to reach the deeper deposits of the Southern basin.

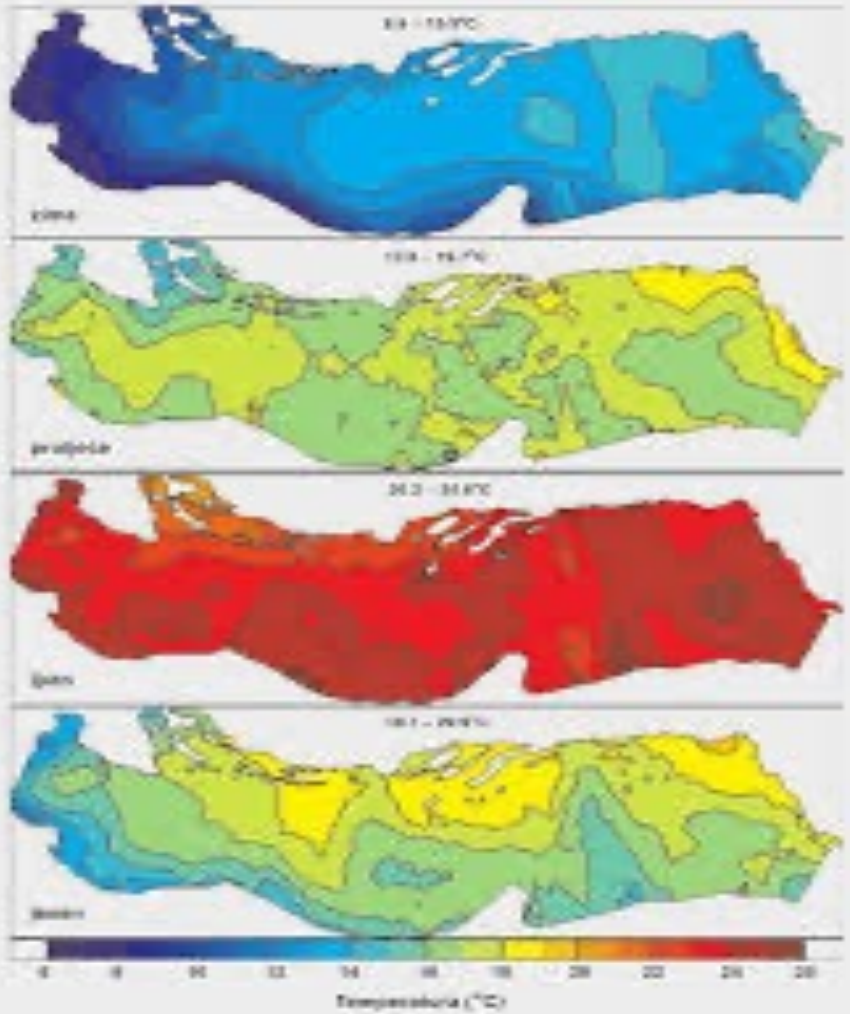
More offshore, after a transitional facies with sediments of various granulometry, there is also sand.

Mudy and sandy sediment cover almost all the channel area of the NE Adriatic

The Adriatic has an enormous variety of benthic biomes.

W side – sandy beaches and muddy offshore bottoms

E side – shows a mosaic pattern of level bottom biocenoses



Temperature

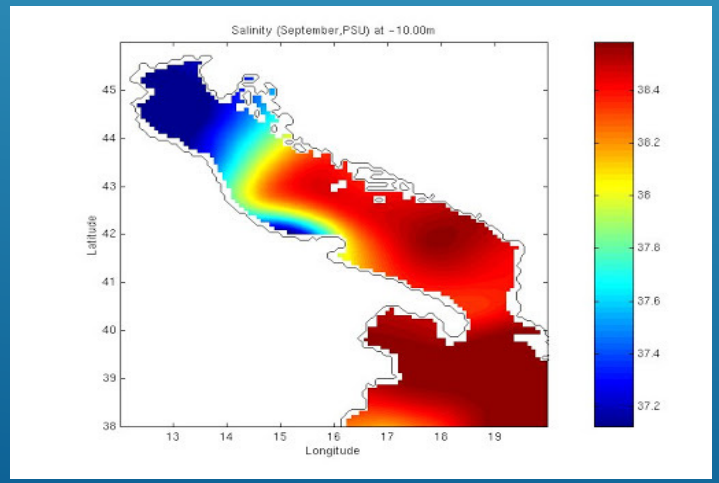
The surface waters undergo a clear seasonal cycle – max values in summer, in winter max mixed layer depth

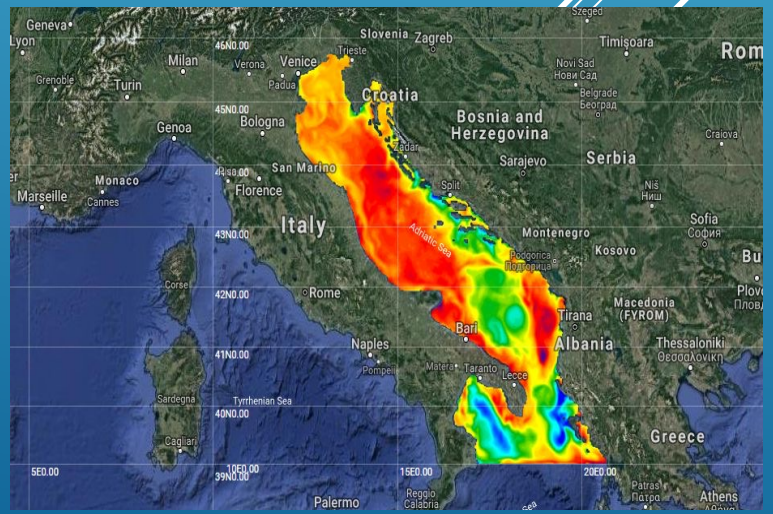
In summer – the surface temp is rather uniform over the entire Adriatic

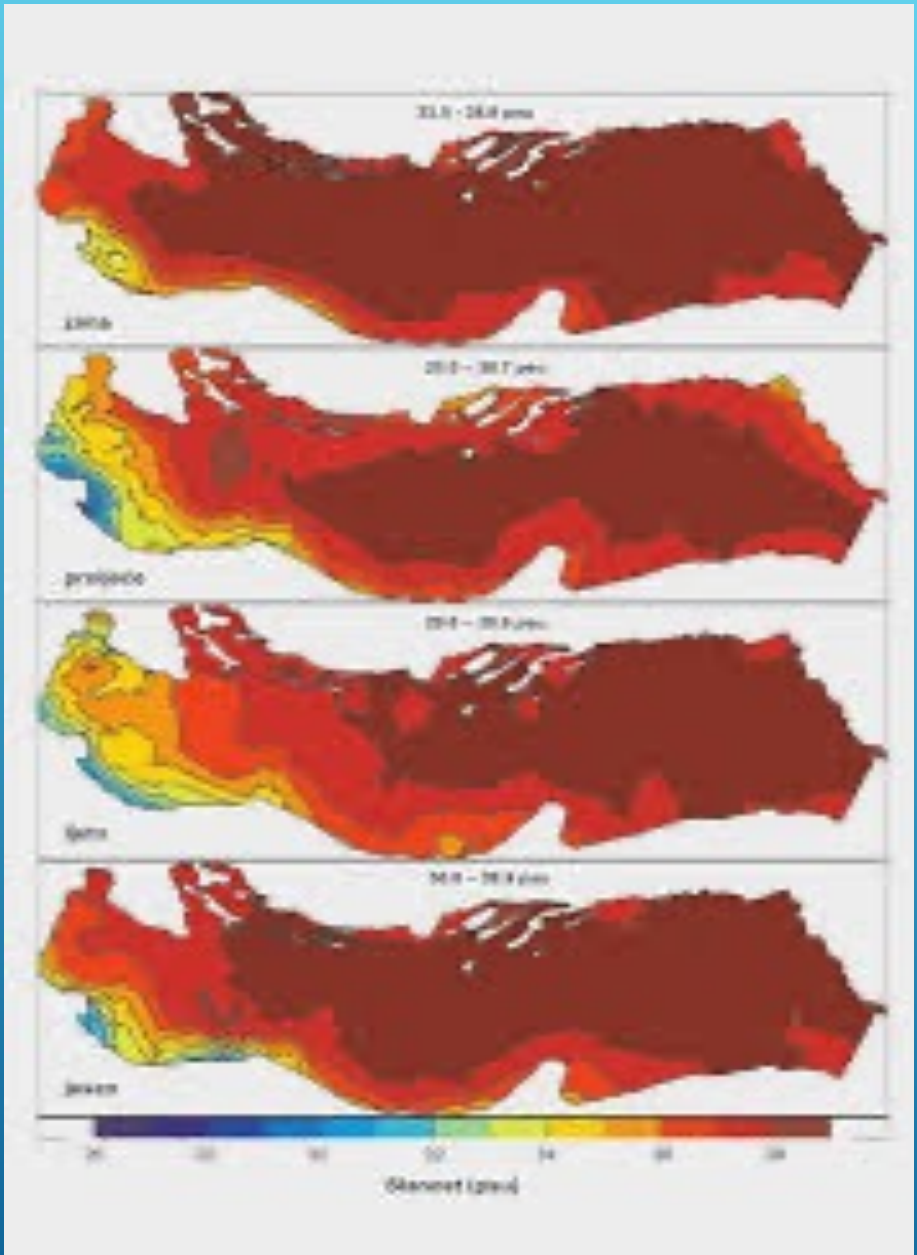
The superficial temp of the open sea waters is about 22-25^{0}C, falling to 11.5^{0}C near the bottom (in Jabuka Pit)

NA well developed thermocline is present in spring and summer down to 30 m depth, in the middle Adriatic the spring-summer thermocline is formed down to 50 m

In some parts of the western coasta and NA, where the cooling of the whole water column occurs waters can be colder than 11^{0}C

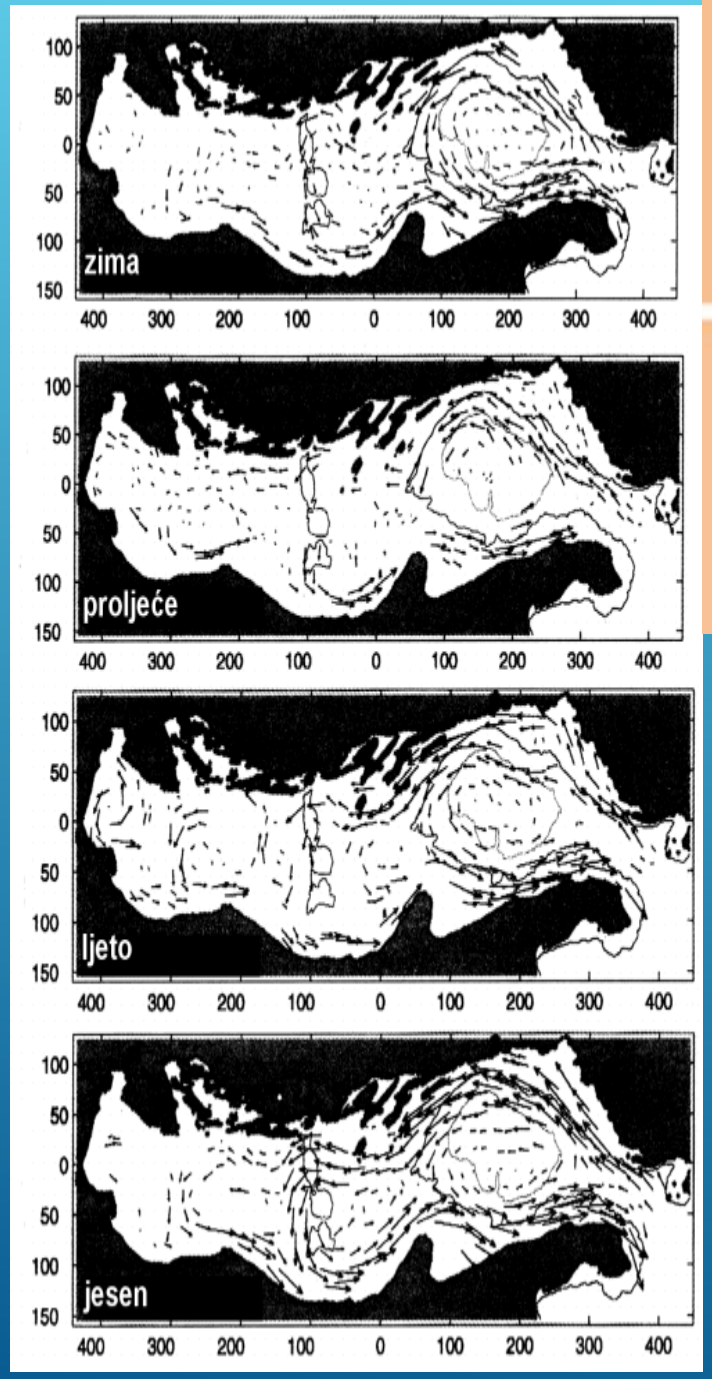


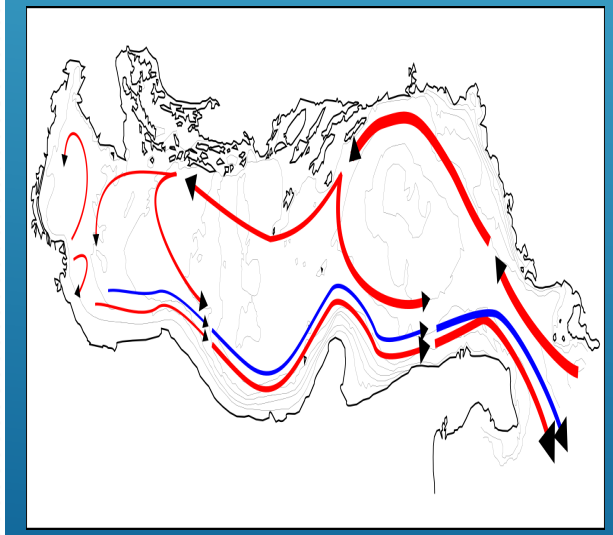




Salinity

- Quite high – an average about 38.3, which is lower than in the Eastern Medit., but higher that in western Medit. (about 37)
- Generally it decreases from south to north and from open sea to the coast.
- Salt balance of the surface layer is clearly affected by freshwater river runoff during spring/summer
- Besides the normal annual variation there are variations that last several years. It is a result of the exchange of sea water masses between Adriatic and the EastMedit sea





General water mass circulation is dominated by typical cyclonical movements: the water masses inflow through the Strait of Otranto from the EastMedit along the eastern side and outflow along the western side

General baroclinic circulation can be classified into current and gyres with seasonal strength and occurrence and change spatial scales in different seasons.

Wintertime conditions are characterized in the first 100 m of depth by a wide northwide flow field while in the other seasons coastal currents develop, particularly in autumn along the eastern coast.

Western side of the Adriatic basin is a site of intense current segments which are disconnected in the 3 sub-basins in spring and summer.

Autumn condition show san overall cyclonic circulation with the intesification of 3 cyclonic gyres in the sub-basins

BIODIVERSITY

		
> 28 000	>12 000	>800
> 660	> 340	51
~ 435	241	41

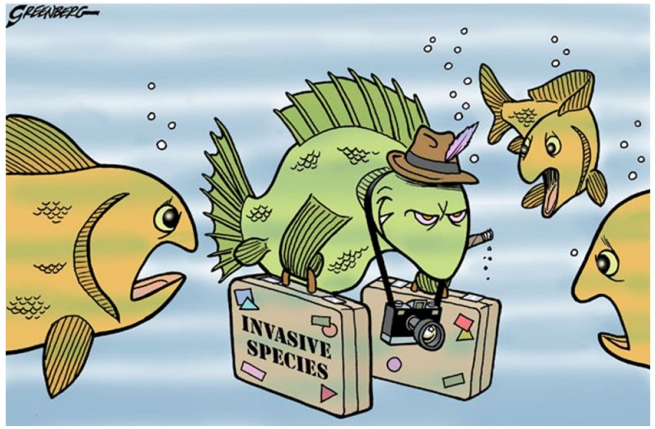
The unique nature of the Adriatic gives rise to an abundance of endemic flora and fauna. The Croatian National Biodiversity Strategy Action Plan identified more than 7,000 animal and plant species in the Adriatic Sea.

A number of rare and threatened species are also found along the Adriatic's eastern coast: it is relatively clearer and less polluted than the western Adriatic coast—in part because the sea currents flow through the Adriatic in a counterclockwise direction, thus bringing clearer waters up the eastern coast and returning increasingly polluted water down the western coast.

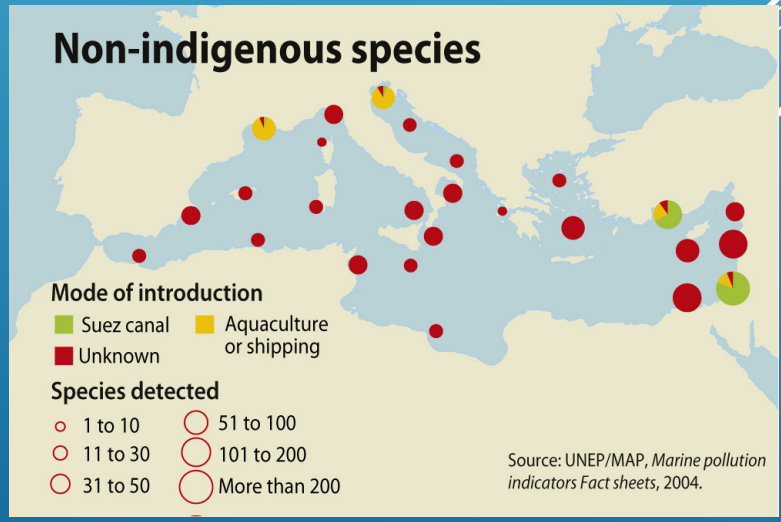
Marine biodiversity in the Adriatic is attributed to its geological history, limited by its present bathymetric, hydrographic, and climatic characteristics, and influenced by present geographical connectivity and anthropogenic processes.

These characteristics have been crucial in shaping the peculiarities of Adriatic ichthyofauna. Although the Adriatic Sea is a part of the Mediterranean, it is an independent biogeographical and ecological subunit, which is evident in the composition and properties of its biological communities.

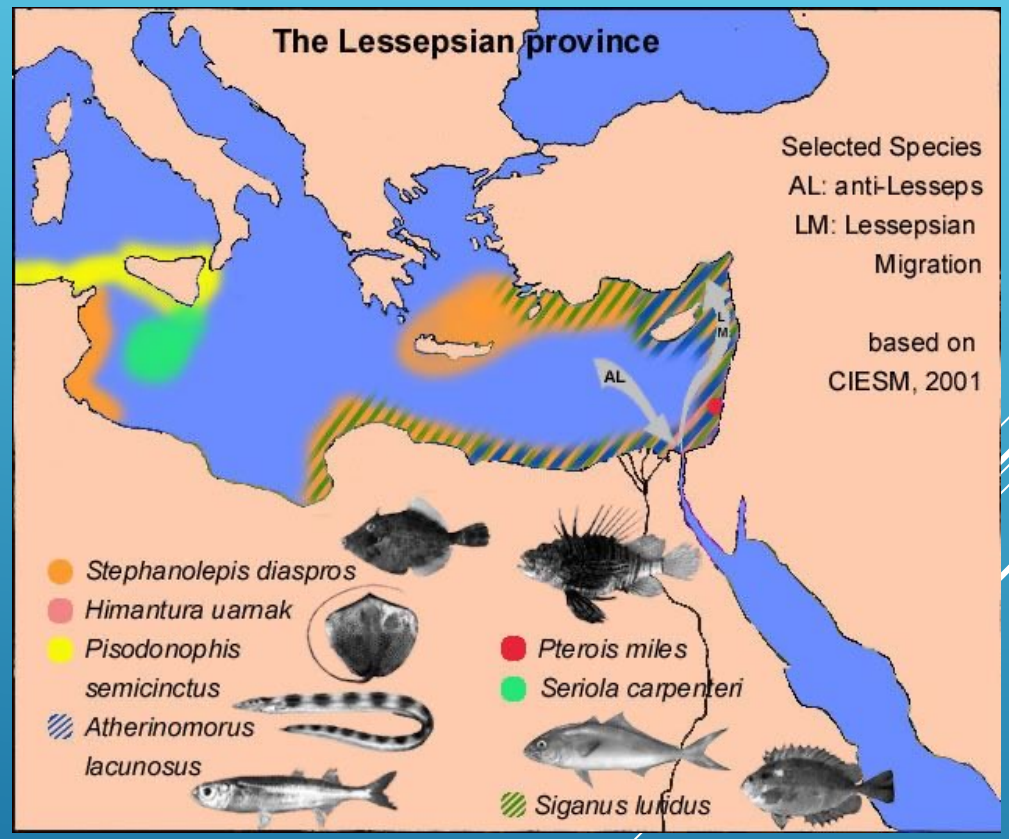
The marine biodiversity of the Mediterranean Sea is currently facing substantial changes in its flora and fauna. It is rapidly changing due to the increasing arrival of non-indigenous fishes and other taxa.



Invasive Species

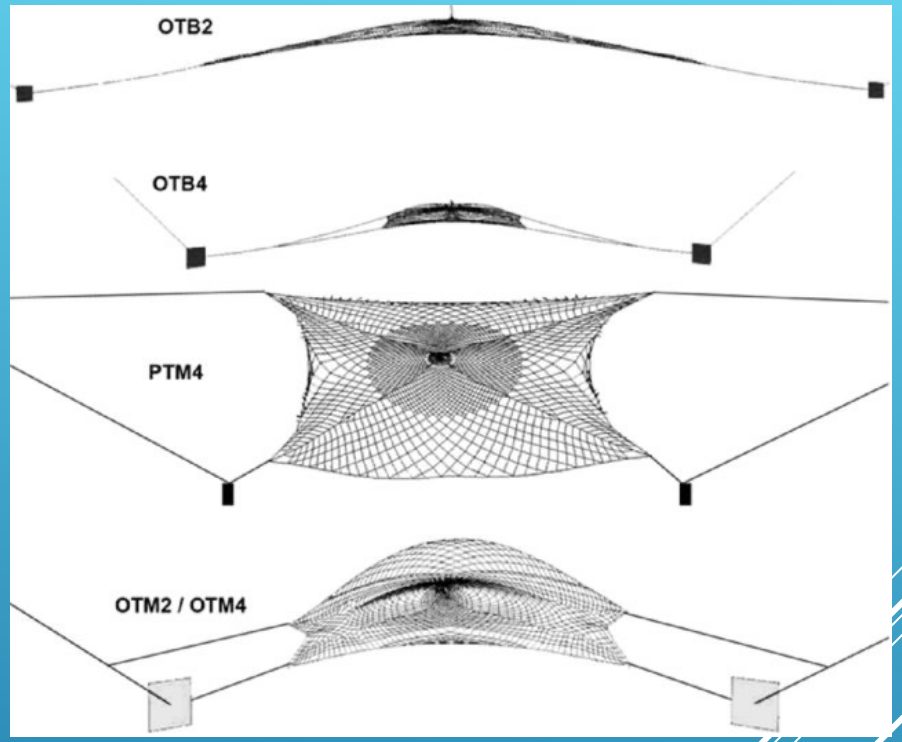


Such changes have also been recorded in the Adriatic Sea. During the last few decades, various factors including climate change, anthropogenic activity, and “Lessepsian migration” have changed the composition of Adriatic ichthyofauna. While “Lessepsian migration” is responsible for the arrival of non-indigenous species through the Suez Canal, climate change has caused northward spreading of southern, thermophilous species, a process known as meridionalisation.



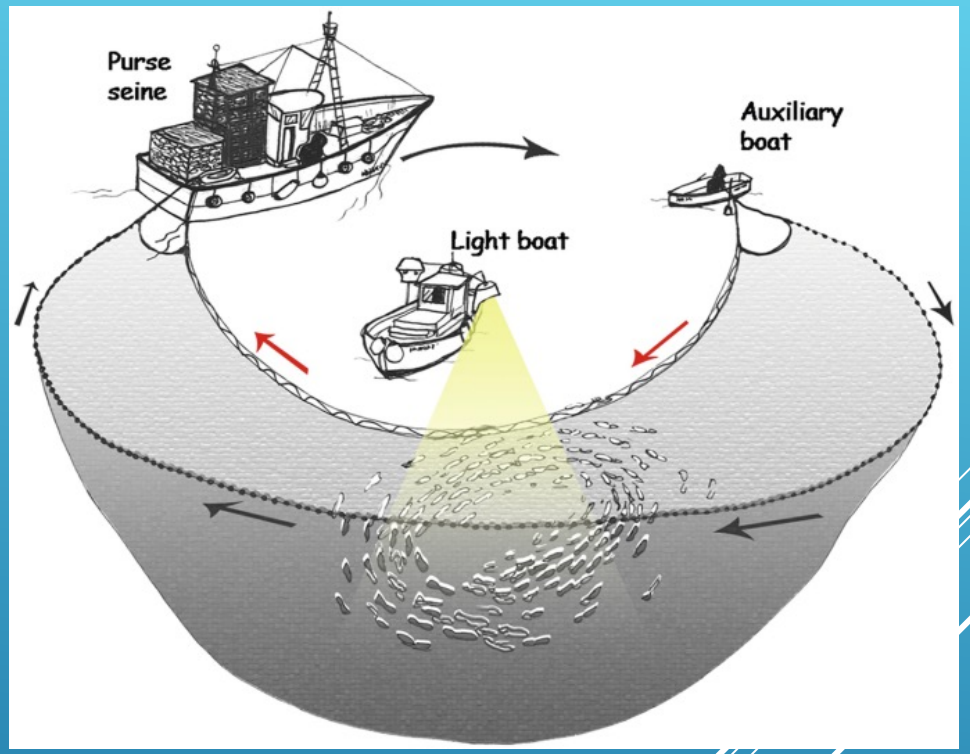
Fisheries activities conducted within the area
2.1. Fishing gears

Two kind of fishing gears are currently used to catch the small pelagic species (mainly anchovy and sardine) in the Adriatic Sea: the most used by the Italian fleet is the “volante” a mid-water pelagic trawl net towed by two vessels, mostly operated in the northern and central areas. Average size of volante vessels is 50 GRT while average engine power is about 400 HP. These vessels fish only by daytime and land their product every evening: the fishing trips last about 11-14 hours. Catches up to 15 tons per couple of boats per day have been recorded in the late seventies and early eighties and at present, maximum catches are about 4 tons per day.



Semi-pelagic 2-panel trawls (OTM2), Semi-pelagic 4-panel trawls (OTM4).

Until the mid-sixties the main gear which was used to catch small pelagic species was light attraction purse seine and is still in use in the Gulf of Trieste and south of Ancona on the Western side and it is the main gear used in Slovenia, Croatia, Montenegro and Albania. The Italian purse seine vessels have an average dimension of 85 GRT and an average engine power of 300 HP; they operate mainly in the central Adriatic and in the Gulf of Trieste; they fish by night in good weather conditions attracting fish with lights. Their activity is often, but not always, suspended during the colder months. In Croatia there is a fishing ban from 15th December till 15th January



Offshore purse-seine fishing activities concerning the bluefin tuna are a very important part of the pelagic fishery within the Adriatic Sea. In Croatia, purse seine is a principal fishing gear used for its capture. The principal fishing grounds for Croatian bluefin tuna purse-seiners are the offshore waters of the central part of the Adriatic Sea. After capture, they are transferred into floating towing cages. This is done in the open sea where the catch has occurred, by simply joining both nets under the sea surface. Once the cages are filled with the right number of tuna they are slowly towed by a tugboat towards the farming locations. The distance between the fishing ground and the farming location can vary from a few to several hundreds of miles (if the fish catch occurs outside the Adriatic Sea).

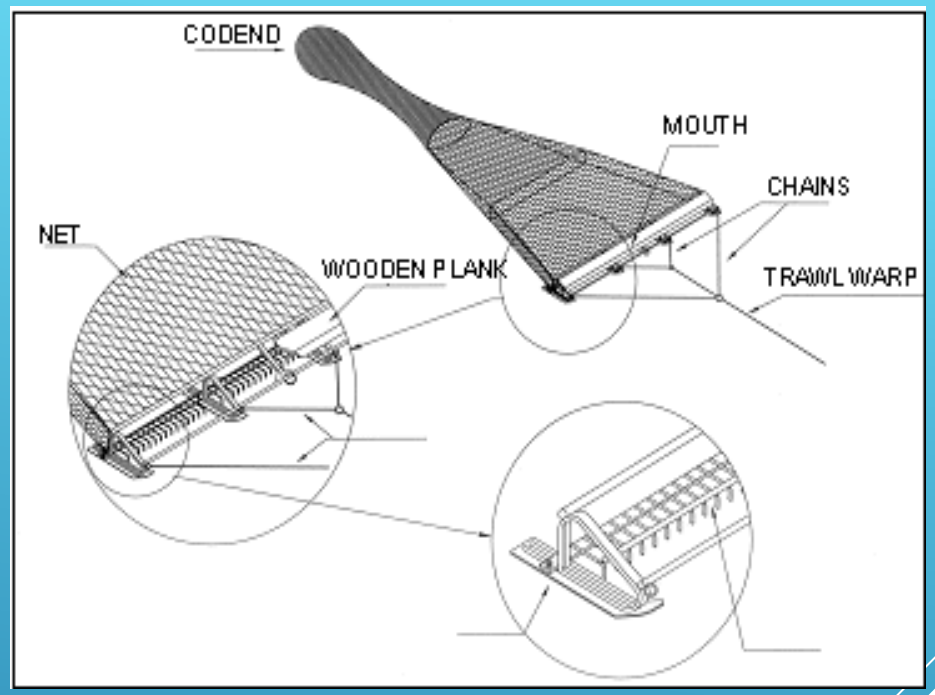
2.2. **Fishing sectors**

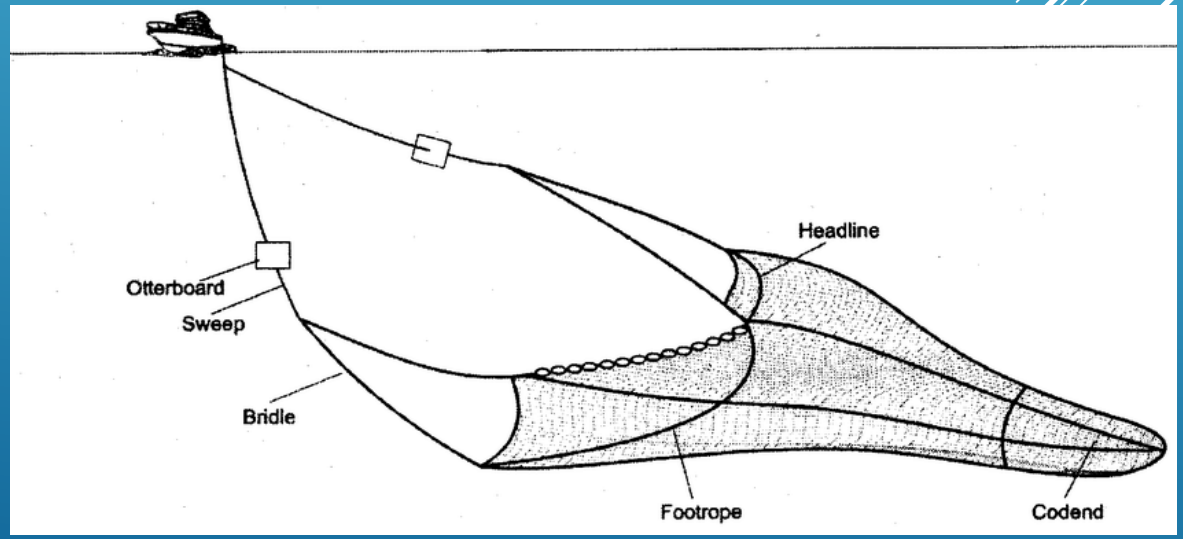
The Adriatic Sea is one of the largest areas of occurrence of demersal and small pelagic shared stocks in the Mediterranean.

The main small pelagic species are sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), horse mackerel (*Trachurus spp.*) and mackerel (*Scomber spp.*). In the northern area, sprat (*Sprattus sprattus*) is found, although it was more abundant during the 1960s and 1970s than nowadays. On the continental shelf from 10-50 m depth, the dominant fish species in terms of biomass are red mullet (*Mullus barbatus*), poor cod (*Trisopterus minutus*), various species of triglids, sole (*Solea solea*), various species of flatfishes, gobies and pandoras (*Pagellus spp.*). From 50 to 100 m deep, anglerfish (*Lophius spp.*), European hake (*Merluccius merluccius*), greater forkbeard (*Phycis blennoides*) and red bandfish (*Cepola rubescens*) are also abundant, as well as blue whiting (*Micromesistius poutassou)* at 100 to 200 m deep.

The continental shelf of the Adriatic Sea is also rich in invertebrate fauna, where some of the most abundant species are cuttlefish (*Sepia officinalis* and *S. elegans*), octopuses (*Eledone moschata, Eledone cirrhosa and Octopus vulgaris)*, squids (*Loligo vulgaris and Alloteuthis media*), mantis shrimps (*Squilla mantis),* shrimps *(Solenocera membranacea and Parapenaeus longirostris),* Norway lobster (*Nephrops norvegicus*) and scallops (*Pecten jacobaeus* and *Chlamys opercularis*).

Classical bottom trawls are used to fish demersal species like red mullets, octopus, sepias or squillas, while another bottom gear, the «rapido» is used for the demersal fishery. This gear is a dredge composed by an anterior rigid metallic framework, a wooden table acting as depressor and maintaining the mouth in close contact with the sea bottom, and a series of iron teeth that penetrate in the sediment. Rapido is used to catch flatfishes and Norway lobsters; this gear is used offshore to fish mainly clams and other mollusks. Bottom trawls and Rapido trawls induce severe sub-lethal and lethal damages on non-target species. Along the Croatian coast bottom trawl fisheries is mainly regulated by spatial and temporal fisheries regulation measures and about 1/3 of territorial sea is closed for bottom trawl fisheries over whole year. Also bottom trawl fishery is closed half year in the majority of the inner sea. In Croatia rapido trawl is allowed only to catch mollusks (Pectinidae).

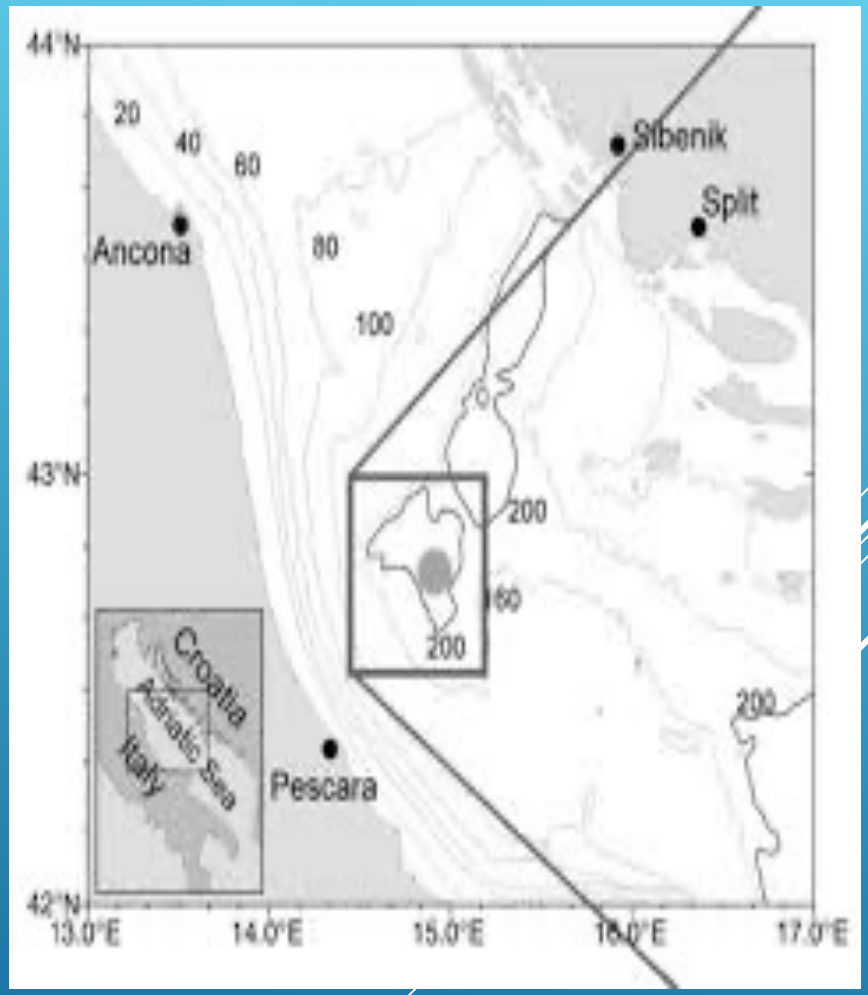




Evidence of the transboundary and straddling nature of some important resources may be drawn from the geographical occurrence pattern of several stocks which are high-value stocks targeted by the Adriatic demersal fishery. In fact beyond the 12 miles zone all the resources are potentially shared among the national fleets that operate in international sea.

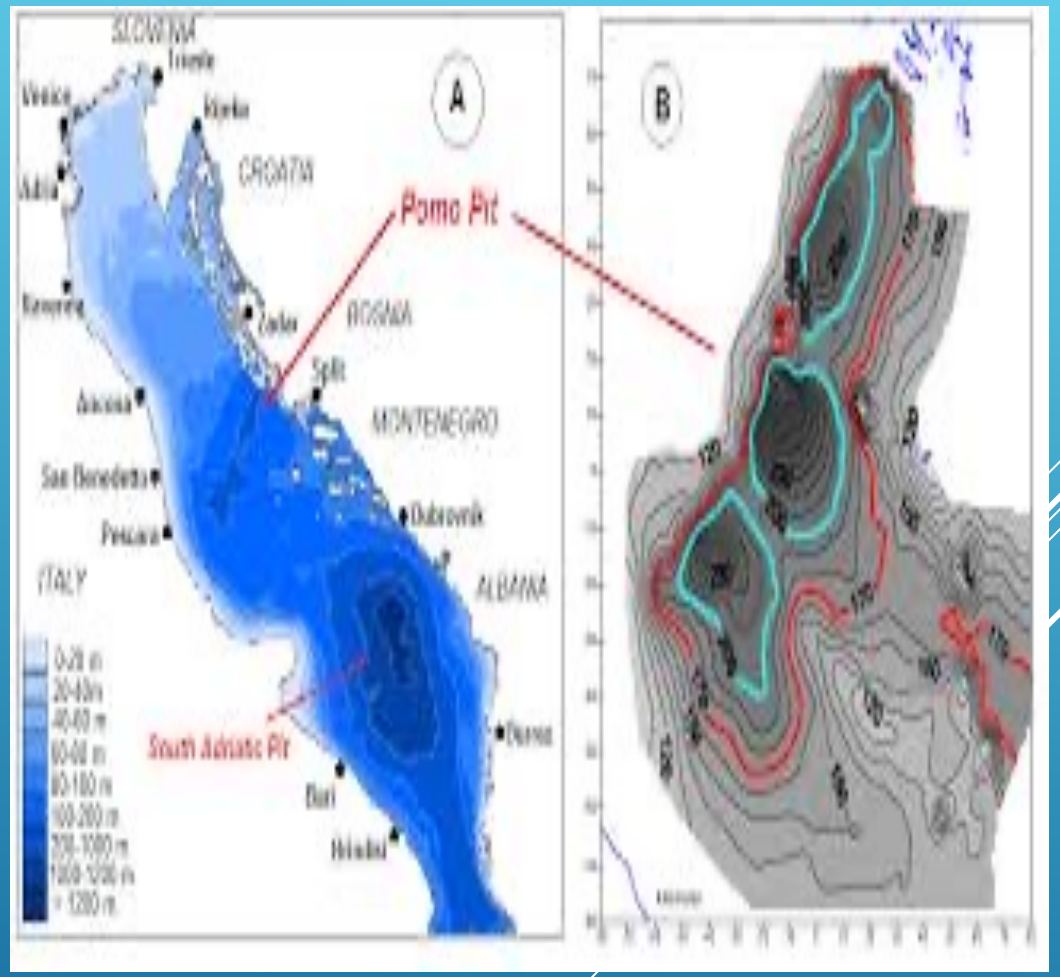
The highest densities of Norway Lobster are in the Pomo Pit and in other areas deeper than 100 meters. Low densities but bigger size/faster growing individuals are found in muddy bottom shallower than 100 metres in Central Northern Adriatic. Intermediate densities are also found around and between the above two areas.

The Pomo Pit (also called Jabuka Pit) is one of the most important habitats for some shared demersal stocks of the Adriatic Sea. Although it covers less than 10% of the total surface of the Adriatic Sea, it is one of the most important fishing grounds especially for the bottom trawl fishery which apply a high fishing pressure on the resources of the area. The bottom of the Pomo pit is characterized by 2 contiguous areas The “fossa centrale” or Pomo/Jabuka Pit) of more than 200 meters deep, which is largely situated within the Croatian territorial waters. Towards the Italian coast there is a second depressed area (the Western Pomo Pit, with depths greater than 200 meters, called "the fondaletto" and separated from the Pomo pit by a sill. Jabuka/Pomo Pit has been the subject of numerous scientific investigations on both sides of the Adriatic



it is a region were cold nutrient reach waters from Northern Adriatic flow near the bottom and get trapped by the bottom shape. It has thus waters with more nutrients near the bottom than near surface waters. These conditions encourage a high abundance of fish and shellfish and the area has long been known as a productive fishing ground, due to the high presence of some species whose stocks are commercially important like hake, shrimps, Norway lobsters and cephalopods.

In addition, the Pomo Pit is an important (or the main) nursery area for for many demersal species and in particular for the stock of hake in the northern and central Adriatic. It is distant 40 nautical miles from the Italian coast and it extends inside the Croatia territorial waters. The area is easily reached by fishing vessels from Italian fishing ports between Ancona and Termoli and Croatian ports between Zadar and Makarska.



Mollusks fishery production in Adriatic area According to the FAO FISHSTAT database, bivalve mollusks fishery seems to be quite significant in the Adriatic area, especially in the North West basin where best edaphic and trophic conditions for propagation of these species are met. Major rivers flowing into this part of the Adriatic Sea, together with extended lagoons along the coast and muddy and sandy bottoms characterized by minor slopes, are the main factors that make this area rich in biocenosis with important bivalve mollusks species. It is worthwhile to cite the presence of extended *Anadara inaequivalvis* beds, an allochthonous species involuntarily introduced in Adriatic towards the end of the '60s, that now proliferate between 1 and 10 miles from the coast, and has yet not found valuable market utilization

Mussels are usually harvested (collected) by hand and less frequently, where rich mussels beds on lagoon bottoms are present, through bottom trawl fishery. The most exploited areas are the ones close to the rocky coastal parts, among which Conero promontory in the Marche region stands out. Equally important are the quantities collected on methaneproducing platforms during cleaning and maintenance activities.

Clams are usually caught by vessels equipped with a hydraulic dredge. In 2000, out of 728 dredge boats registered in Italy, 685 were operative along the Adriatic coast. This fishery system operates on sandy bottoms within 1 mile from the coast. Normative applied to this capture system contains the following indications: gears dimensions, catches limit, vessels dimensions, engine power, clam size. Fishing areas are managed by compartmental management consortiums to which all fishermen are affiliated. Some of these vessels are used or other bivalve mollusks fisheries as well, such as smooth callista (*Callista chione*) and razor-clams (Solen spp. e Ensis spp.). Production is around 30.000 tons per year

Eastern coast clams production (stripped venus) is only reported for Albania referring to the period 1987–1996. The trend shows a progressive decrease from the initial amount of 700 t (FAO Fishstat). Although reduced clam beds are present along the northern coast of this country, collection of any kind is not allowed.

In Croatia, particularly in the northern Adriatic area, along Istrian penninsula coast, *Pecten jacobaeus* is a very important species targeted by a good part of the fleet using dredges. In other areas the capture fisheries of Pectinidae (scallops and queen scallops) has nowadays become marginal. In the past Pectinidae species were collected in the northern Adriatic with bottom trawl gears called "rapidi", vessels equipped with fixed dredges originally constructed for flat fish fisheries.

Natural harvesting of Japanese littleneck clams (Tapes semidecussatus, *Ruditapes philippinarum*) an introduced species in Northern Adriatic lagoons is very developed and yielding about 30.000 tons of clams, it can be practiced according to gear, quota and area regulations in specific areas, identified by hygienic and sanitary parameters.

3. Targeted species

The high number of species exploited by the demersal fishery characterizes the Adriatic fisheries (as well as Mediterranean fisheries in general) as remarkably multi-specific. As it has been said before the Adriatic Sea is probably the largest and the best-defined area of occurrence of shared stocks in the Mediterranean. The most important demersal and small pelagic commercial species whose stocks are shared in the Adriatic were identified and agreed upon by regional experts convened by the AdriaMed FAO Regional Project. The recognition of the shared-stock status of the priority species (Table 4) was subsequently proposed to the national management authorities of Albania, Croatia, Italy and Slovenia and then endorsed at the 28th Session of the GFCM in 2003.

3.1 **Pelagic main species**

Small pelagic fish species are widely distributed in the Adriatic Sea and play an important role in the commercial fisheries of all countries located along the coast of the Adriatic Sea. The main species of small pelagic fish are sardine, Sardina pilchardus, anchovy, *Engraulis encrasicolus*, Atlantic mackerel, *Scomber scombrus*, chub mackerel, *Scomber japonicus* and sprat, *Sprattus sprattus*. Other species also occasionally caught in small pelagic fisheries in the Adriatic Sea are the horse mackerel Trachurus trachurus, Mediterranean horse mackerel Trachurus mediterraneus, Mediterranean sand smelt Atherina hepsetus, Blotched pickarel Spicara maena and bogue Boops boops. Anchovies and sardines are fished by purse seiners, attracting fish by light and pelagic trawlers belonging to Italy, Croatia and Slovenia. The fishery takes place all year round: a closure period is observed for the Italian pelagic trawlers on August, while the closure is from 15th December to 15th January in Croatia.

Pelagic fishing fleet activity on the eastern part of the Adriatic has always been directed mostly at sardines and the Croatian catches represent the main part of the total catches). Small pelagic fishes are the main fisheries resources of the Adriatic Sea, accounting for a large share of the total catches. The group represented approximately 46% of the total marine catches of the Adriatic from 2000 to 2010, being 99% of this total accounted for by sardine and anchovy. Sardine and anchovy are the most abundant and economically important small pelagic species in the Adriatic Sea, with stock regularly assessed by GFCM and FAO-ADRIAMED Working Group on Small Pelagics

A General overview of capture fisheries landing trends from the Adriatic over 40 years (1970 - 2011) can be extracted from the open access FAO statistics FishstatJ software. In this database the reliability of Nominal landing can differ greatly between countries and regions and cannot be easily assessed, however these data roughly outline the fisheries production performance of the region.

Historically the eastern Adriatic countries targeted mainly sardine, but since the mid-1990s there has been an increase in anchovy catches in the east, specifically by Croatia.

Total catch of sardine increased steadily between 1970 and 1981 when a maximum was recorded at 88,518 tons. This was followed by a sharp decrease between 1982 and 1995 (the war in the former Yugoslavia from 1990 to 1995 was one important factor that affected the fisheries from eastern Adriatic countries in that period). Catches remained below 40,000 tons since then, with two peaks in 1998 and 2010 of about 36,000 tons. Data from the northern and central Adriatic Sea (GSA 17) for 2011 indicate that catches have continued to increase in more recent years.

The eastern Adriatic fishery (represented by the Yugoslavian Federal Republic until the independence of Croatia and Slovenia in 1991) experienced a marked decline between 1990 and 1995, followed by a period on increasing catches by Croatia until 2010. Italy accounted for a large share of the catches until the early 1990s, declining in importance since then. In 2010 Italy reported 6,880 tons of sardine, Croatia 29,600 and Slovenia 403 tons. Catches by Montenegro (and Serbia and Montenegro) have been below 100 tons, with Montenegrin catches in 2010 of 35 tons

In 2011 the closure season for the Italian fleet was extended to 60 days (August and September). Pelagic catch dominated the marine fish landing, particularly in the East Coast fishery, even though from the mid1980s the contribution of pelagics to total fish landings decreased remarkably as a consequence of the successive downsizing of the anchovy and sardine stocks and, more recently, of the economic changes which took place in the eastern coastal countries.

Anchovy catches increased between 1970 and 1974, reaching about 42,900 tons, decreased to 18,100 tons in 1977, increasing sharply in the following two years. The fishery attained its maximum historical level in 1979 when 62,462 tons were landed. Catches collapsed afterwards, reaching the historical minimum of 7,055 tons in 1987. The collapse of the fishery was followed by a period of relative stability in catches, which oscillated around 10,000 tons/year from 1988 to 1992. The fishery experienced a recovery since then, reaching a peak of 57,650 tons in 2006. Catches declined after that, being at about 46,000 per year in 2009 and 2010. Data from the northern and central Adriatic Sea (GSA 17) for 2011 indicate that catches have continued to decline in more recent years.

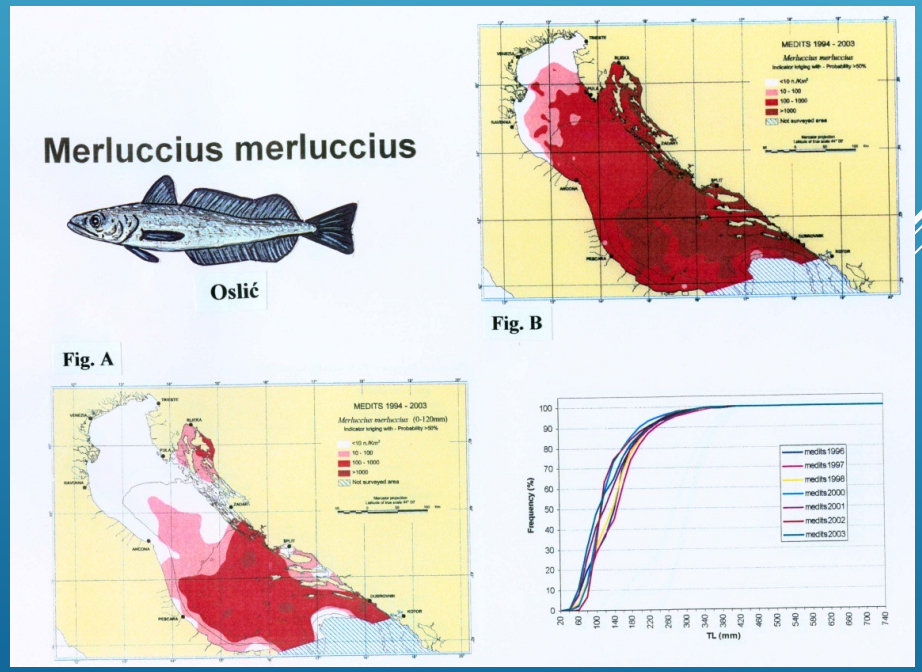
3.2 Demersal main species In the Adriatic Sea,

the demersal fishery takes place on the entire continental shelf and on a part of the continental slope in the southern Adriatic. Most of the fishing activity is carried out by trawlers and the use of fixed gear is usually limited to the area unsuitable for trawling.
The demersal fishery is a multispecies fishery and the main target species are: European hake (Merluccius merluccius), Red mullet (Mullus barbatus), breams (Pagellus spp.), Whiting (Merlangius merlangus), anglerfish (Lophius spp.), flatfish (Solea vulgaris,Psetta maxima, Scophthtalmus rhombus, Platichys flesus), Eledone spp., Common cuttlefish (Sepia officinalis), squids (Loligo and Illex), Norway lobster (Nephrops norvegicus) and Deepwater rose shrimp (Parapenaeus longirostris).

The Hake (Merluccius merluccius)

The hake (Merluccius merluccius) is largely distributed in the Adriatic, excepted in the northern part of GSA 17, north of the mouth of the Po river and coastal shallow waters. The juveniles are concentrated in the middle Adriatic around 150 meters depth, while adult individuals are commonly found at depths greater than 250 meters. This species is mainly caught by trawlers but is also frequently present in the catches of gillnets and entangling nets. In the Adriatic hake spawns throughout the year, but with different intensity

The peak spawning takes place in winter and summer. In the Pomo Pit the first deposition occurs in winter in the deep waters (up to 200 m). In the period between spring and summer, spawning takes place in shallower water. The nursery areas are located on the slopes in areas adjacent to the Pomo pit at depths between 150 and 200 meters.



The Norway lobster (Nephrops norvegicus)

The Norway lobster (Nephrops norvegicus) is widely distributed in the central and northern Adriatic, at depths of more than 50 meters but the most important densities of this species are located on Pomo pit grounds. Juveniles are concentrated in deep areas, over 200 m. There are substantial differences in average length between the population of the Pomo Pit and those of the rest of the Adriatic. These differences are the result of the diversity of ecological factors, which lead to a reduction in the growth of Nephrops norvegicus (and other benthic decapods) in the Pomo Pit.

The Red mullet (Mullus barbatus)

The Red mullet (Mullus barbatus) is distributed all over the GSA 17 and performs seasonal migrations. The adult population is distributed along the central and eastern part of the Adriatic, while the juveniles are found in the western coastal area, where it remains until the early winter and then moves to the depths of the sea. The species is mainly fished by bottom trawl nets from both Italian and Croatian fleet. Smaller quantities are also caught with Italian trammel nets and gill nets. Slovenian catches are low (only 2 t reported in 2007). A closure of 45 days in late summer has been enforced in 2011 - 2012 for the Italian fleet. Before 2011 the closure period was 30 days in summer.

The common sole (Solea vulgaris)

The common sole (Solea vulgaris) is distributed In the northern and central Adriatic depending on the age: the adult specimens are present along the coast of the Istrian coast, while the younger ones are present in the Italian coastal waters, especially at the mouth of the river Po. The majority of the population moves from north to south along the Italian coast, and probably from south to north along the eastern coast. The highest catches occur in the fall.

The Deepwater rose shrimp (Parapenaeus longirostris)

The Deepwater rose shrimp (Parapenaeus longirostris) is an important species in the demersal trawl fishery of the whole Geographical Sub Area 18, as it Is distributed mainly in the southern Adriatic. It is not very abundant In the central. with the exception of Pomo pit, where it is present mainly on muddy bottoms between 130 and 190 feet deep.

The Mantis shrimp (Squilla mantis)

The Mantis shrimp (Squilla mantis) is distributed over a wide band parallel to the coast between 15 and 70 m depth in the upper and middle Adriatic. In this area, mantis shrimp is exploited by bottom otter trawl, gillnet and rapido trawl. This species is exploited all year round essentially by the Italian trawlers and ranks first among the crustacean landed in the Adriatic ports. The Slovenian annual landings are much lower while in Croatian landings statistics the species is absent. Trawl catch is mainly composed by age 1 and 2 individuals while the older age classes are poorly represented in the catch. As concerns artisanal fisheries, S. mantis is an alternate target of gillnetters targeting Solea solea, especially during spring summer seasons in the coastal area. The species is not present in the list of shared stock of GFCM as it is present and commercially fished mainly in the Italian Territorial Waters.

4. The status of the stocks

4.1 Small Pelagic resources

Anchovy (Engraulis encrasicolus) in GSA 17 Main Italian fishing harbours for anchovies in the Adriatic harbours can be considered Trieste, Chioggia, Porto Garibaldi, Cesenatico, Rimini, Cattolica, Ancona, San Benedetto del Tronto and Vieste: in these harbours about 85% of the catch of anchovies is landed. Other important harbours are Grado, Mara no Lagunare, Caorle, Goro, Fano and Giulianova.Anchovy landings during the last thirty years are characterized by two major factors: the landing peak of more than 50000 t in1981 and the subsequent decline to the minimum of 10000 t in 1987, which lasted till the early 1990s. Since then yield has been increasing.

Whether anchovy in the Adriatic Sea is part of one or two stocks is uncertain. The hypothesis of two distinct populations is based on morphometric and allozymic differences between northern and southern Adriatic anchovy. This hypothesis has not been supported by more recent genetic data. For stock assessment purposes, anchovy caught in the northern-central Adriatic (GSA 17) has been considered part of a single stock and has been assessed separately from the stock in GSA 18.

A first attempt to assess the stock of small pelagics (anchovy and sardine) in the whole Adriatic was carried out in 2011 (29). The authors noted however that some work has still to be done in order to make a reliable assessment of the stock in the combined areas, including better information on catches in GSA 18, which are currently considered unrealistic.

Therefore the information presented below is based on the last available stock assessment of the species in each GSA. Stock assessments and biomass estimations of anchovy have been carried out in the last twenty years using direct methods as echo surveys and ichthyoplankton surveys as well as indirect (catch and effort and VPA) methods .

In the GSA 17 the trend in biomass of anchovy increased until 2005, then decreases until 2009, and then increases again. The 2011 spawning stock biomass estimate is between 309361 tons and 264565 tons. The current biomass is above the reference points Blim and Bpa proposed by the GFCM. The fishing mortality decreases constantly until 2007 and then increases again, being higher for age 2 and 3. The stock can be considered as sustainably exploited; the level of abundance is considered intermediate (current biomass = 333404 tons) higher than the proposed (179000 tons) and (250600 tons) reference points.

Since this stock can display large fluctuations associated with analogous fluctuations in recruitment, and since the exploitation rate is equal to the precautionary threshold, the advice is not to increase fishing mortality. Moreover numerous studies have shown that the dynamics of anchovy and sardine populations are strongly influenced by success in the recruitment that is, on the other hand, strongly influenced by environmental conditions.

It has been argued for a long time whether there are two separate stocks of anchovies in the Adriatic one in shallow waters (less than 50 meters of depth) of the northern western Adriatic, and the other in deeper off shore waters of the central southern Adriatic with extensive migrations.

The biological basis for this stock differentiation (i.e. spatial and/or temporal separation in spawning) are still to be clarified but it is evident that the spatial distribution of shared stock of anchovy is not limited to GSA17 area only, but it is extended in GSA18 area also. Therefore, future assessments will try to take into account combined data from these two GSAs. It should be noted that Adriatic small pelagic fishery is multispecies and effort on sardine stock cannot be separated from effort on stock of anchovy.

Sardine (Sardina pilchardus)in GSA 17

The Croatian catches of sardine represent the great part of the total catches of the Adriatic Sea. Exploitation is based on all the age classes from 0 to 6+. The current assessments show that the trend in biomass of sardine started a slow but continuous increase since 2000. The 2011 biomass estimation showed rather high values. The current biomass (Between 483369 and 215050 t) is above the reference points Blim and Bpa proposed by the GFCM.

The fishing mortality starts to increase in 2007 for all the ages. Available genetic data indicates that sardine in GSA 17 constitute a single stock. The situation in GSA 18 is less clear. Stock assessment of sardine has been done until recently considering stocks in GSA 17 and GSA 18 separately. However in 2012 the Working Group on Stock Assessment of Small Pelagics recognized that spatial distribution of shared stock of sardine is not limited to GSA17 area only, but it is extended in GSA18 area also. The Working Group also noted that an important nursery area of sardine is located in Gulf of Manfredonia (GSA18) where sardine is exploited by a fry fishery.

Biomass of the stocks in GSA 17 decreased continuously from the 1980s to 2000. In the most recent years, a moderate recovery of the stock has been observed , accompanied by parallel increases in recruitment and catches

The present status of the stock up to 2011 can be described with high fishing mortality and intermediate abundance (Current biomass higher than Blim and Bpa reference points).Biomass level as well as recruitment level showed a steep increase in 2011. Because of that there are no sign that the stock of sardine in the Adriatic Sea is suffering for high fishing mortality. Nevertheless, since this stock can display large fluctuations associated with analogous fluctuations in recruitment, the GFCM advice is not to increase the fishing effort. Besides, since numerous studies have shown that the dynamics of anchovy and sardine populations are strongly influenced by success in the recruitment, which is, on the other hand, strongly influenced by environmental conditions, like for anchovy. Also the spatial distribution of shared stock of sardine is not limited to GSA17 area only, but it is extended in GSA18 area also. Therefore, WG suggest that future assessments try to take into account combined data from these two GSAs. Moreover, an important nursery area of this stock is located in Gulf of Manfredonia (GSA18) where the sardine stock used to be exploited by fry fishery (the fishery was closed in June 2010)

4.2 Demersal resources

Assessment of demersal resources has been carried out on most species of fishes using mainly trawl surveys and confirming that in late 1980's, the demersal resources were overfished

The Adriatic demersal catches are composed mainly of individuals of the age classes 0, 1 or 2. Therefore, trends in abundance reflect more a fluctuation in recruitment than a response to the fishing effort. Also, the landing of some species, for example European hake, has been sustained for a relatively long period in spite of heavy apparently unsustainable exploitation. This could be due to the adult occurrence in deeper waters outside the traditional trawl fishing grounds, as it occurs in the canyons of the Gulf of Lions (GSA 7)

Hake (Merluccius merluccius)

Hake is one of the most important species in the Geographical subarea 18 representing about 20% of landings from trawlers. The nominal landing of the European hake for the whole Adriatic Sea has been increasing since 1984 reaching the maximum of about 7000 t in 1994. Since then, this growing landing trend has reversed sharply declining. In 2011 the landings of hake were about 3,792t in the west side with the higher production from trawlers (3,258 t) followed by longliners (534 t). Along the east side the production from trawlers in 2011 was about 439 t divided by 37 t from Montenegro and 402 t from Albania. The hake is one of the most studied demersal species in the Adriatic Sea, partly due to its substantial impact (due to the species abundance and economic value) on fishery activities in the basin.

The current assessment results show a sharp increase of recruitment in 2005 and thereafter a level similar or higher than the past years. In 2008 a new though lower peak was observed. No trends were detected. Total fishing mortality showed a decreasing trend to 2004 and then an increase in 2005 and 2006. Catches and mortality are dominated by the trawl fishing system.

The stock is in overfishing and thus GFCM recommends considering a considerable reduction of the fishing mortality. Given these results it is necessary to consider that a remarkable reduction of the fishing mortality is necessary (27b). As observed in 2011, the fishing mortality from the Italian bottom trawlers represents about 80% of the total F in the GSA 18 and that of the Italian longlines is accounting for about 9.5%, with an overall percentage of about 90%, while Montenegrin trawlers account only for about 1% of the F exerted on hake in the GSA and Albanian trawlers of about 9.7%.

Moreover, the production of hake in GSA 18 is split in 12.5% caught by Italian longlines, 77.2% by Italian trawlers, about 1% by Montenegrin trawlers and about 9.4% by Albanian trawlers.

Common sole (Solea solea) in GSA 17

Rapido trawl landings were traditionally dominated by small sized specimens; they are basically composed by 0+, 1 and 2 year old individuals. Set net fishery lands mostly the same portion of the population, while the otter trawl fishery, exploiting wider fishing grounds, shows a different size distribution of the landings. In the eastern part of the basin common sole is exploited mainly by set netters using trammel net. The catch composition is dominated by adults. Current assessment results show that the common sole stock in GSA 17 is subjected to overfishing, being the current F (2011) higher than the GFCM reference point (a proxy of FMSY).

A reduction of fishing pressure have been recommended, also taking into account that the exploitation is mainly orientated towards juveniles and the success of recruitment seems to be strictly related to environmental conditions (GFCM suggests that this could be achieved by a two months closure for rapido trawling inside 11 km (6 nm) offshore along the Italian coast, after the fishing ban). Moreover, it is not sure that the adoption of a larger mesh size would correspond to a decrease of juvenile catches. The same uncertainty regards the adoption of square mesh.

Red mullet (Mullus barbatus) in GSA 17

The signals coming from the MEDITS survey are positive, suggesting a stable biomass and a really high recruitment estimated for the 2012. However the current stock assessments show that the estimated fishing mortality for red mullet in 2011 reaches very high value for the Italian fleet in particular for specimens between 15 and 17 cm, while the fishing mortality estimated for the Croatian fleet increases for much bigger individuals (from 17 cm), but still remaining at lower values.

The spawning stock biomass follow a slight decreasing trend starting in 2008 from 9000 t to 6300 t in 2011. Similar considerations can be applied to the trend in total biomass, which decreased by 50% from 2008 (50000 t) to 2011 (25000 t). The current analysis evidenced the different fishing patterns of the two fleets exploiting the species, which is also determined by the behavior of the species. The Italian fleet is clearly targeting recruitment; besides, the current fishing mortality for the Croatian fleet is low while F for the Italian fleet is above both reference 27 points, showing a possible situation of growth overfishing.

GFCM suggest that It could be wise to reduce the fishing mortality on the recruitment and this could be obtained by a prolongation of the closed season for trawling along the Western Adriatic coast where in autumn age 0 recruits born in summer are concentrated

Deepwater pink shrimp (Parapenaeus longirostris) in GSA 18

MEDITS trawl surveys data showed that the abundance of this shrimp was steadily growing from1999 to 2005 than a decreasing was observed in 20062007 followed by a new increase in 2008 and 2009, while in 2010 and 2011 the abundance is decreasing again. Current assessment results by VPA show that the highest fishing mortalities are applied on the age groups 1 and 2. The yield per recruit analysis indicates a current level fishing mortality highest than the target reference point. The main part (71%) of the total F in the GSA 18 is exerted by the Italian fleet, while Montenegrin trawlers account only for about 1.7% of the F exerted on the GSA and Albanian trawlers of about 27.1%. The stock is considered in overfishing and a reduction of the fishing mortality will be necessaryi. This could be achieved with a multiannual plan based on a reduction of fishing mortality through fishing activity limitations and possibly fishing capacity decreasing.

Mantis shrimp (Squilla mantis) in GSA 17

Current assessment results show that the stock is subjected to overfishing. The Mantis shrimp in GSA 17 is exploited unsustainably, being the current F (2011) estimates with higher than the GFCM reference point (a proxy of FMSY). Moreover decreasing trends have been observed for recruitment and Spawning Stock Biomass in the VPA results and for the relative abundance and biomass in MEDITS trawl surveys. A reduction of fishing pressure is recommended. The relevant fleet effort or catches (demersal otter trawl fishing fleet) should be reduced until fishing mortality is below or at the proposed reference level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multiannual management plan taking into account mixed fisheries considerations

Elasmobranch fisheries in the Adriatic Sea

There are several checklists of elasmobranchs in the Adriatic. Most of the lists are reporting more than 50 species, depending on which species status is considered as valid or doubtful. Most recent checklist of elasmobranchs in the Adriatic Sea is reporting total of 53 species, within 28 sharks, 1 chimaera and 24 batoids species have been reported as permanent residents or occasionally visiting species .

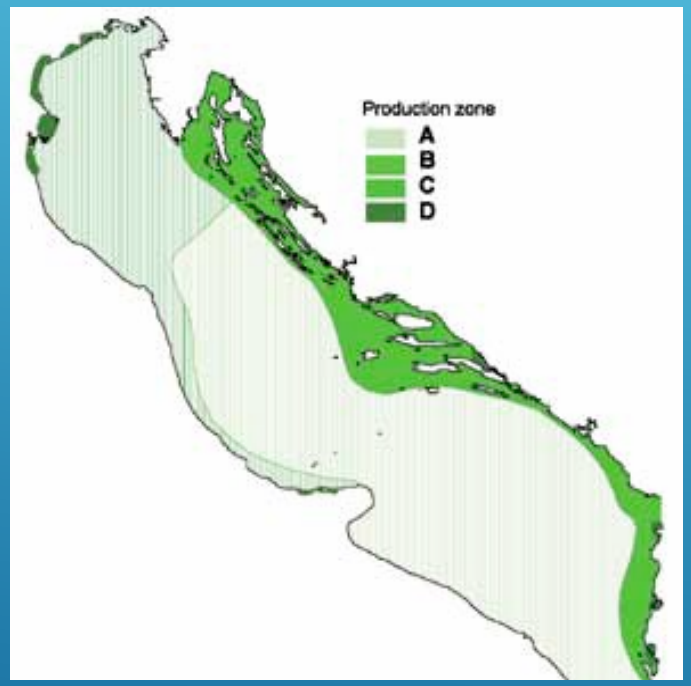
Most of the elasmobranchs are not target species in the Adriatic Sea but they are caught mainly as bycatch of bottom trawls, gillnets and longlines, as well as by pelagic longlines and other fishing gear used in tuna, small pelagic fish and sword fisheries. Smaller elasmobranchs, especially small sharks, ray and skates are also often and commercially important species of trawls. In certain areas, during some seasons, dogfish and hound sharks are targeted with gillnets. Hence, a part of commercial fishery, during recent decade, sport and recreational fisherman have started to target large sharks in big game fishing (tresher shark, blue shark and porbeagle).

By analyzing FAO statistics on the total landing of the elasmobranch fisheries, reported as „Sharks, rays, chimaeras“ group, in the Adriatic Division 37.2.1 within the period 1970-2010, a 40 year-long period, a maximum of landings has been reached in 1982 with about 2649 t, while minimum landings of 292 t were reported in 2002

Moreover, the comparison between compared “Hvar 1948” and the “Medits 1998” bottom trawl surveys showed that the main change in composition and distribution of demersal fish resources was the decrease of elasmobranch diversity and frequency. Skates and rays showed the greatest change in biomass percentage. Furthermore, there was a change in community structure: reduction of long lived and slowly growing species. For example, small sized species such as smallspotted catshark (Scyliorhinus canicula) and the brown ray (Raja miraletus) were frequently collected in both surveys, while some larger sharks and rays species disappeared or were rarely found during Medits survey in 1998. Species specific data are revealing that for certain species a situation is even much worse. E.g. extracted data for thornback ray, Raja clavata shows that from species with high abundance and widespread distribution throughout whole Adriatic, thornback ray was restricted to small limited area with low abundance

By analyzing trawl surveys carried out in the area over the last six decades, a structurally depleted elasmobranch community was detected (24). The high elasmobranch abundance and diversity characterizing the central Adriatic during the Hvar survey in 1948–49 disappeared. Yet, species richness and abundance were higher in the eastern coastal areas than elsewhere. Elasmobranch abundance in Croatian territorial waters was almost one order of magnitude higher than in Italian, where sharks and rays were largely absent except for a relatively high-density zone in the upper Adriatic (above the 50 m isobath,) mainly composed of spurdogs, smooth-hounds, and eagle rays. Overall, sharks declined stronger than rays (−95.6% vs. −87.7%), and more shark than ray species recorded significant declines.

Ecology and demersal resources



The Adriatic receives considerable nutrients enrichment from river runoff which leads to high primary production. N and C Adriatic thus affect all links in food chains and allows high production of fish. It represents one of the most productive Medit areas for fishery purpose.

In summer, when meteo-marine conditions are suitable, stratification, which separates warmer surcface water of low salinity from deeper and colder more saline water, may occur, producing ideal condition for exceptional algal blooms, and extended hypoxia and anoxia. Damages to demersal resources as well as to sedentary and benthic resources may be considerable.

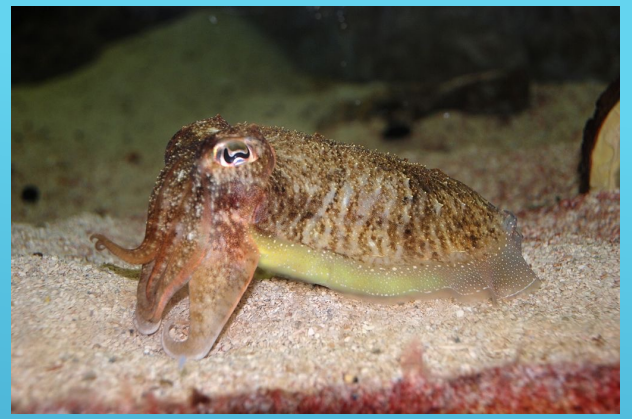
Demersal species distribution, seems to be linked more to biocenosis than depth, although biocenosis are considerably affected by both depth and sediment type.

There is a great variability of distribution of species, most of them being generally distributed in small areas, although seasonal migrations.

Many species complete their biological cycle throughout the whole basin, with reproduction area localized along the Italian (common cuttlefish, tub gurnard) or Croatian coasts (sole).

Recruits of many species aggregate along the western coast in summer and when they grow up, after two or three months, migrate towards the open sea because of the less extreme conditions in this area during autumn any early winter.

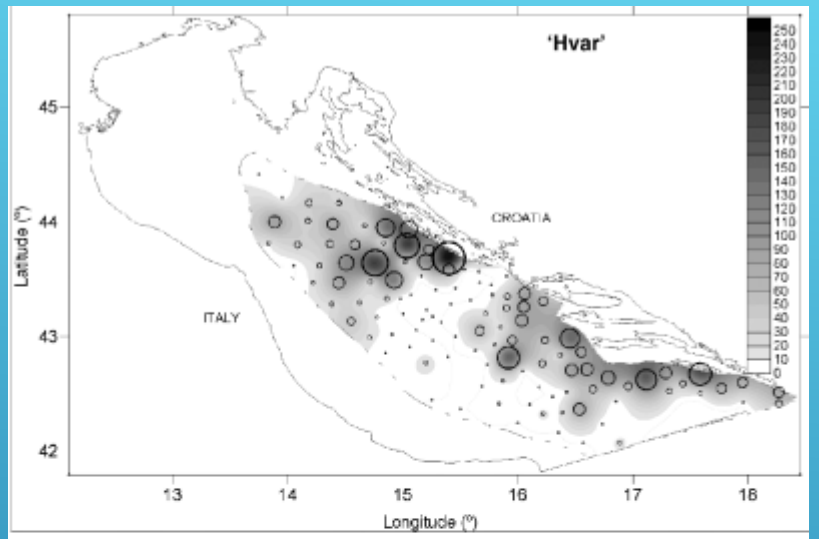
There are several documented changes in the structure of demersal community in the Adriatic during last decades. There was a decrease of biomass with time, mainly observed in commercial demersal species, as a result of increasing fishing impact until 2002.

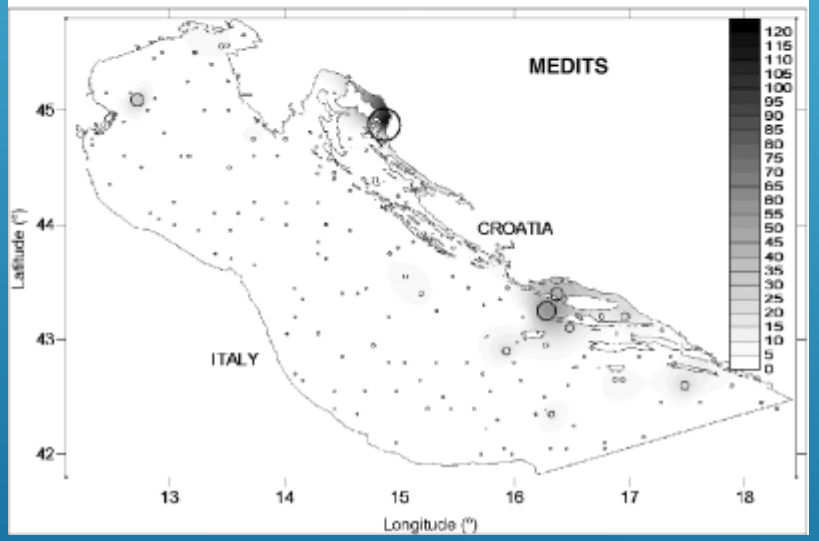


Sepia officinalis

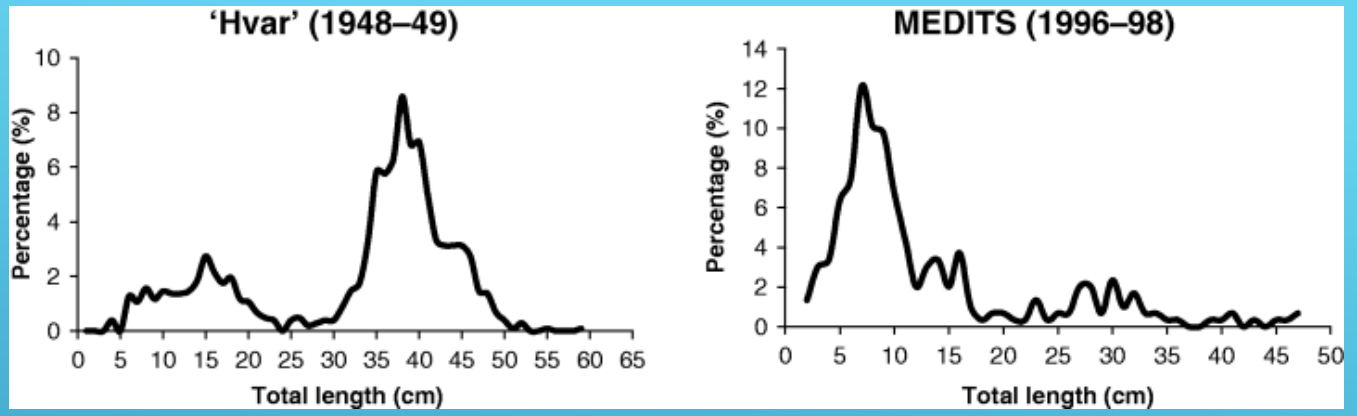
Chelidonichthys lucerna

Solea solea,





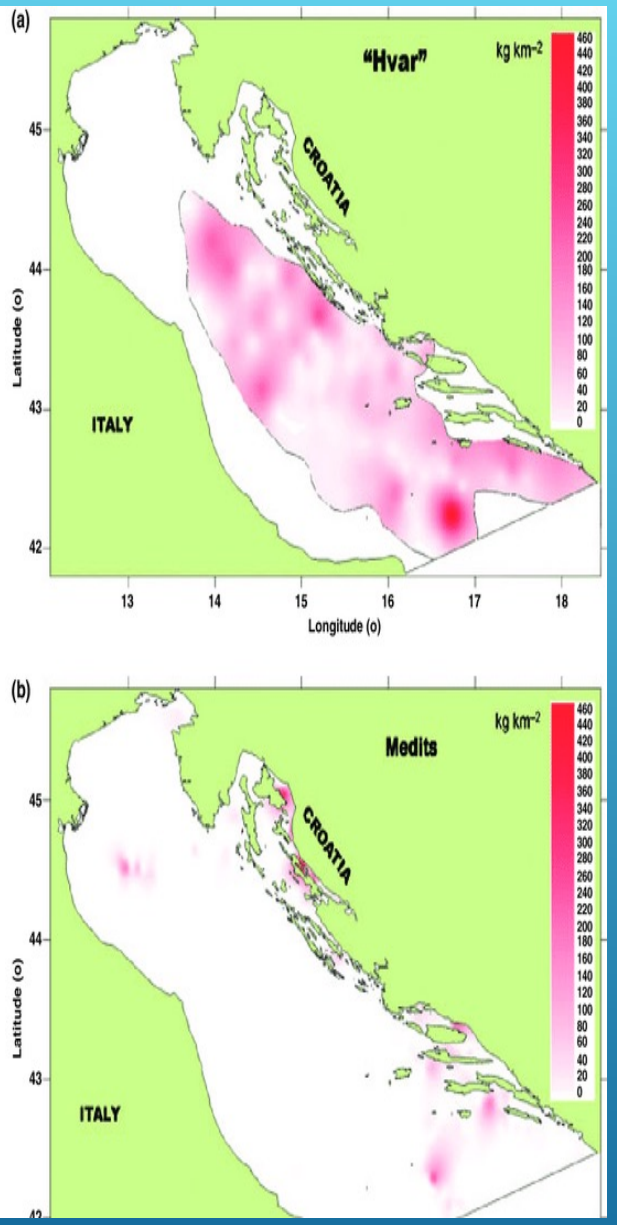
Spatial distribution of *Zeus faber* in the Adriatic Sea (kg km^{-2}) during 'Hvar' 1948–1949 expedition and during 1996–1998 MEDITS program (diameter of circles is proportional to the biomass index at each station)



Length–frequency distribution during 'Hvar' 1948–1949 and MEDITS 1996–1998

The length frequency distribution of John Dory during the 'Hvar' expedition was considerably different from that of the MEDITS. In 1948–1949, 72.5% of the capture had a total body length of over 30 cm. In 1996–1998 these larger sizes were found only in only 15.5% of the individuals, and juveniles (3–17 cm) were dominant in the catches.

The average value of the total body length for the entire sample was 32.65 cm during the 'Hvar' expedition and only 18.71 cm for the MEDITS. These negative changes were observed in both sexes. In the 1948–1949 expedition, the average body length of males was 33.93 and 36.80 cm for females, whereas during the1996–1998 surveys the average length was only 20.33 cm in males and 25.24 cm in females



Adriatic Sea spatial distribution of *R. clavata*: (a) Hvar expedition 1948–49 and (b) MEDITS (1996–2006

Investigations showed that negative changes have occurred in the *R. clavata* population in the Adriatic Sea within a 60-year period, including: (i) reduction in the distributional area of the species, especially in the open Adriatic Sea where the thorn-back ray is now only sporadically fished, (ii) mean abundance index of the species shows a significant decline, (iii) drastic decrease in the *R. clavata* portion of total fish catches, (iv) changes in the demographic composition of the population, with an increase in the mean length of fished specimens, and (v) decrease in total length at first sexual maturity of females

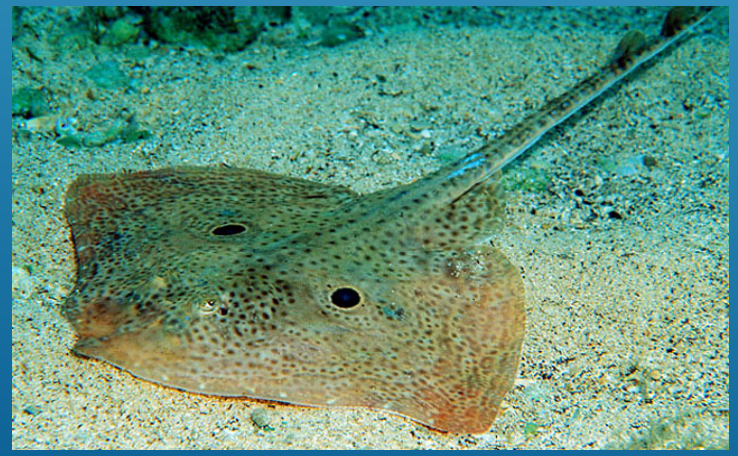
Moreover, from the comparison of two trawl survey carried out in 1948 and in 1998, a decrease of elasmobranchs importance, diversity and occurrence was observed; somebony fish (most small sized species as a red mullet), replaced elasmobranchs as the top of the catches.

However, some differences were found in the relative occurrence and abundance by elasmobranch species: such as smallspotted catshark (*Scyliorhinus canicula*) and brown ray (*Raja miraletus*) were frequently collected while other species (bigger shark species and other rays) disappeared or were rarely found.

Life history parameters of the species could explain the difeferent reaction of elasmobranchs to the fishery.

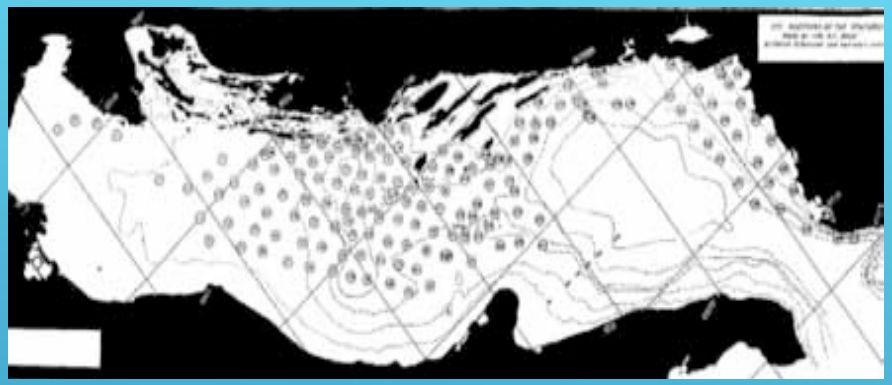
Mullus barbatus

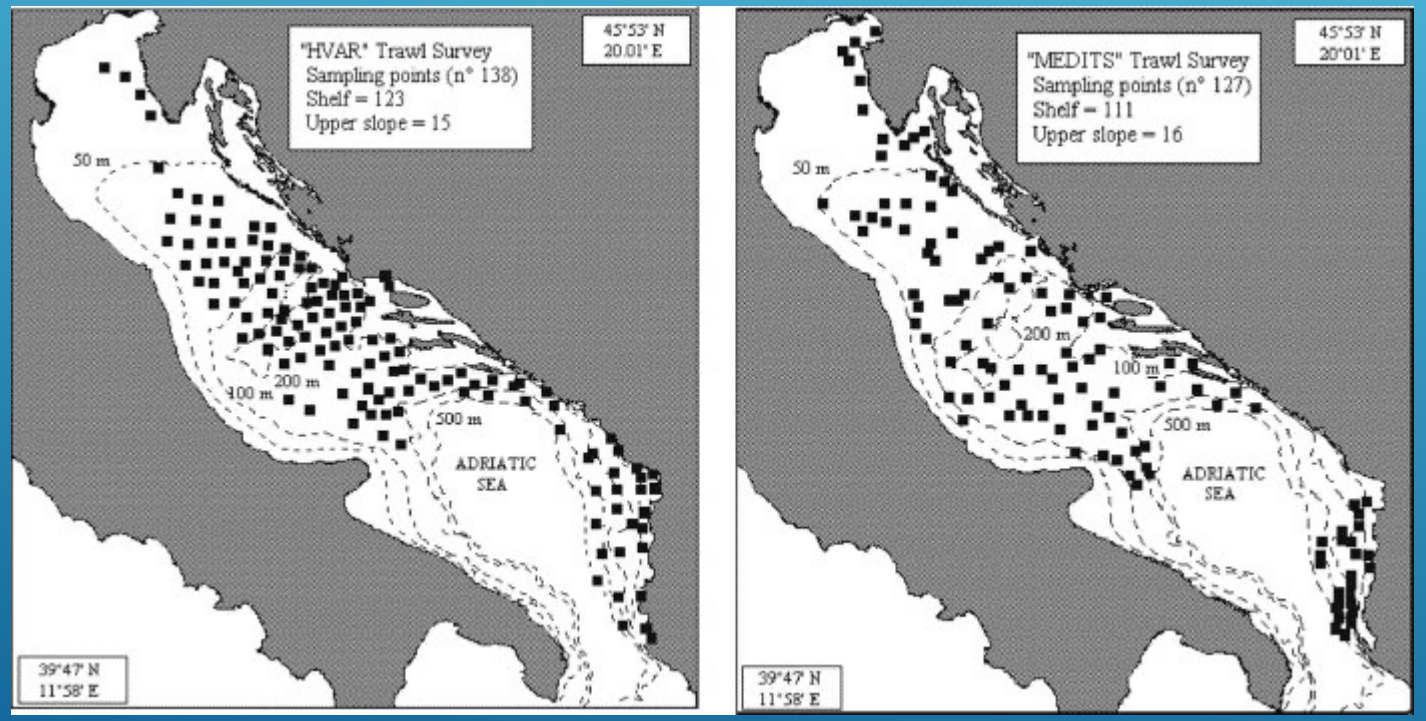
Scyliorhinus canicula



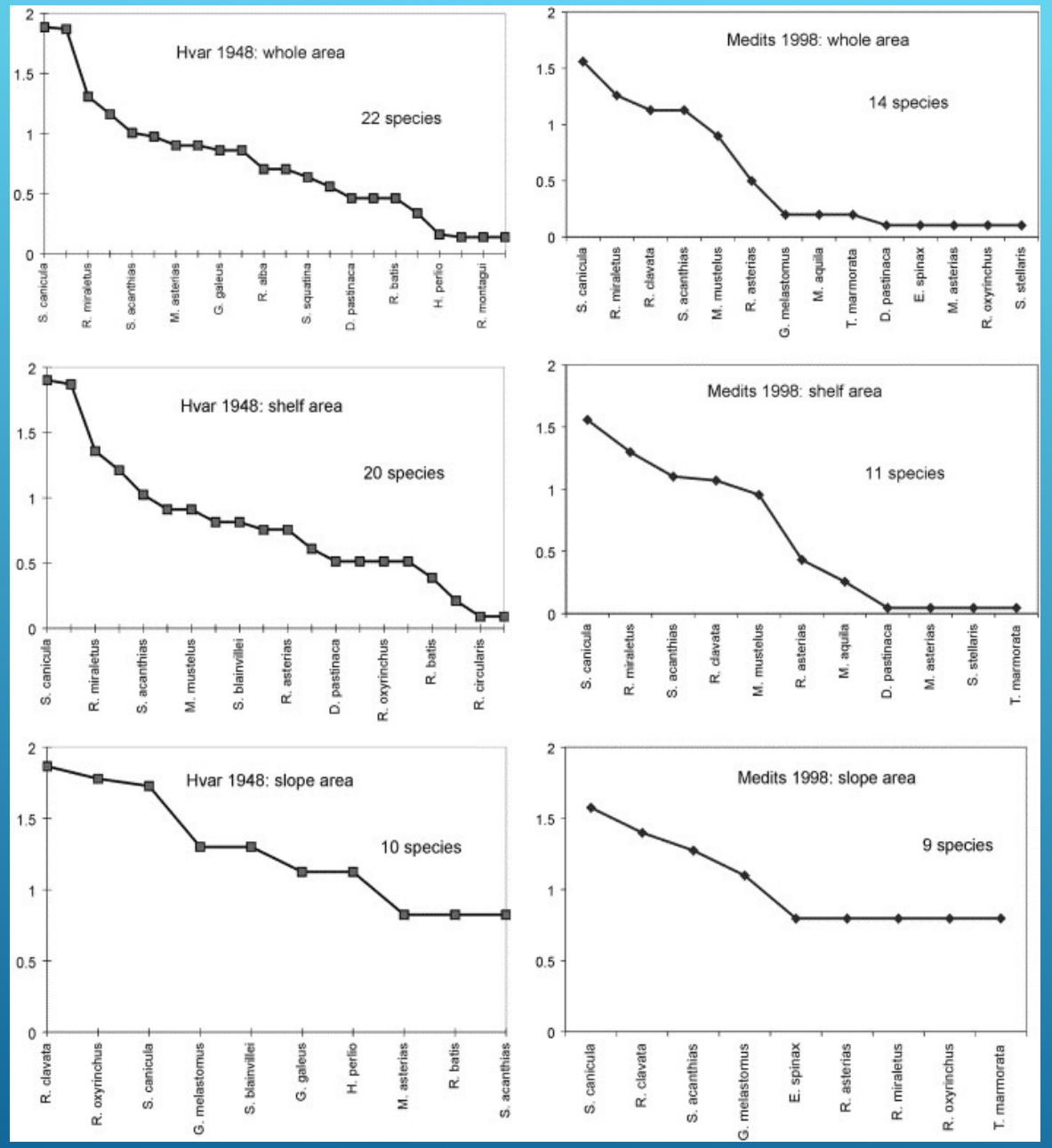
Raja miraletus

On the other hand, resources abundance, species assemblages distribution and fluctuations observed in biomass of low and intermediate trophic level, such as pelagic fish invertebrates and small-medium size demersal fish, could be affected by the time changes of environmental parameters and climatic anomalies as well as direct and indirect effects of fishing.

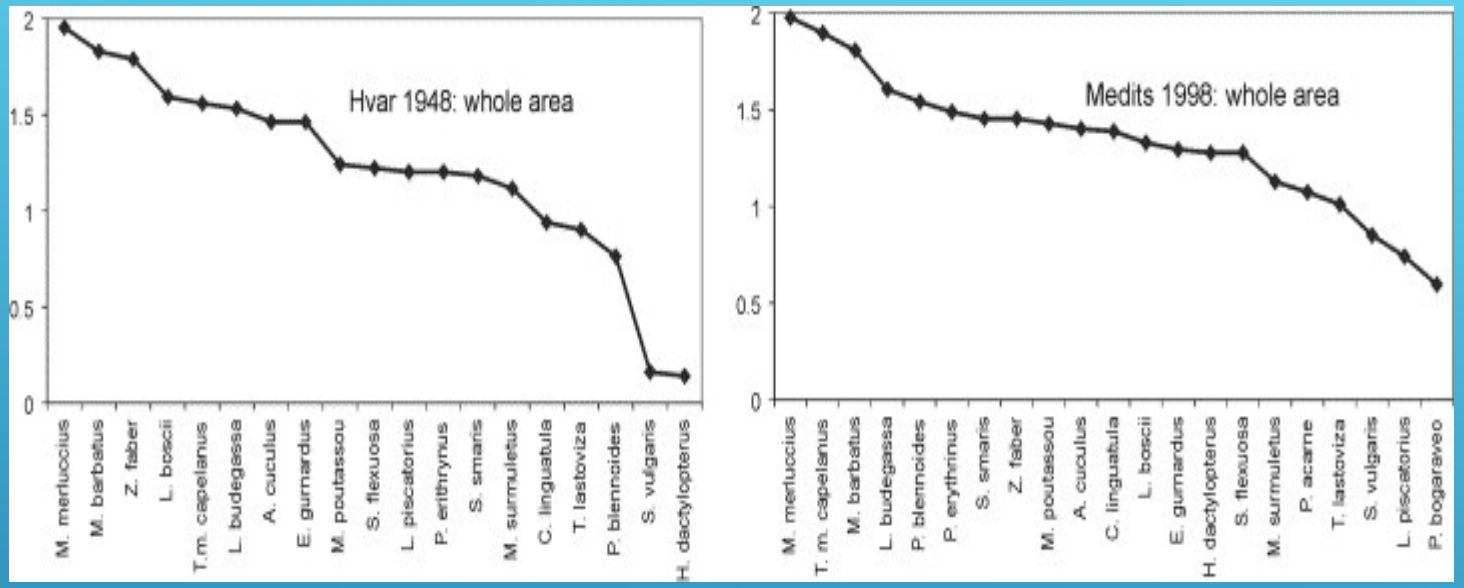




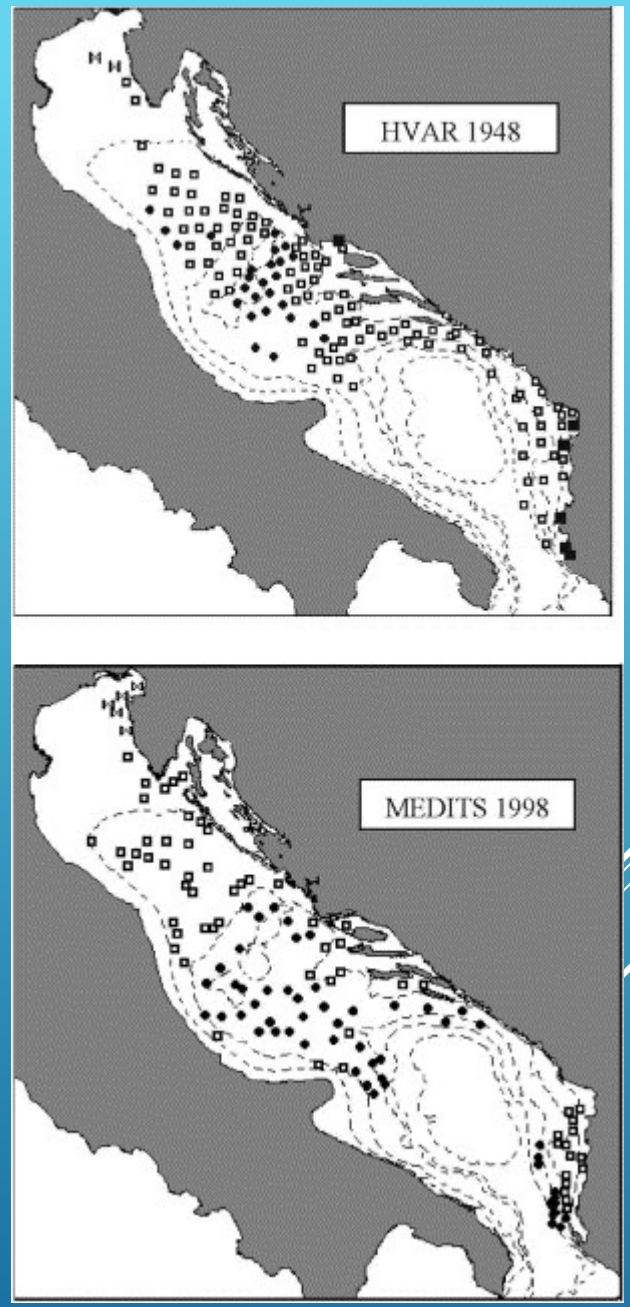
Investigated area and sampling points of the surveys (Hvar 1948; Medits 1998).



Occurrence (frequency log-transformed data) of elasmobranch species collected during the surveys “Hvar 1948” and “Medits 1998”.



Occurrence (frequency log-transformed data) of bony fish "fishery target species" collected during the surveys "Hvar 1948" and "Medits 1998".



Map representation of fish assemblages distribution (results from cluster analysis).

Adriatic fishing fleet and fishery

Shallow waters and soft bottoms, which cover a large area moving away from the coast, have made the

Adriatic particularly suitable for trawl fishery, bottom and beam trawling for demersal species. Owing to several reasons (i.e.) available technology, services, infrasructures) vessel fishing power and fleet capacity can be assumed vary widely between national fleets.

According to the official statistic in year 2009 number of the bottom trawlers , total GT and kW, as well as annual catch in the GSA 17:

	Number of trawlers	Total GT	Total Kw	Annual landing
Italy	747	32475	155972	27564
Croatia	503	11960	71508	4500
Slovenia	21	281	2999	134

From this data is visible disproportion in the size and characteristic of the bottom trawler fishing fleet along western and eastern coast in the GSA17. Ratio between Cro and Italy in num of trawlers in GSA 17 is 40%:60%, in terms of total GT 27%:73%, and in terms of total Kw 31%:69%.

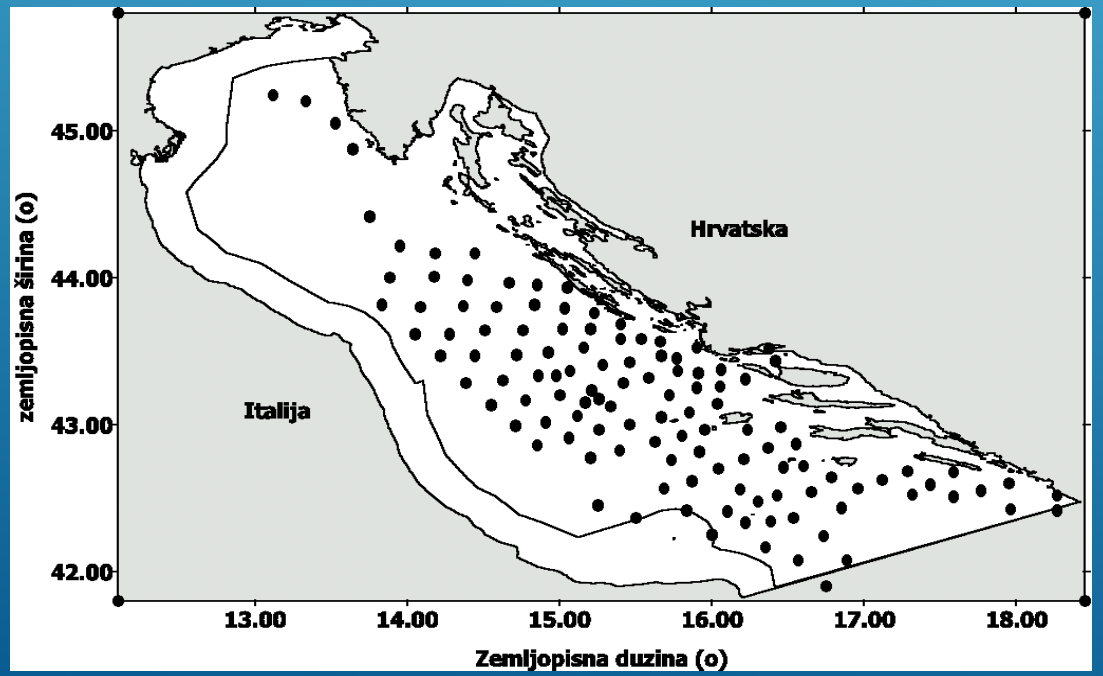
Due to the big differenes in fishing fleet composition, area of exploitation and level of fishing effort, ratio in total annual catch of trawlers in Croatia and Italy is very different (14%:86%%). Beacuse of differences in the level of exploitation, biomass indices as well as population and community structure of demersal resources are different along eastern than western coast.

Unfortunately, in the Adriatic landing stattistics, as well as fishing effort data, are generally questionable and although statistical dana exist, their realibilty is poor; the most reliable information about demersal resources comes from direct method as experimental trawl-survey.

The Adriatic demersal fishery (as well as the Mediterranean fisheries, in general) is a multispecies fishery and the main target species are many although the relative importance of species is different among the different areas. The fishery exploitation is mainly concentrated on short lived species and juveniles under 2-3 years of age, so trends in abundance of many species reflect more a fluctuation in recruitment than a response to fishing effort.

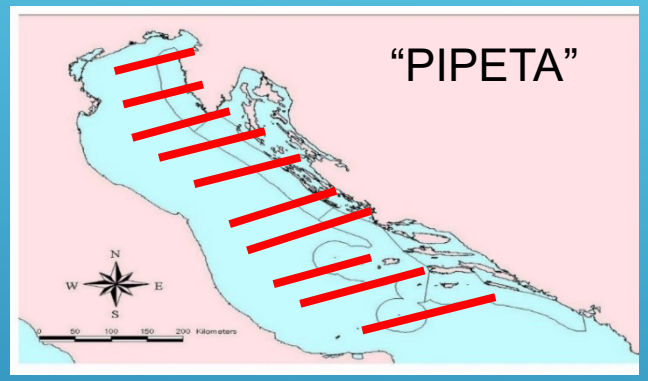
"HVAR" EXPEDITION

- Period: 1948/49
- First fisheries biological expedition in the Adriatic Sea
- 176 stations, open Adriatic
- Virgin state of demersal resources



The purpose was to determine the qualitative and quantitative charactristic of demersal communities of fish, crustaceans and cephalopods. The research was conducted on the accessible continental shelf in the territorail waters of former Yugoslavia and Albania and in the international waters to apporx. 20 Nm off the Italian Coast.

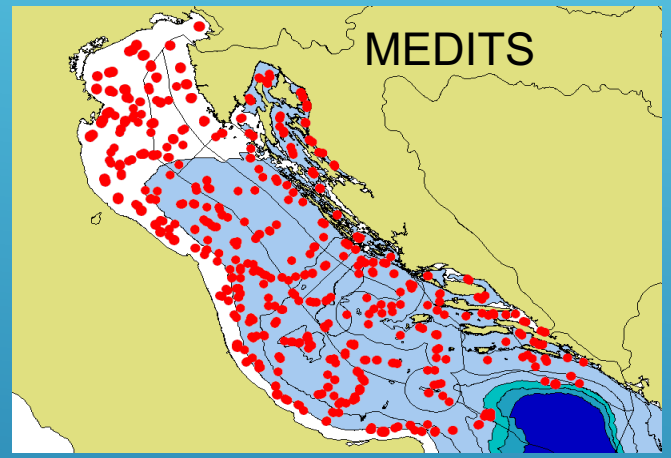
“PIPETA” expedition (1973/74; 1982-1994)



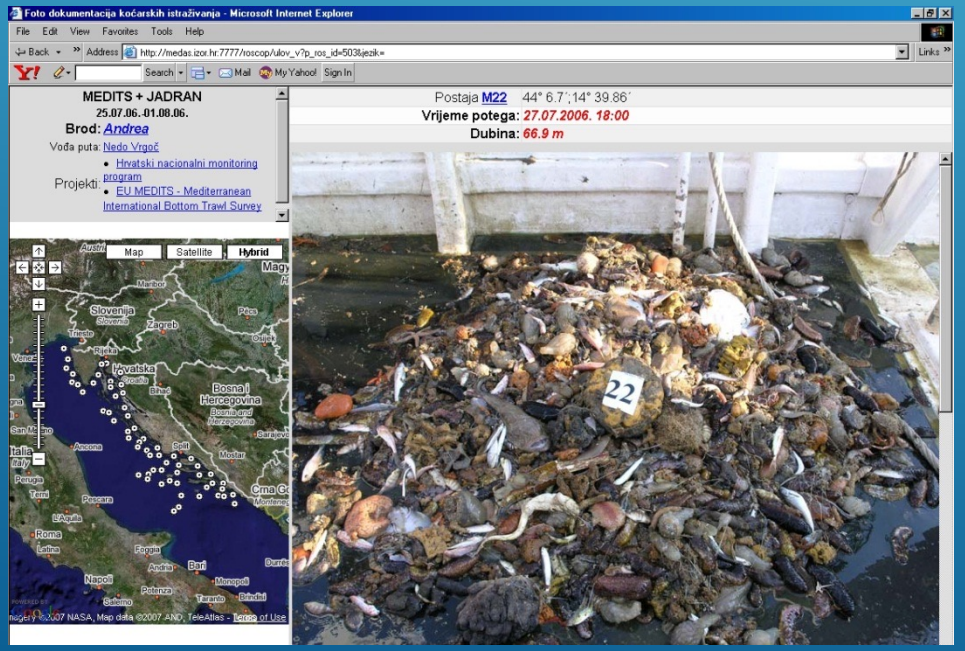
- Laboratory of Marine Biolog and Fisheries of Fano (Italy) in cooperation with IOR Split Croatia
- Started the most extensive research of demersal communities
- North and Central Adriatic to the Monte Gargano Cape; stations arranged in 9 profiles; samples taken with a typical commercial bottom trawl net – „tartana”

- GRUND programme was continuation of the Pipeta expedition – ended in 2007

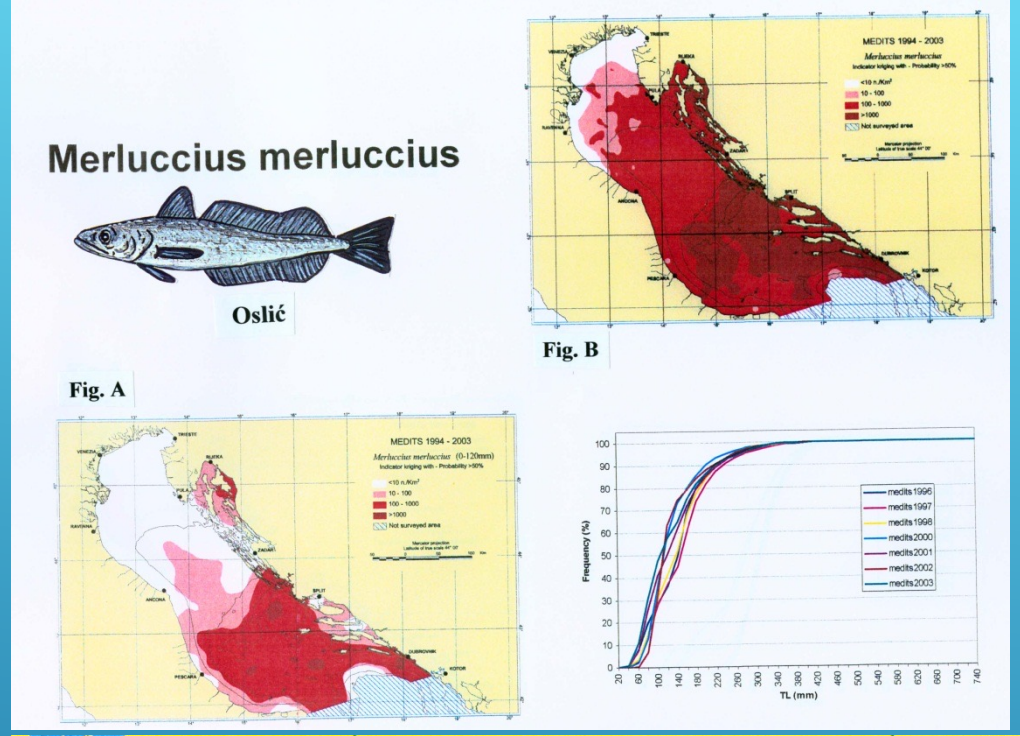
EU -MEDITS

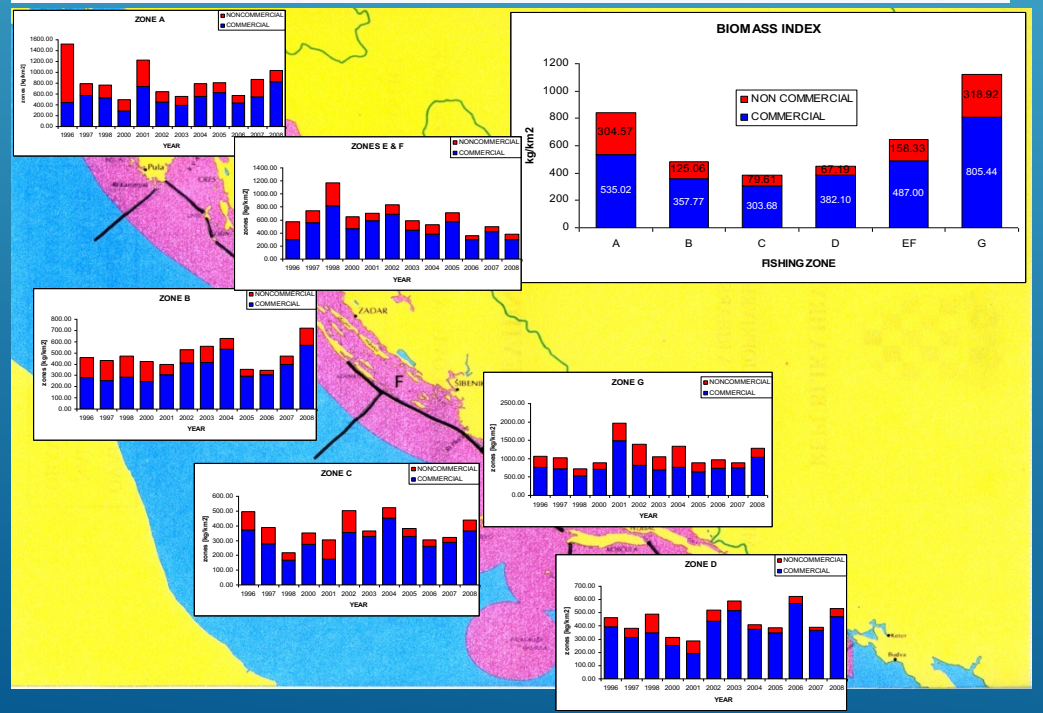


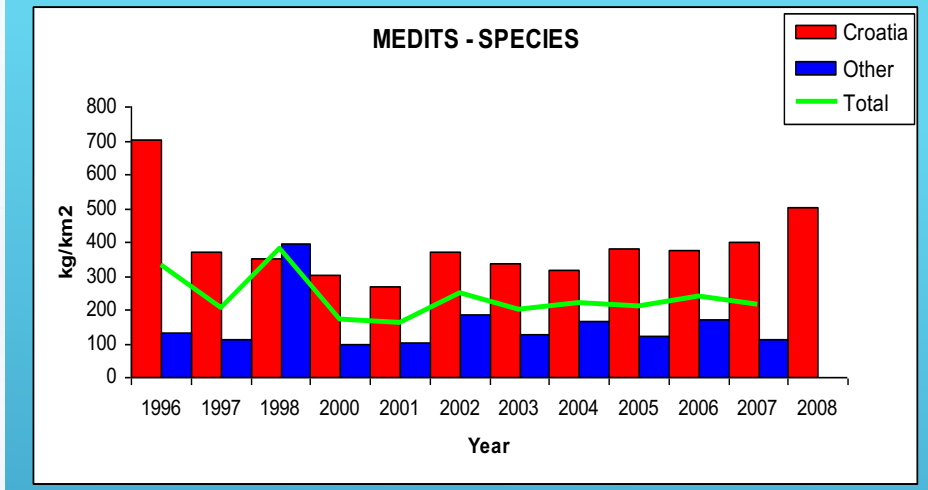
The EU has founded new demersal surveys in the Adriatic since 1994 in the framework of MEDITS programme which covers all the trawlable areas on shelves and the slope using the same standardised protocol nd is carried out once a year in the spring-summer period.

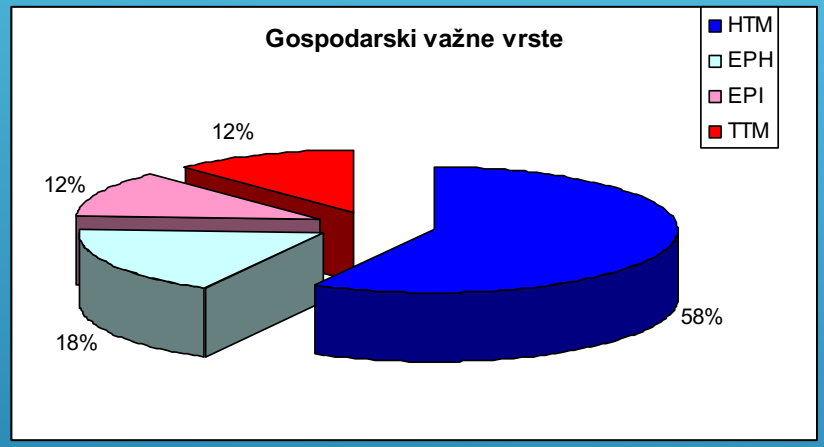


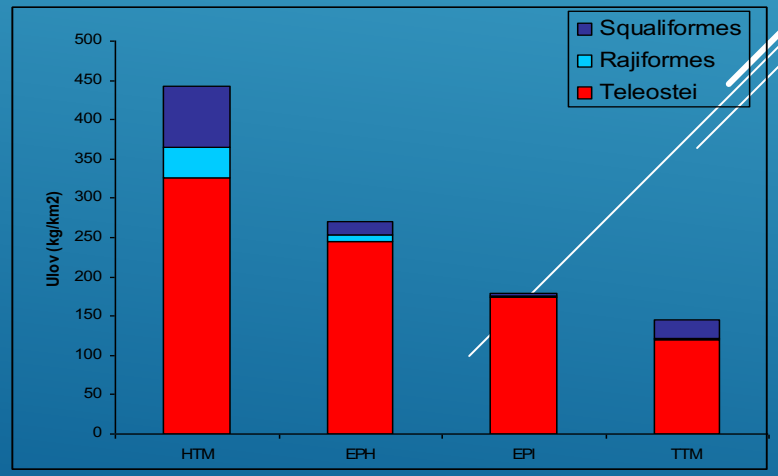
- from1994 (1996)
- spring-summer period
- Around 180 stations in GSA17
- trawl GOC 73
- More than 50 target species
- Joint data bases (GSA 17)


Merluccius merluccius
Oslić
Fig. A
Fig. B
MEDITS 1994 - 2003
Merluccius merluccius
Indicator kriging with - Probability >50%
<10 n./Km²
10 - 100
100 - 1000
>1000
Not surveyed area
MEDITS 1994 - 2003
Merluccius merluccius (0-120mm)
Indicator kriging with - Probability >50%
<10 n./Km²
10 - 100
100 - 1000
>1000
Not surveyed area
Frequency (%)
TL (mm)
medits 1996
medits 1997
medits 1998
medits 2000
medits 2001
medits 2002
medits 2003


ZONE A
NONCOMMERCIAL
COMMERCIAL
YEAR
ZONES E & F
ZONE B
ZONE G
ZONE C
ZONE D
BIOMASS INDEX
NON COMMERCIAL
COMMERCIAL
kg/km2
304.57
535.02
125.08
357.77
79.61
303.68
67.19
382.10
158.33
487.00
318.92
805.44
A
B
C
D
EF
G
FISHING ZONE
ZADAR
Pula

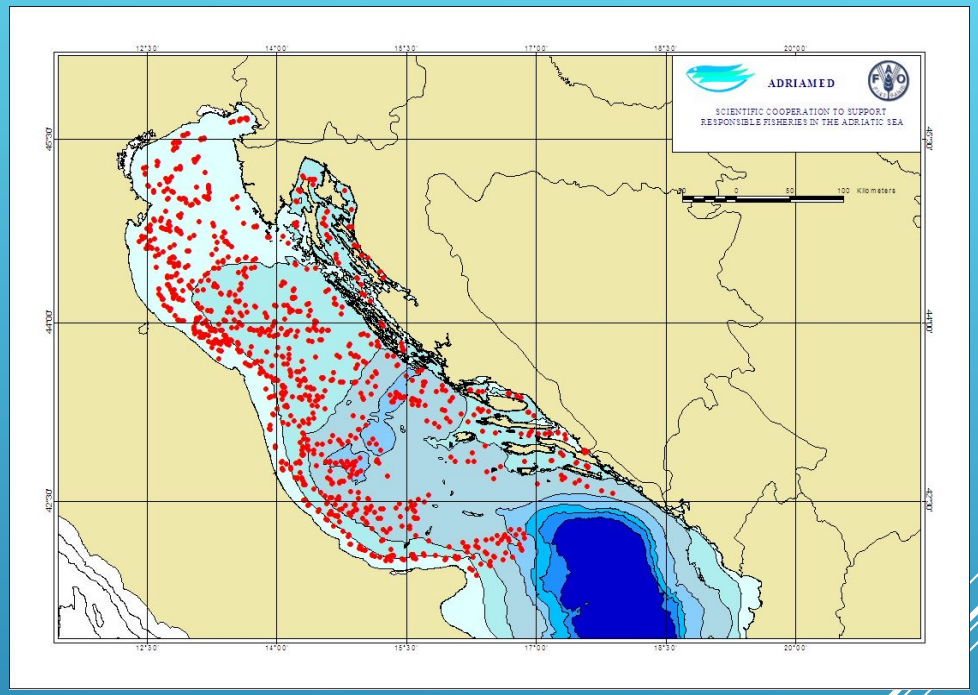

MEDITS - SPECIES
Croatia
Other
Total
kg/km2
Year
1996
1997
1998
2000
2001
2002
2003
2004
2005
2006
2007
2008


Gospodarski važne vrste
HTM
EPH
EPI
TTM
12%
12%
18%
58%

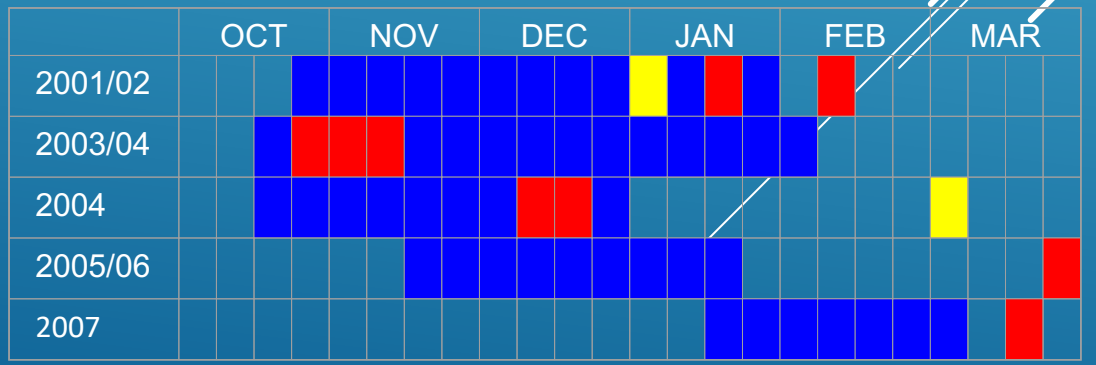

Squaliformes
Rajiformes
Teleostei
Ulov (kg/km2)
HTM
EPH
EPI
TTM

ADRIAMED TRAWL SURVEY

- Zemlje : CRO, SLO, MNG, ALB
- Početak : 2001/2002
- Jesensko-zimsko razdoblje
- Hrvatska 40 postaja
- Komercijalna mreža
- Uzorkovanje usklađeno sa istraživanjima GRUND i MEDITS
- Zajednička baza podataka GSA 17 i GSA 18



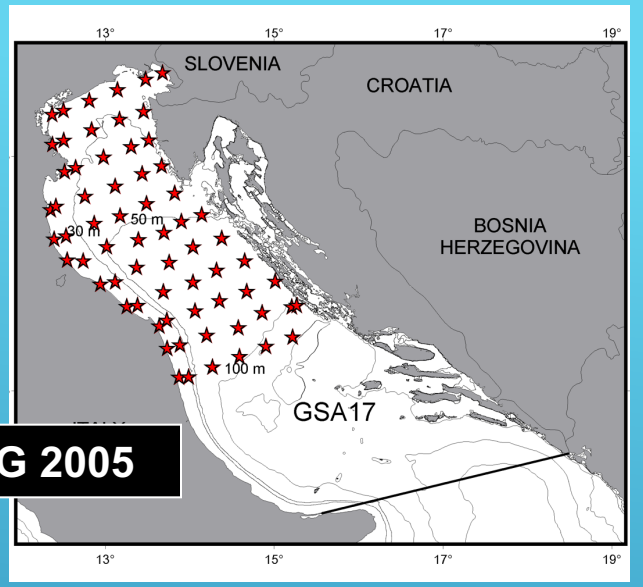
AdriaMed TS + GRUND in the GSA 17



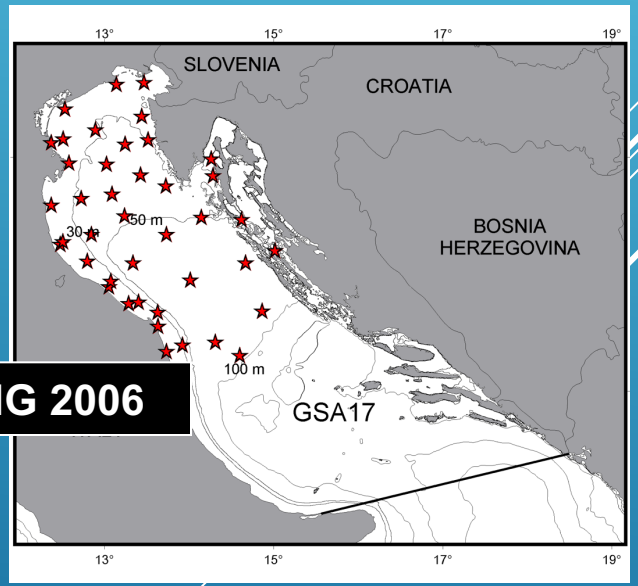
In recent times new lines of investigations are acrried out using different methodology (Deep Sea Surveys, Solemon project, Underwater TV Surveys and genetic investigations).

- From 2005 - (Ancona, Cioggia, Split)
- Sampling with beam trawl "rapido" (+landing place ITA)
- Two survey per year
- Extension in whole GSA 17 and 18 through FAO AdriaMeda

"SoleMon"



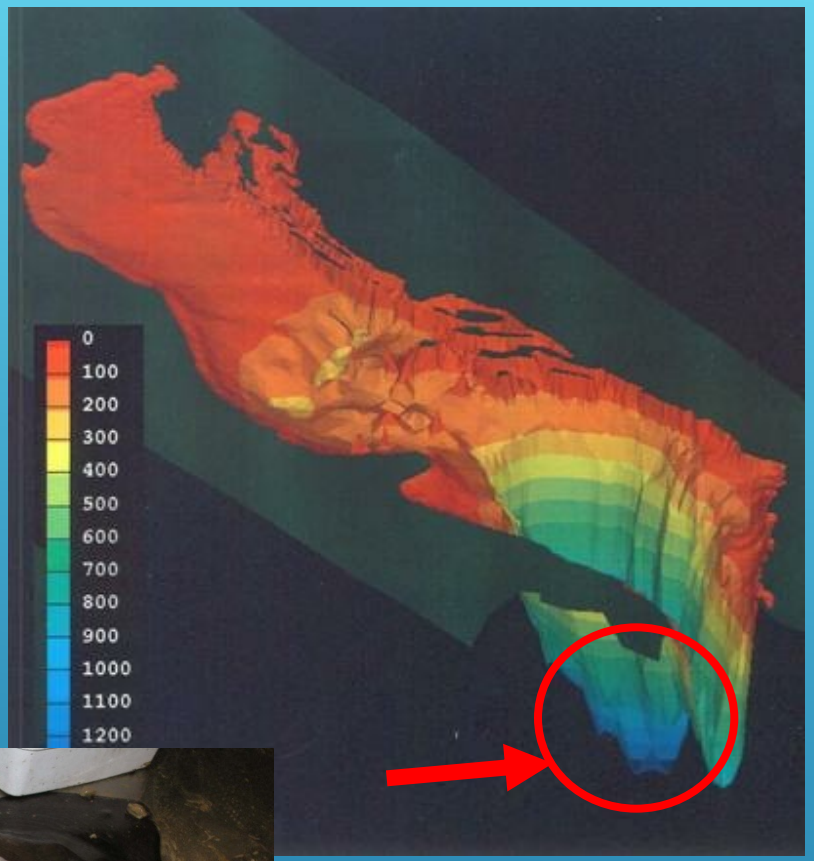
SPRING 2005



SPRING 2006

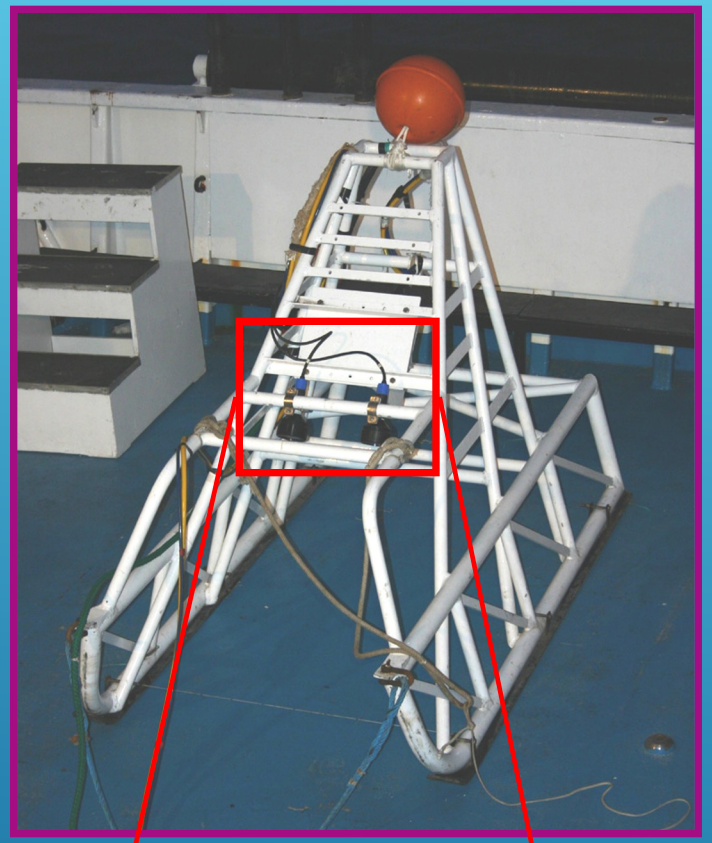
EKSPERIMENTALNA ISTRAŽIVANJA DUBOKOG JADRANA

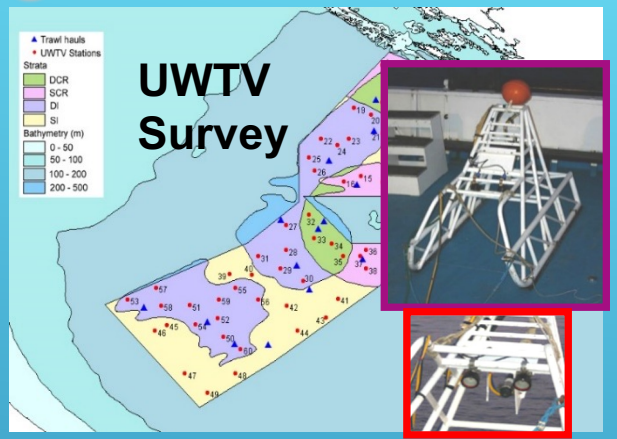
- Okvir : AdriaMed
- Početak 2008
- Ribolovni alati:
  - pelagička koća
  - pridnena koća
  - parangal
  - vrše

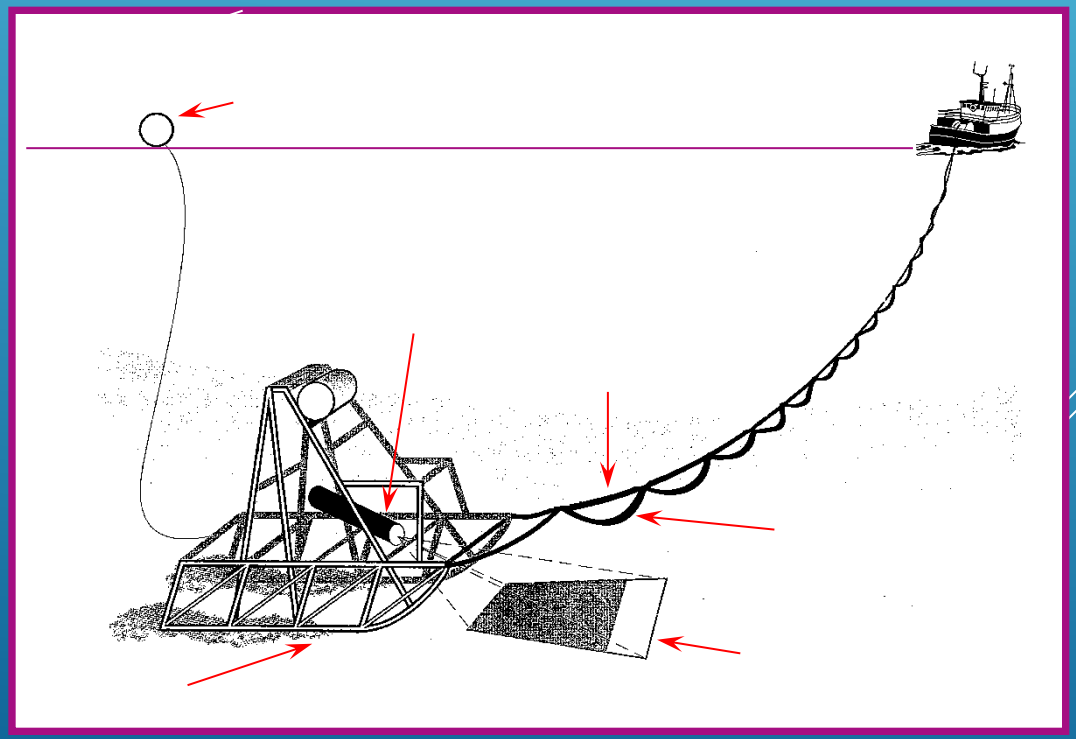


UWTV istraživanja Jabučke kotline

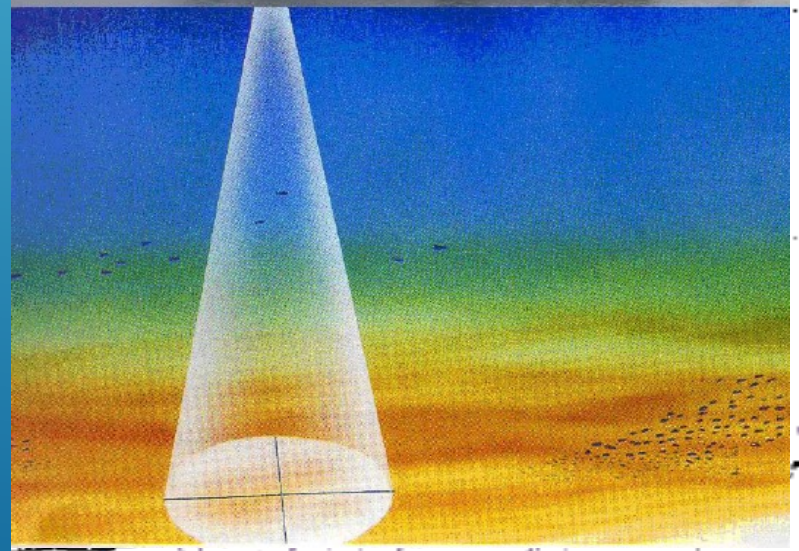
- početak 2009
- IOR i CNR Ankona
- procjena škampa





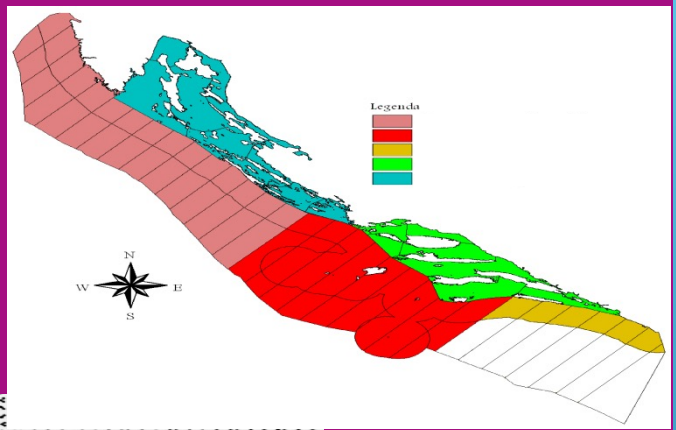


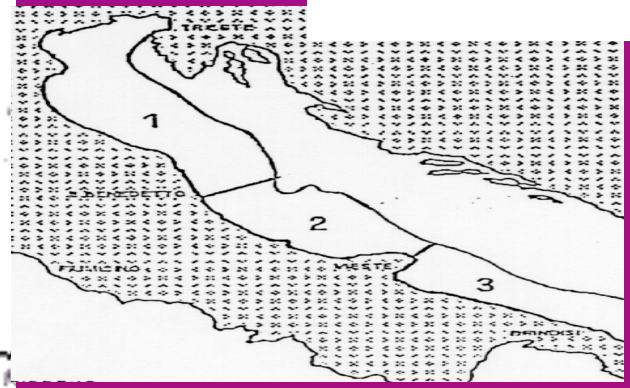
MEDIAS– ACOUSTIC SURVEY



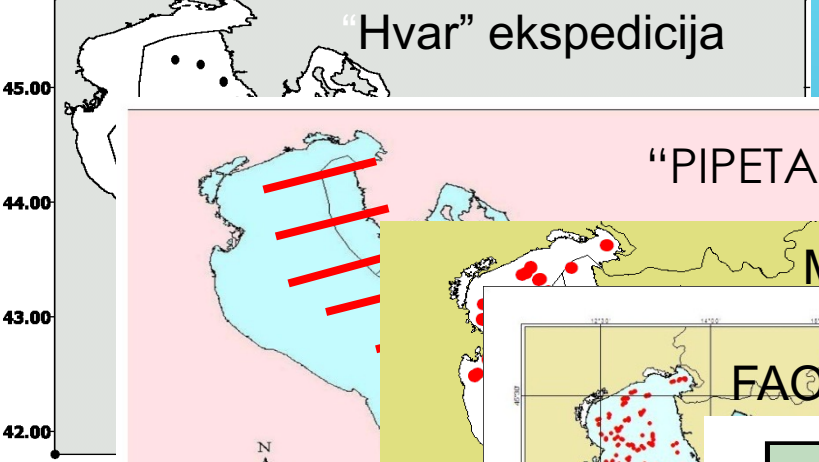
Svrha istraživanja:

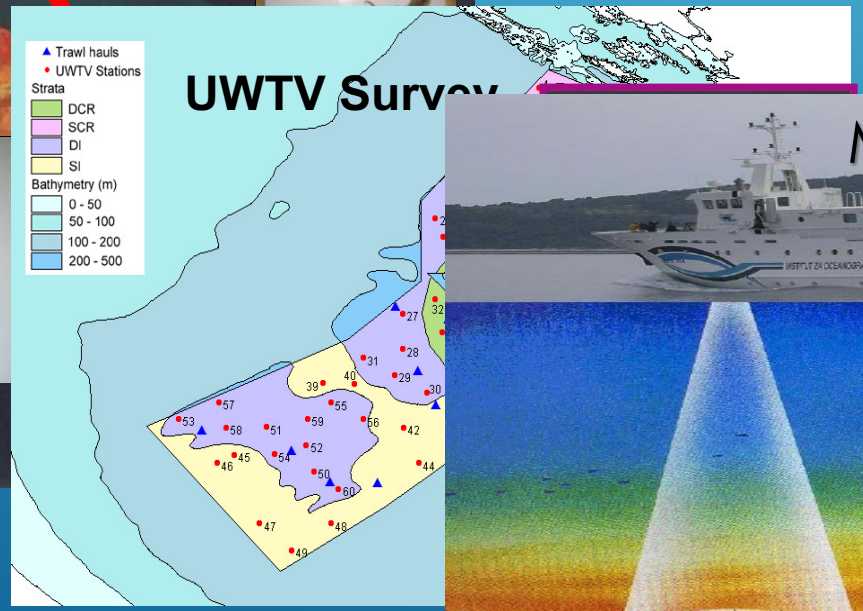
dobivanje uvida u prostornu rasprostranjenost i stanje populacija ciljanih vrsta sitne plave ribe, (inćuna, papaline i srdele).

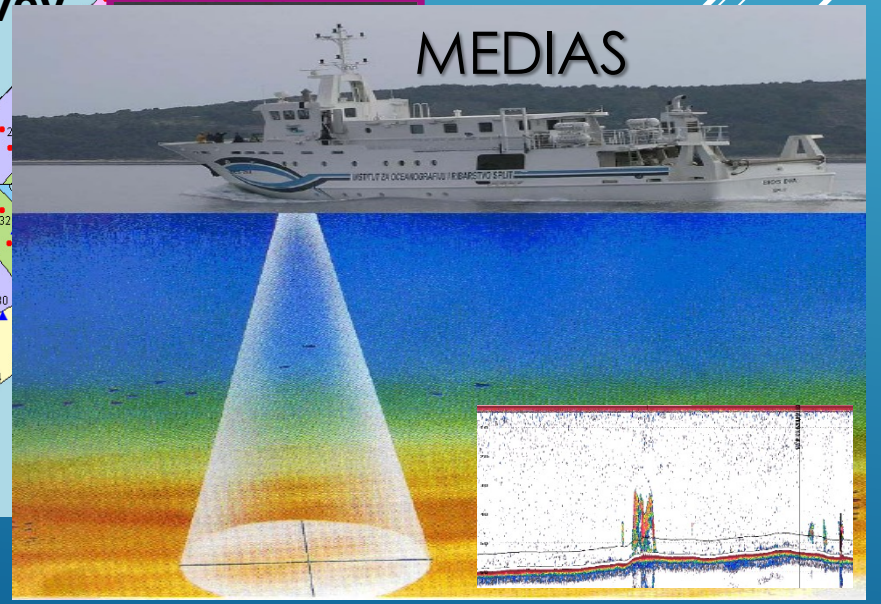




SCIENTIFIC RESEARCHES IN THE ADRIATIC SEA

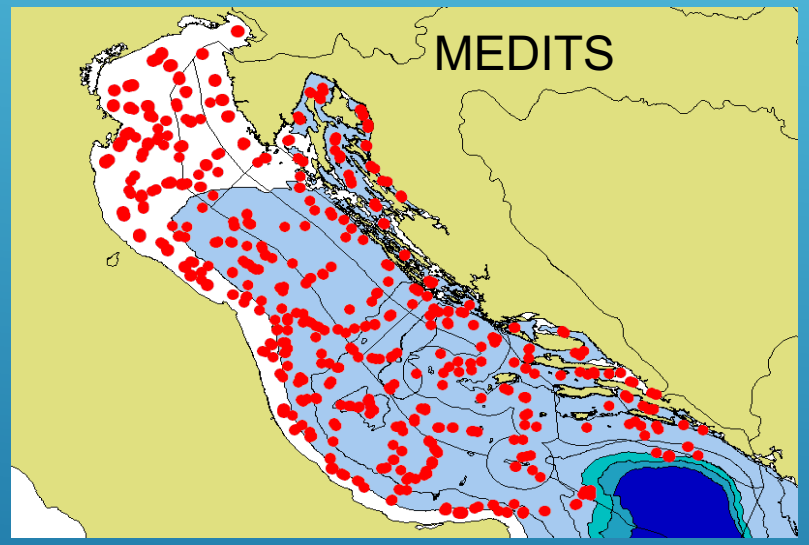






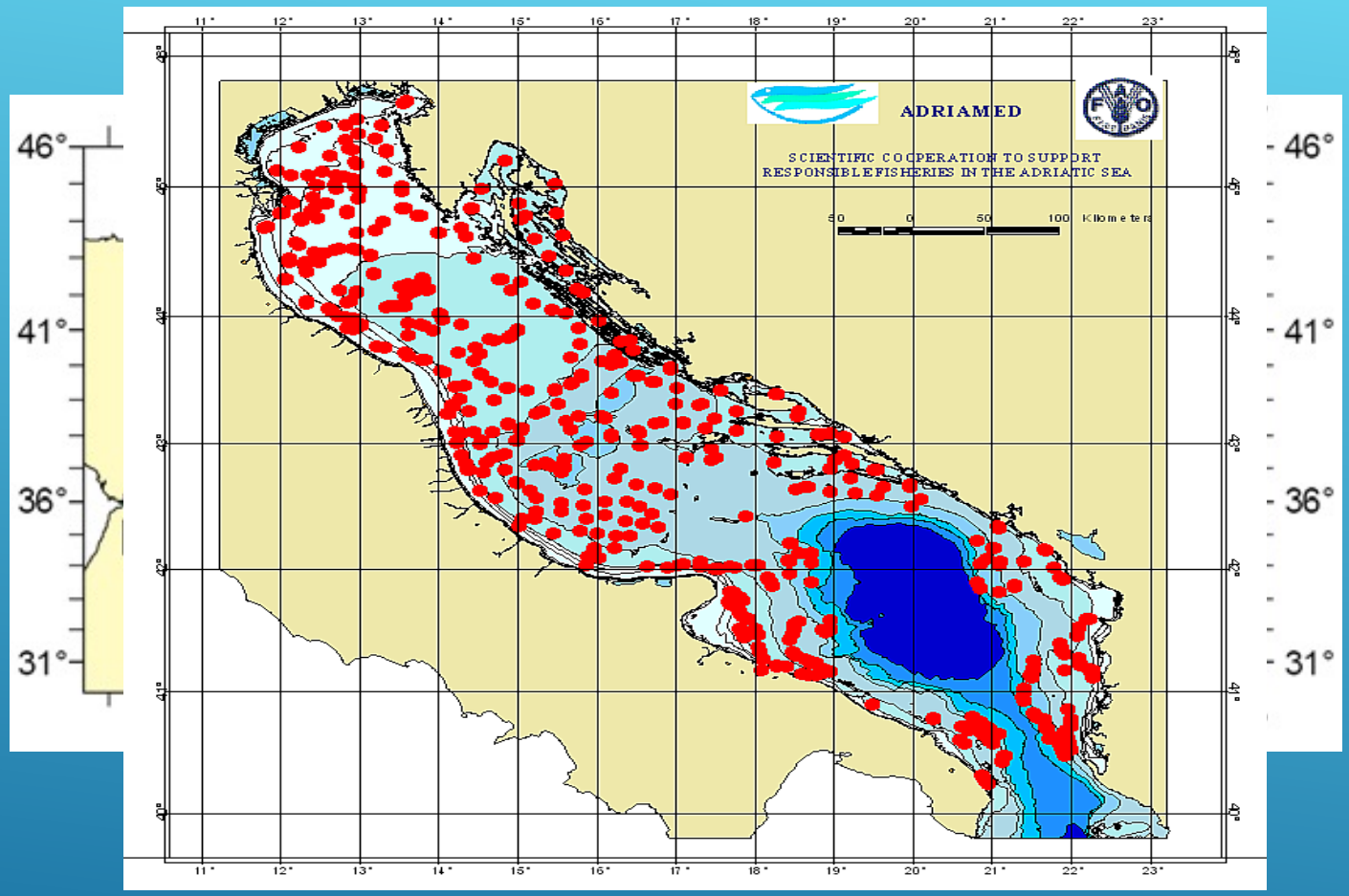
DCF (2013)

- Monitoring of commerci… fisheries
- (demersal, costal, pelagic, tuna)
- Scientific surveys
  - (MEDITS, MEDIAS)



The Mediterranean International Trawl Survey programme is an international bottom trawl survey designed to produce basic information on demersal resources in the Meditrerranean Sea, in terms of population distribution and demographic structure, on the continental shelves and along the upper slopes from 10 to 800 m depth. In the Adriatic sea the study area covers whole GSA 17, Northern and Central Adriatic since 1996. The Laboratory of Marine Biology and Fishery of Fano, Institute of Oceanography and Fisheries Split, Fishery Research Institute of Slovenia are involved in Project.

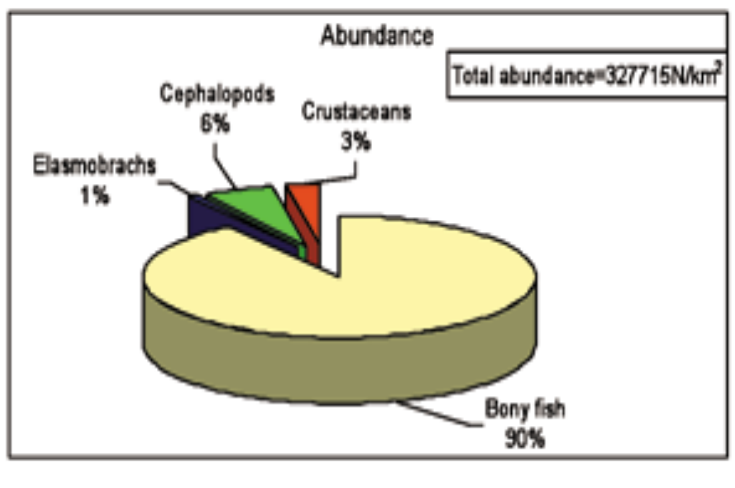
EU MEDITS



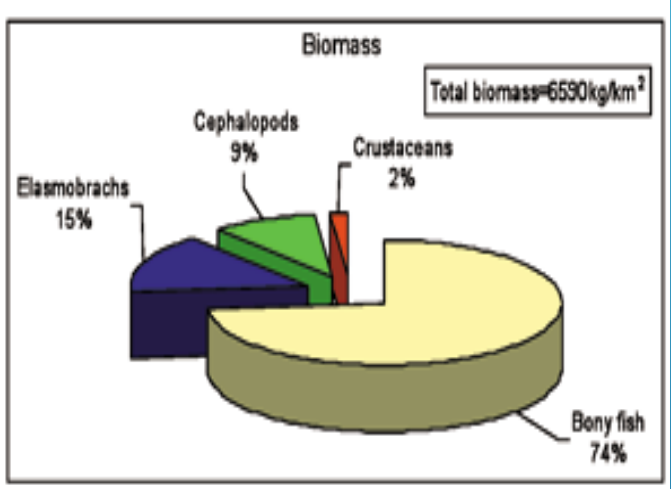
ESP, FRA, ITA, GRE, SLO, CIP, CRO, ALB, MNE, MAL, MAR
From 1994. Spring – Summer period.
Common Protocol
Specially designed scientific bottom trawl net GOC 73
270 stations in the Adriatic Sea

RESULTS

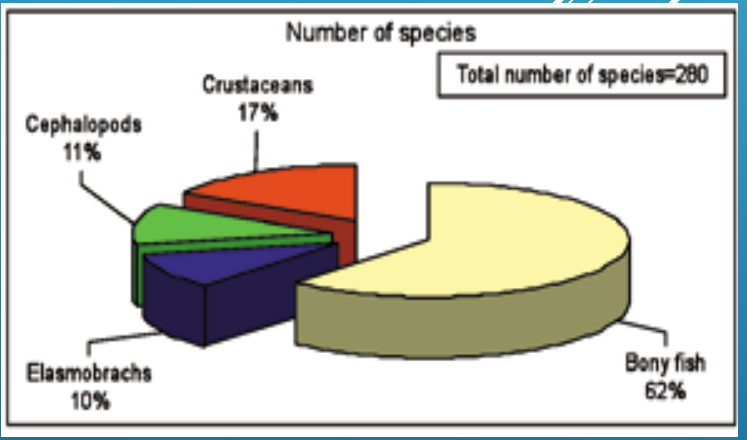
The percentage in abundance, biomass and number of species in the total catches for the main faunal categories



bony fish 90%

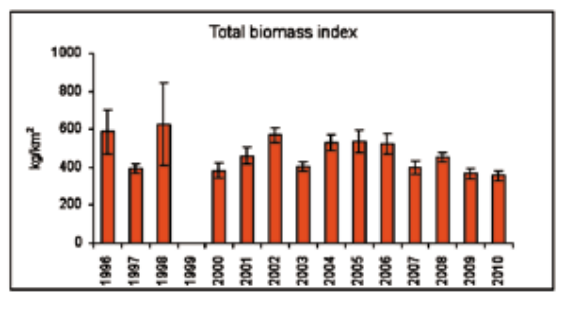


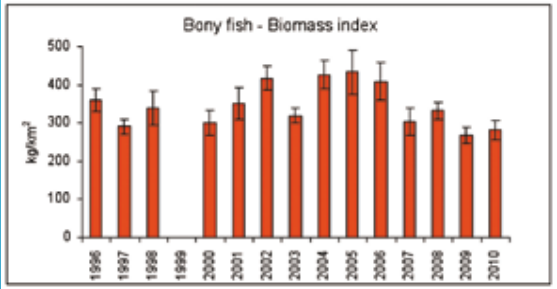
bony fish 74%

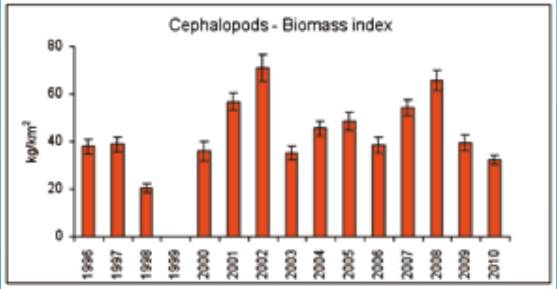


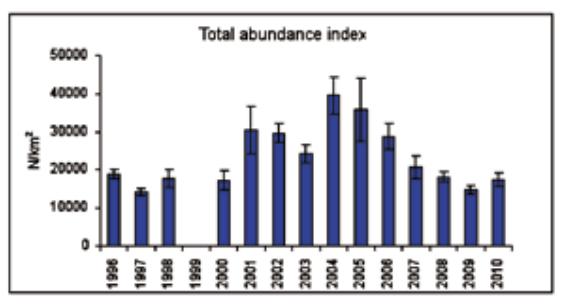
bony fish 62%

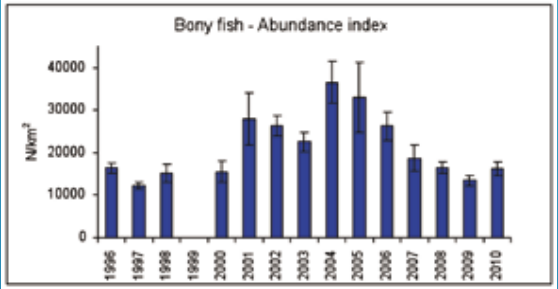
The trend over the whole period of the total abundance, biomass and number of species caught in the MEDITS surveys for the main faunal categories (bony fish, elasmobranches, cephalopods and crustaceans) and for the total of catches, as well.

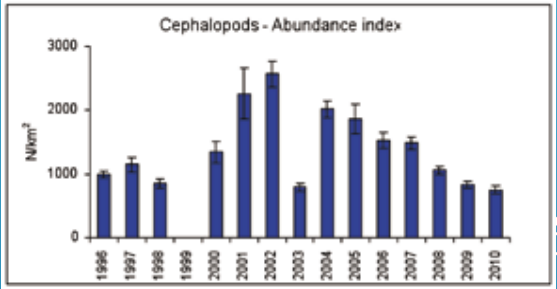


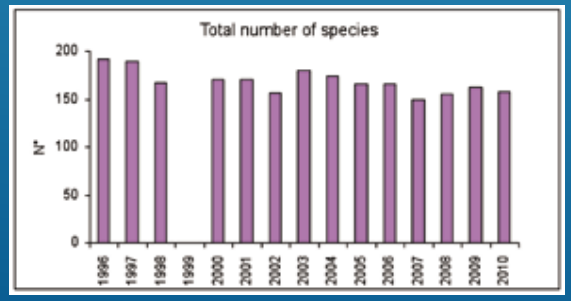


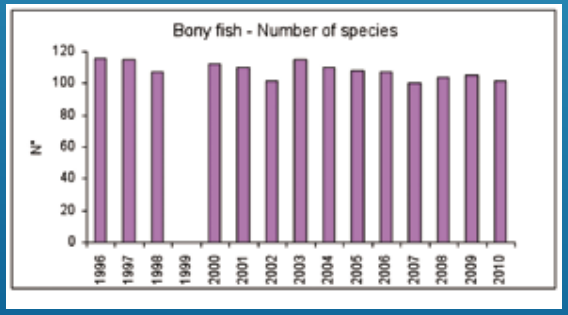


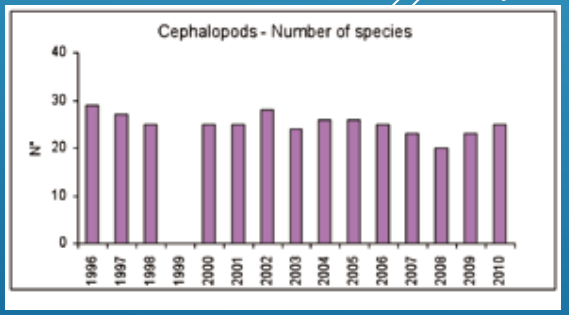


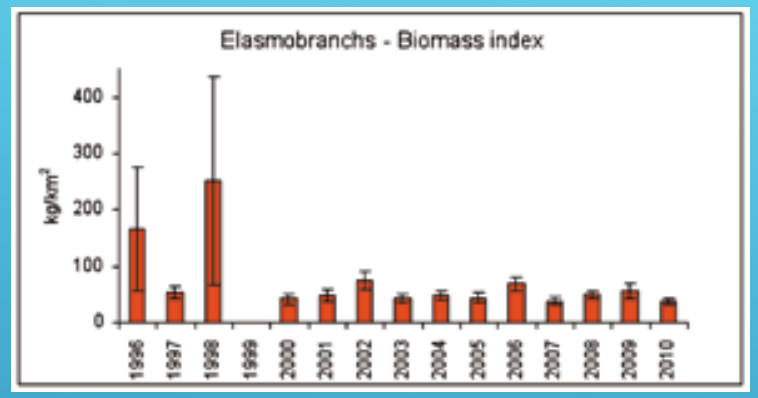


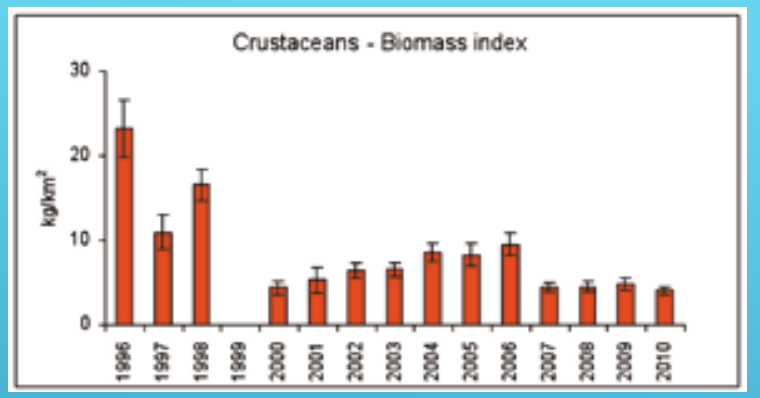


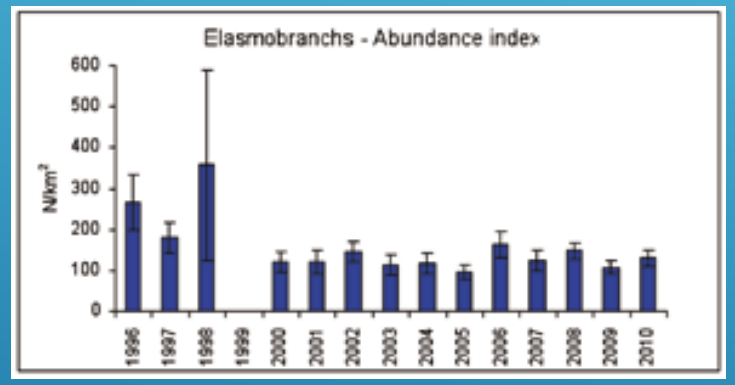


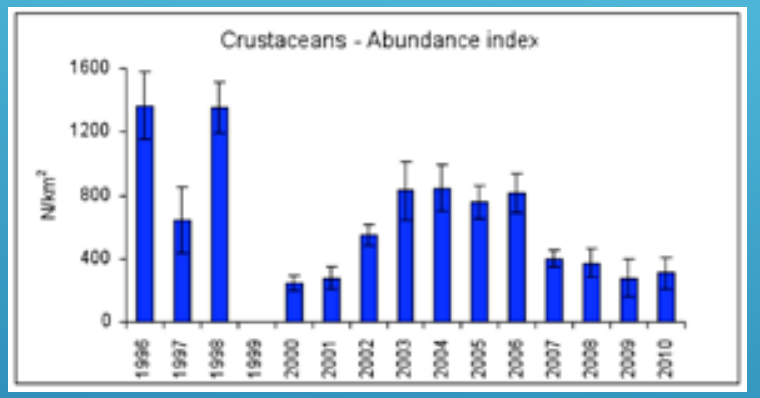


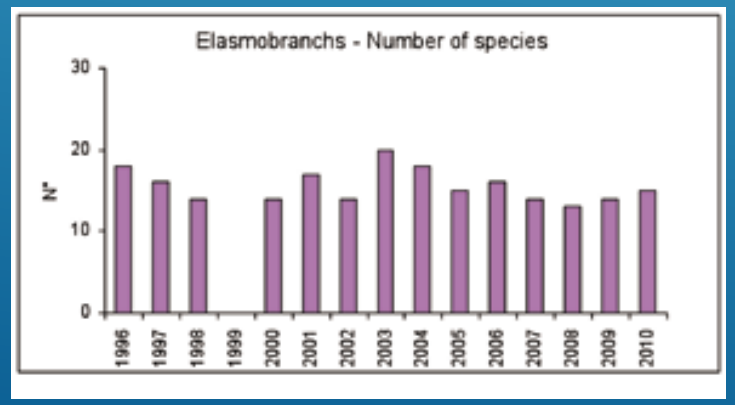


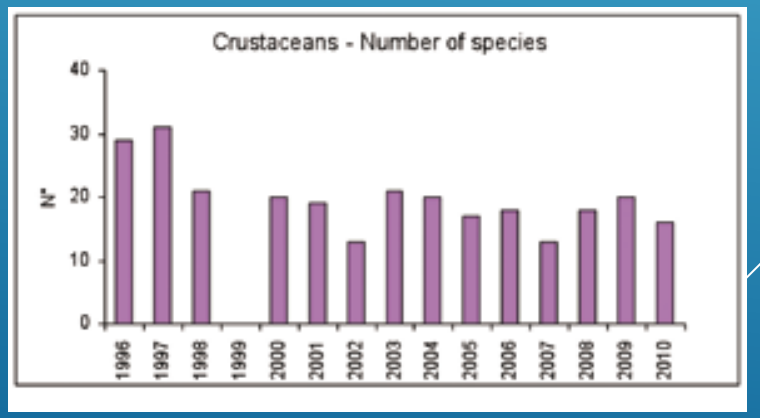

Elasmobranchs - Biomass index
kg/km²
0
100
200
300
400
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

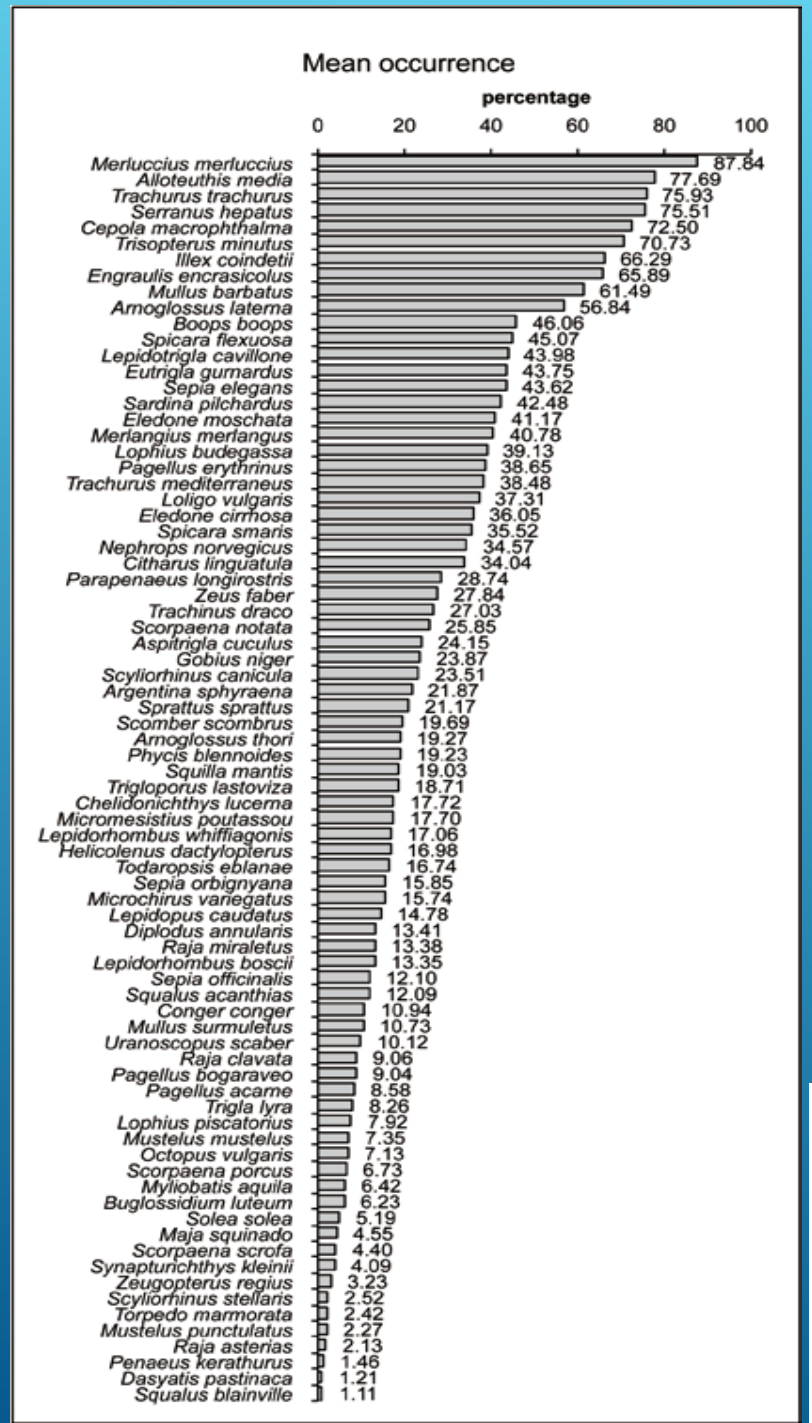

Crustaceans - Biomass index
kg/km²
0
10
20
30
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


Elasmobranchs - Abundance index
N/km²
0
100
200
300
400
500
600
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


Crustaceans - Abundance index
N/km²
0
400
800
1200
1600
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

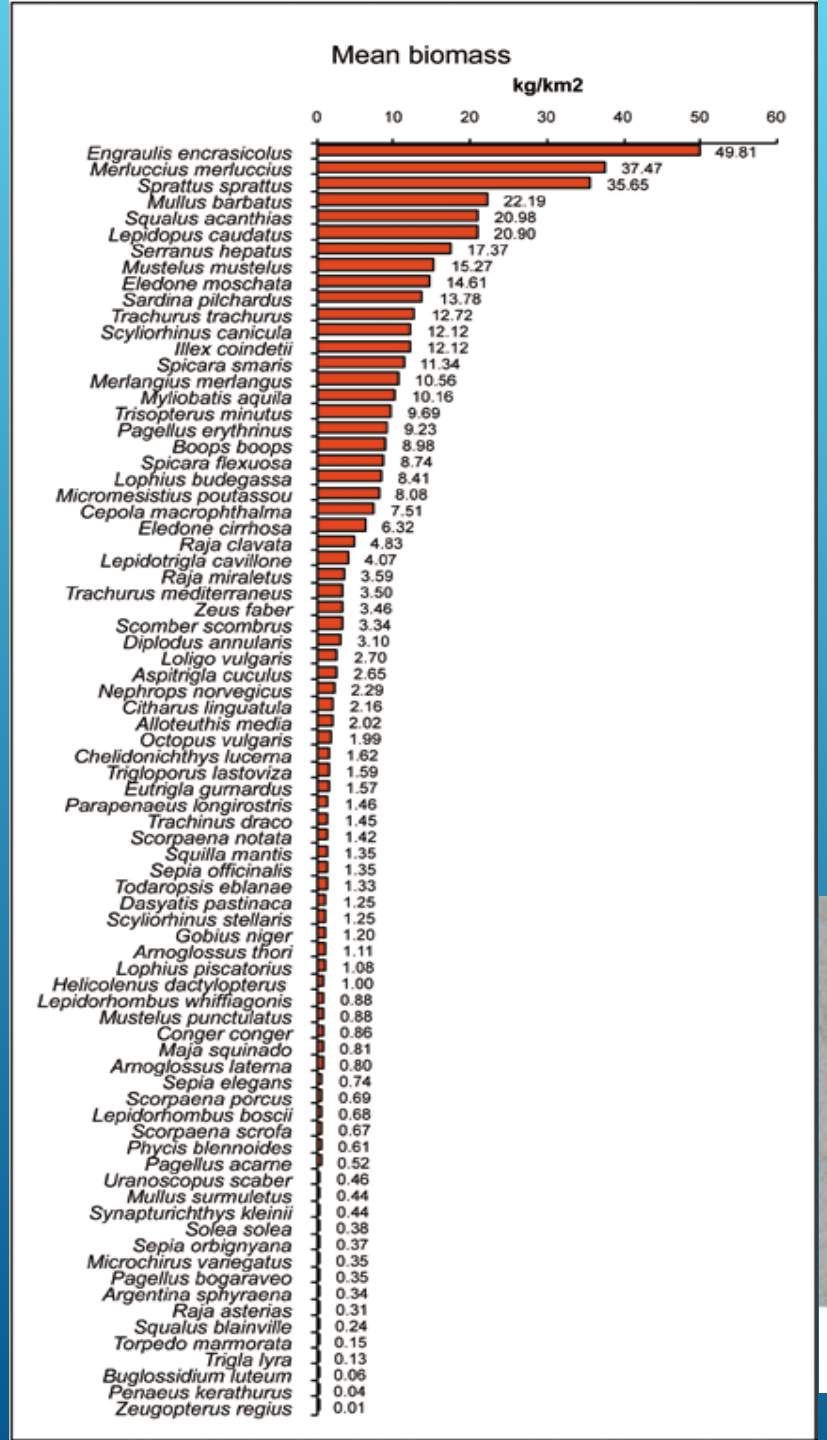

Elasmobranchs - Number of species
N°
0
10
20
30
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


Crustaceans - Number of species
N°
0
10
20
30
40
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

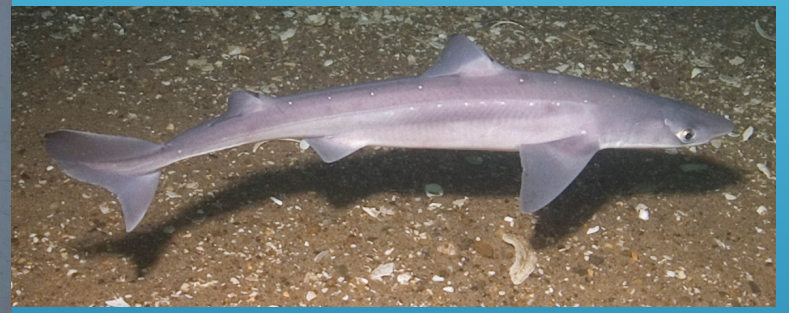


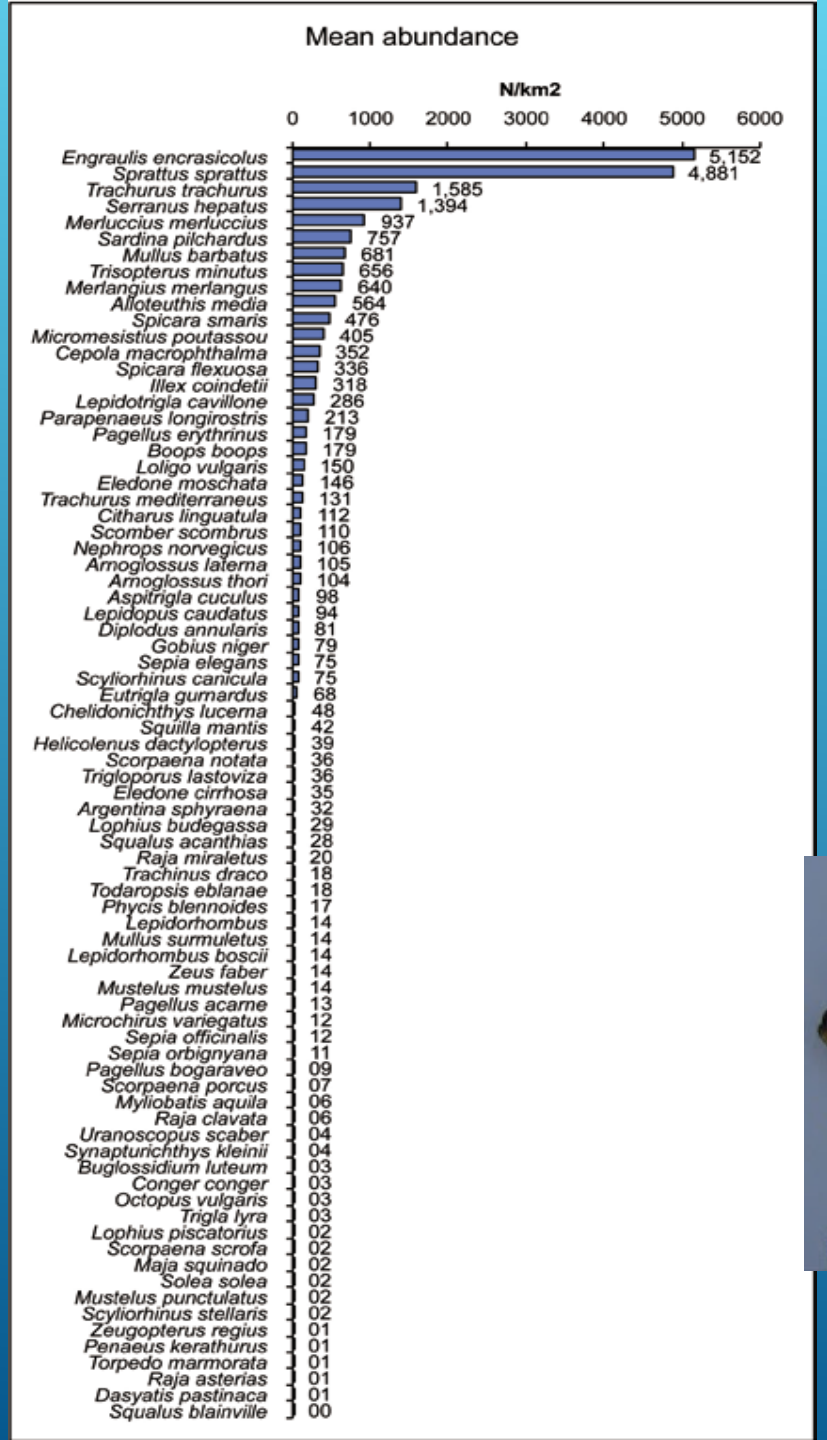
List of the species ranked by mean occurrence from 1996-2020.

Ten species have occurrence higher than 50% of station.



List of the species ranked by mean biomass index from 1996-2020. The highest value are reported for two small pelagic species *Engraulis encrasicolus (first place with index of biomass 49.81 kg/km2) and Sprattus sprattus (third place 35.65 kg/km2). On the second place is Merluccius merluccius (34.47 kg/km2), followed by: Mullus barbatus (22.19 kg/km2), Squalus acanthias (20.98 kg/km2) and Lepidopus caudatus (20.90 kg/km2). Totally 26 species are represented with biomass indeks lower than 1 kg/km2)*



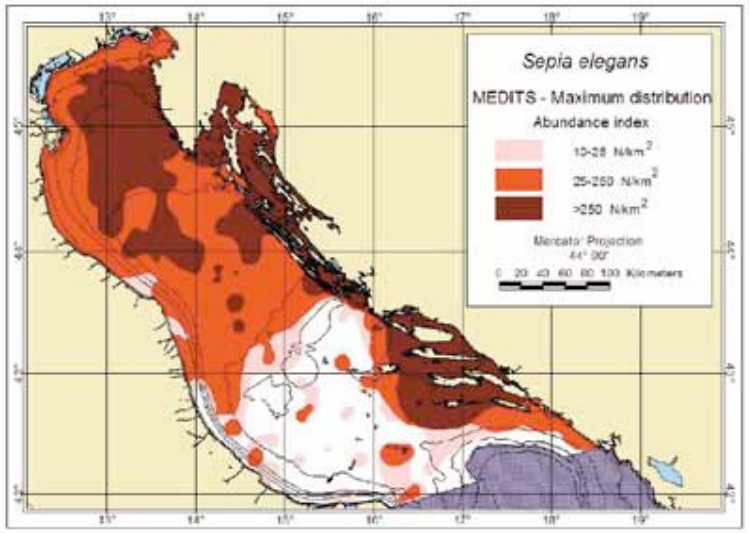


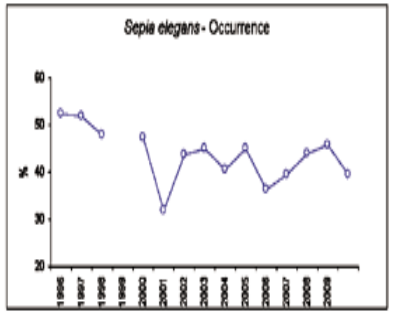
List of the species ranked by mean abundance index from 1996-2020.

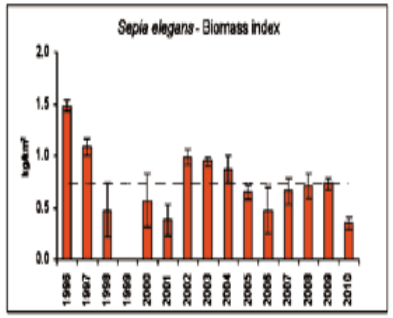
The highest abundance indices have been recorded for small pelagic species Engraulis encrasicolus 5152 N/km2 and Sprattus sprattus 4841 N/km2. Other most abundant species are: Trachurus trachurus 1555 N/km2, Serranus hepatus 1394 N/km2, Merluccius merluccius 938 N/km2, Sardina pilchardus 757 N/km2, Mullus barbatus 681 N/km2, Trisopterus minutus 656 N/km2, Alloteuthis media 640 N/km2.

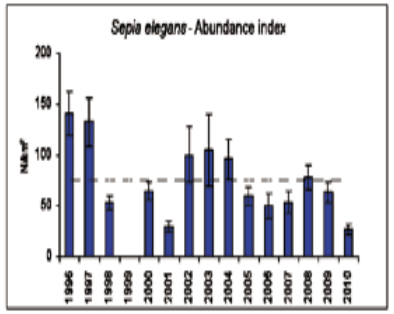
Sipica rumenka, (*Sepia elegans* Blainville, 1827)

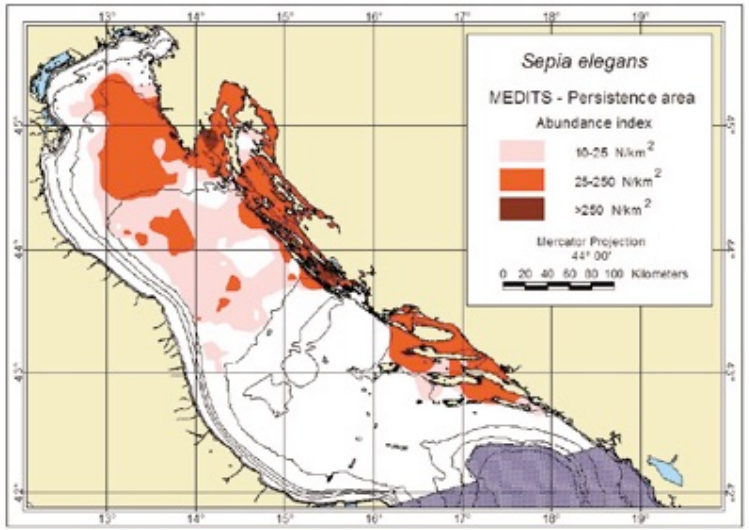
EN: Elegant cuttlefish; IT: Seppia elegante; SL: Mala sipa







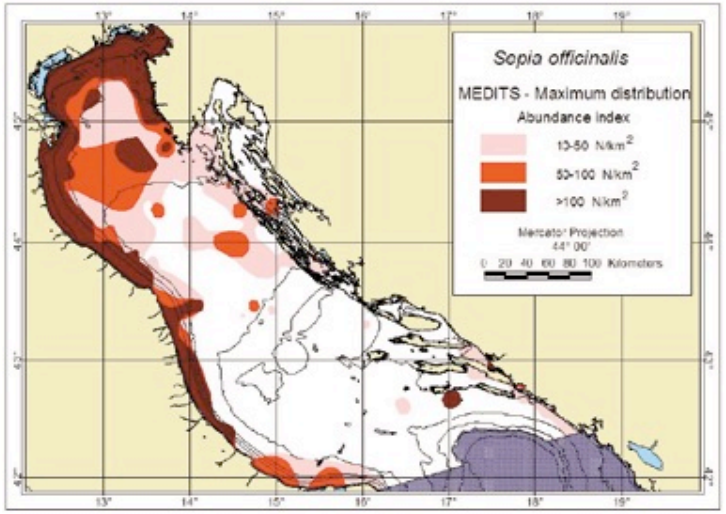


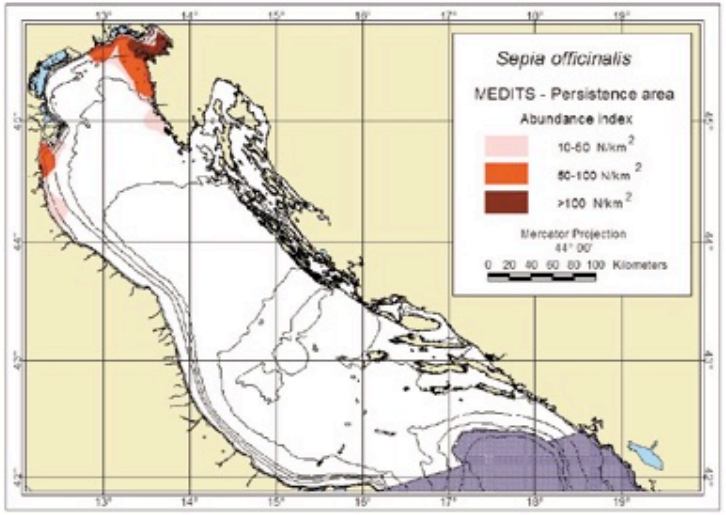


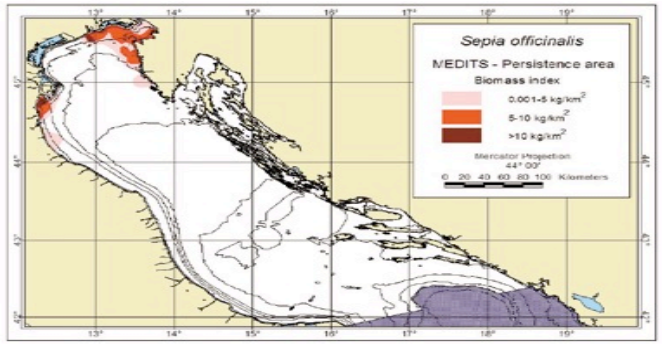
It is found within 100 m of depth, although greatest abundance were steadily found on sandy bottoms between 30 and 50 m of depth of the N Adriatic and the whole eastern channel area. Occurrence highlighted a decreasing trend in the first three years, after 2000 the occurrence is stable around a mean value of 43.6%. Although biomass and abundance indeks fluctuated widely over the period, generally a decreasing trend has been observed, for both indices toucing lowest value in 2010. Medium value of biomass indeks is 0.7 kg km2, abundance indeks of 75 specimens per km2

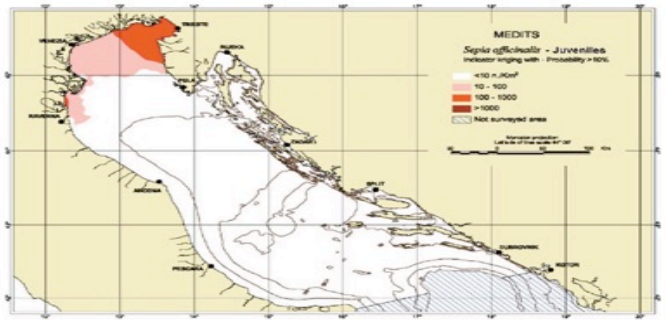
Sipa, (*Sepia officinalis* Linnaeus, 1758)

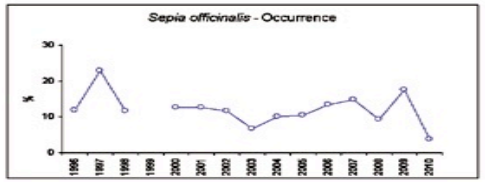
EN: Common cuttlefish; IT: Seppia; SL: Sipa

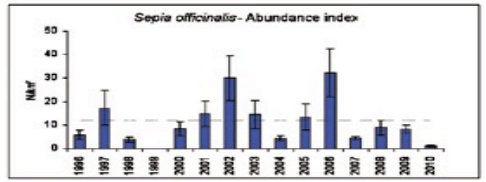


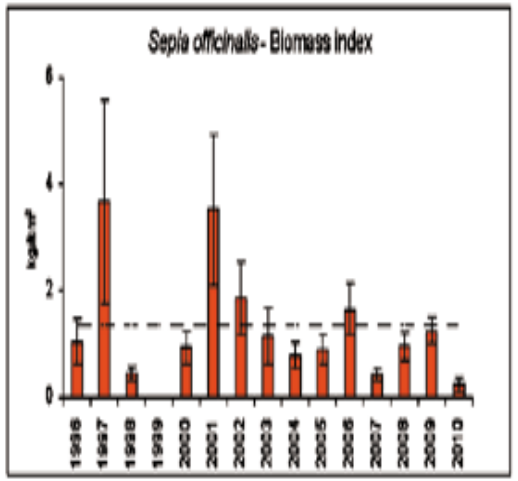


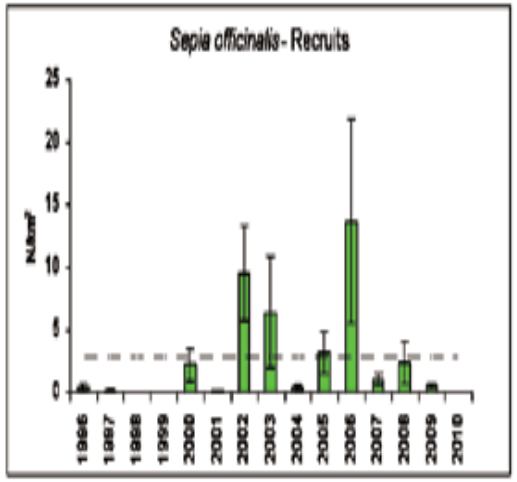


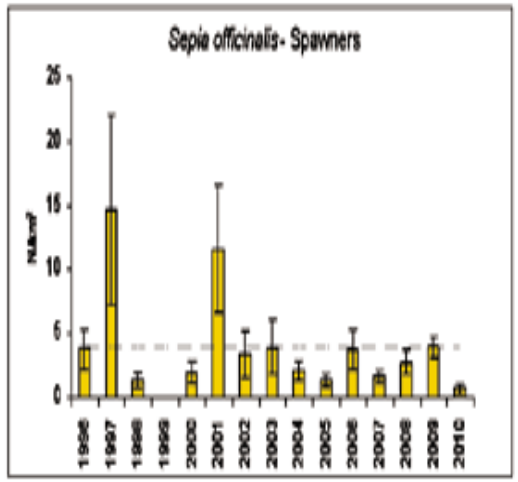


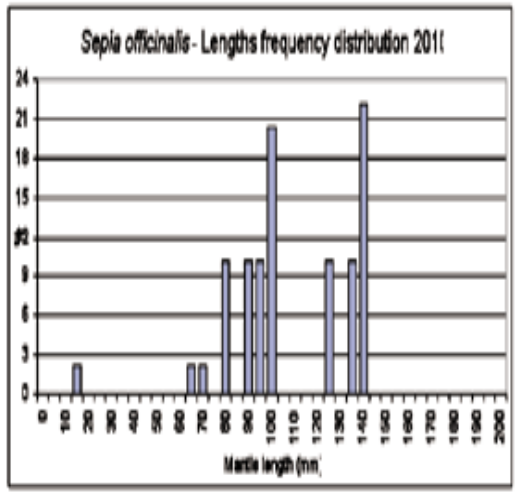












Common cuttlefish has a very short biological cycle with large migration. Its spatial distribution and size composition are strongly influenced by season.

During MEDITS survey is found on shallow water of the coastal area. Juveniles are distributed in the shallow coastal water of the northernmost part of the Adriatic.

Frequency of occurrence fluctuated around a mean value of 12%; in 2010 touching the minimum value.

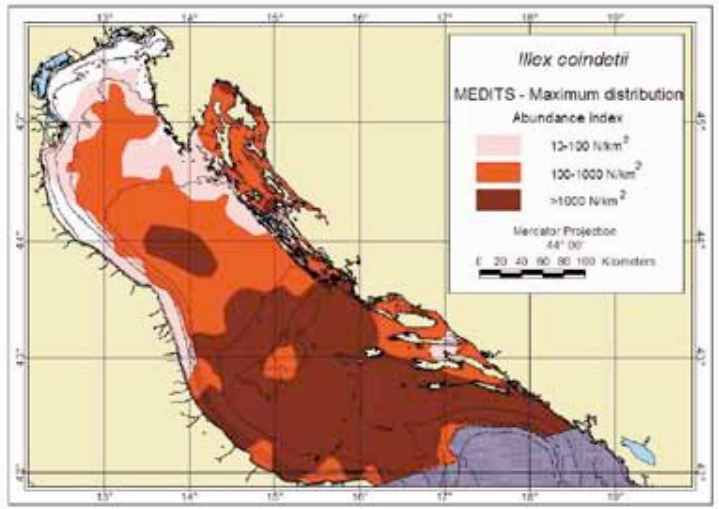
The indices of abundance and biomass showed large fluctuation touching lowest value in 2010.

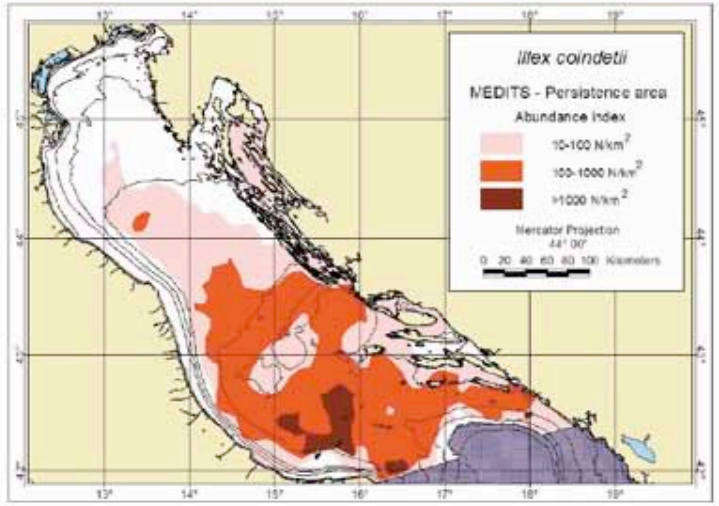
Medium value of biomass indeks is 1.3 kg per square km, and abundance index of12 specimens per km2.

The abundance of recruits and spawners are strongly influenced by coincidence or not of period of sampling with the spawning season.

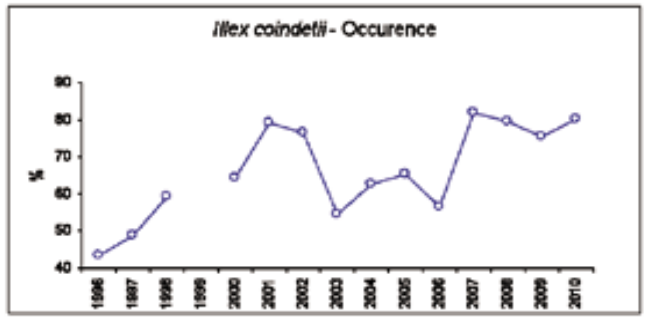
The length frequency distribution for 2010, whit a small number of specimens caught, show the proportion of spawners and recruits in the catch.

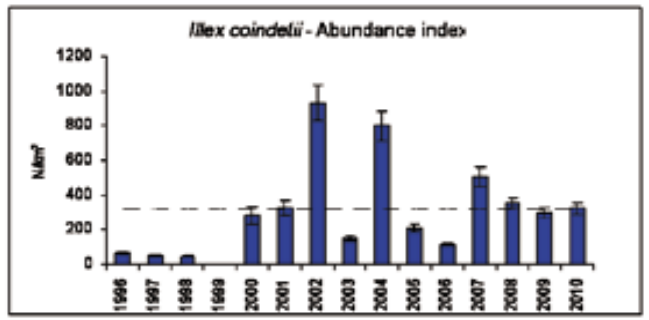
Lignjun, (Illex coindetii (Verany, 1839)) EN: Broadtail shortfin squid; IT: Totano; SL: Kratkoplavuti ligenj

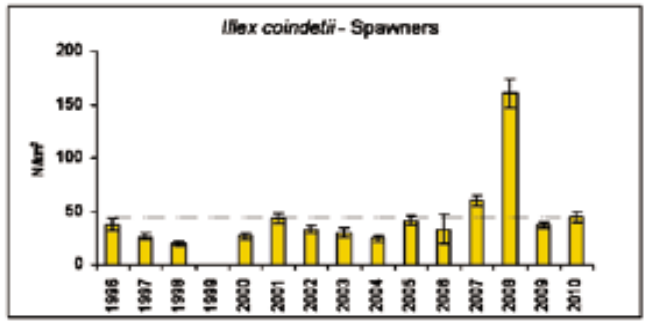


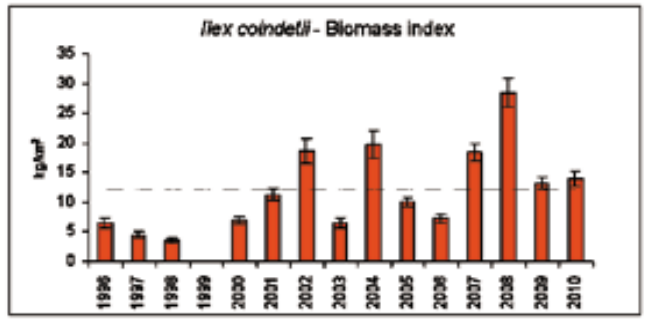


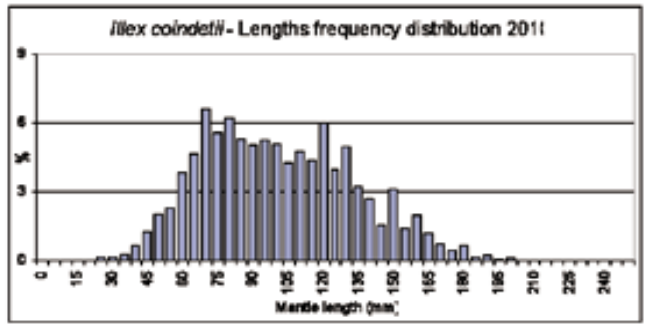
Max spatial distribution
Persistance area









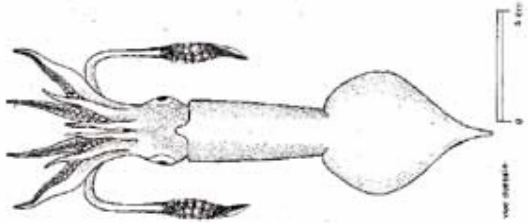


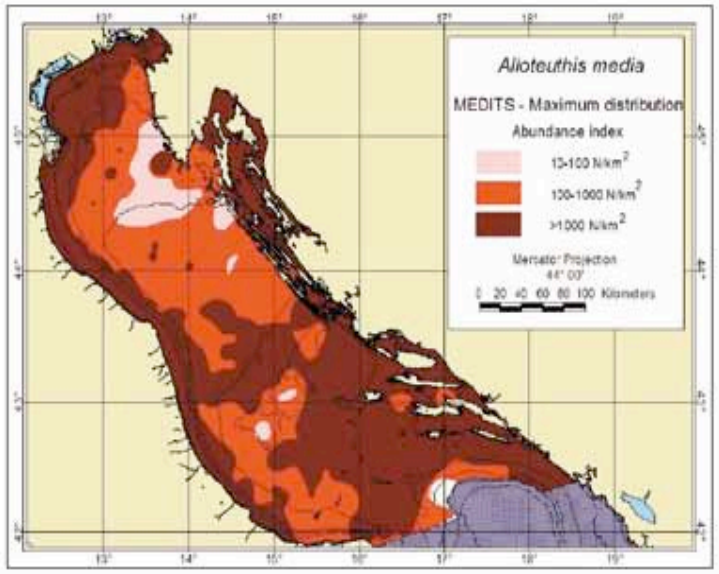
It is widely distributed throughout the N and C Adriatic mainly in the area deeper than 20-25 m. It is mostly abundant and steadily found in water deeper than 100 m. Occurrence, in spite of the high fluctuations during the period, highlighted an increasing trend, varying from 47% in 1996 to 81% in 2007 and 2010. Density indicators fluctuated widely and, on the whole, the population showed a gradual increase.

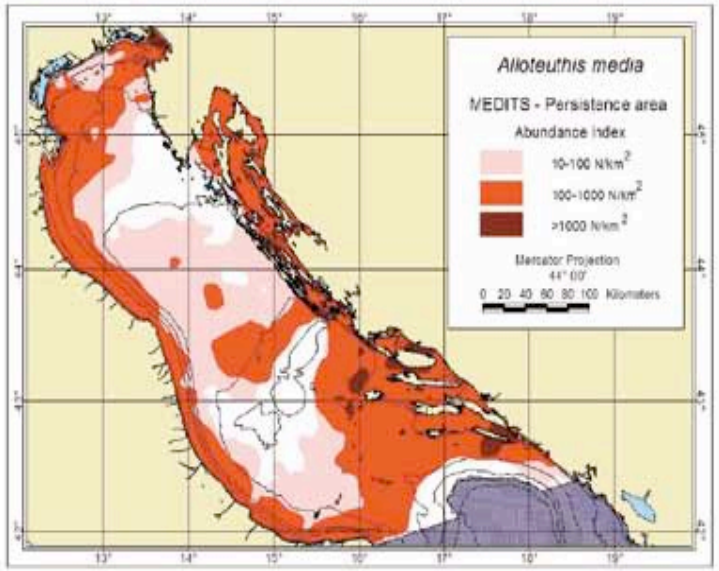
Medium value of biomass is 12,1 kg / km2 and abundance indeks of 318 specimens /km2. The short biological cycle influence the fluctuation of abundance, biomass, spawners and recruit indices. Length frequncy distribution in 2010 ranged from 24 to 200 mm.

Lignjica, (*Alloteuthis media* (Linnaeus, 1758))

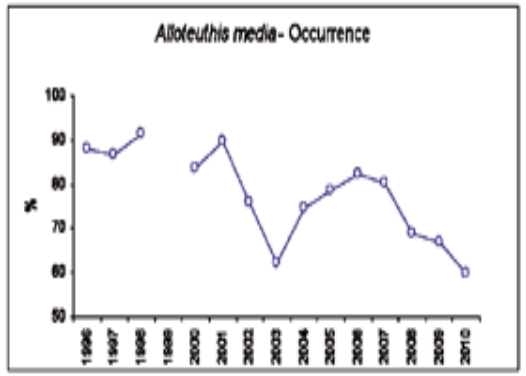
EN: Midsize squid; IT: Calamaretto; SL: Pritlikavi ligenj

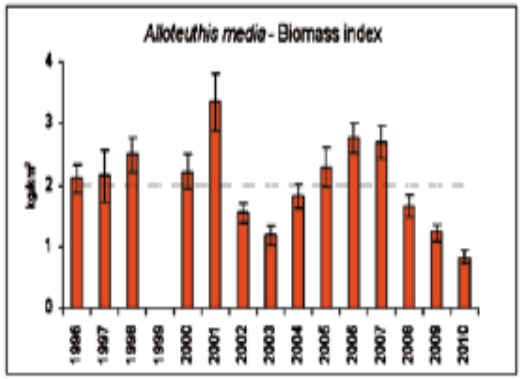


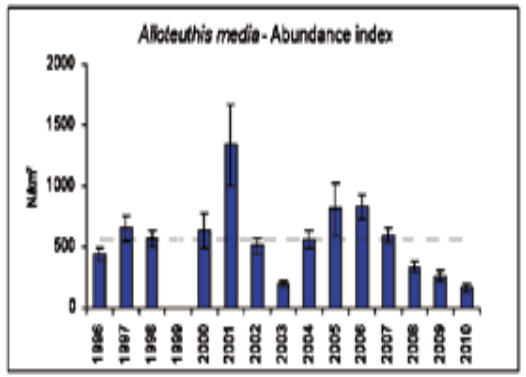




Midsize squid is widely distributed on sand and muddy bottoms of the whole basin, with greatest abundance along coastal area of the channel area of the Central Adriatic. A decreasing trend of its frequency of occurrence was observed, ranging from 91% in 1998 to 60% in 2010. Abundance and biomass indices fluctuated without clear trend over the period. A mean value of 564 specimens per km2 respectively was recorded. A constant decrease was observed over the last 5 years with recent values touched lowest values.

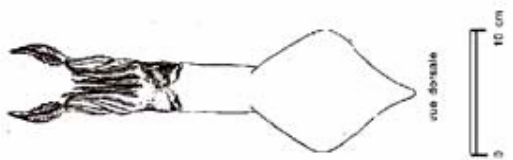






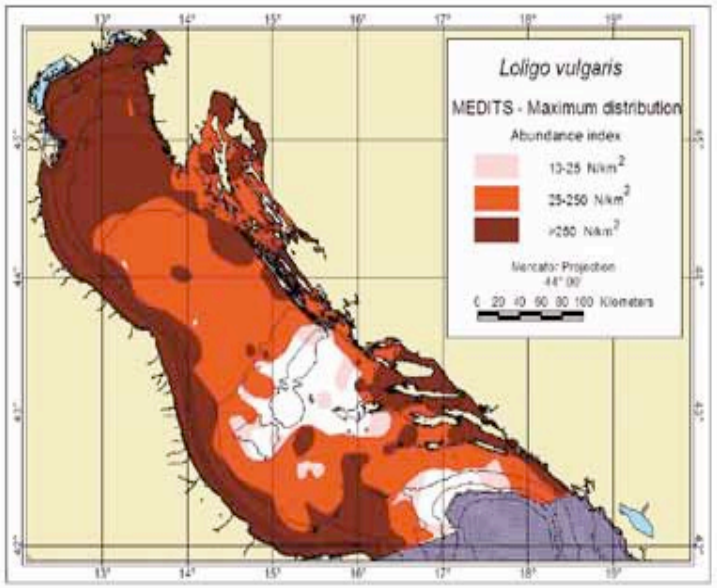
Lignja, *(Loligo vulgaris* (Lamarck, 1798))

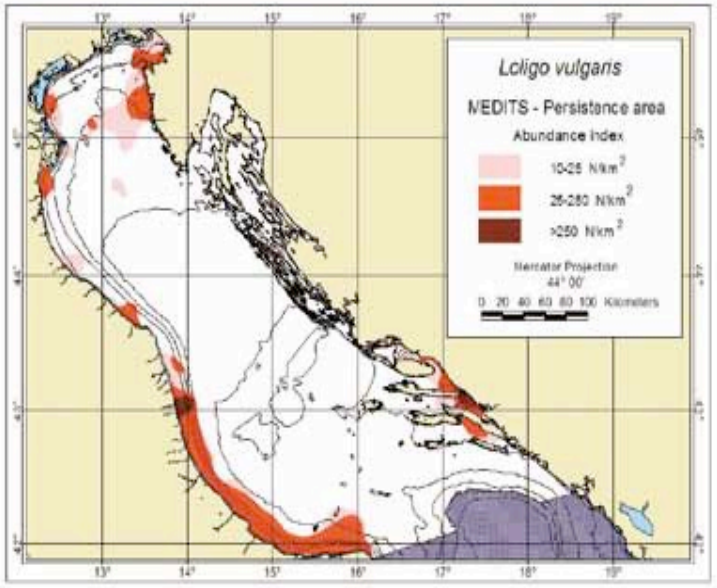
EN: European squid; IT: Calamaro; SL: Ligenj

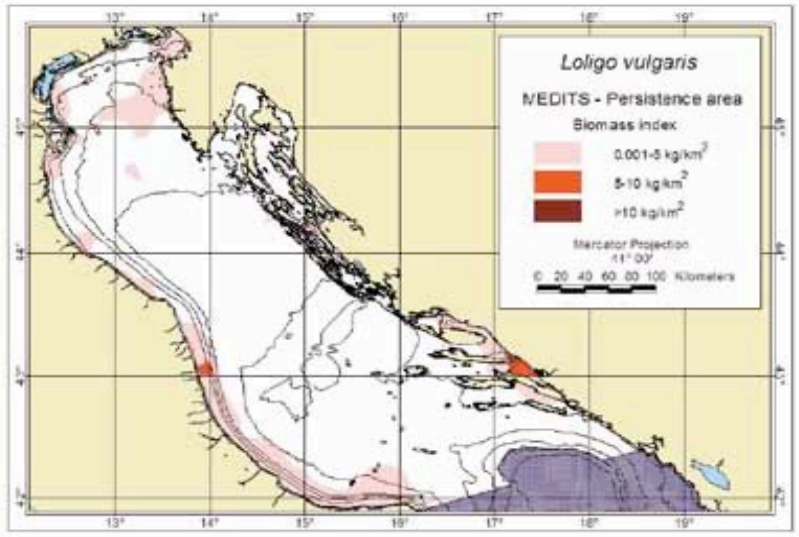


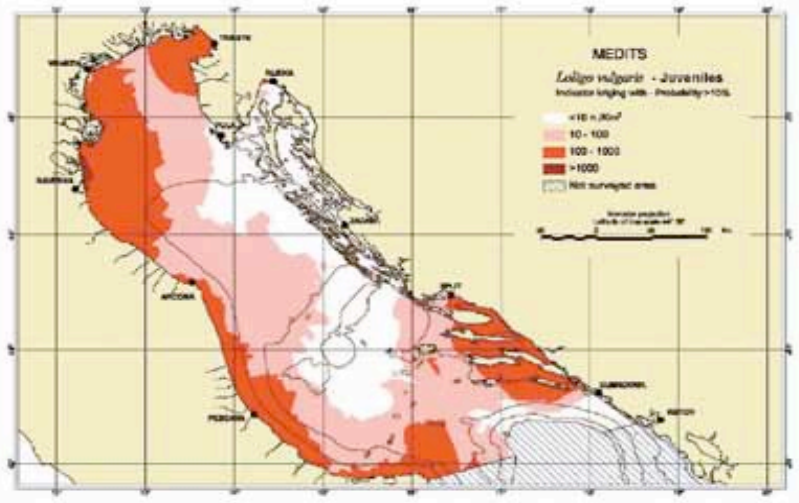
Max spatial distribution

Persitence area







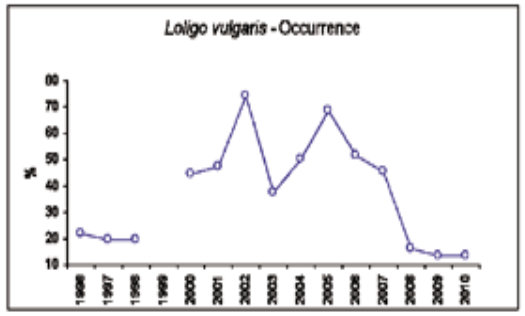


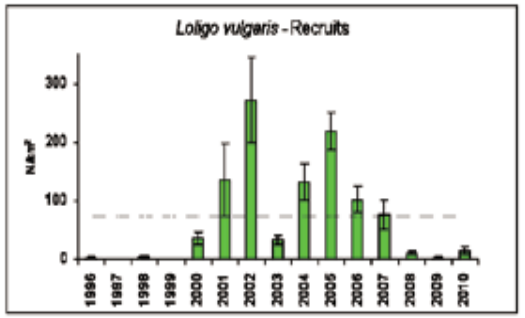
Persistence area of the biomass index
Distribution area of juveniles

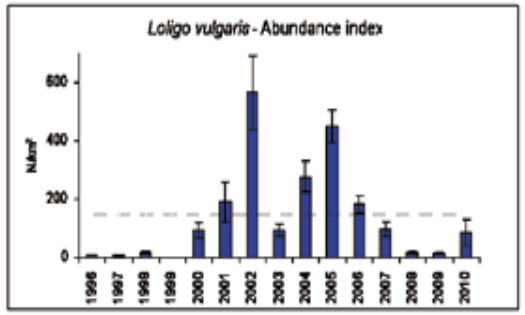
It is distributed throughout the whole basin mainly in depth lower than 150 m. Only in the ddepest areas of the Pomo pit and the southernmost part of the basin it is not found. Greatest abundances are found in shallow water of coastal and channel areas up to 50 m deep. Juveniles are mainly distributed in shallow coastal waters.

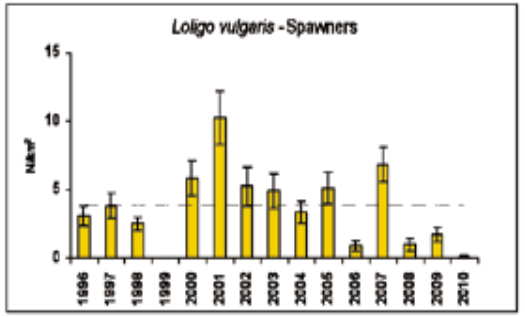
The occurrence fluctuated around a mean value of 37% and a strong decrease was recorded in the last 3 years. Abundance and biomass indices fluctuated widely with two peaks in 2002 and 2005 which reflected the strength of recruitment. A mean value of 150 specimens per km2 and 2.7 kg /km2 respectively was recorded for abundance and biomass.

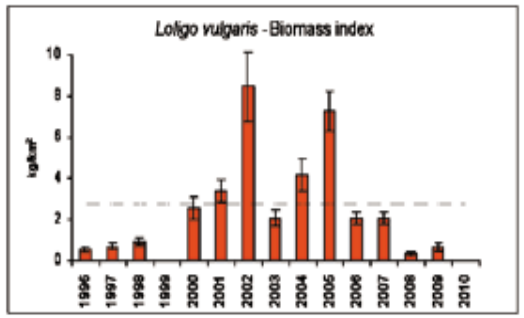
Although no obvious trend was detected, spawners fraction highlighted a decrease after a peak in 2001, with last 3 years touching values at minimum historical level.
Length frequency distribution from 2010 shows predominance of young species in the population.

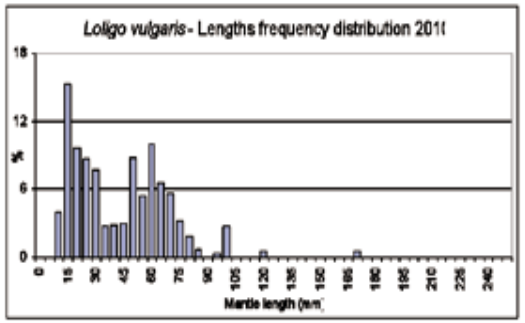






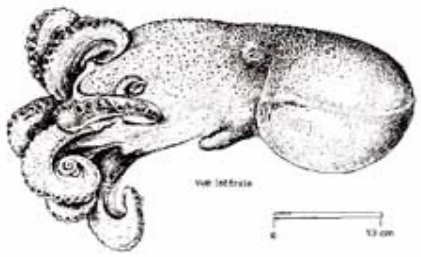




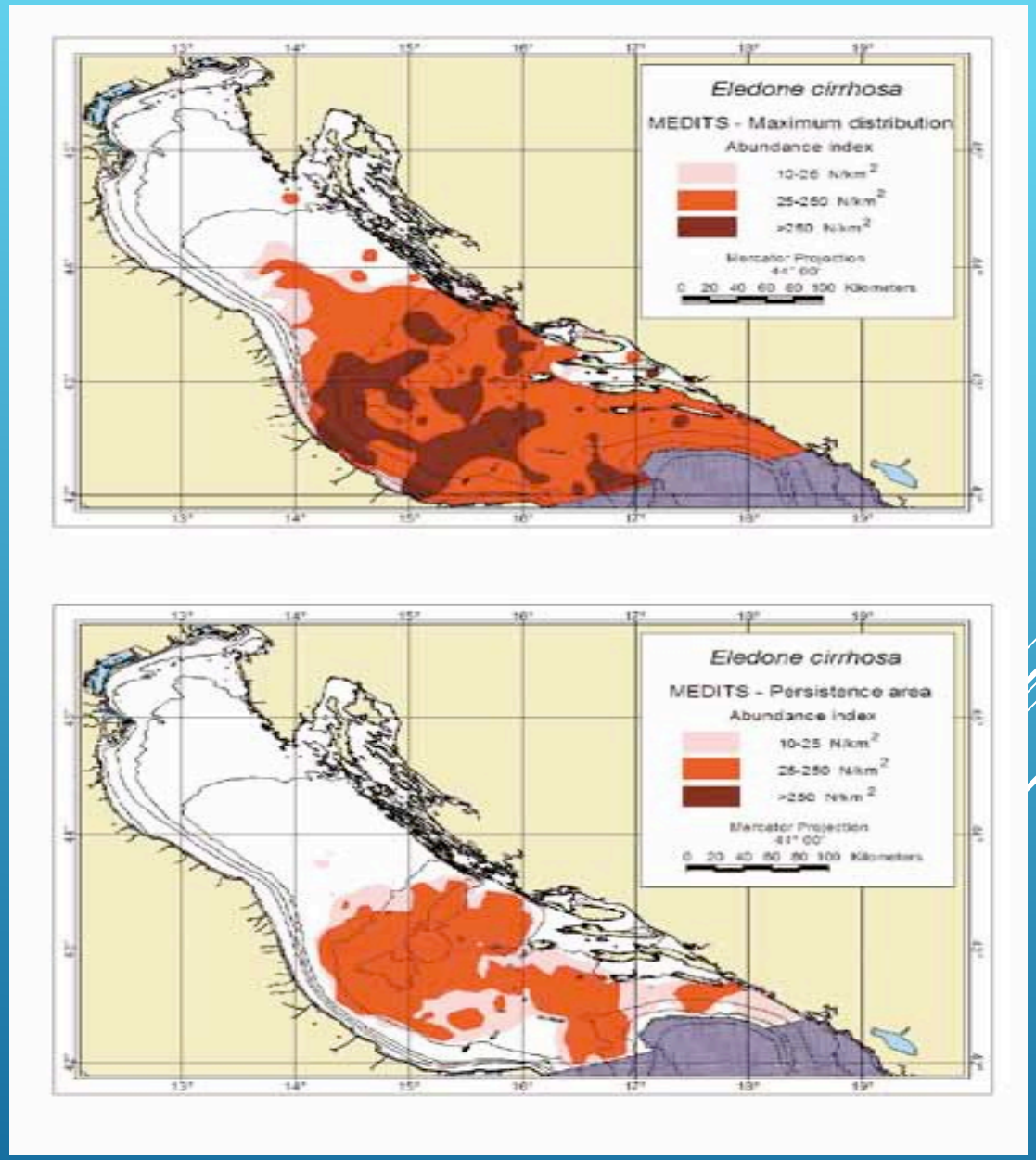


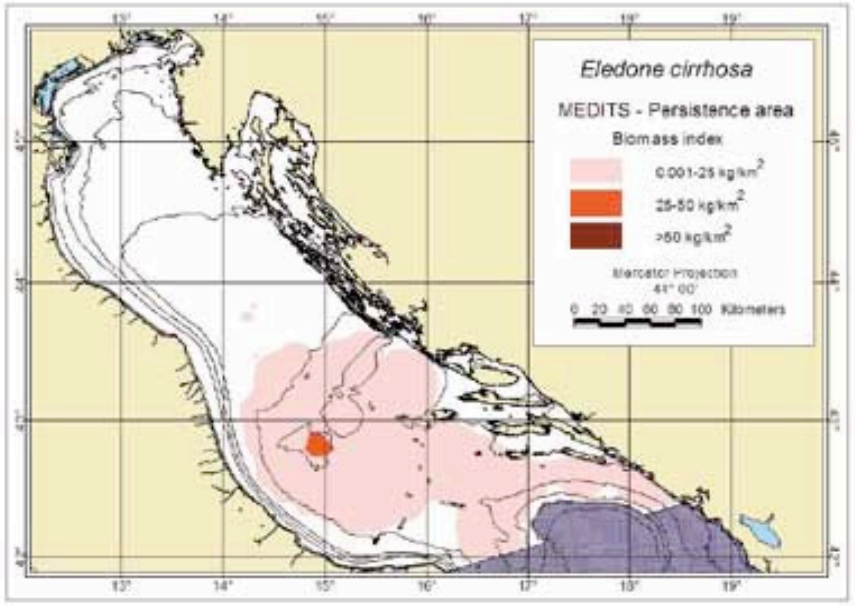
Bijeli muzgavac, (*Eledone cirrhosa* (Lamarck, 1798))

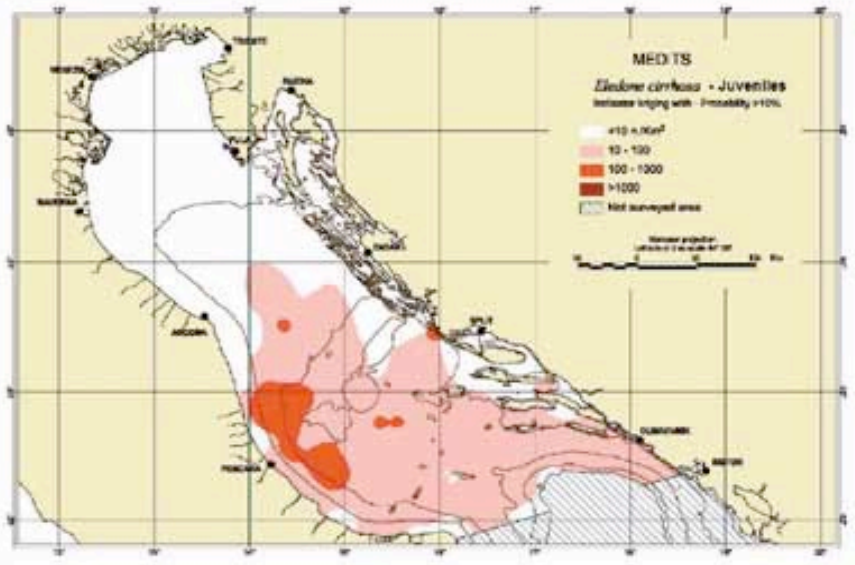
EN: Horned octopus; IT: Moscardino bianco; SL: Kodrasta hobotnica



Maximum spatial distribution
Persistence area

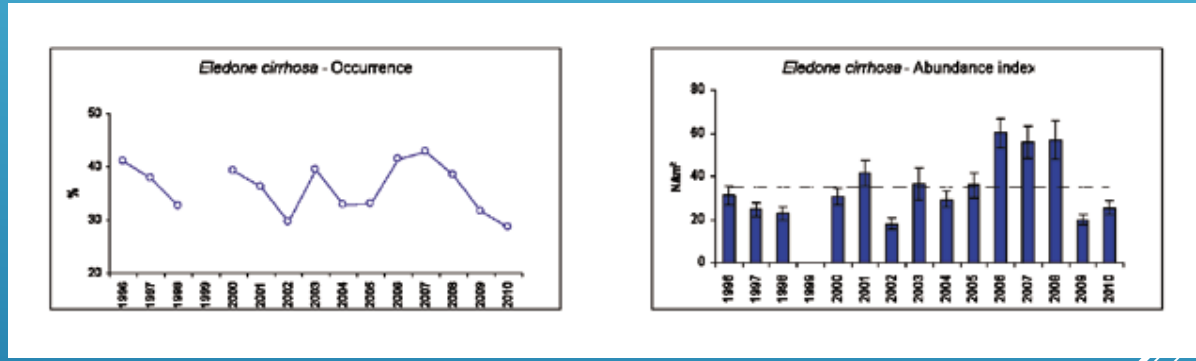






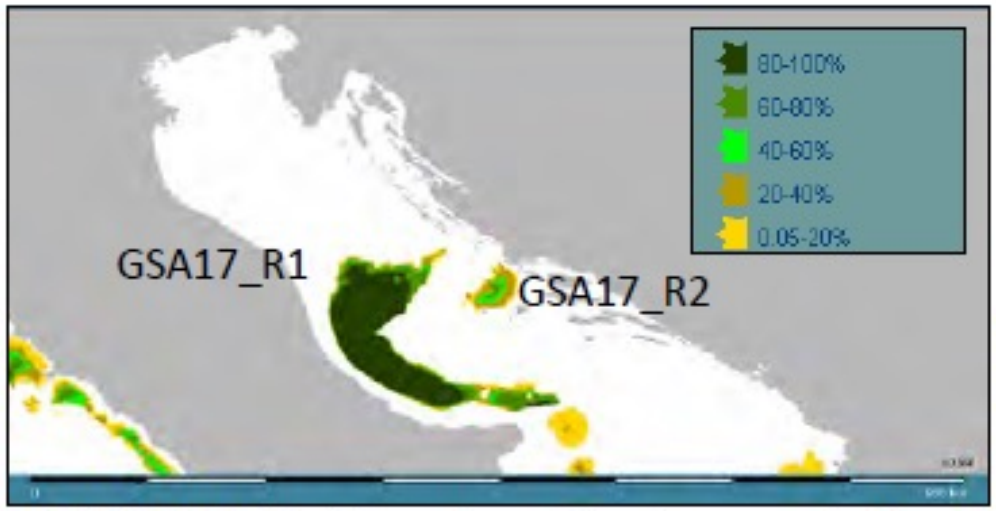
Persistence area of the biomass indeks
Distribution area of juveniles

Its distribution extends over the whole central basin, excepted shallow coastal water. Distribution area of this species is complementary to musky octopus and these two species partially overlap only in the small part of the central Adriatic. Juveniles are found in the same distribution area of the whole population.



Occurrence is around mean value of 36%. Abundance and biomass indices fluctuated without highlighted obvious trends, around a mean value of 35 specimens per km2 and 6.3 kg per km2.

HORNED OCTOPUS – *Eledone cirrhosa*



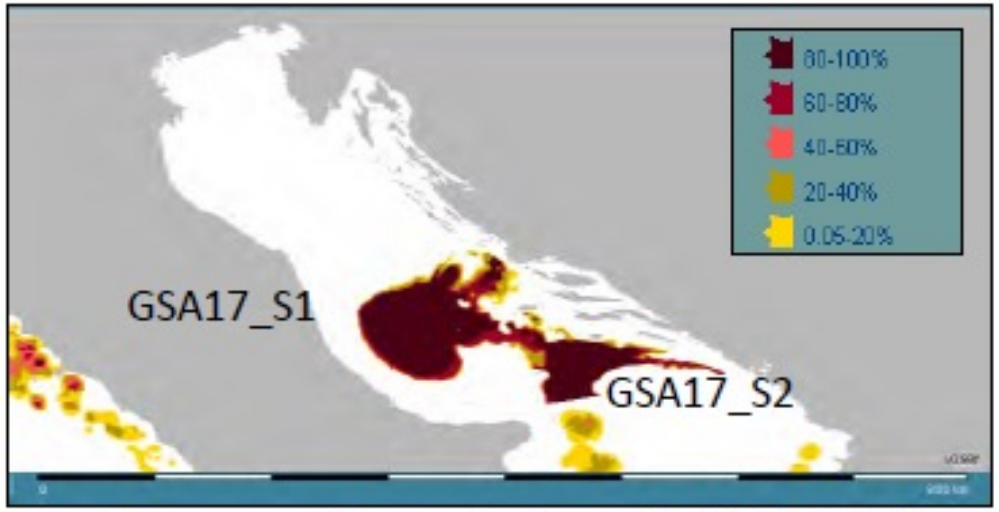


Fig. 2.2.5.11.5. Position of persistent nursery (left) and spawning areas of horned octopus (right) in GSA17

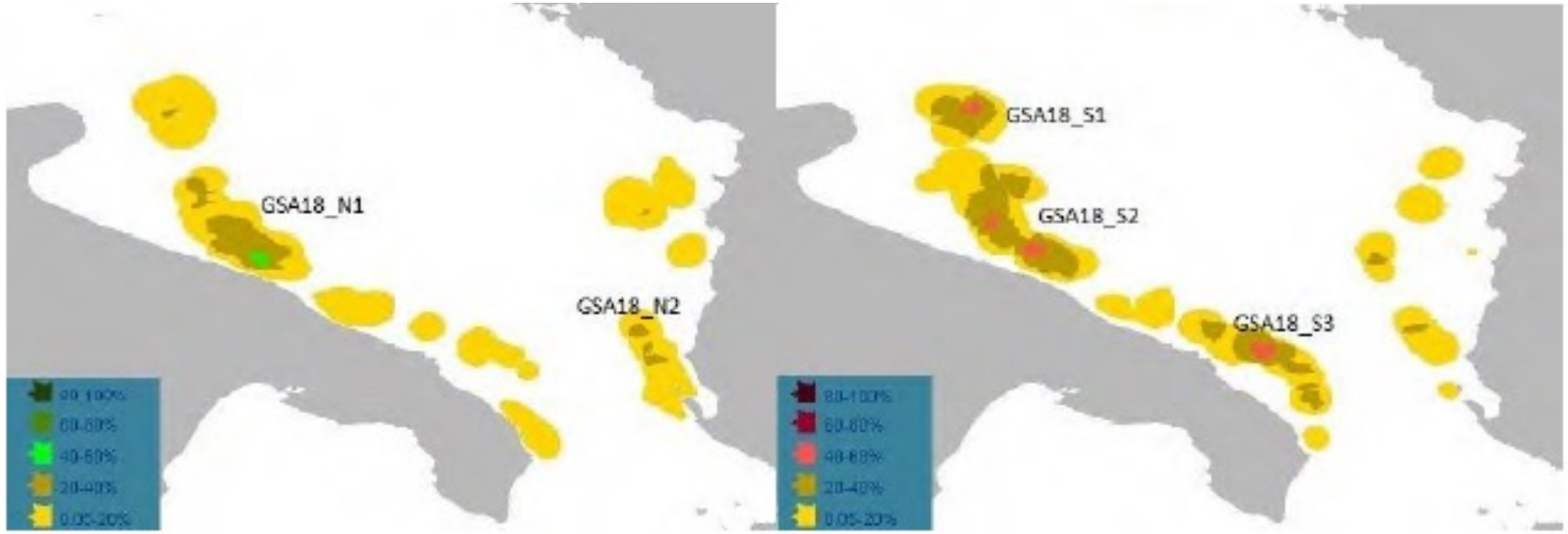
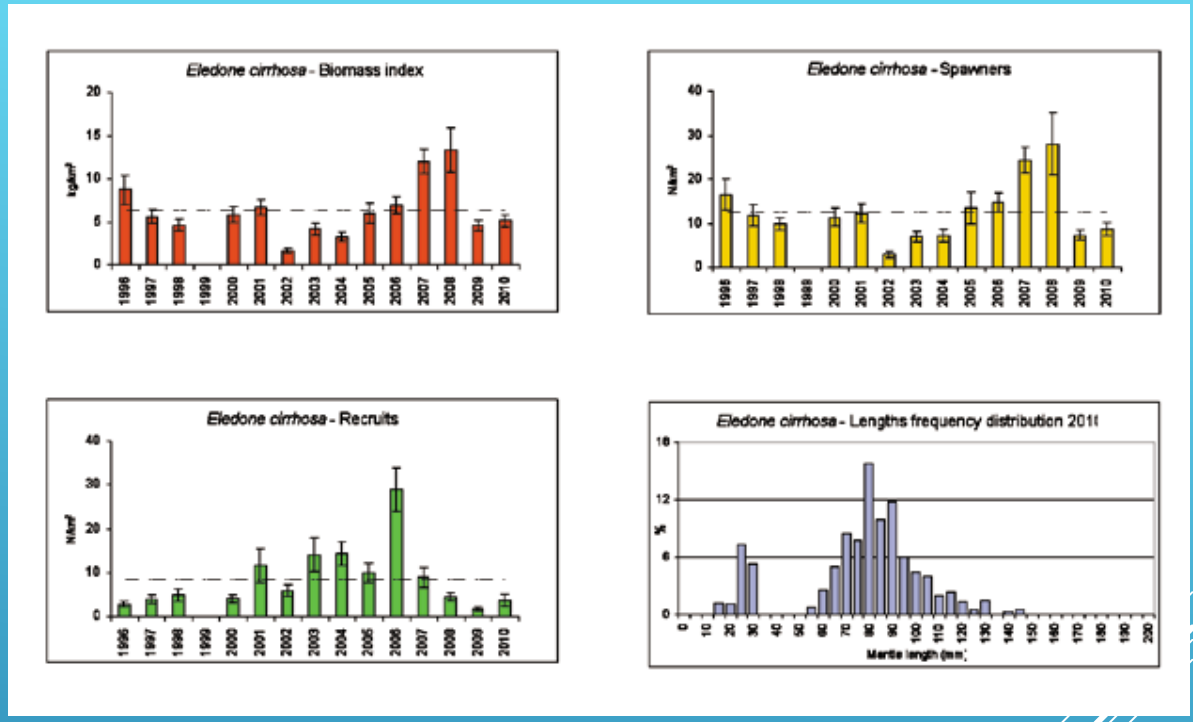


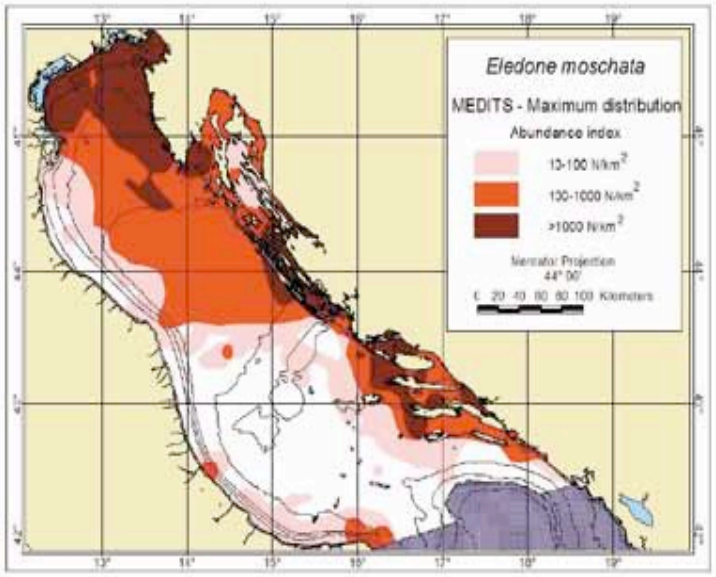
Fig. 2.2.5.11.6. Position of persistent nursery (left) and spawning areas of horned octopus (right) in GSA 18

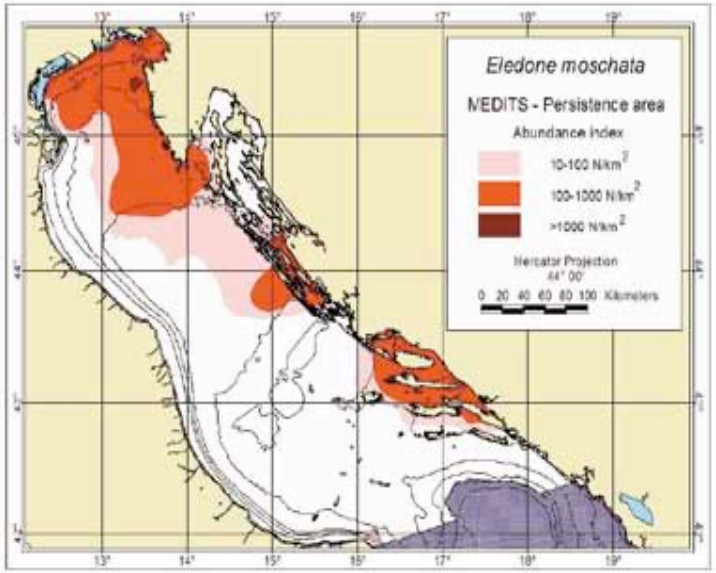
Fluctuation of both spawners and recruits indeks has also been observed. Length frequency distribution from 2010 shows two age groups with recruitment class.



Crni muzgavac, (*Eledone moschata* (Lamarck, 1798))

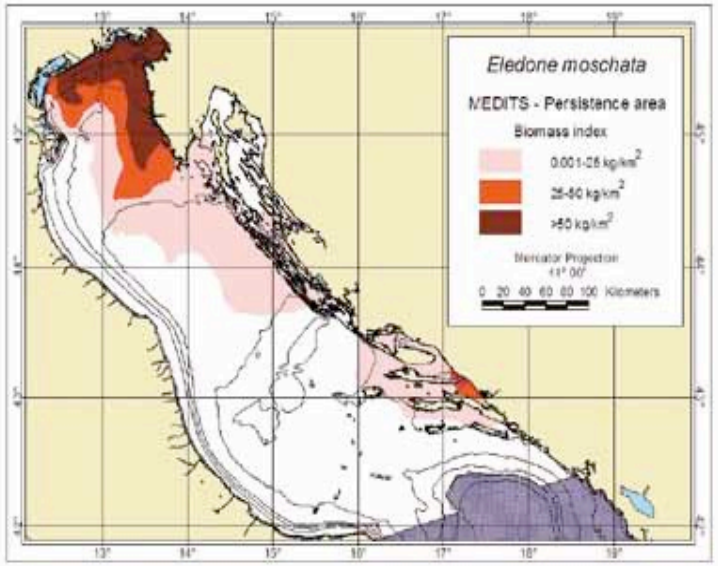
EN: Musky octopus; IT: Moscardino muschiato; SL: Moškatna hobotnica

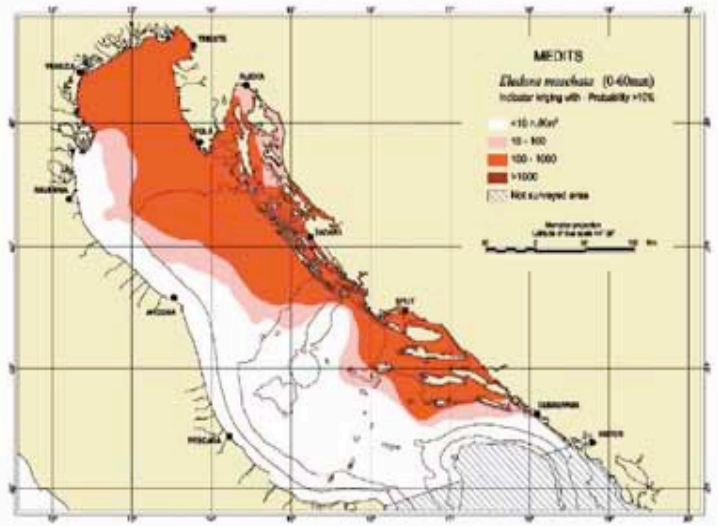




Maximum spatial distribution
Persistence area

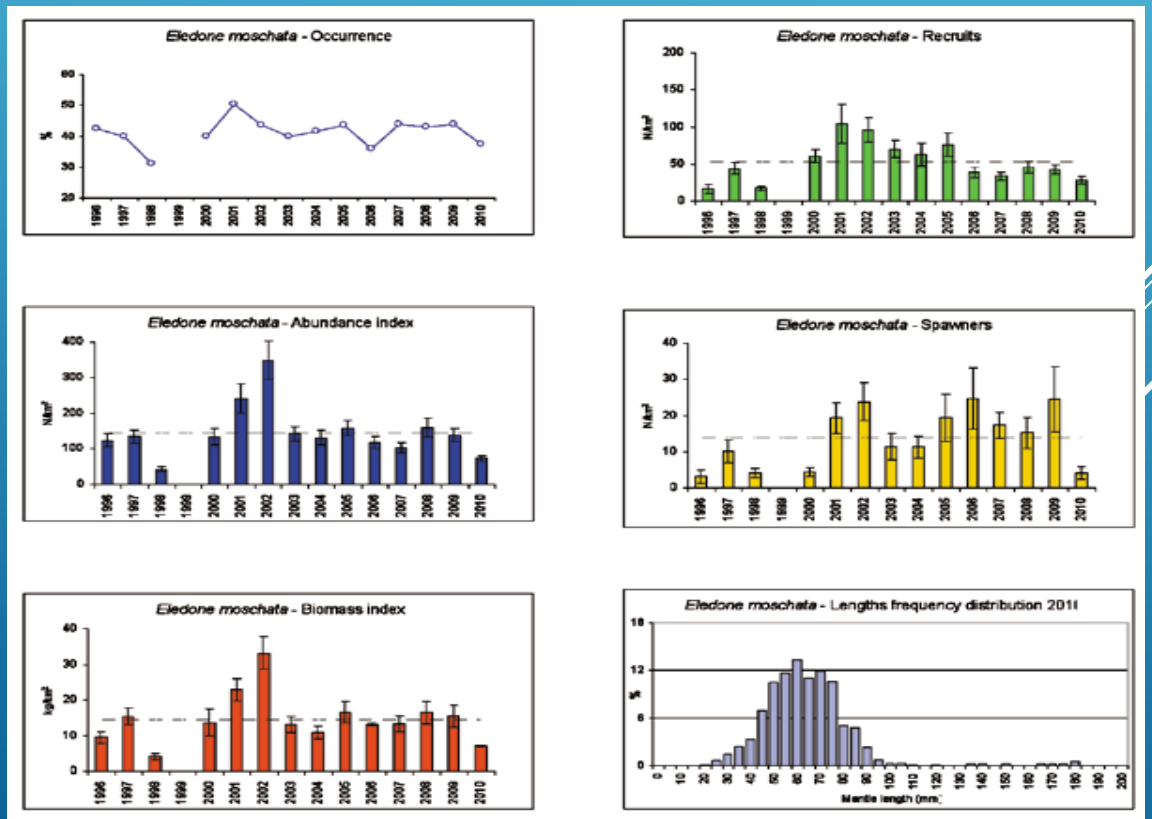
Distribution area is complementary to the distribution of horned octopus. It extends over the whole Northern Central Adriatic and along shallow coastal water of the Central Adriatic. The highest catches are recorded on sandy and muddy bottoms up to 50 m depth.





Persistence area of the biomass index
Distribution area of juveniles

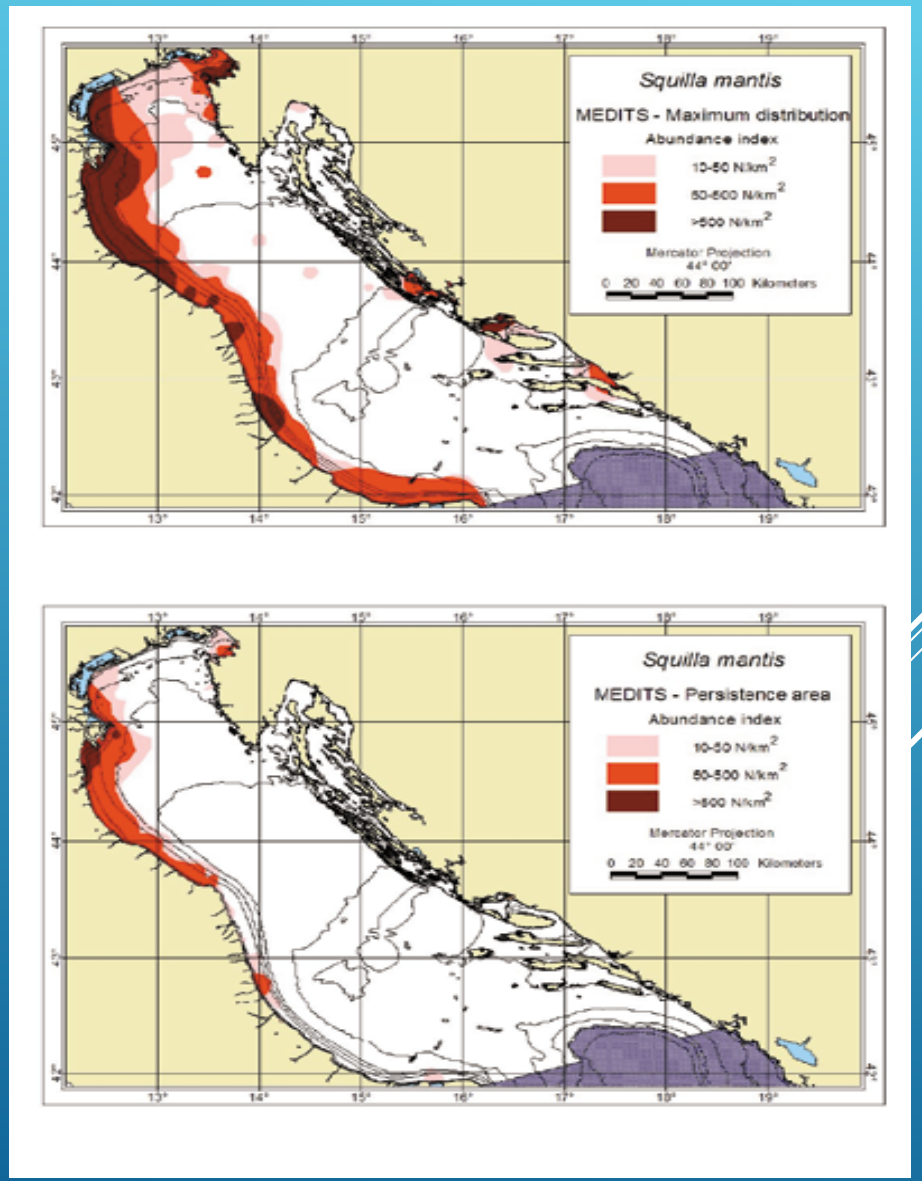
Juveniles cover the same distribution area of the whole population. Occurrence kept rather constant around a mean value of 41%. Abundance and biomass indeks showed no obvious trend over the period – a mean value of 146 speciemns per km2 and 14.6 kg per km2 were recorded for abundance and biomass respectively. A peak of both indices was recorded in 2002.



Fluctuation of recruits and spawners indices has been observed. Musky octopus is short living species with life span of two years and length frequency distribution in 2010 show the new year class and few remaining individuals of the precedent year.

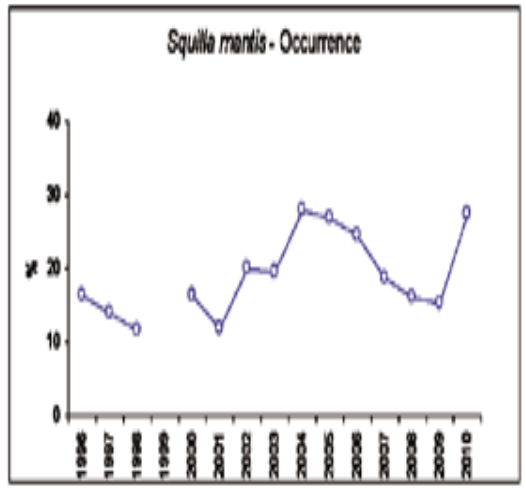
Kanoć, (*Squilla mantis* (Linnaeus, 1758))

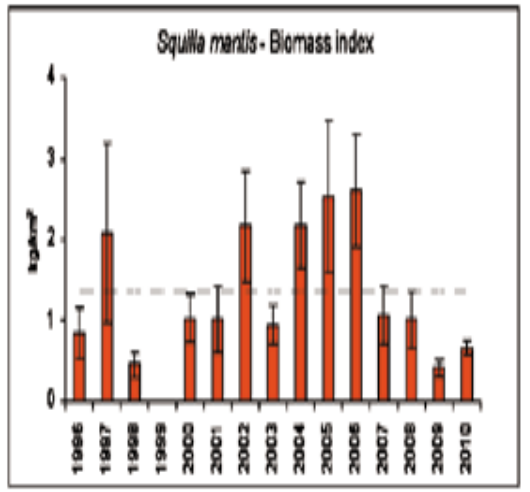
EN: Spottail mantis shrimp; IT: Pannocchia; SL: Morska bogomolka

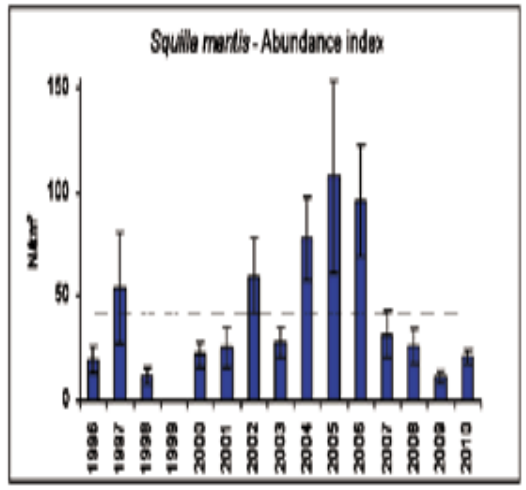


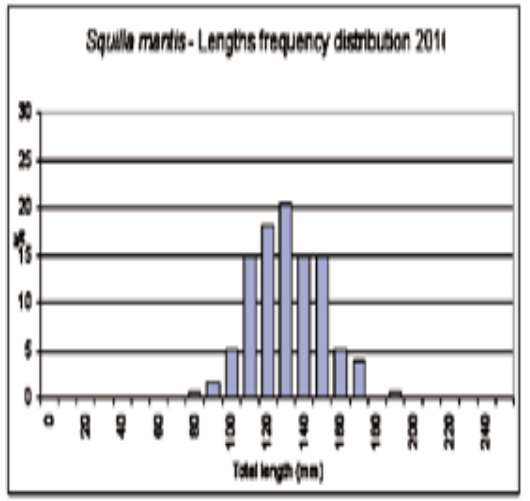
It lives in burrow in the mud or sandy-mud bottom, and is vulnerable to the bottom trawl net only when came out, generally during the night. This species is found on muddy bottoms of shallow coastal water, mainly along Italian side. Greatest catches are steadily performed closed to the Po delta and to the south of this river.

Occurrence fluctuated around a mean value of 19%. Density and biomass indicators fluctuated without obvious trend around a mean value of 42 specimens per km2 and 1.4 kg per square km. A clear decrease was observed in the last four years. The length frequency distribution from 2010 is unimodal.



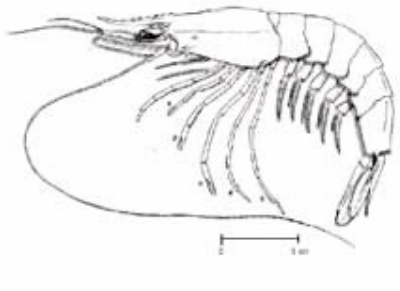




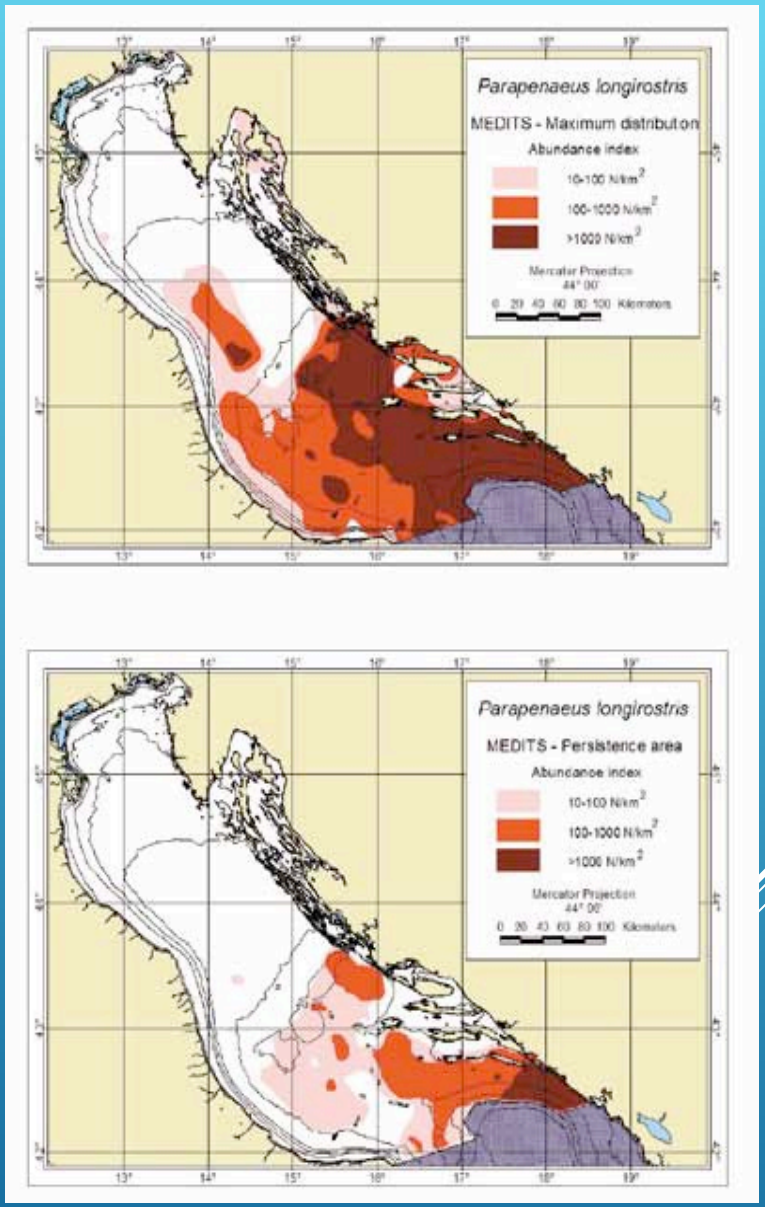


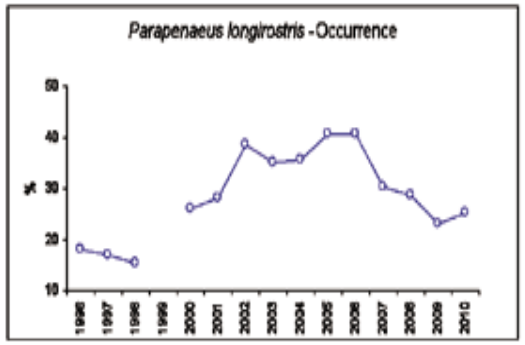
Kozica, (*Parapenaeus longirostris* (Lucas, 1846))

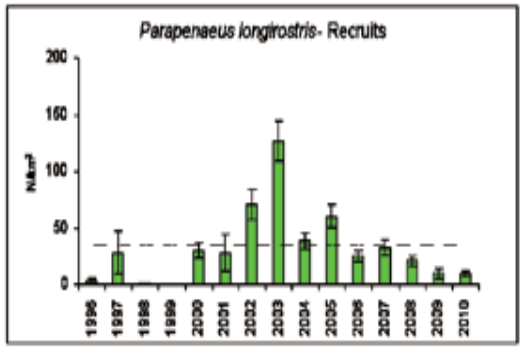
EN: Deep-water rose shrimp; IT: Gambero rosa; SL: Dolgoostna rdeča kozica

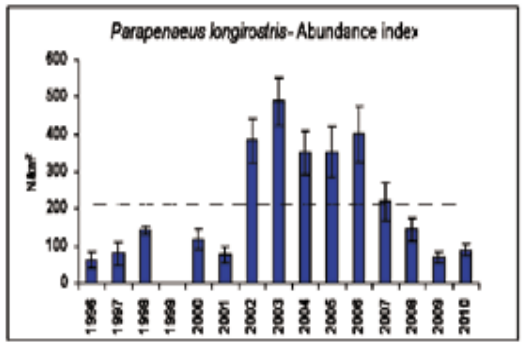


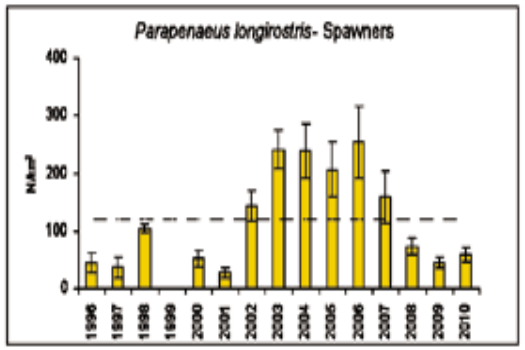
Distribution area extended to the whole Central basin, where it was found fom 70 m depth. Highest abundances wer steadily found on muddy bottoms off the Dubrovnik coast and off Korčula and Vis islands.

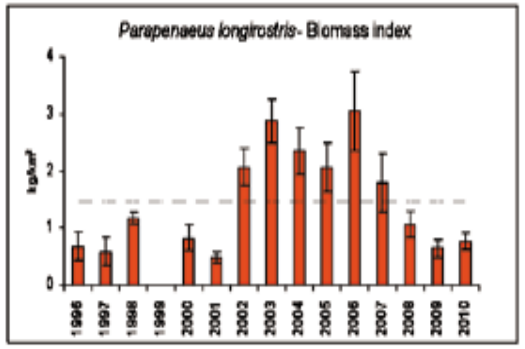


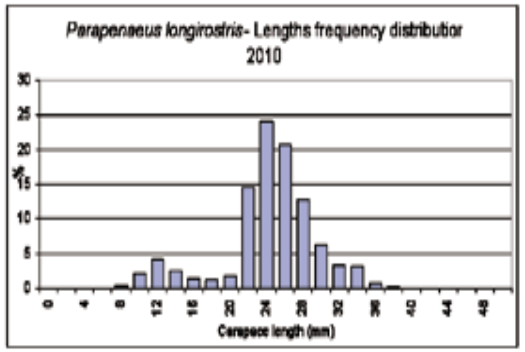








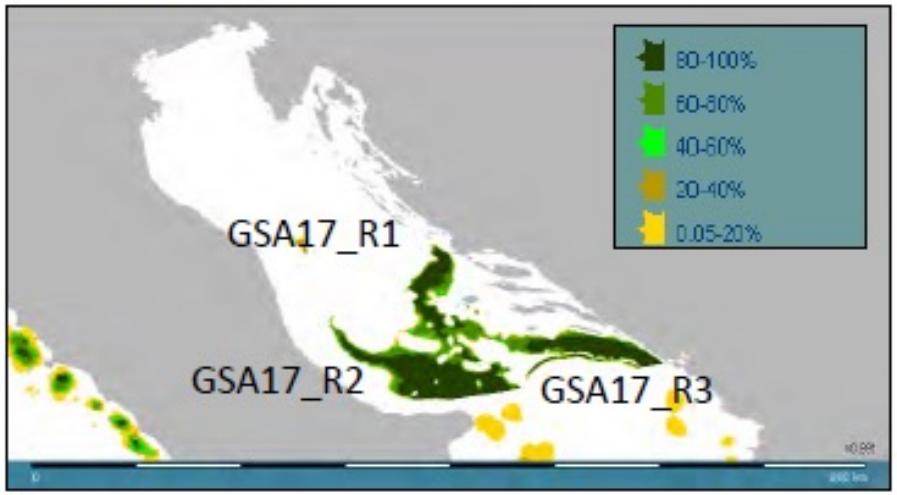




Abundance and biomass indices showed highest values in the period from 2002 to 2007 whit a decreasing trend in the last 5 years. Changes in abundance were followed by changes of occurrence.

Medium value of abundance indeks is 213 specimens per square km, and of biomas 1.5 kg per square km. The indeks of recruits showed a max in 2003. The spawners were abundant from 2002 to 2007. The length frequency distribution from 2010 showed a bimodal situation. It is important to consider the population analysed is a fraction of a bigger population living in the south Adriatic sea.

DEEP-SEA PINK SHRIMP – *Parapaneous longinostris*



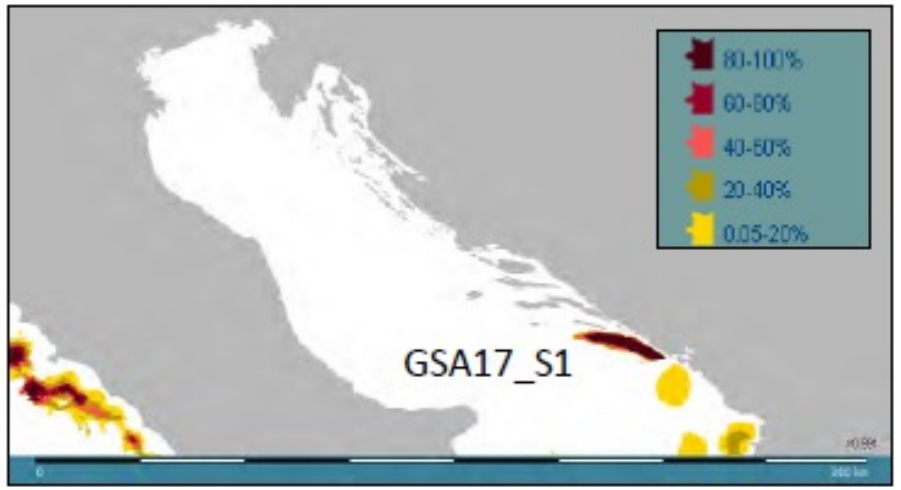


Fig. 2.2.5.9.6. Position of persistent nursery (left) and spawning areas (right) of deep-sea pink shrimp in GSA 17

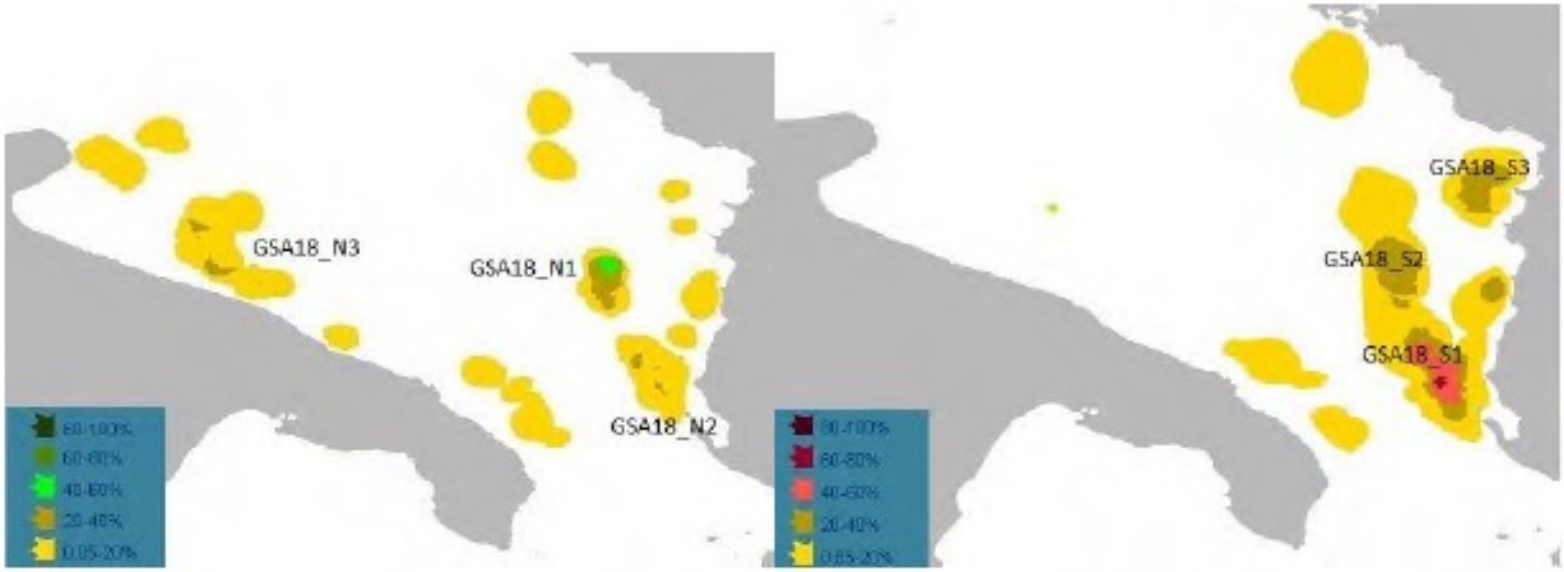
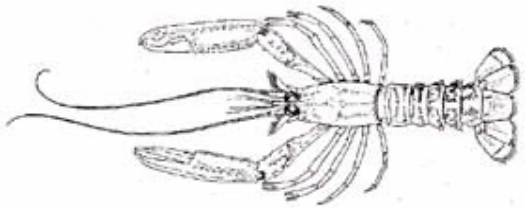


Fig. 2.2.5.9.7. Position of persistent nursery (left) and spawning areas (right) of deep-sea pink shrimp in

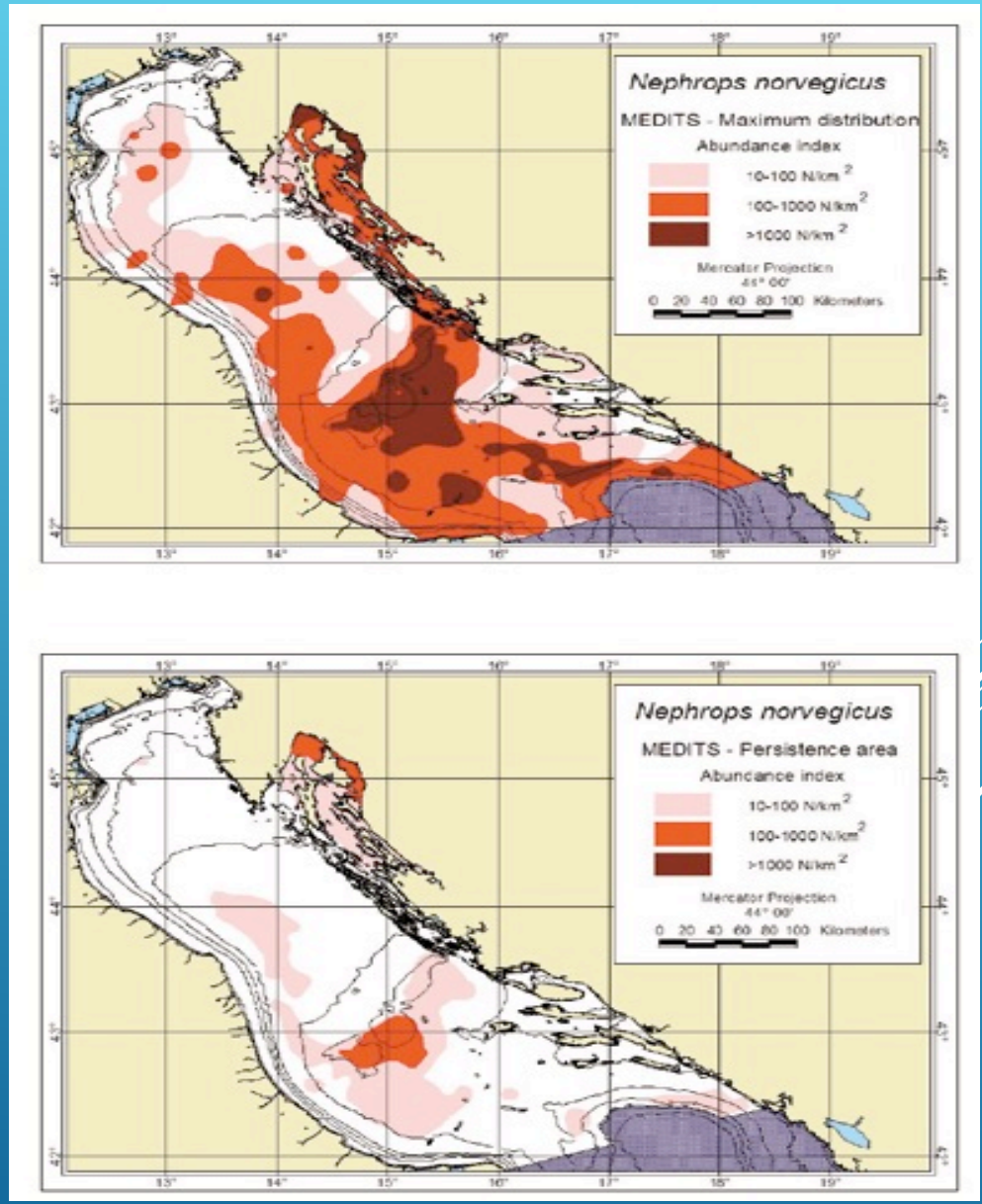
Škamp, (*Nephrops norvegicus* (Linnaeus, 1758))

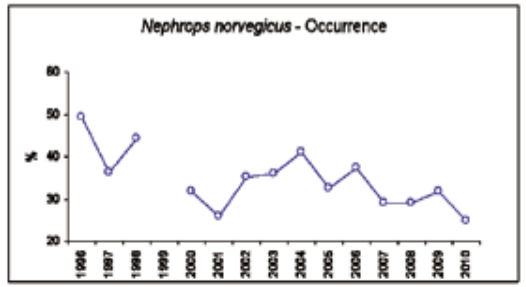
EN: Norway lobster; IT: Scampo; SL: Škamp

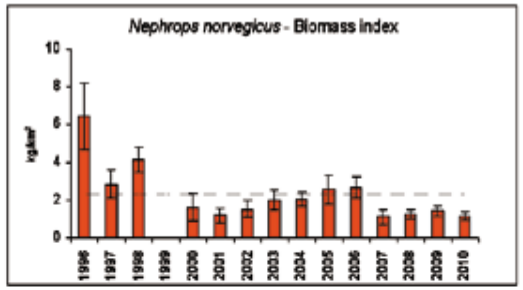


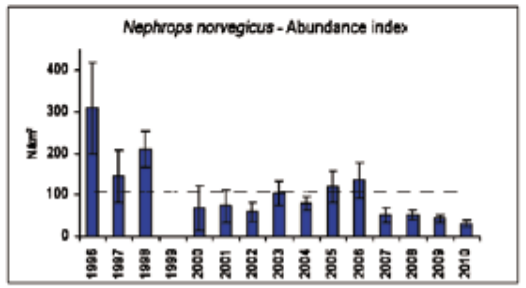
It is found from shallow waters in the southenmost part of the basin. Great densities of individuals are caught off Ancona and in Velebit channel, although the most abundant population is steadily on muddy bottoms of the central Adriatic, in the Jabuka pit region.

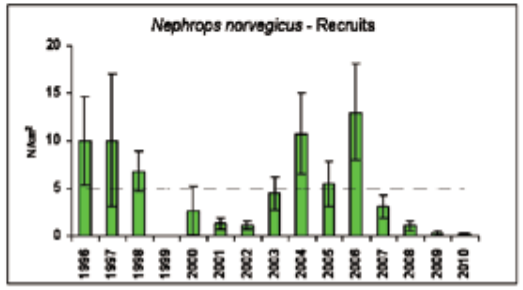
The frequency of occurrence ranged from a max of 49% in 1996 to min of 25% in 2010 and also population abundance clearly decreased throughout the period., touching the min historical values in the last years.

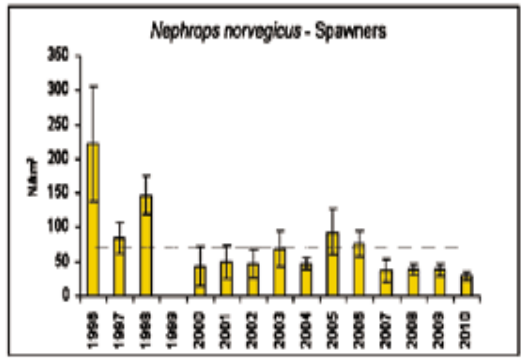


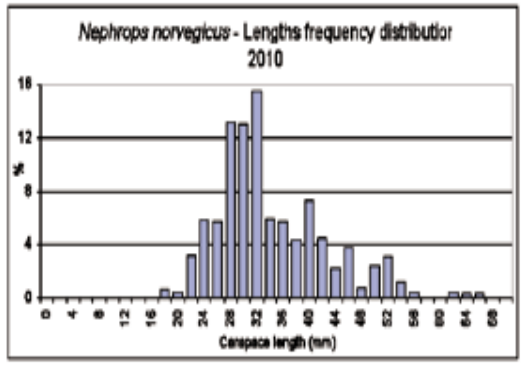












Medium value of abundance indeks is 106 specimens per square km, while for the biomass is 2.3 kg per square km. Values of the four last years index are lower than the mean value.

The decline involves both the recruits and the spawners fraction.

The species lives in burrow and the mud and comes out during the night. Medit surveys sampling was done only during the daytime. This fact can have an impact to the results of density indices of species.

The lengths frequency distribution from 2010 showed the prevalance of juveniles.

NORWAY LOBSTER – *Nephrops norvegicus*

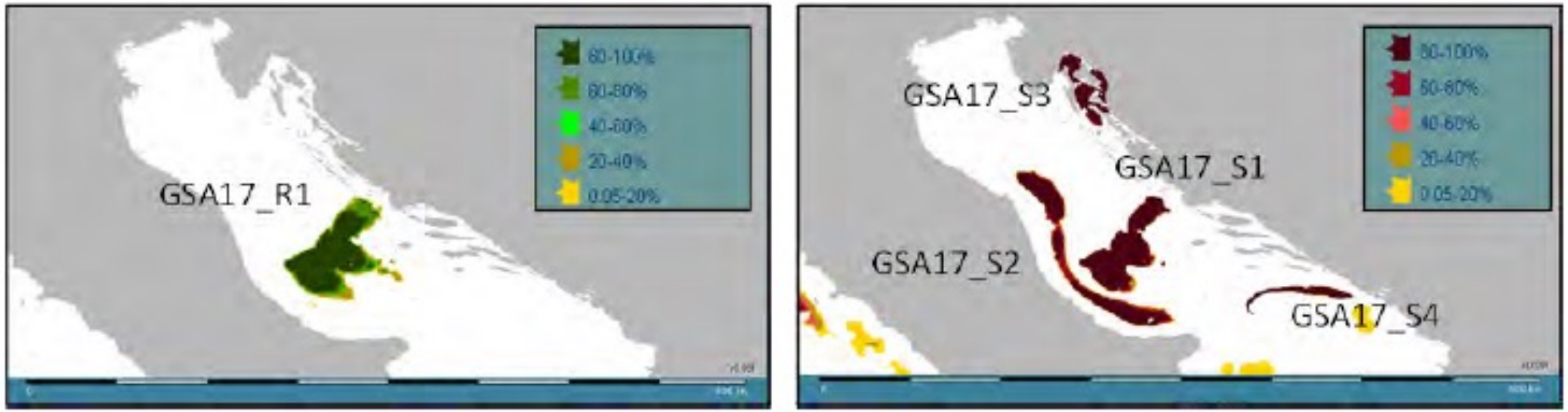
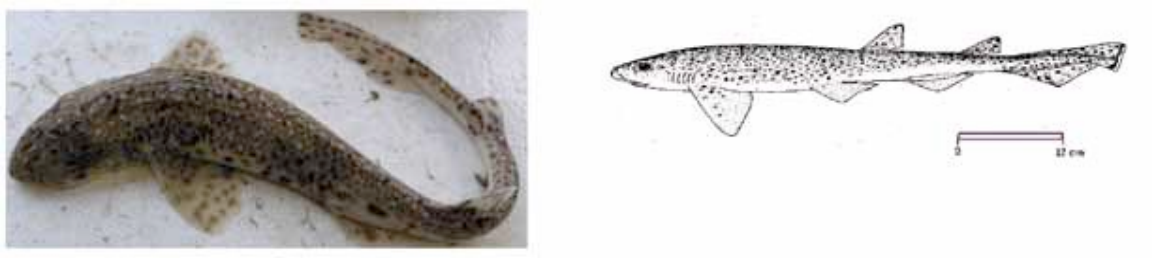


Fig. 2.2.5.10.7. Position of persistent nursery (left) and spawning areas (right) of Norway lobster in GSA 17.

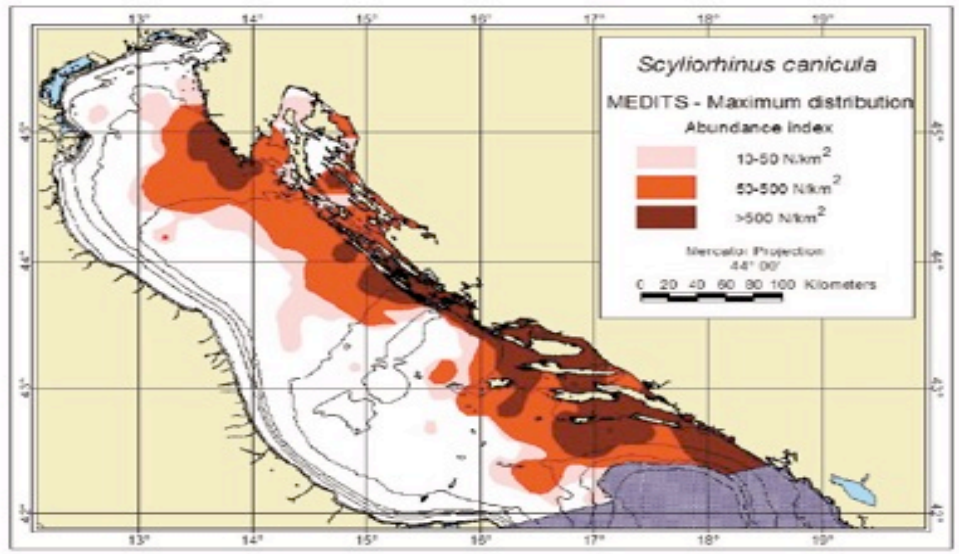
Fig. 2.2.5.10.8. Position of persistent spawning areas of Norway lobster in GSA 18

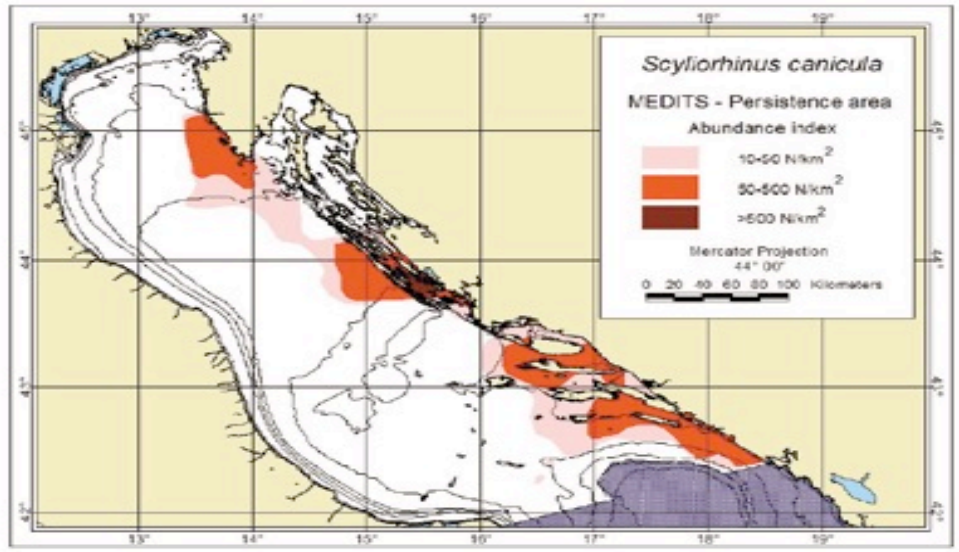
Mačka bjelica, (*Scyliorhinus canicula* (Linnaeus, 1758))

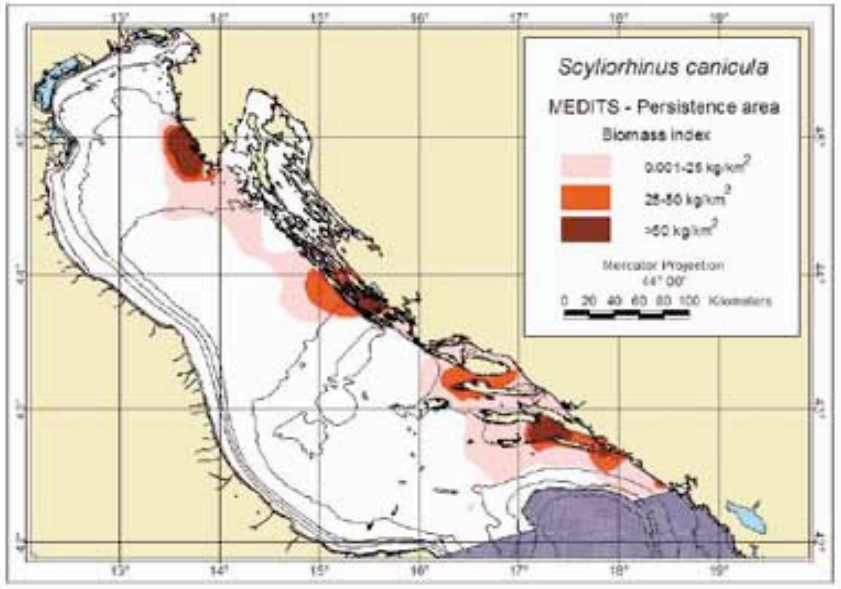
EN: Smallspotted catshark; IT: Gattuccio; SL: Morska mačka

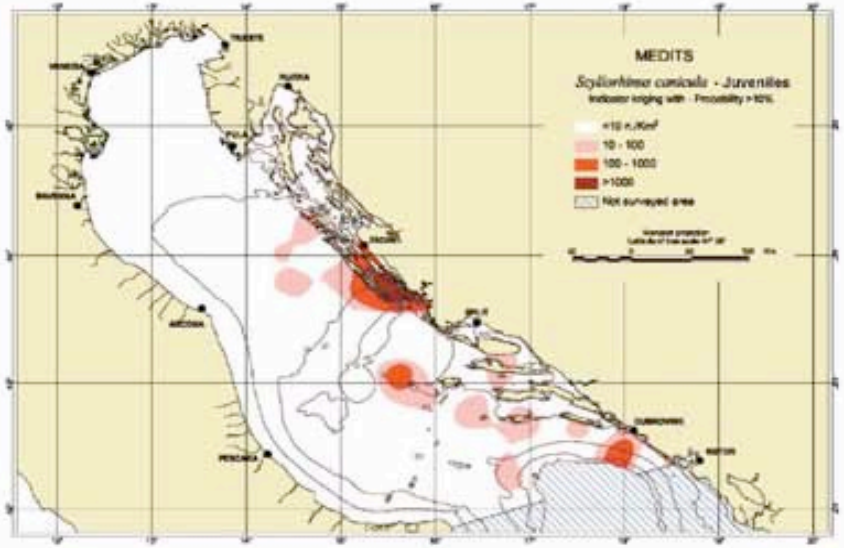


Distribution area is mainly restricted to the eastern part within the medan line; it is more abundant on the biocenosis of both coastal and offshore detritic bottoms. Juveniles are mainly found in the channel area of the central Adriatic. Occurrence ranged between 18% in 2005 and 29% in 1998 without obvious trend. Generally, abundance and biomass Indices showed a decreasing trend over the whole period with high fluctuation. Medium value of abundance indeks is 75 specimens per km2, and of biomass 12.1 kg per km2.

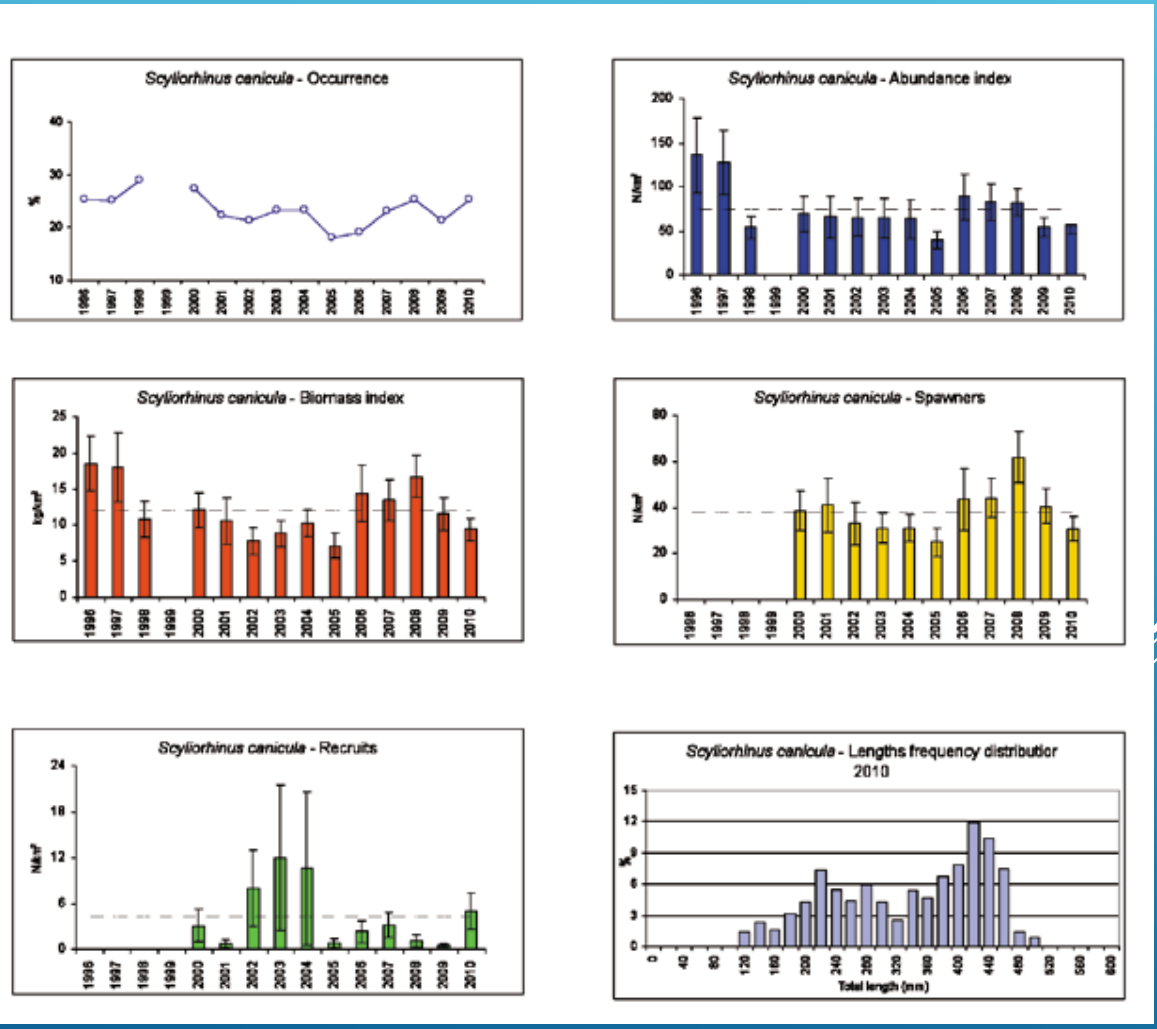






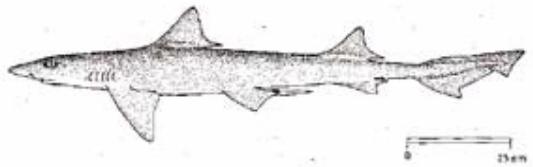


Fluctuation of both recruits and spawners indices have been recorded from 2000, with recruits reaching greater values from 2002 to 2004 and spawners reaching max value in 2008. The lengths frequency distribution shows a polimodal distribution whit max frequency at 42 cm of length

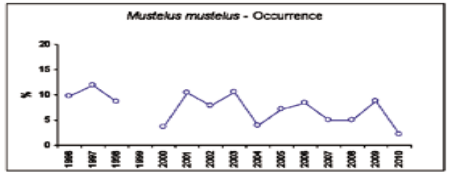


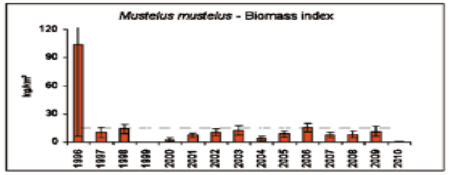
Pas mekuš, (*Mustelus mustelus* (Linnaeus, 1758)) EN:

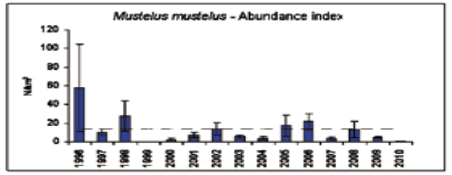
Smooth-hound; IT: Palombo; SL: Navadni morski pes

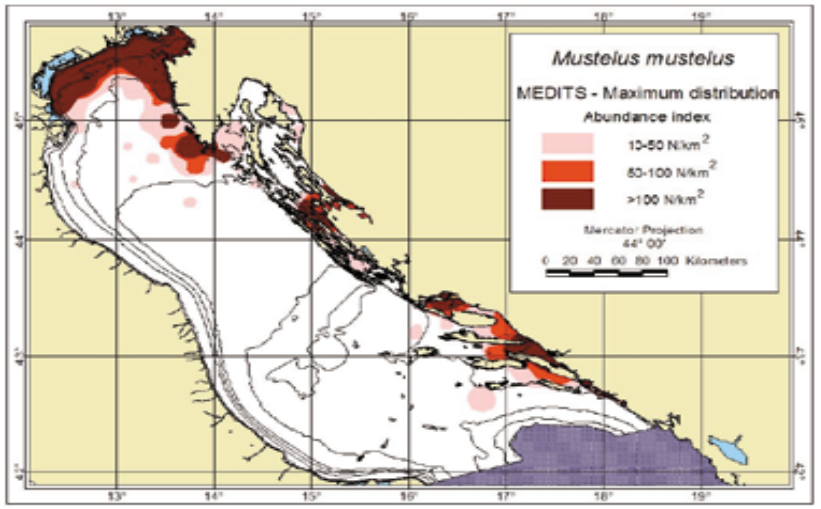


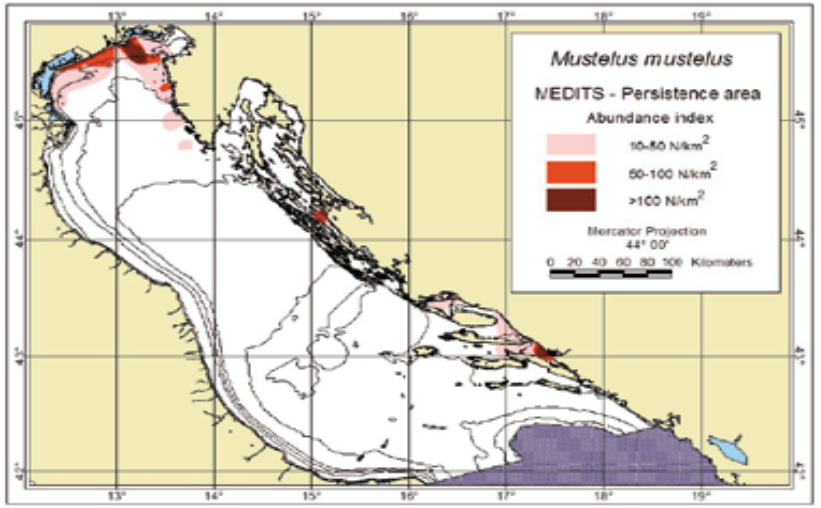
It is mainly distributed in the area with relict sand bottoms of the Northernmost part of the basin and in the channel area of the Central Adriatic. Frequency of occurrence varied around a mean value of 7% with more of less decreasing trend. Abundance index fluctuated around a mean value of 14 specimens per km2 and biomass around a mean value of 15.3 kg per km2, both indices touching their minimum historical value in 2010.



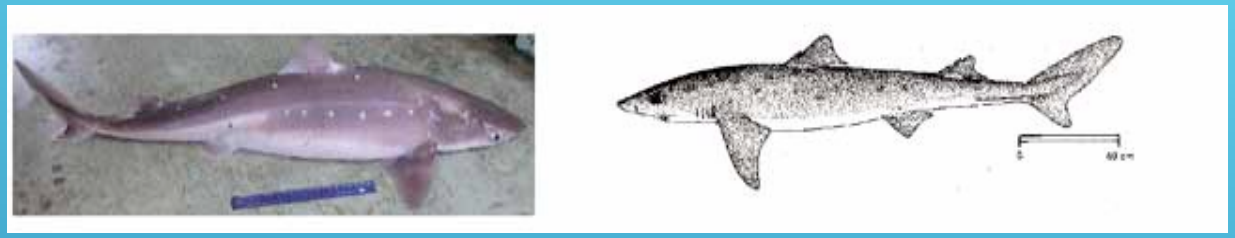




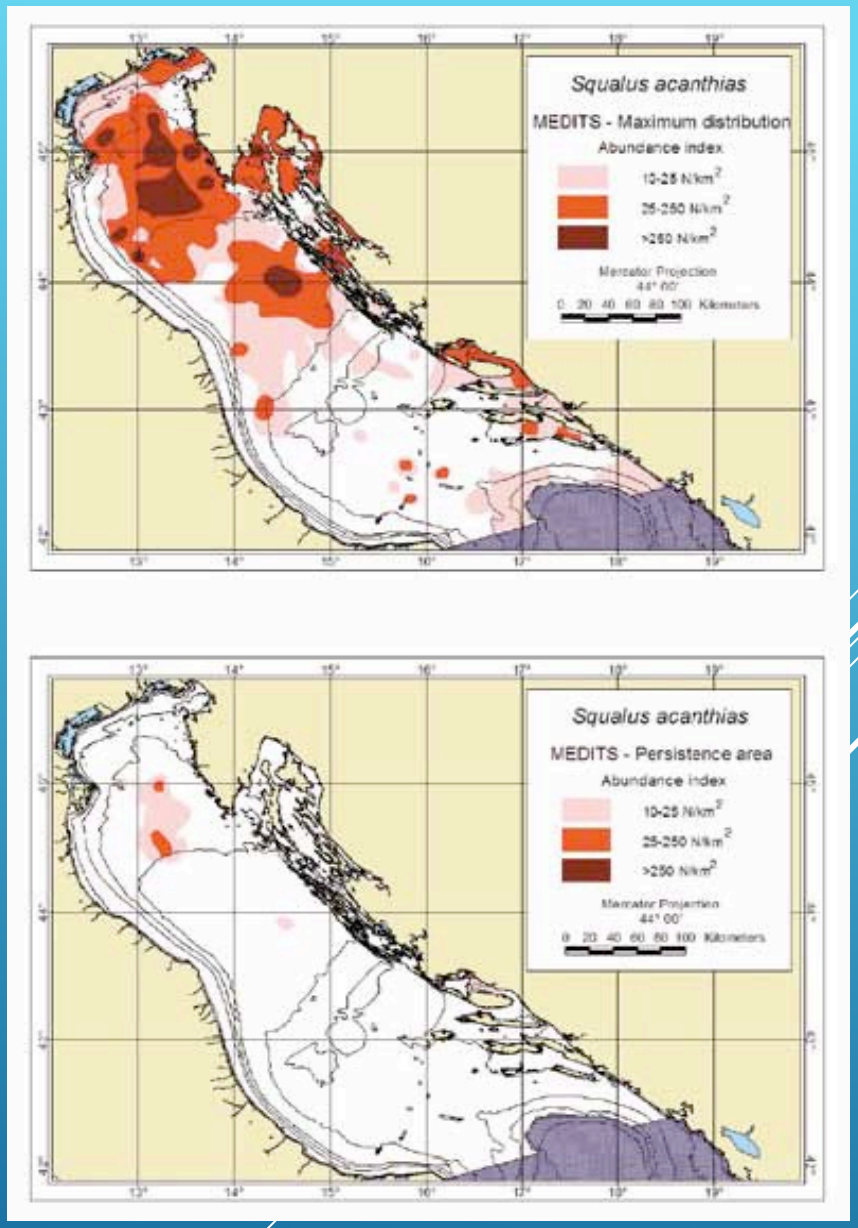


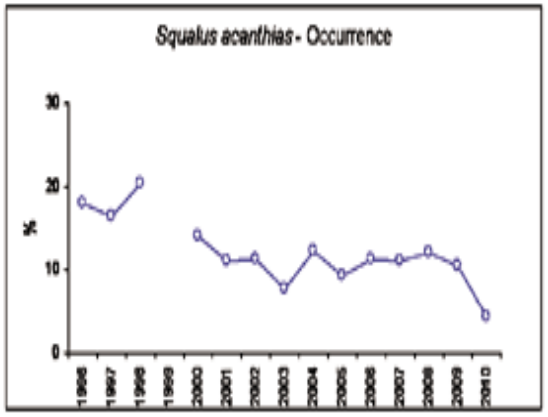


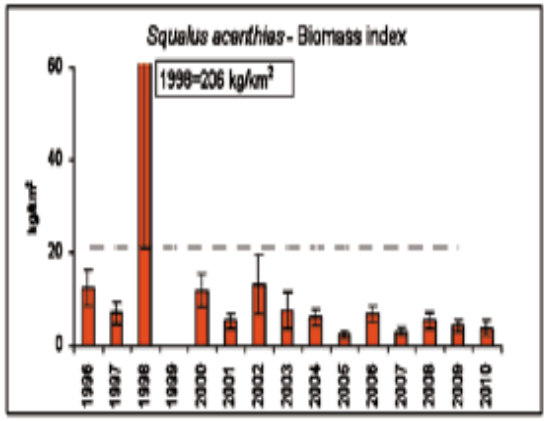
Kostelj, *Squalus acanthias* Linnaeus, 1758
EN: Spiny dogfish; IT: Spinarolo; SL: Trnež

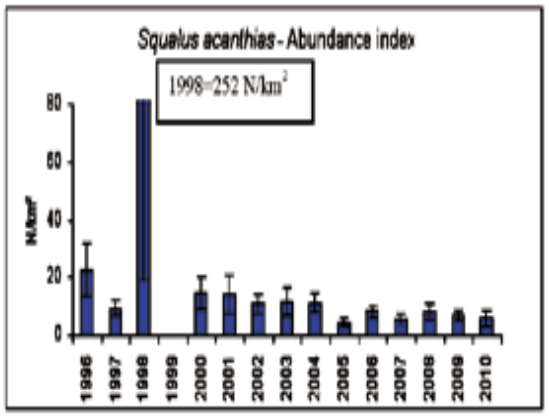


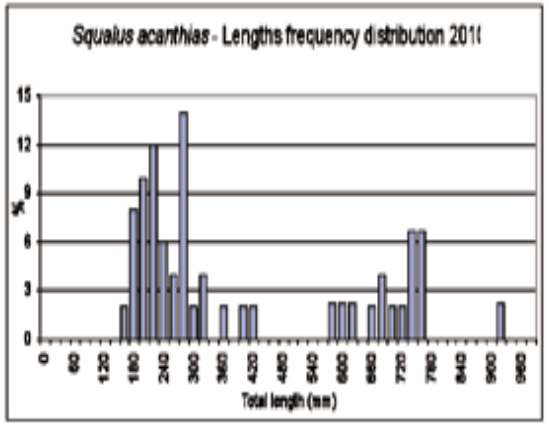
It is distributed throughout the basin, generally in area shallower than 100 m of depth. It is more abundant on relict sand bottoms and in the channel areas.







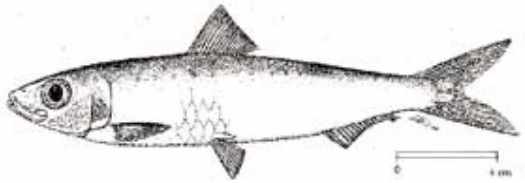




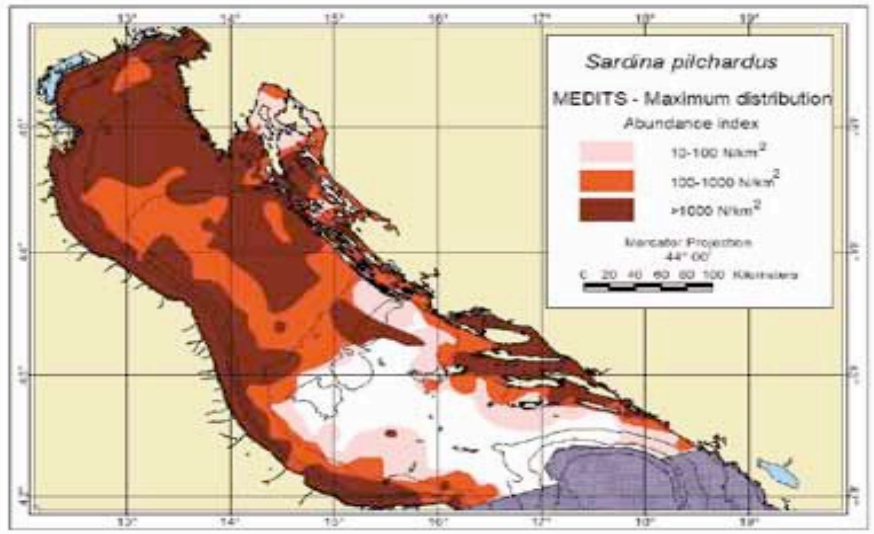
A decreasing trend was detected in the occurrence that always showed very low values, ranging between 20% (1998) and 4%(2010). Decreasing trend in both abundance and biomass was observed. Medium value
of abundance indeks is 28 specimens per km2, and of biomass 21 kg per km2. The values for 1998 were clearly greater than values of the following years and are linked to a catch of a large group of individuals.
Lengt frequency distribution from 2010 shows a polimodal ditribution with greater importance of a first year class.

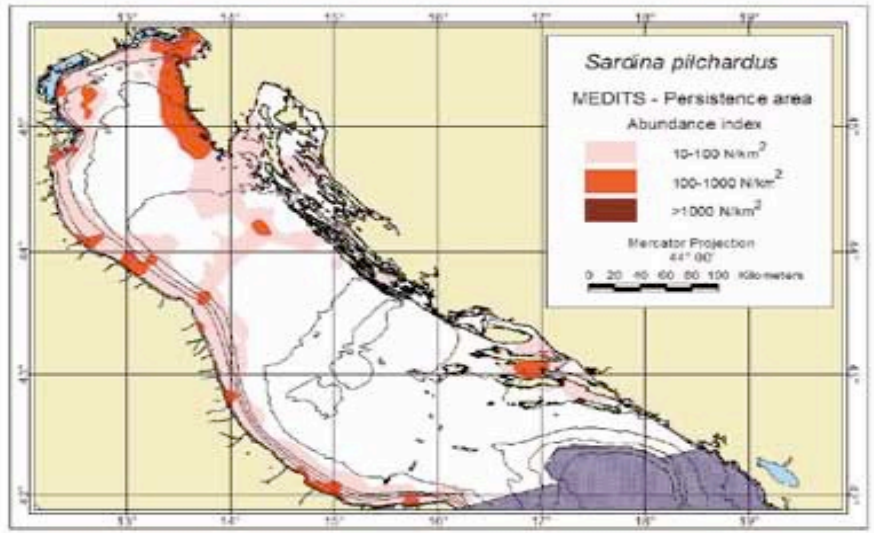
Srdela, *(Sardina pilchardus* (Walbaum, 1792))

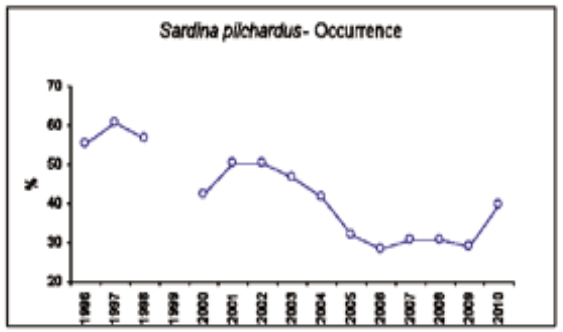
EN: Sardine; IT: Sardina; SL: Sardela

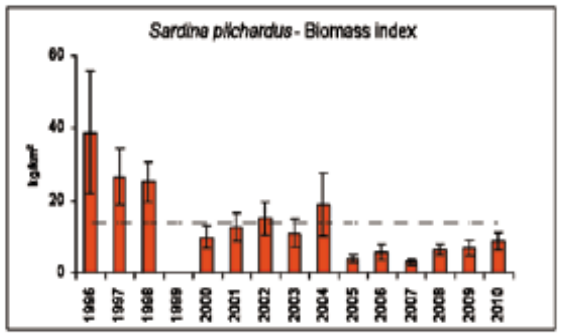


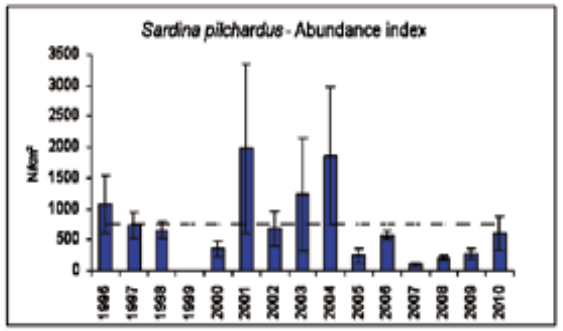
Sardine has been found in the whole basin mostly between 10 and 100 m of depth, with greatest amount of sardine steadily caught along coastal areas. Frequency of occurrence vried from 28.5% to 60.7% with a mean value of 42.4%. The negative trend of occurrence has been observed from 1996 to 2009 followed by positive trend in last years.







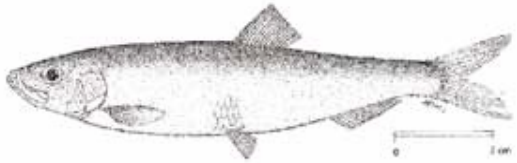




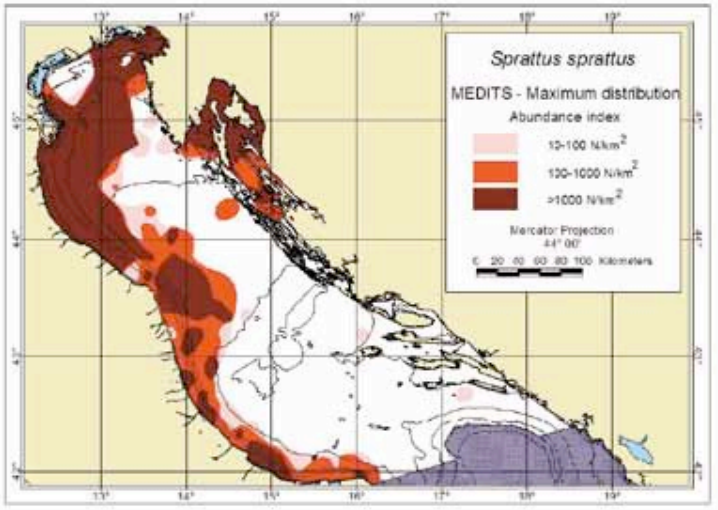
Regarding abundance and biomass indexes the fluctuation of abundance with a mean value of 757 specimens and decreasing of biomass indexes with a mean value of 13.8 kg per km2 has been observed.

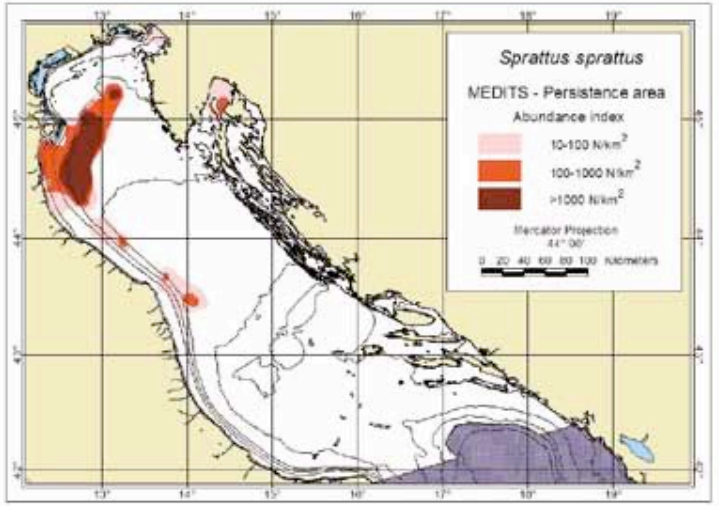
Papalina, (*Sprattus sprattus* (Linnaeus, 1758))

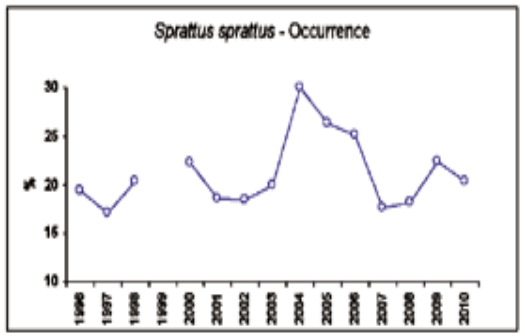
EN: Sprat; IT: Spratto; SL: Papalina

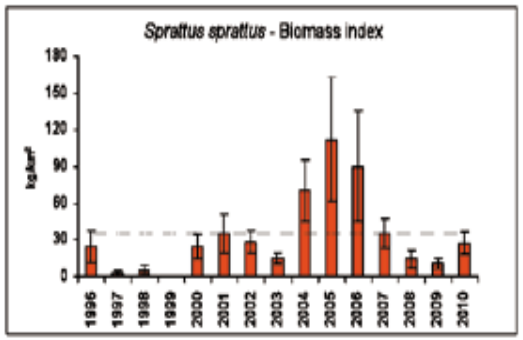


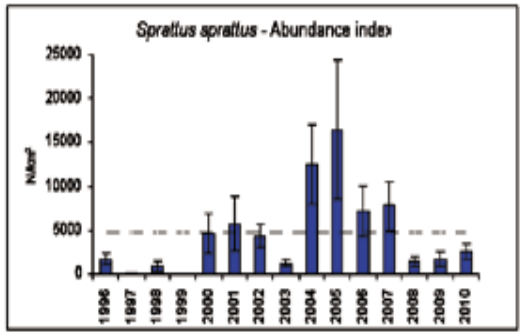
Sprat has been mainly found in shallow water of the basin, up to 50 m depth, both along the western coastal area and in the Velebit Channel. The greatest abundance was Steadily caught close to the Po river Delta.









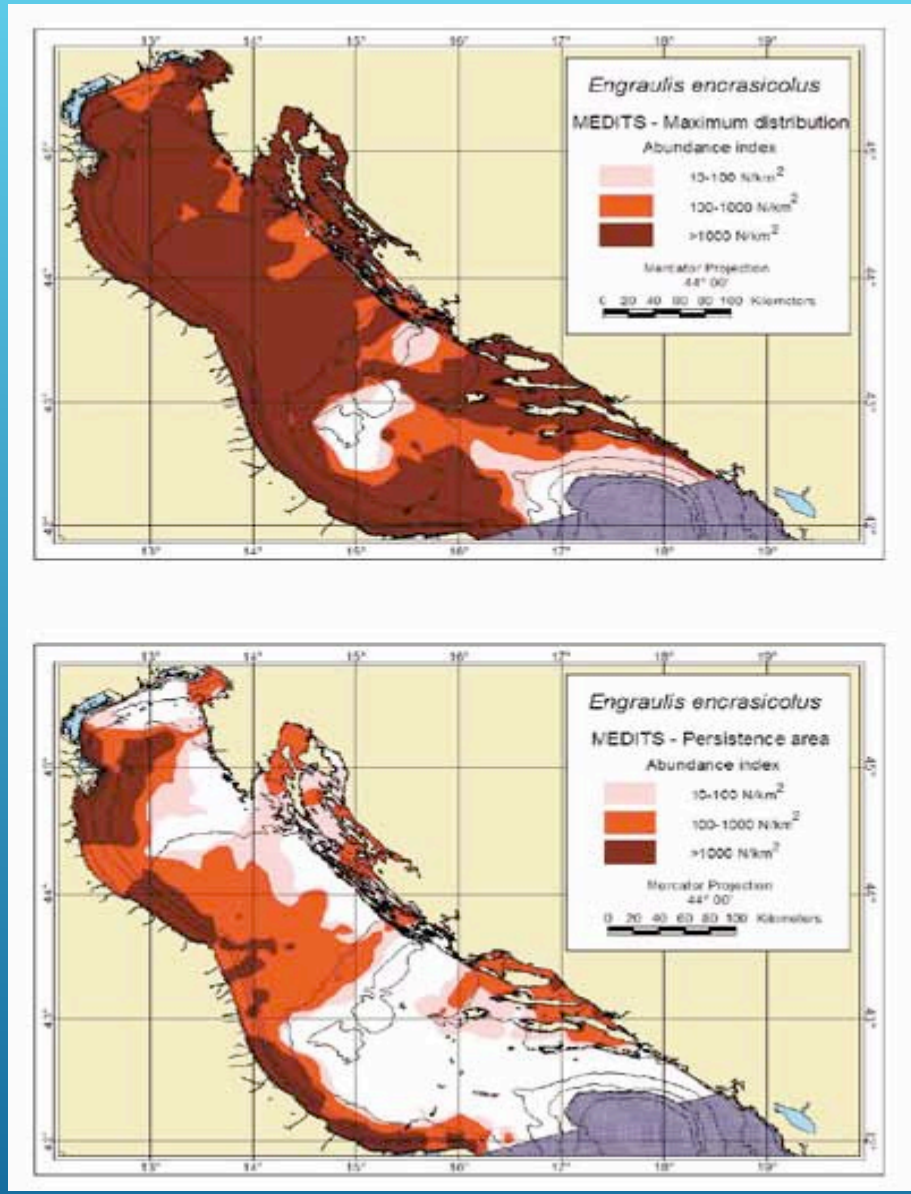


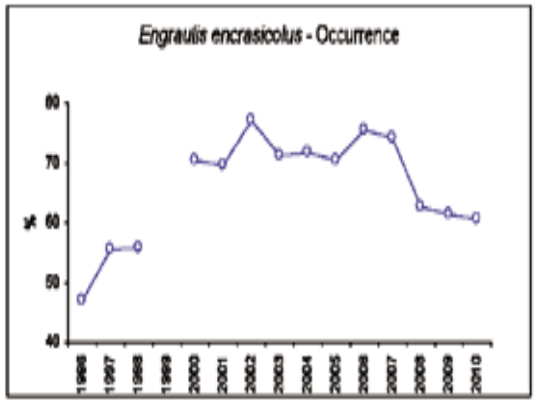
Frequency of occurrence varied from 17% to 30% with a mean value of 21.1%. During the whole period the fluctuation of occurrence has been observed. Also regarding abundance and biomass indexes the fluctuation has been observed with a mean values of 4481 specimens and 35.7 kg per km2

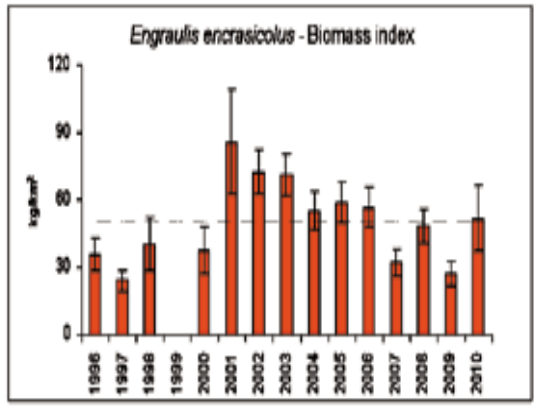
Brgljun, Inćun (*Engraulis encrasicolus* (Linnaeus, 1758))

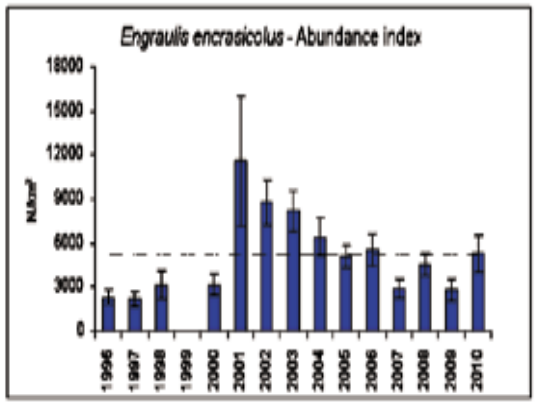
EN: Anchovy; IT: Acciuga, alice; SL: Sardon

Anchovy has been found in the whole basin, with the Exception of areas deeper than 200 m. High and permanent Abundance of anchovy has been observed in the western Coastal area. Along the easetrn coast high abundance was steadily found in the Gulf of Trieste and in the channels.



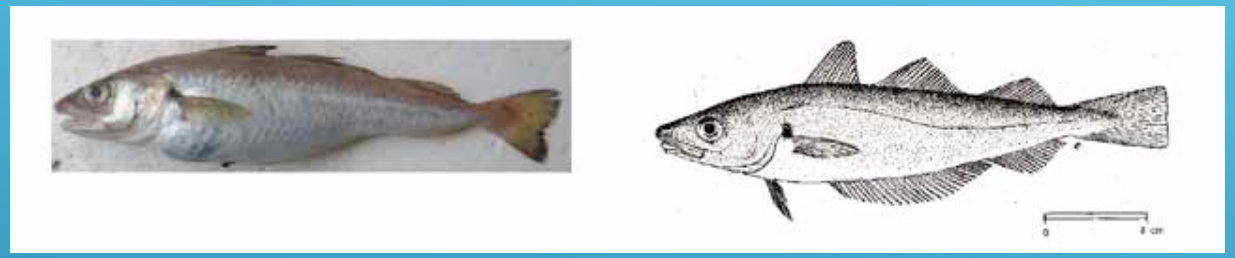




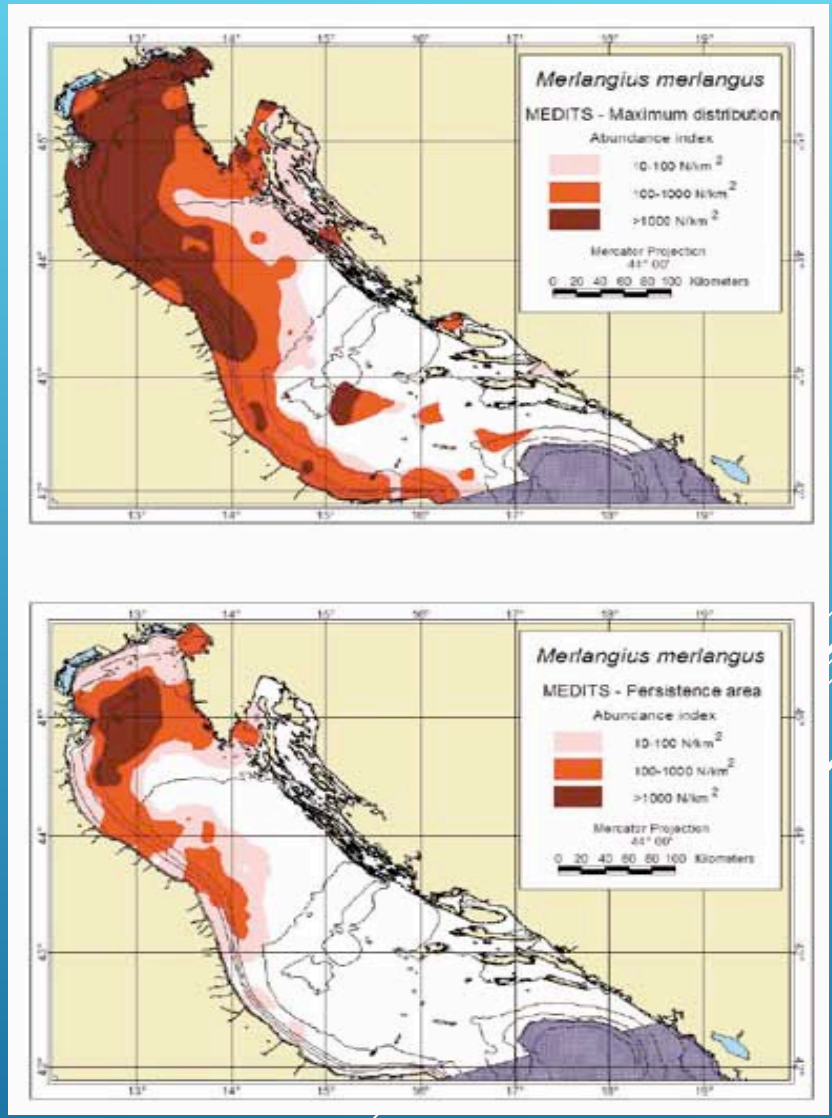


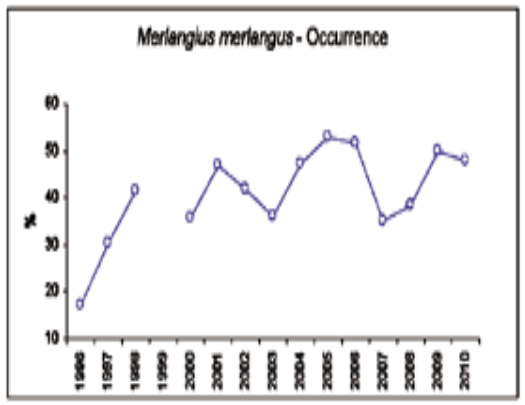
Frequency of occurrence varied from 47.0% to 77.1% with a mean value of 65.9%. During the whole period The fluctuation of occurrence has been observed. Regarding abundance and biomass indexes the fluctuation were observed with a mean values of 5152 specimens and 49.8 kg per km2.

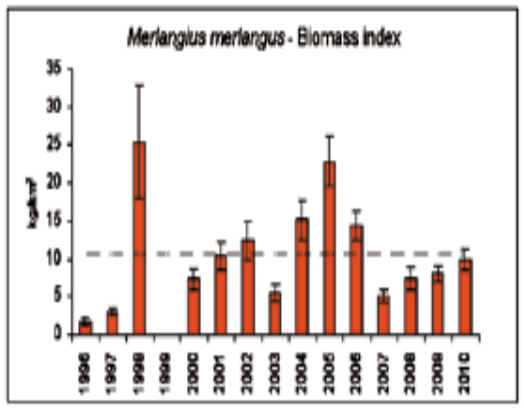
Pišmolj, (*Merlangius merlangus* (Linnaeus, 1758))
EN: Whiting; IT: Merlano; SL: Mol

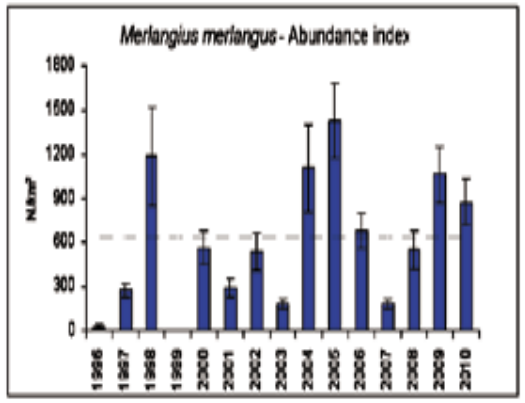


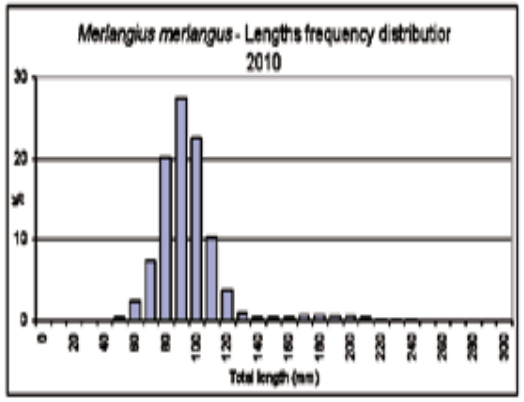
Whiting has been widely distributed in shallow water of the whole Northern basin and along western coastal area uo to the Cape Gargano. Highest abundance and biomass was steadily found on the Norternmost part of the Adriatic. Frequency of occurrence varied from 17.2% to 52.8% with a mean value of 40.8%.







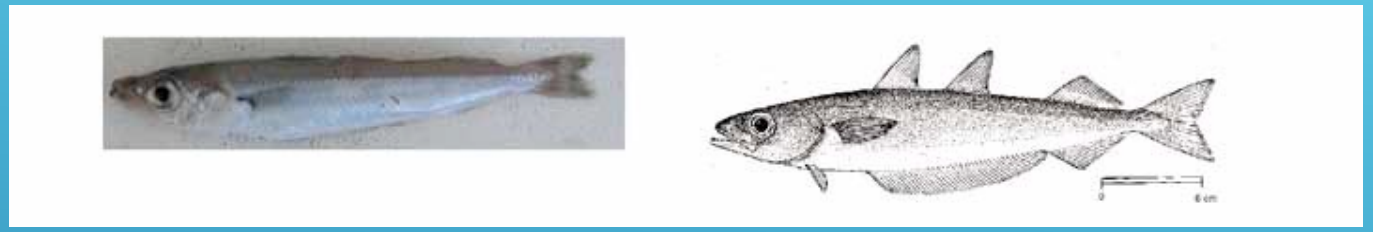




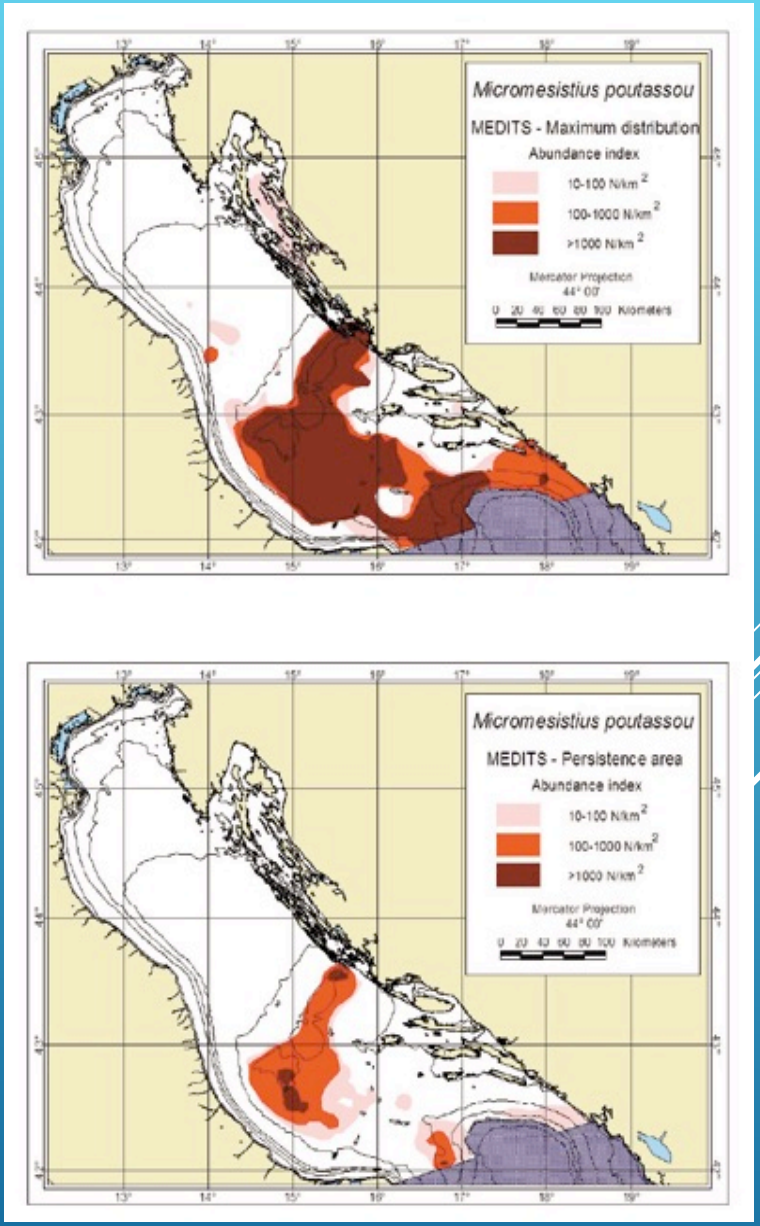
During the whole period the fluctuation of occurrence has been observed. Regarding abundance and biomass Indexes the fluctuation has been observed with a mean values of 640 specimens and 10,6 kg per km2.

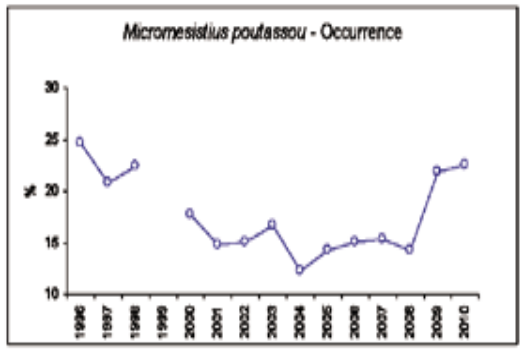
The length frequency distribution in 2010 showed a dominance of small individuals.

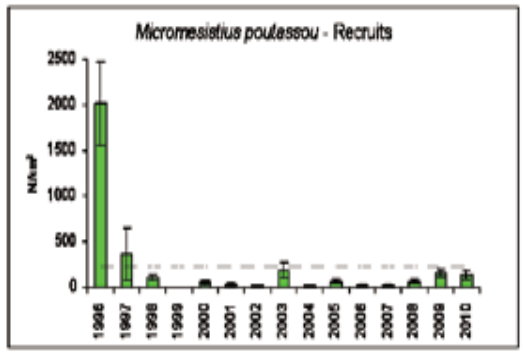
Ugotica pučinka, (*Micromesistius poutassou* (Risso, 1827)) EN:
Blue whiting; IT: Potassolo; SL: Sinji mol

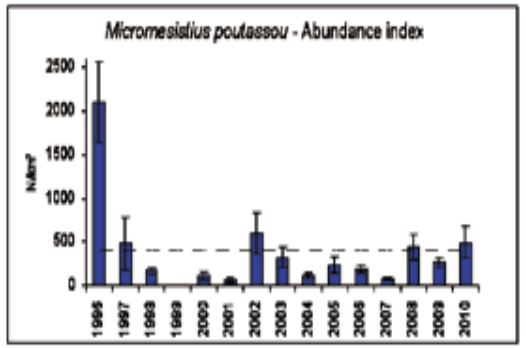


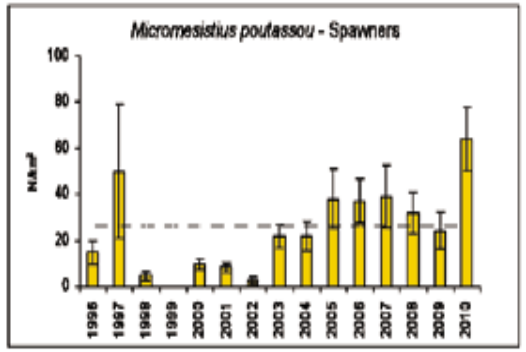
It has been mainly distributed in the open central Adriatic on silt-clay and clay-silt bottomes deeper tha 130 m. Frequency of occurrence varied from 12.2% to 24.6% with a man value of 17.7%.

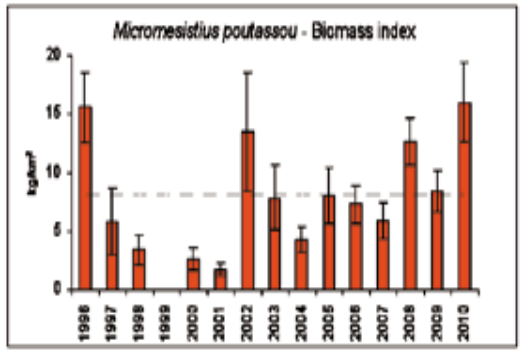


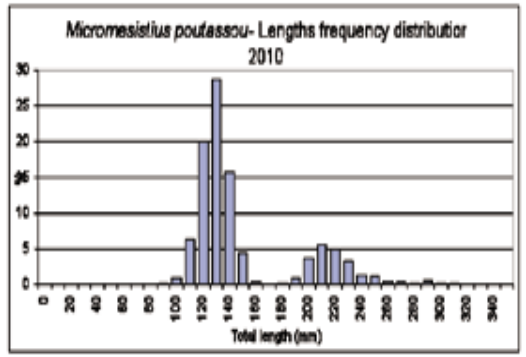










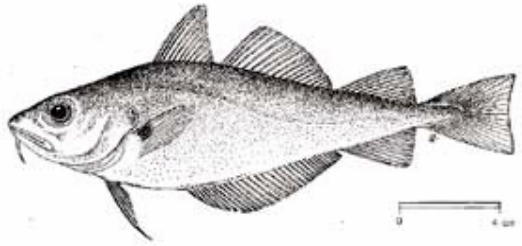


During the whole period the fluctuation of occurrence has been observed. Regarding abundance and biomass indexes The fluctuation has been observed with a mean values of 405 Speciemns and 8.1 kg per m2. The significant and persistent Decrease of recruitment has been observed after first year with a mean value of 233 recruits per km2.

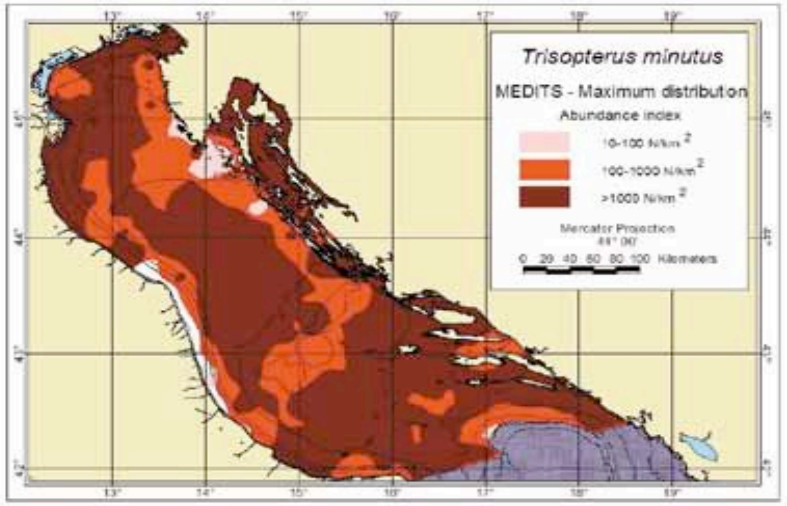
The general trenda in number of spawners has been positive with a mean value of 26 spawners per km2. The length frequency distribution in 2010 showed a dominance of small Individuals with two clearly visible cohorts.

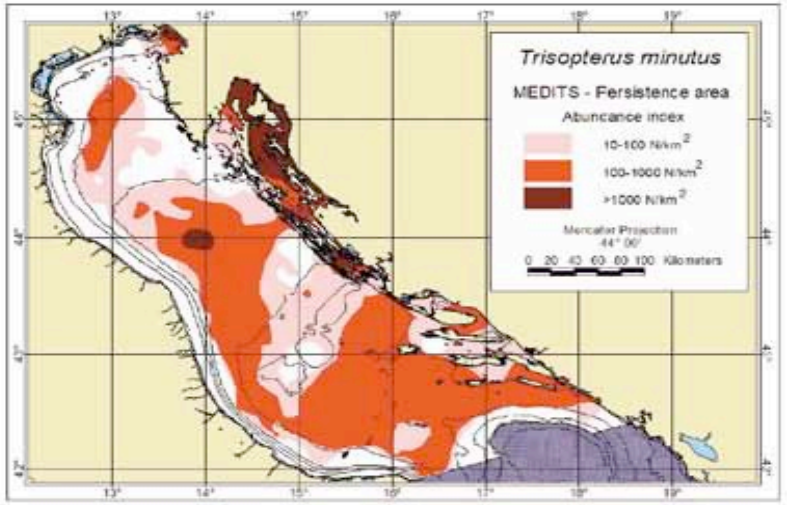
Ugotica, (*Trisopterus minutus* (Linnaeus, 1758))

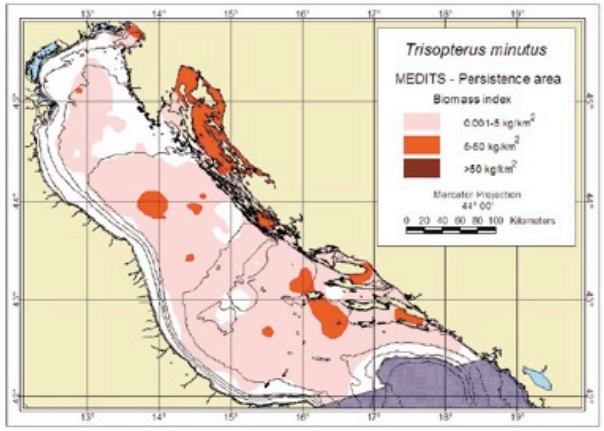
EN: Poor cod; IT: Merluzzetto giallo; SL: Molič

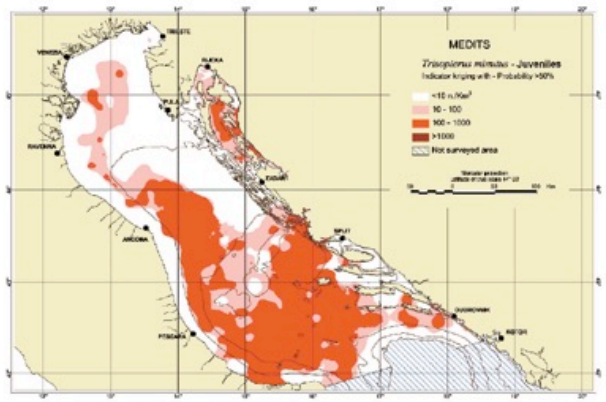


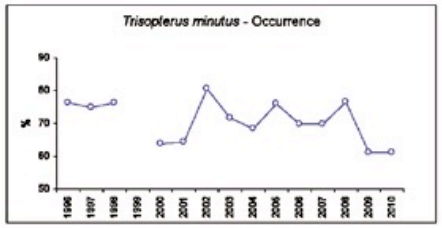
It has been widely distributed in the whole area, with the exception of restricted areas along coastal area. It is very common and steadily found on muddy and sandy bottoms off Ancona and in the northern Channel area. Juveniles are distributed in the same areas of the whole population.

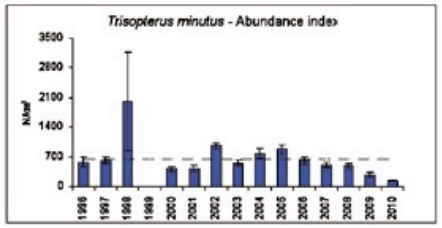




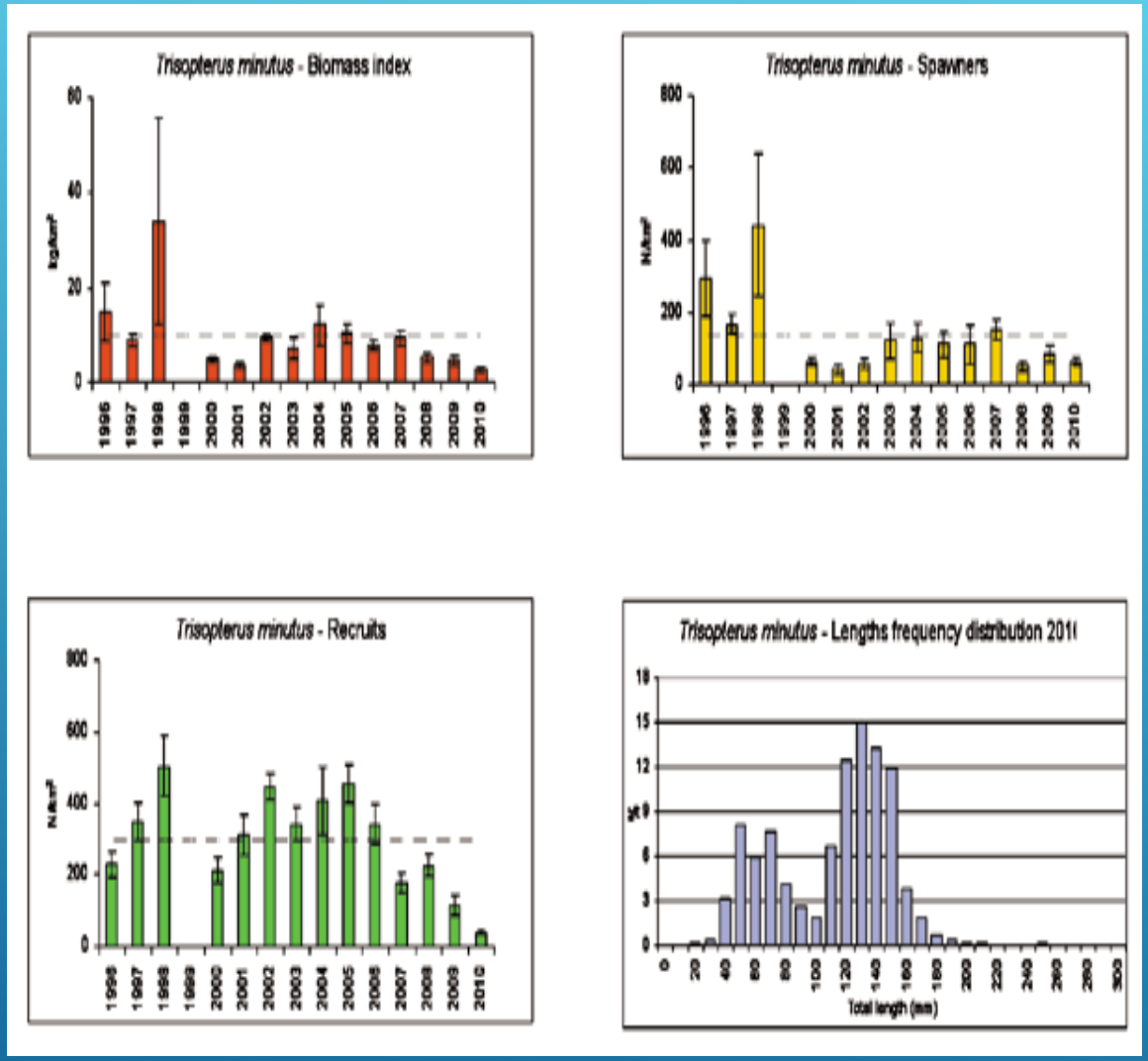








Frequncy of occurrence varied from 61% to 80.5% With a mean value of 70.7%. During the whole period the decreasing of occurrence has been observed. Regarding abundance and biomass indexes the decreasing has been observed with a mean values of 656 specimens and 9.7 kg per km2.

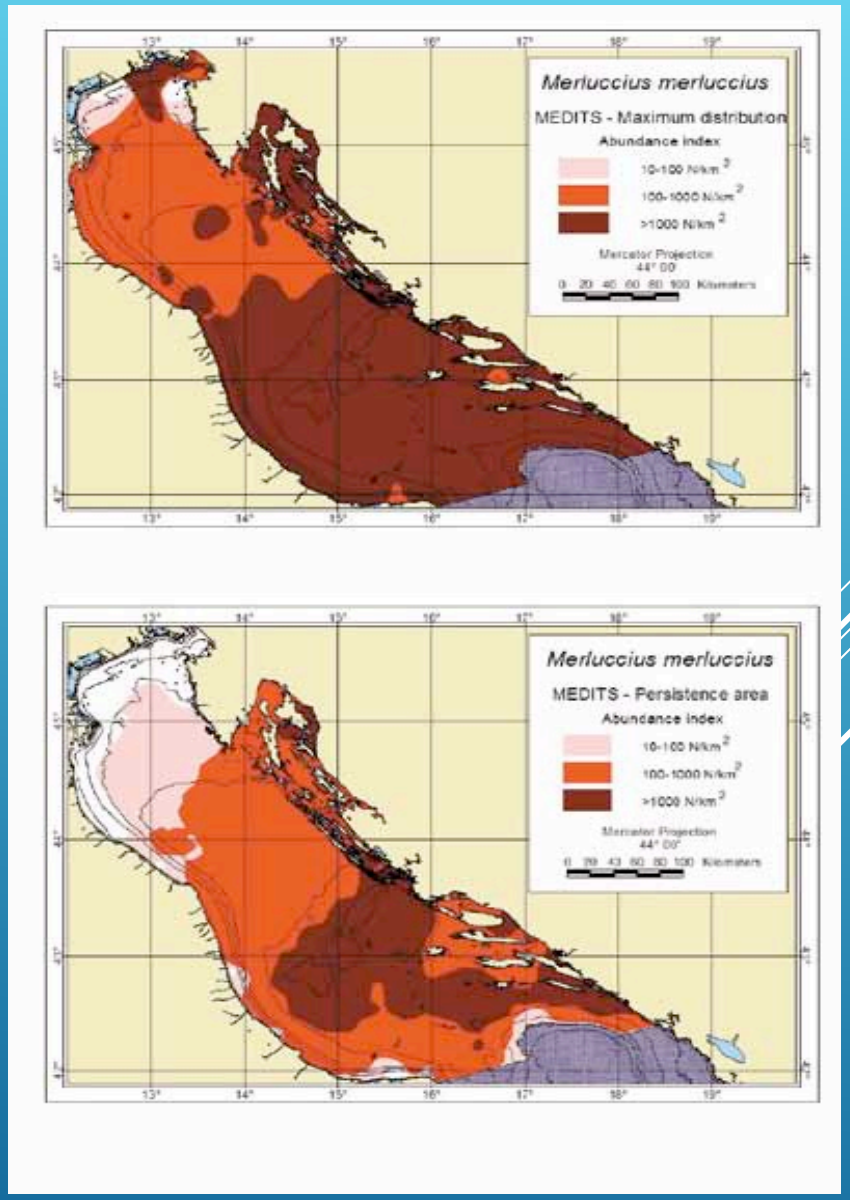


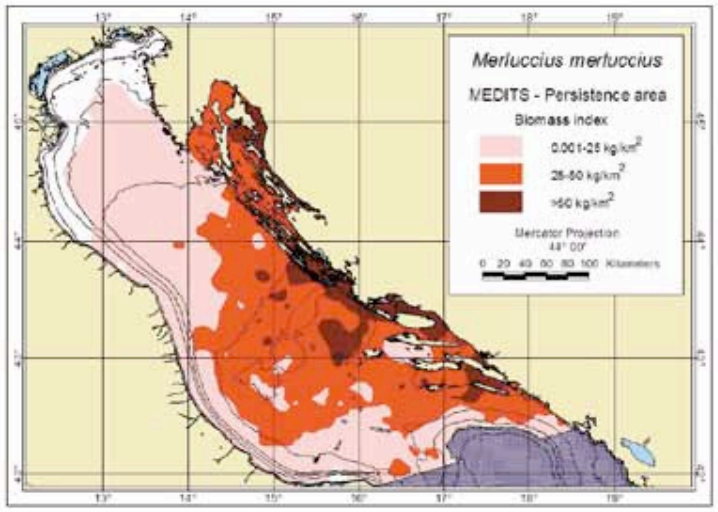
There was also fluctuation in the number of spawners with a mean value of 135 spawners per km2. The length frequency distribution in 2010 showed a dominance of small individuals with two clearly visible cohorts.

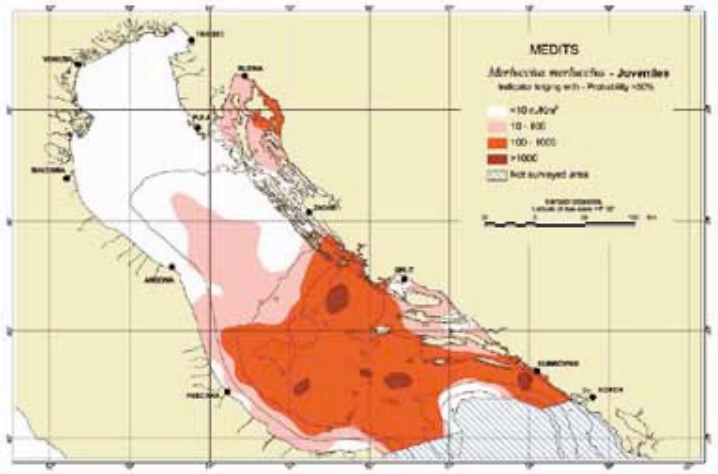
Oslić, (*Merluccius merluccius* (Linnaeus, 1758))

EN: European hake; IT: Nasello; SL: Oslič

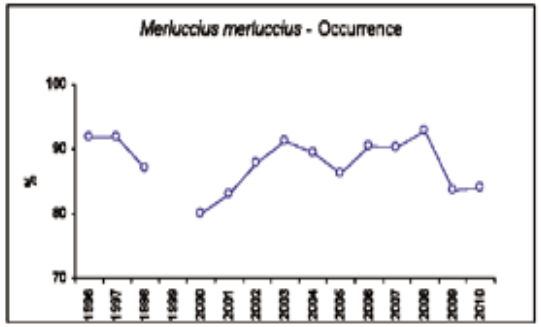
It has been widely distributed in the whole area, with the exception of small areas in the northernmost areas. Greatest abundance was steadily found in the central Adriatic in water deeper than 100 m, where population is mainly composed of juveniles.

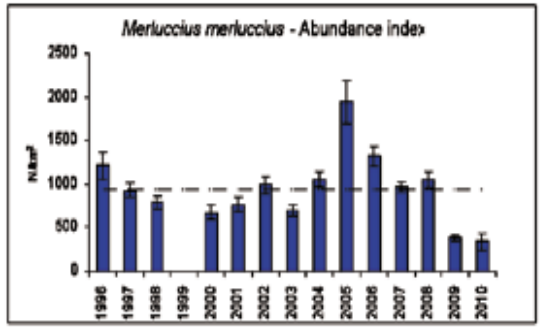


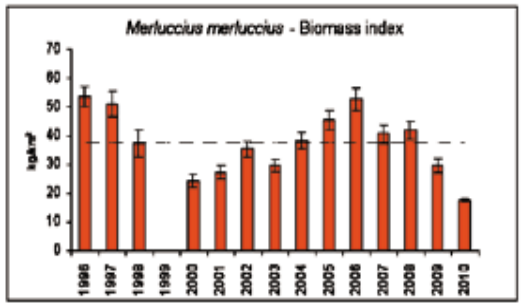


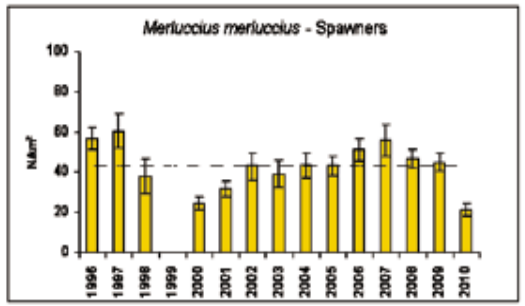


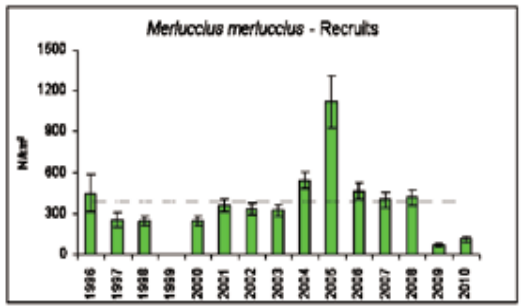
Greatest biomass was steadily found in the eastern part of the Adriatic. Frequency of occurrence varied form 80% to 92.9% with a mean value of 87.8%.
During the whole period of the fluctuation of occurrence has been observed.

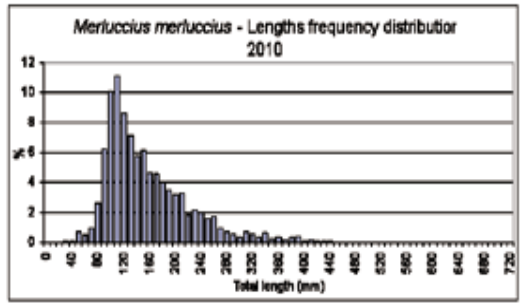












Regarding abundance and biomass indexes the fluctuation has been observed with a mean values of 93.7 specimens and 37.5 kg per km2.
The fluctuation of recruitment has been observed with a mean value of 43 spawners per km2.
The length frequency distribution in 2010 showed a dominance of small individuals with one clearly visible cohort.

HAKE - *Merluccius merluccius*

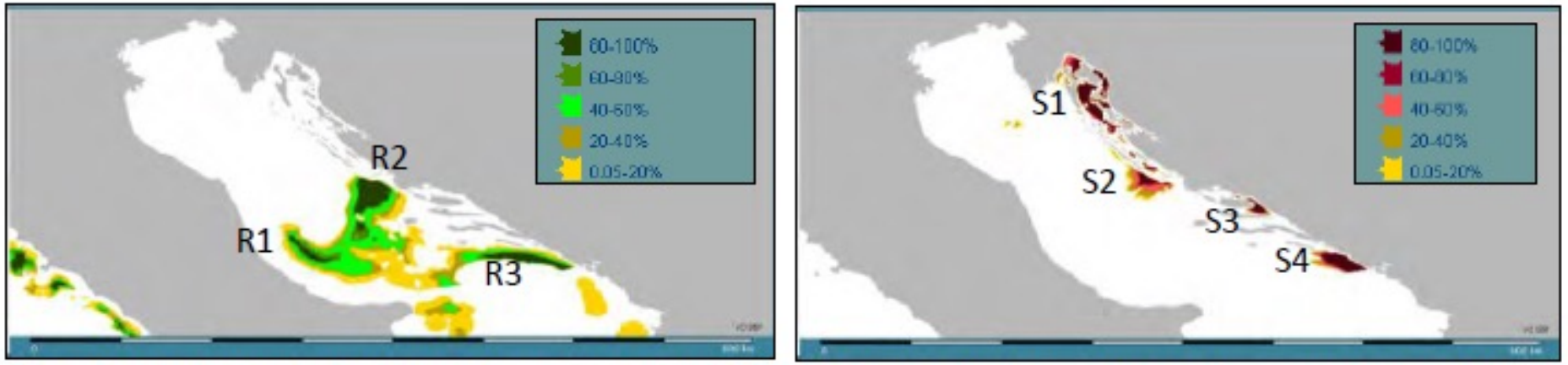


Fig 2.2.5.1.7. Position of persistent nursery (left) and persistent areas of potential spawners (right) in GSA 17

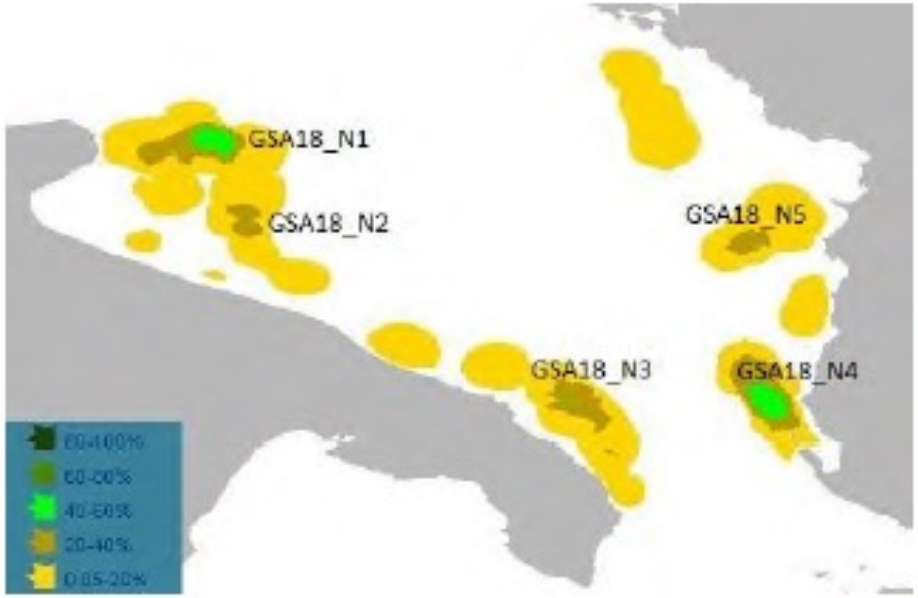
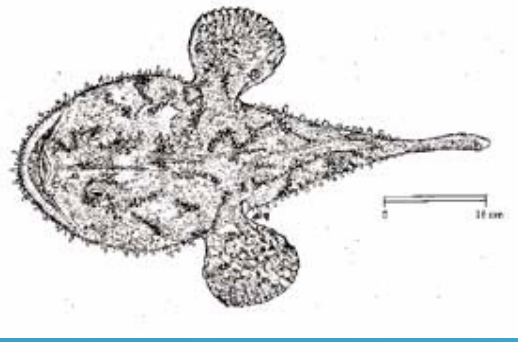
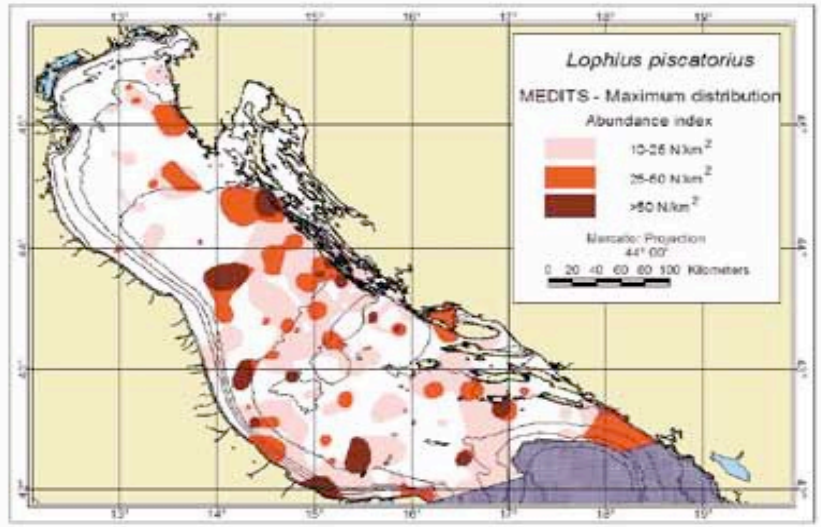


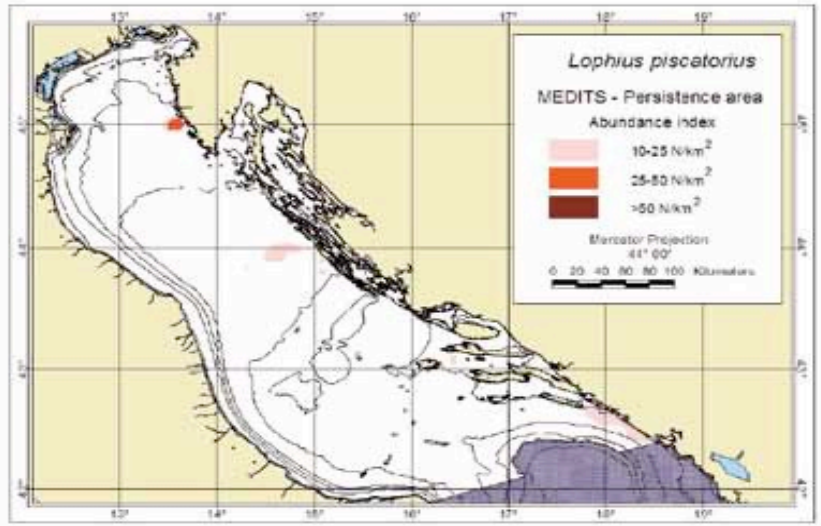
Fig. 2.2.5.1.8. Position of persistent nursery areas of hake in GSA18

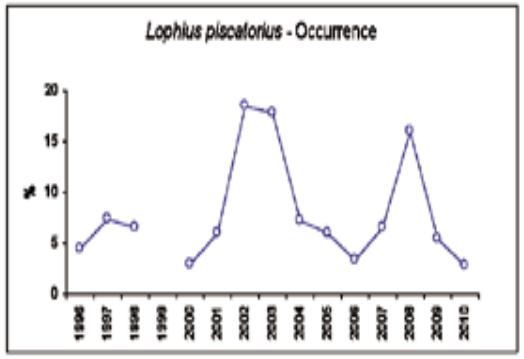
Grdobina (mrkulja), (*Lophius piscatorius* Linnaeus, 1758)
EN: Angler; IT: Rana pescatrice; SL: Morska spaka

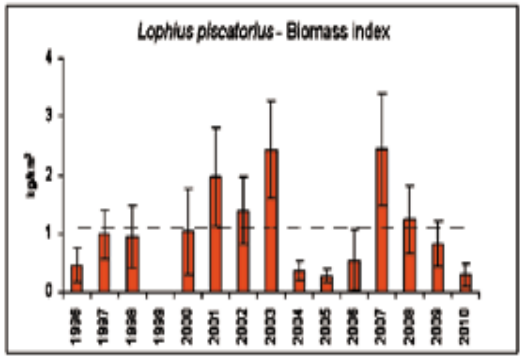


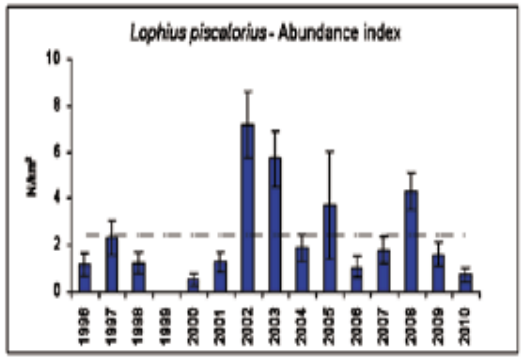
Sporadc catches of angler fish has been recorded in the whole basin, mostly at depths greater than 50 m. Frequency of occurrence varied From 2,8% to 18,4% with amean value of 7.9%.





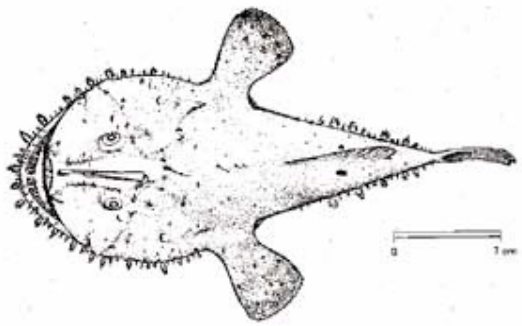




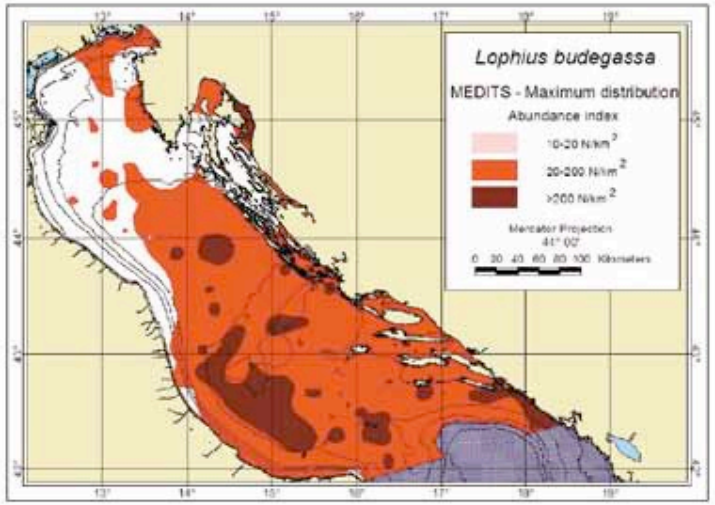


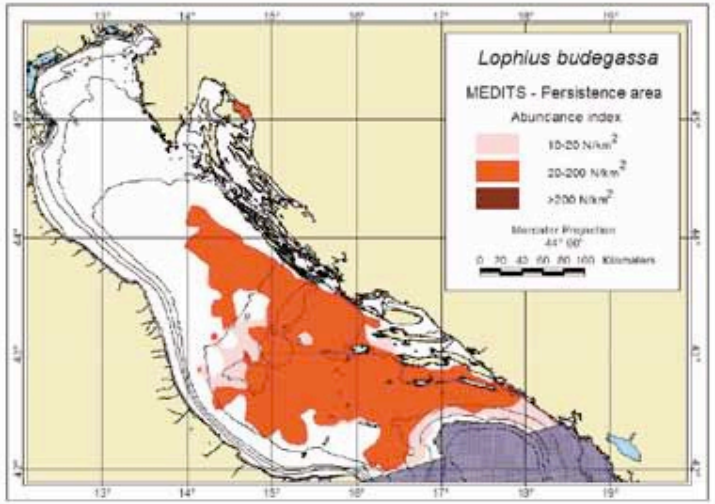
During the whole period the fluctuation of occurrence has been observed. Regarding abundance and biomass indexes the fluctuation patterns has been observed with a mean values of 3 speciemens and 1.1 kg per km2.

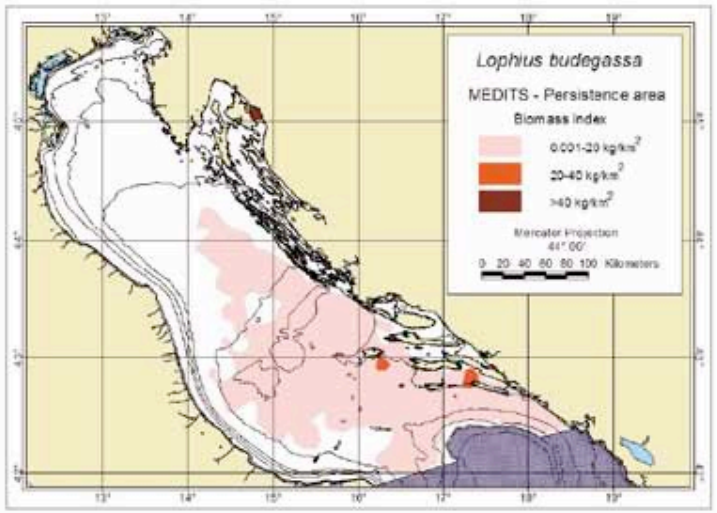
Grdobina žutka, (*Lophius budegassa* Spinola, 1807)
EN: Black-bellied angler; IT: Budego; SL: Mala morska spaka

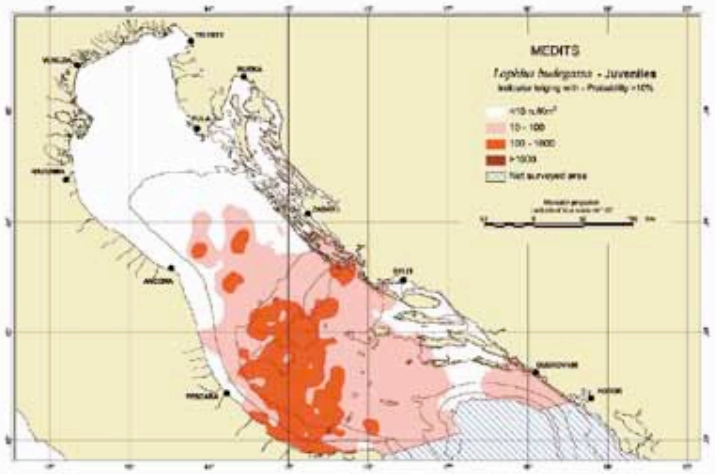


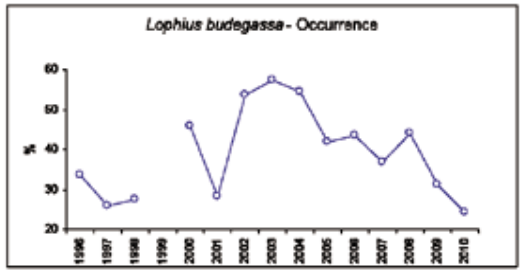
It has been found across the whole area, with the exception of the Northernmost part of the Adriatic, in water deeper than 50 m.
The highest number of individuals was steadily detect on silt-clay and clay -silt bootoms of the open Central Adriatic and the Velebit channel.

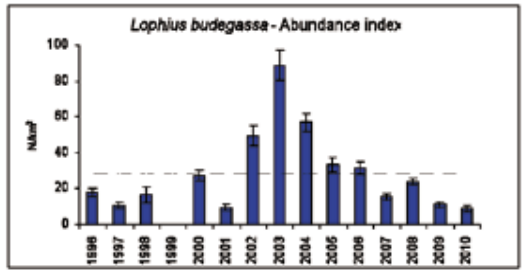




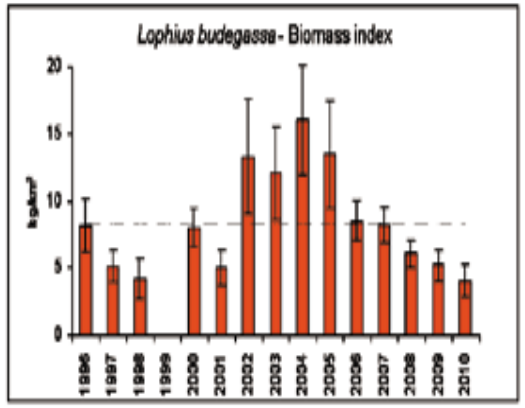


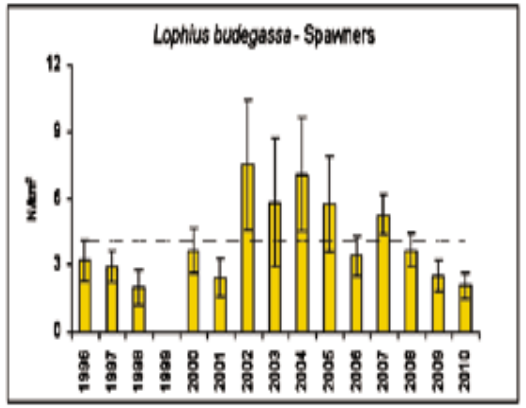


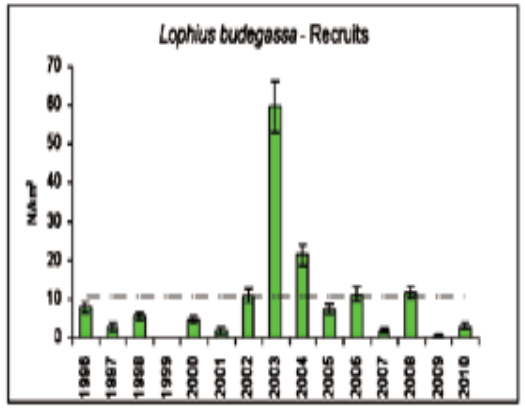


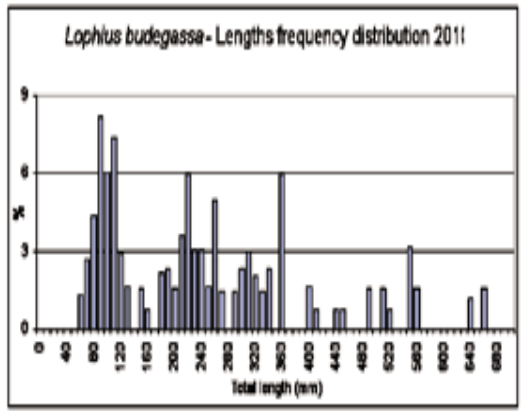


Juveniles were mainly distributed in the Central Adriatic.
Frequency of occurrence varied from 24.2% to 57.2% with a mean value of 39.1%.
During the whole period the fluctuation of occurrence has been observed.







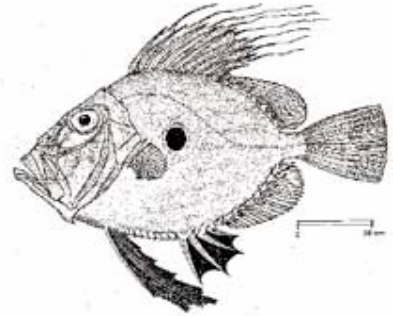


The fluctuation of abundance with a mean value of 8,4 kg per km2 have been observed. The fluctuation of recruitment has been observed with a mean value of 11 recruits per km2. There was also fluctuation in the number of spawners with a mean value of 4 spawners per km2.

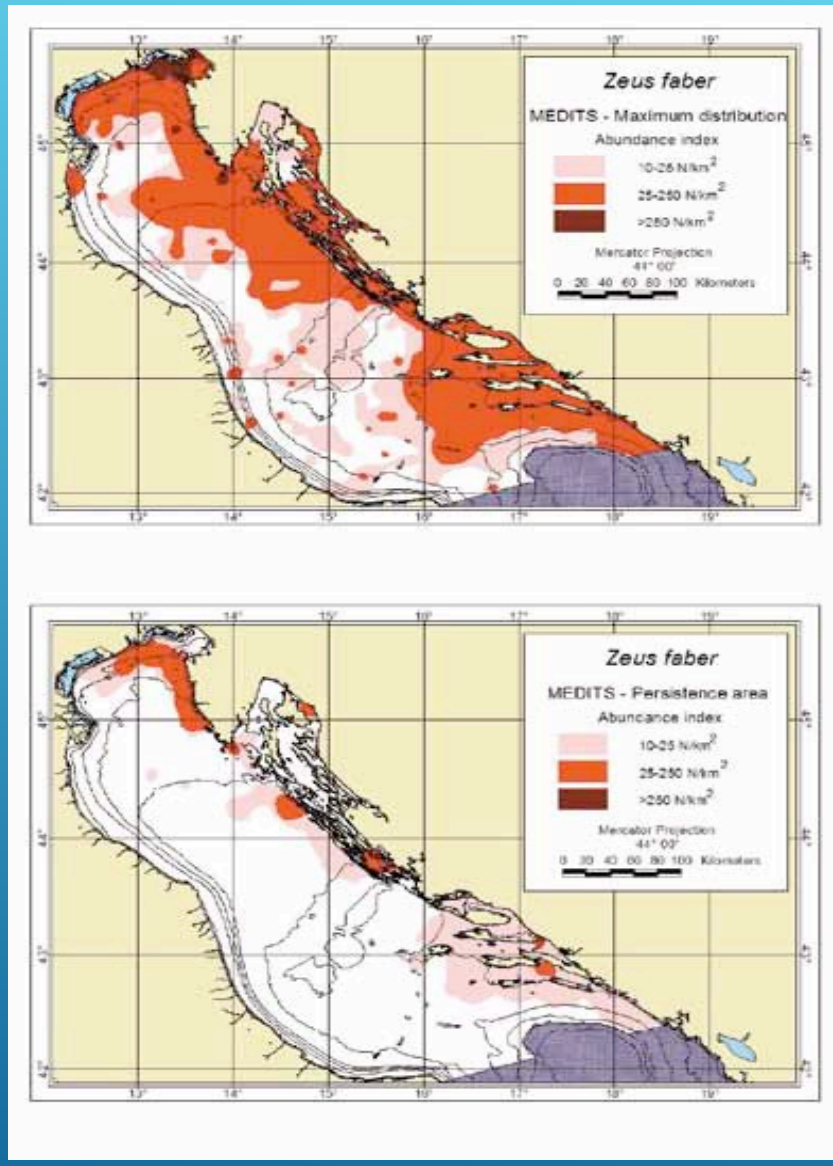
The length frequency distribution in 2010 showed a dominance of small individuals with three visible cohorts.

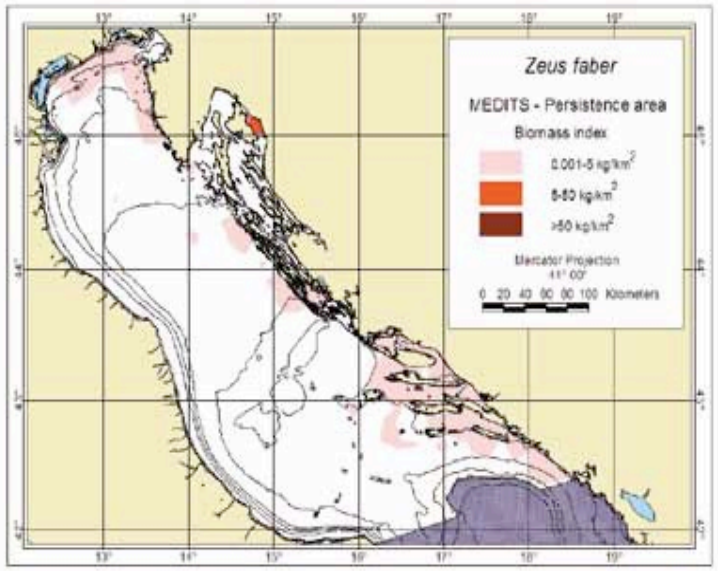
Kovač, (*Zeus faber* Linnaeus, 1758)

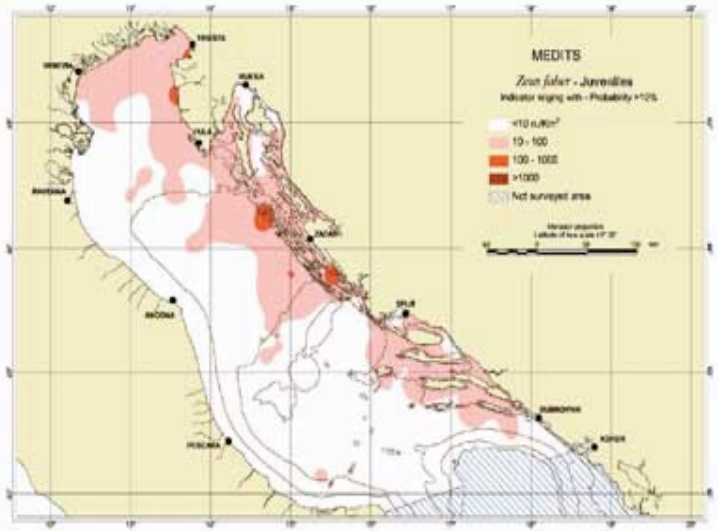
EN: John dory; IT: Pesce San Pietro; SL: Kovač

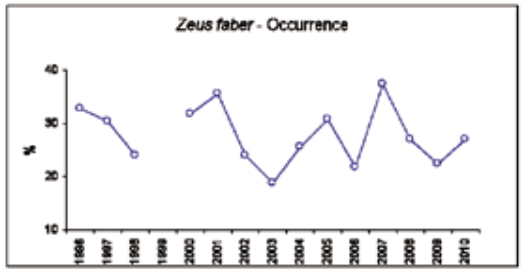


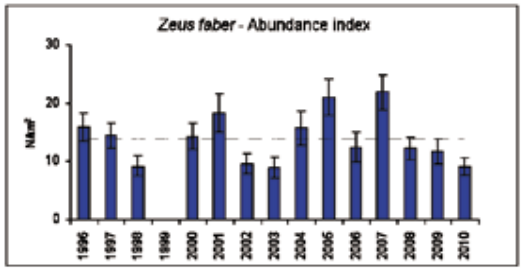
Distribution area has been extended in the eastern part of the basin within the median line.
Juveniles were distributed in the same area of the whole population.



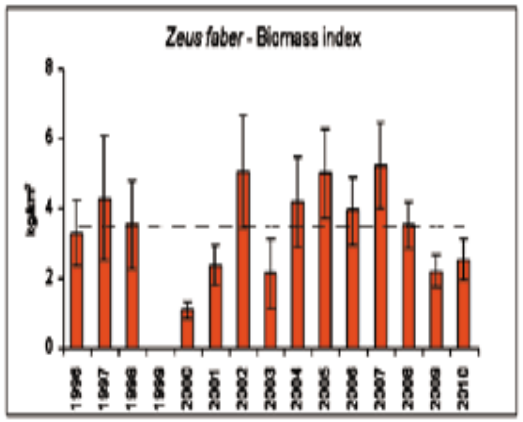


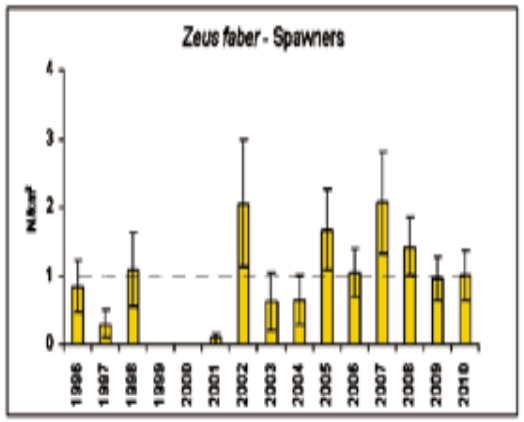


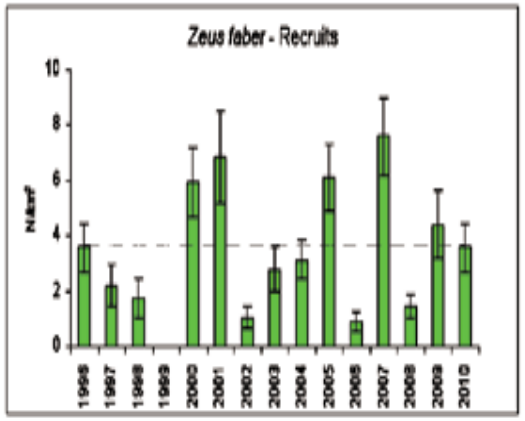


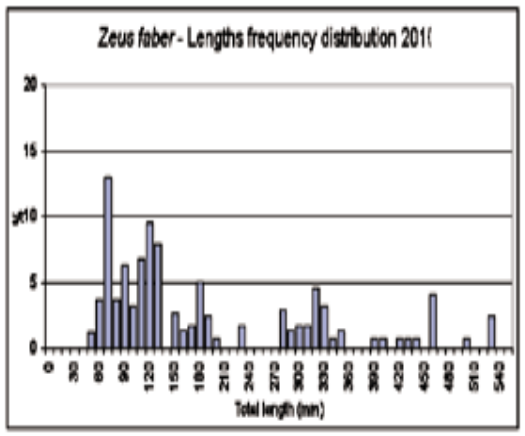


Frequency of occurrence varied from 18,9% to 37,4% with a mean value of 27.8%. During the whole period the fluctuation of occurrence has been observed.





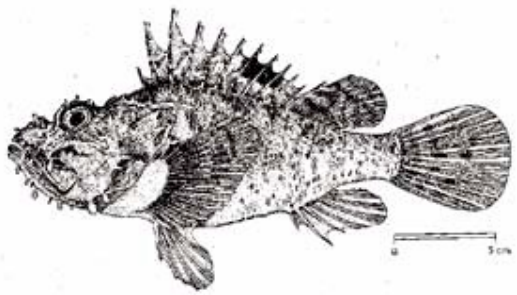




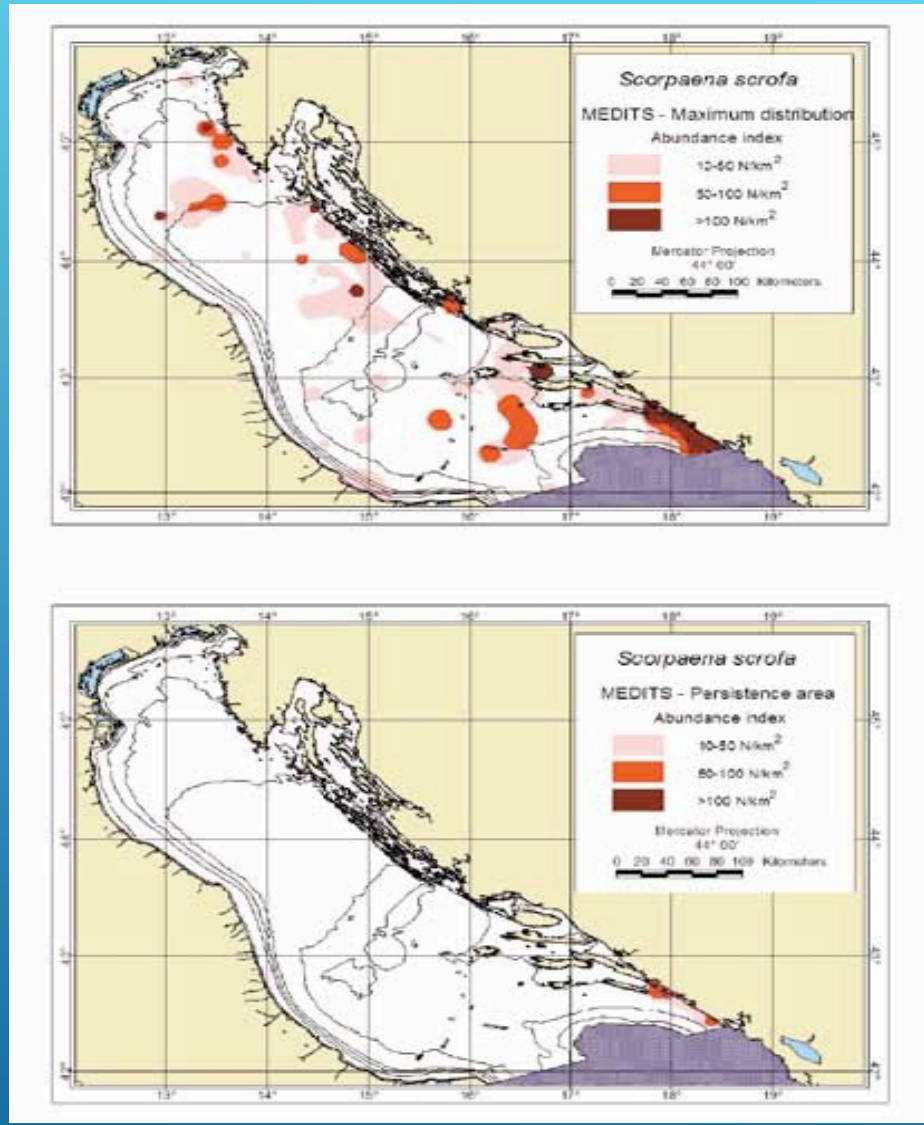
Regarding abundance and biomass indexes the fluctuation pattern has been observed with a mean value of 14 specimens and 3,5 kg per km2.
The fluctuation of recruitment has been observed with a mean value of 4 recruits per km2.
There was also fluctuation in the number of spawners with a mean value of 1 spawner per km2.
The length frequency distribution in 2010 showed a dominance of small individuals with two visible cohorts.

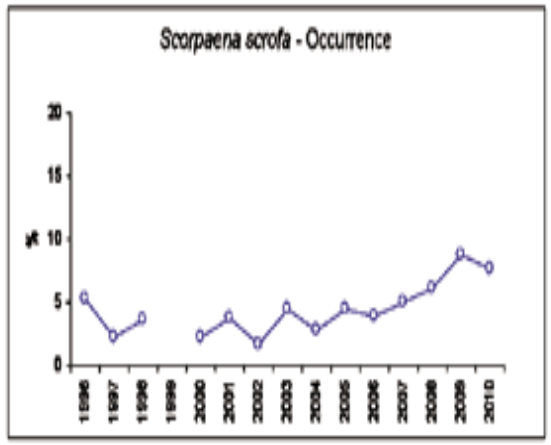
Škrpina, (*Scorpaena scrofa* Linnaeus, 1758) EN:

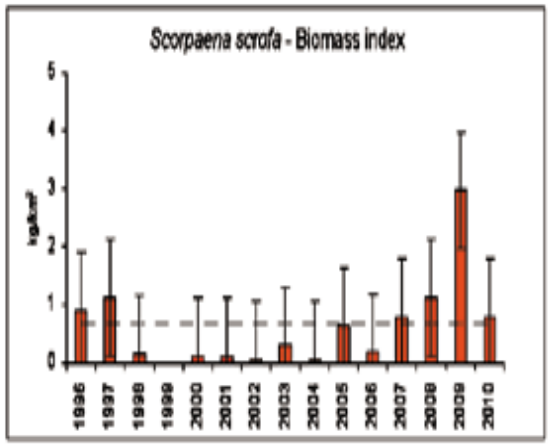
Red scorpionfish; IT: Scorfano rosso; SL: Velika škarpena

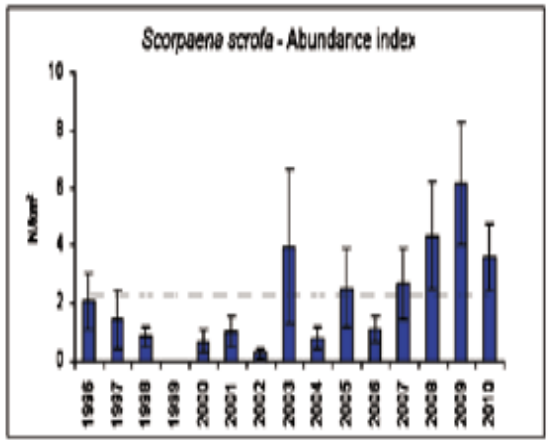


Sporadic catches has been recorded in the whole basin, mainly on the eastern side.





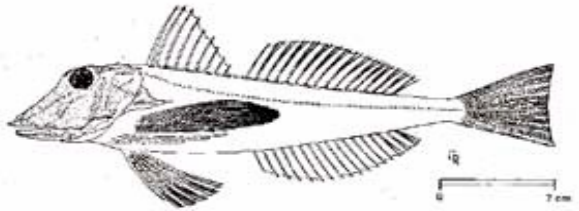




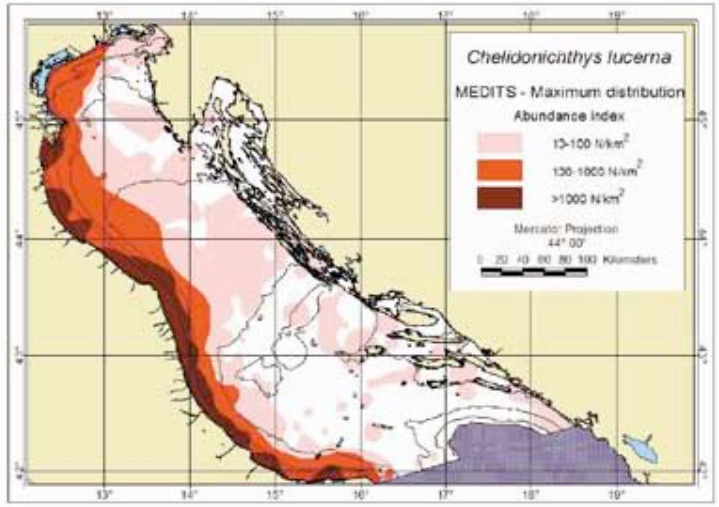
Frequency of occurrence varied from 1,7% to 8,7 with a mean value of 4,4%.
During the whole period the increase of occurrence has been observed.
Regarding abundance and biomass indexes the fluctuation has been observed with a mean values of 2 specimens and 0,7 kg per km2.

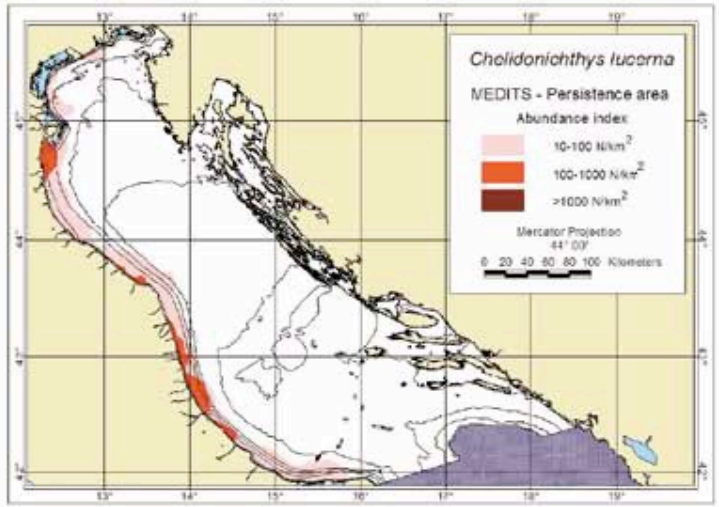
Lastavica balavica, (*Chelidonichthys lucerna* (Linnaeus, 1758))

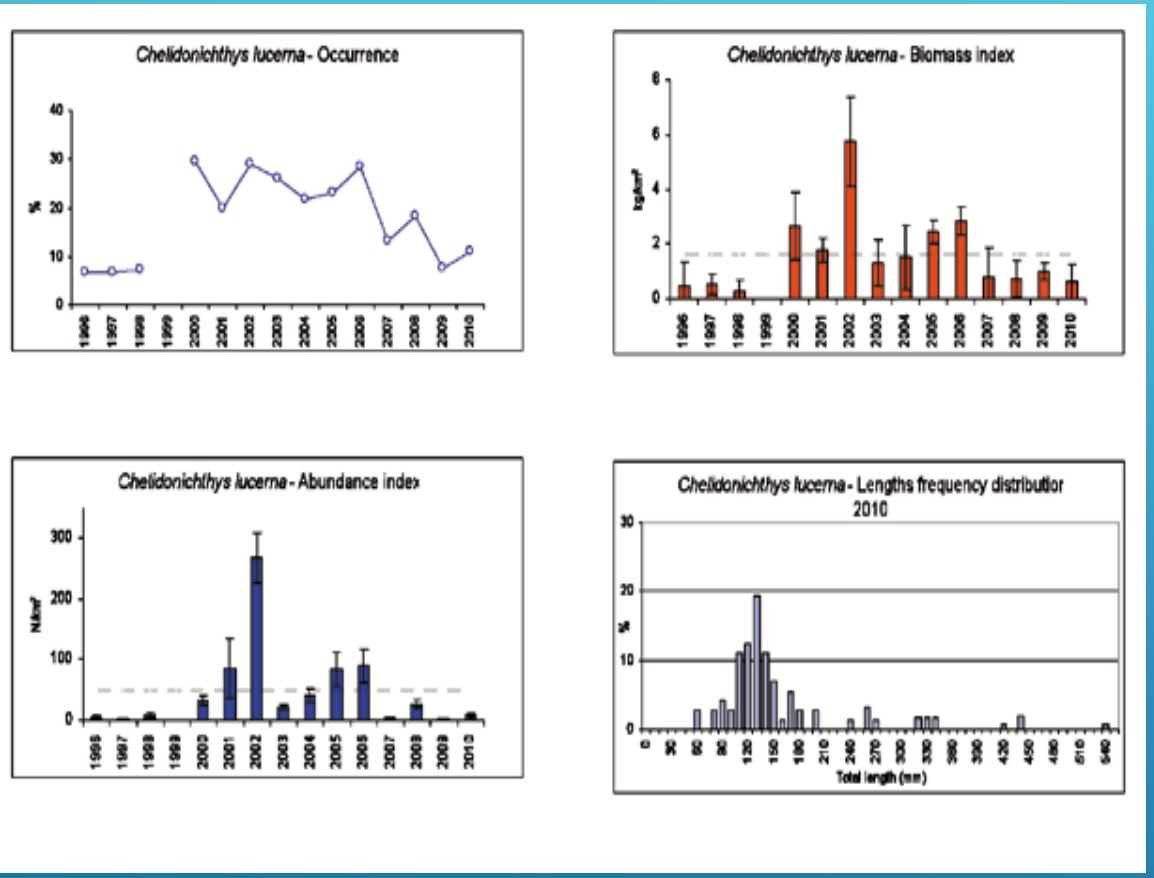
EN: Tub gurnard; IT: Gallinella; SL: Veliki krulec



It has been mainly distributed along shallow costal water along the western side of the basin.



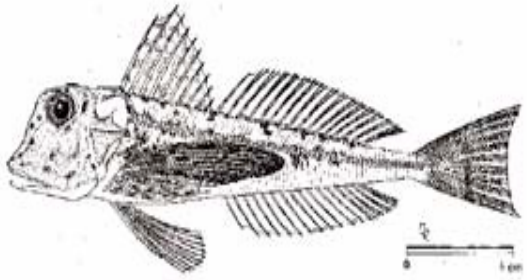




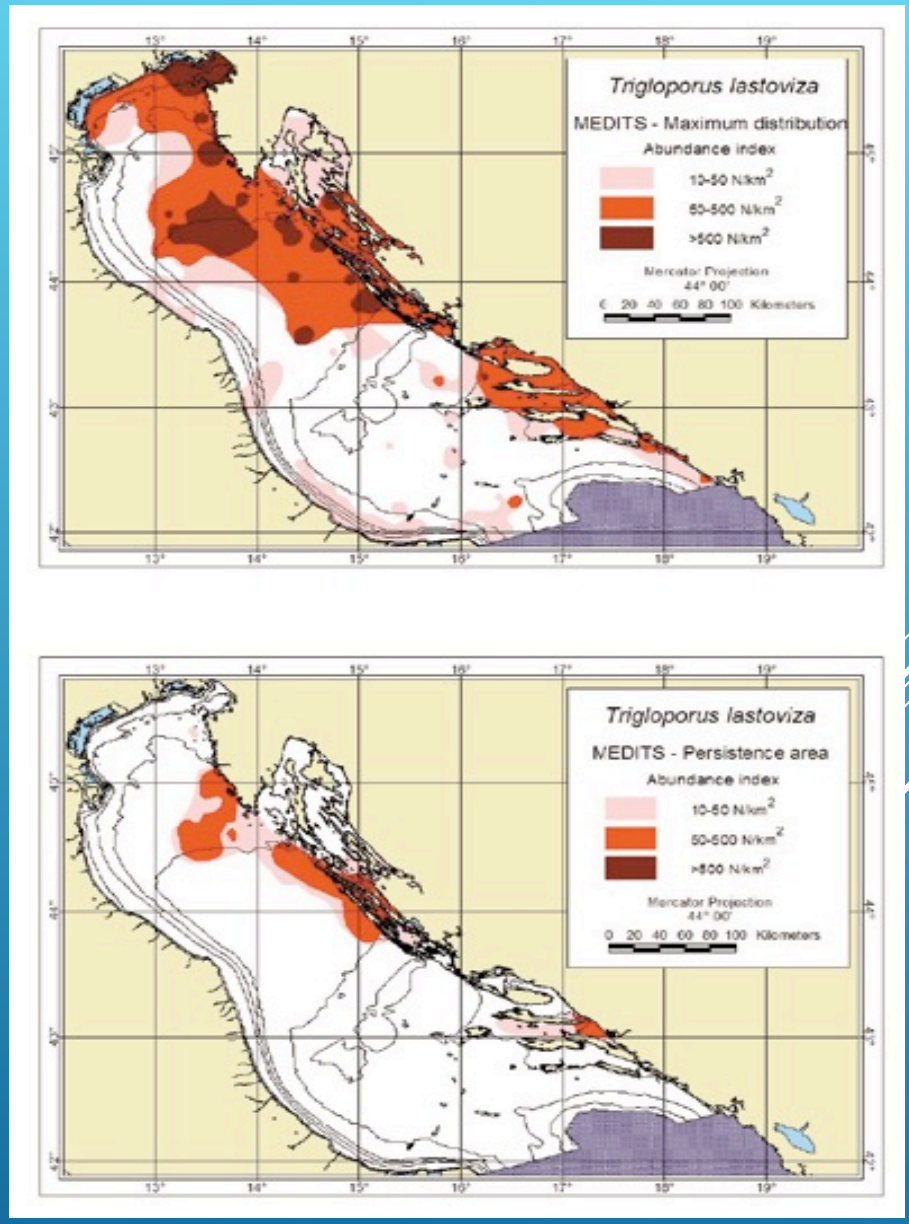
Frequency of occurrence varied from 6.7% to 29.6% with a mean value of 17.8%. During the whole period the decrease of occurrence has been observed . Regarding abundance and biomass indexes the fluctuation patterns have been observed with a mean values of 48 specimens and 1.6 kg per km2.
The length frequency distribution in 2010 showed a dominance of small individuals with one visible cohort.

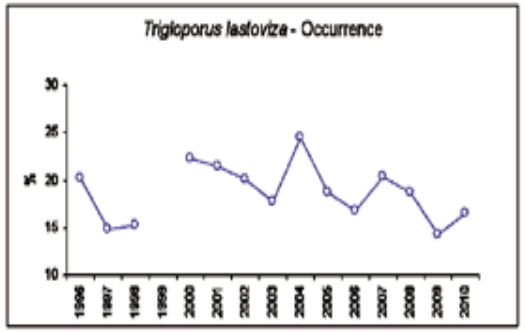
Lastavica glavulja, (*Trigloporus lastoviza* (Bonnaterre, 1788))

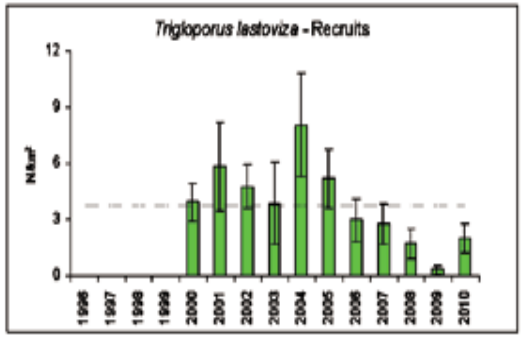
EN: Streaked gurnard; IT: Capone ubriaco; SL: Progasti krulec

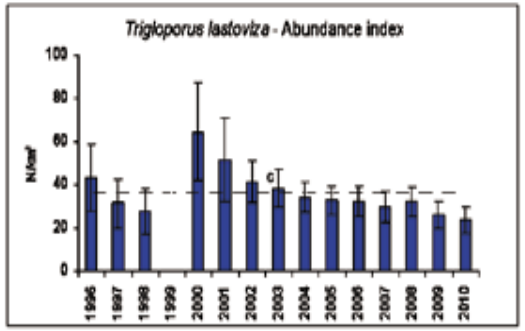


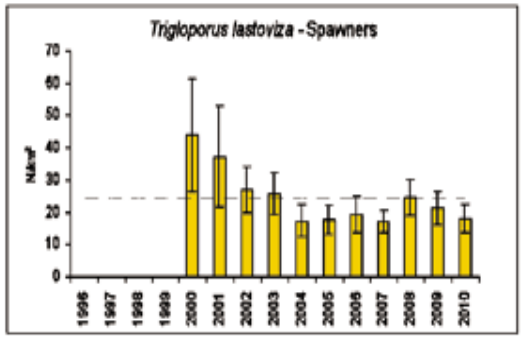
It has been mainly distributed in the median and eastern part of the North Adriatic, and in the channel area from Split to Dubrovnik, generally down to 100 m.

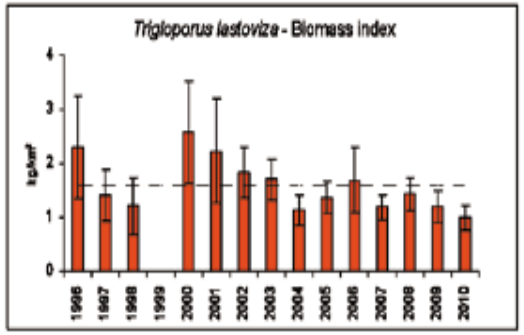


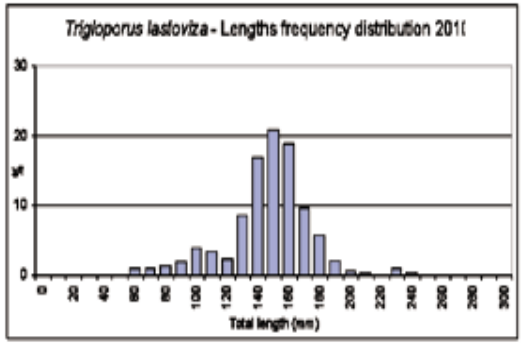








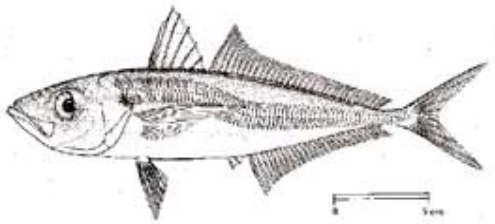




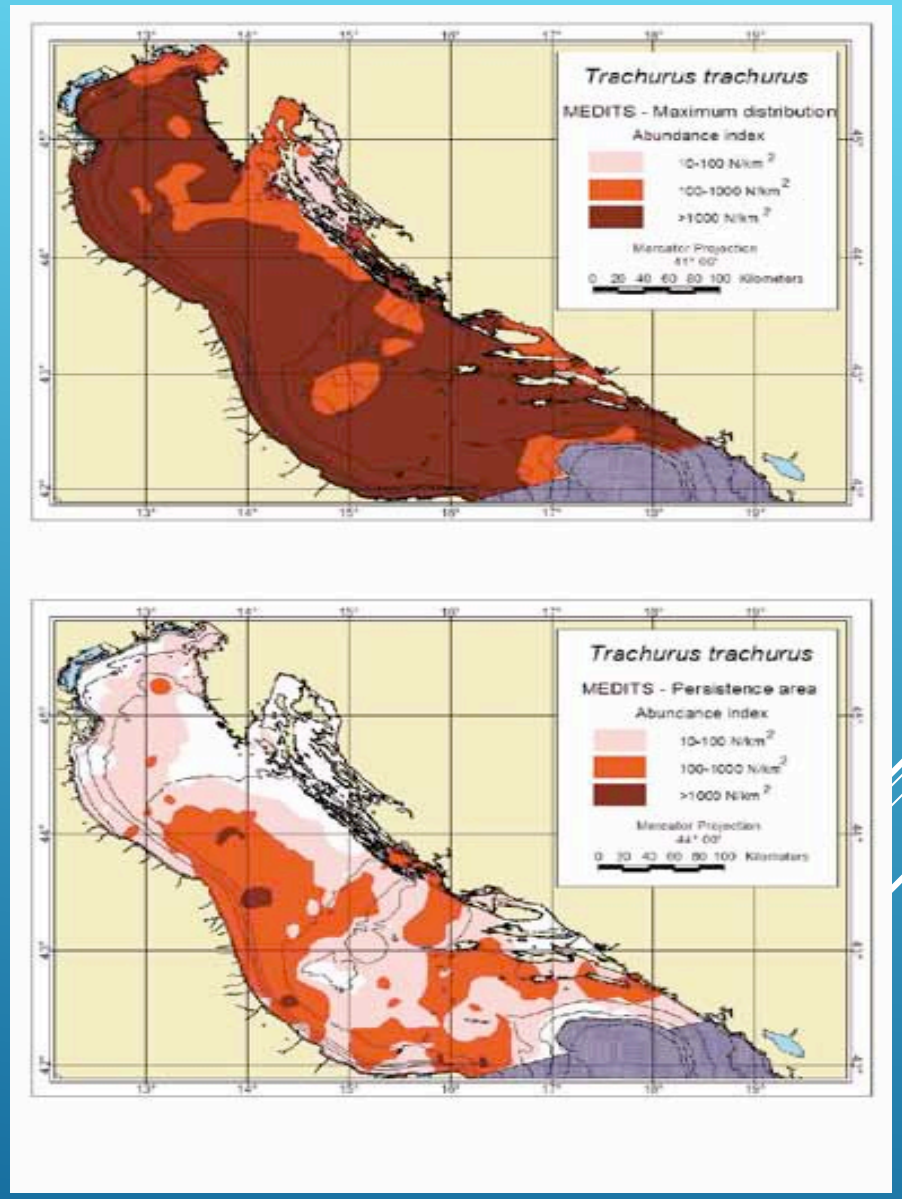
Frequency of occurrence varied from 14.2% to 24,4% with a mean value of 18,7%.
During the whole period the decrease of occurrence has been observed.
Regarding abundance and biomass indexes the fluctuation patterns have been observed with a mean values of 36 specimens and 1,6 kg per km2.
The decrease of recruitment has been observed with a mean value of 4 recruits per km2.
There was fluctuation in the number of spawners with a mean value of 25 spawners per km2.
The length frequency distribution in 2010 showed a dominance of small individuals with one visible cohort.

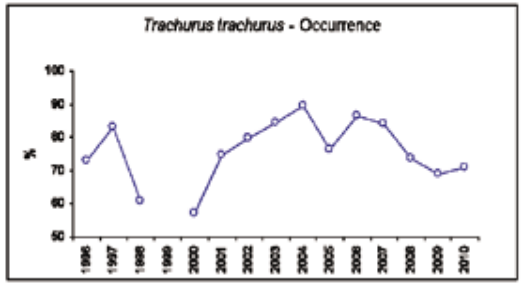
Šarun, (*Trachurus trachurus* (Linnaeus, 1758))

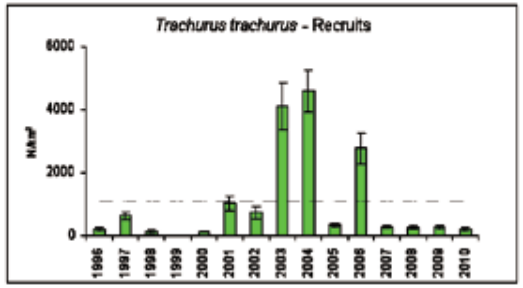
EN: Atlantic horse mackerel; IT: Suro; SL: Šur

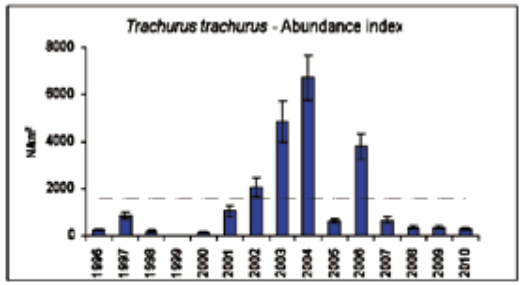


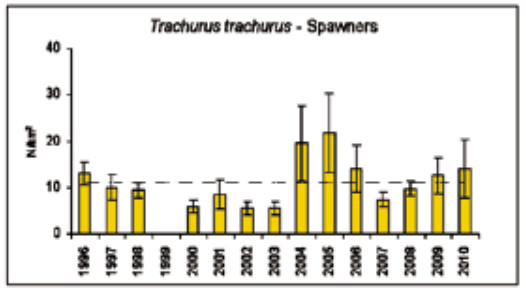
It was widely distributed in the whole Adriatic with greatest abundance steadily found on clayey silt and silty clay muddy bottoms in the open Adriatic.

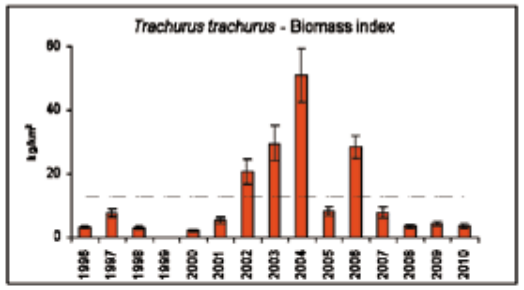


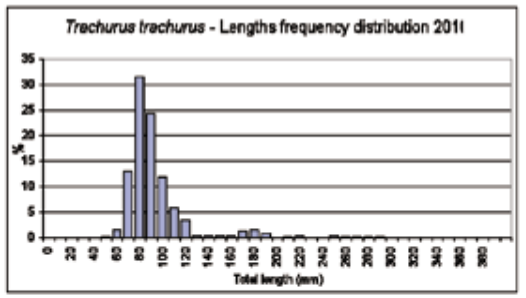












Frequency of occurrence was always high and varied Between 57% (2000) and 89% (2004) with a medium value of 75,9%.

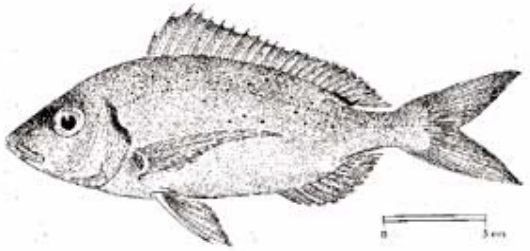
Abundance and biomass indices show very high fluctuation with max value in 2004. Medium value of abundance was 1584 specimens per km2, and abundance indeks 12,7 kg per km2. Fluctuations of density indeks throughout the investigated period were reflecting fluctuations of the recruits, which in all years of investigation represented the main fraction of population.

Namely, sampling period of the MEDITS survey coincide wth recruitment of this species in the Adriatic sea (spring).

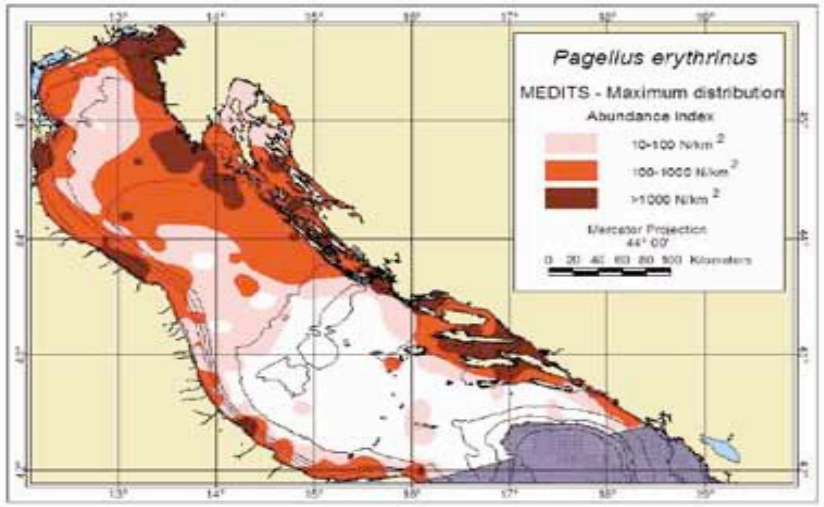
Length frequency distribution ranged from 4 to 30 cm with domination of recruits in the whole population.

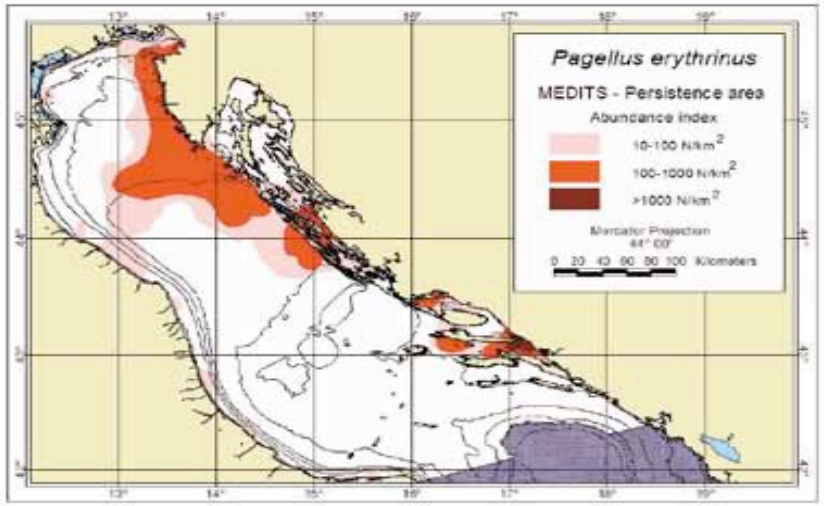
Arbun, (*Pagellus erythrinus* (Linnaeus, 1758))

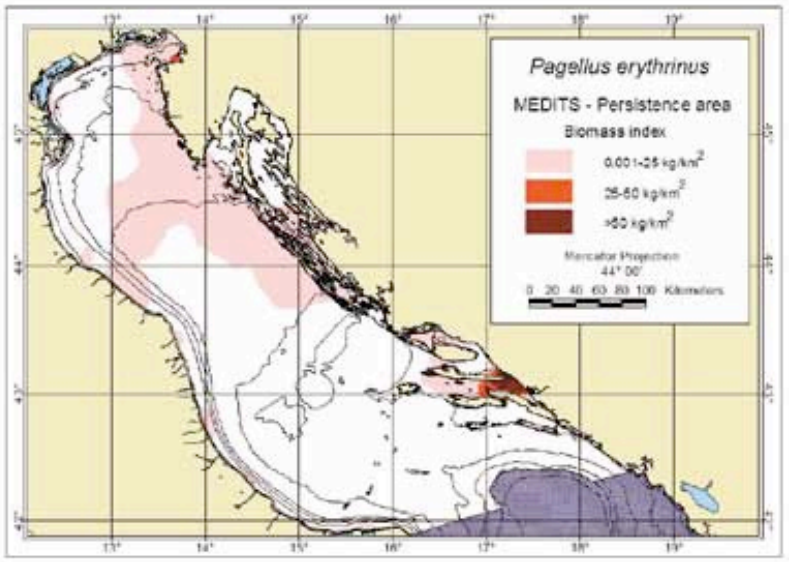
EN: Pandora; IT: Pagello fragolino; SL: Ribon

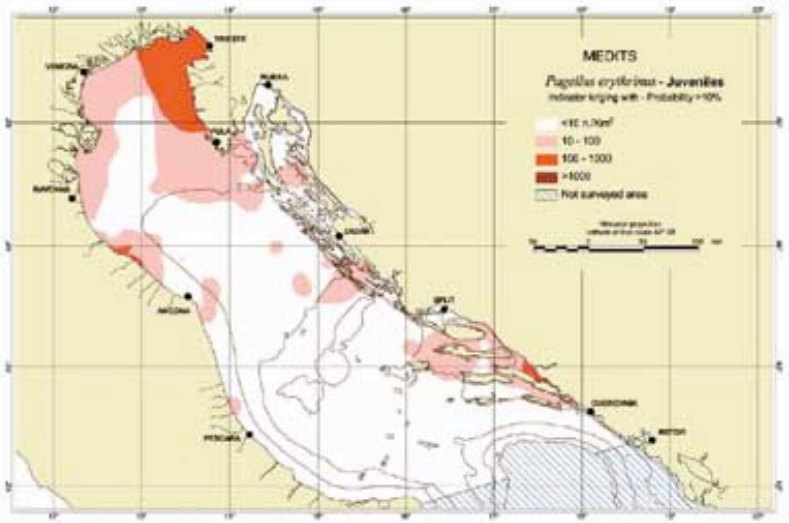


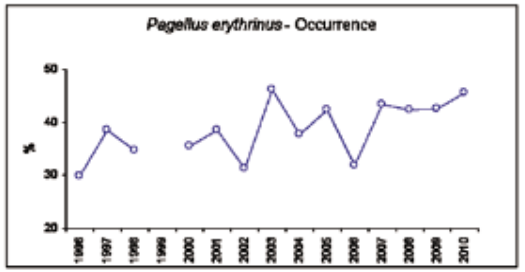
Common pandora is widely distributed across the whole basin within isobath of 100m. The greatest abundance are steadily found along the eastern Adriatic coast, especially along western Istrian coast and in the channel area of central Adriatic, while the biggest biomass indeks is recorded in the estuary of Neretva river.
Juveniles are distributed in shallow water.

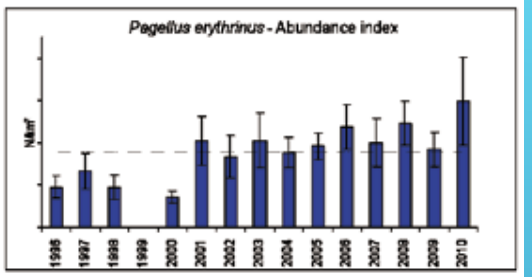






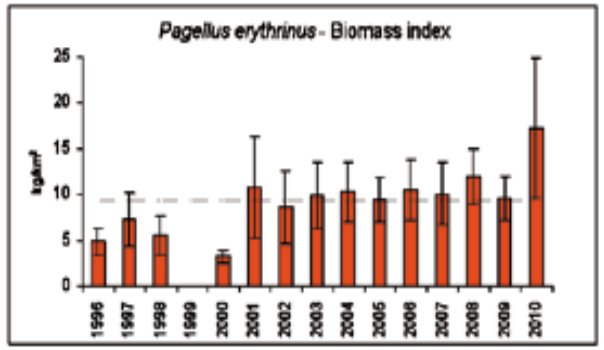


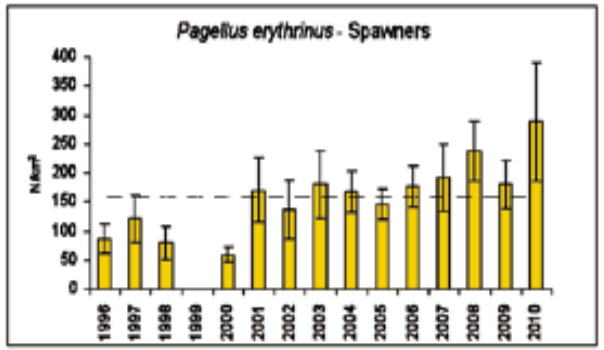


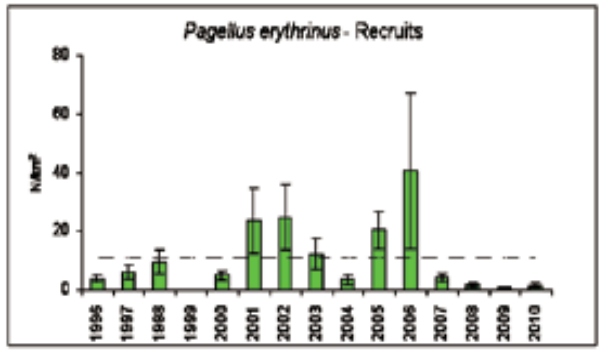


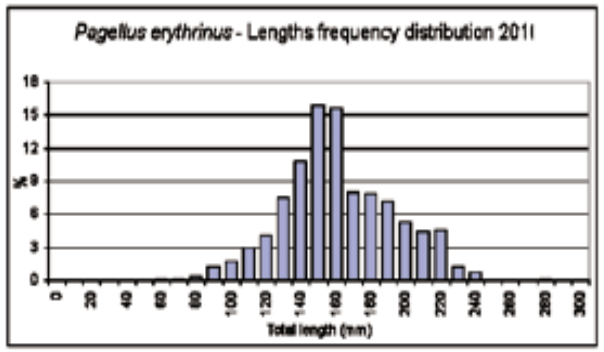
Occurrence of this species showed a significant increasing trend in investigation period, with minor fluctuation from year to year. Mean occurrence was 38,6%.

Abundance and biomass indicators showed increasing trend until 2011, and then more or less stabile situation till 2010. Medium value of abundance is 179 speciemns per km2, and medium biomass is 9,2 per km2. The peak of abundance in 2010 is result of unusual big catches of pandora in Neretva estuary area. The population is composed mainly from adult specimens with increasing trend of spawners in the last ten years.





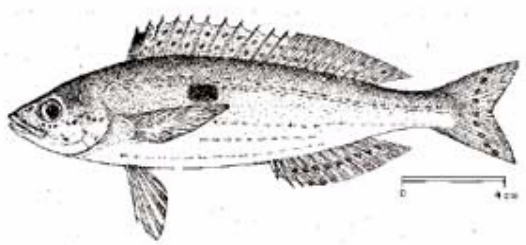




Population increase was mainly due to the spawners fraction while recruits showed high fluctuations with extremely decreasing trend in the last few years. This decrease in the recruitment may result in the decrease of population density in the following years. Regarding frequency of length distribution in the year 2010, majority of population was caught in the length range from 12 to 22 cm (i.e. adult specimens).

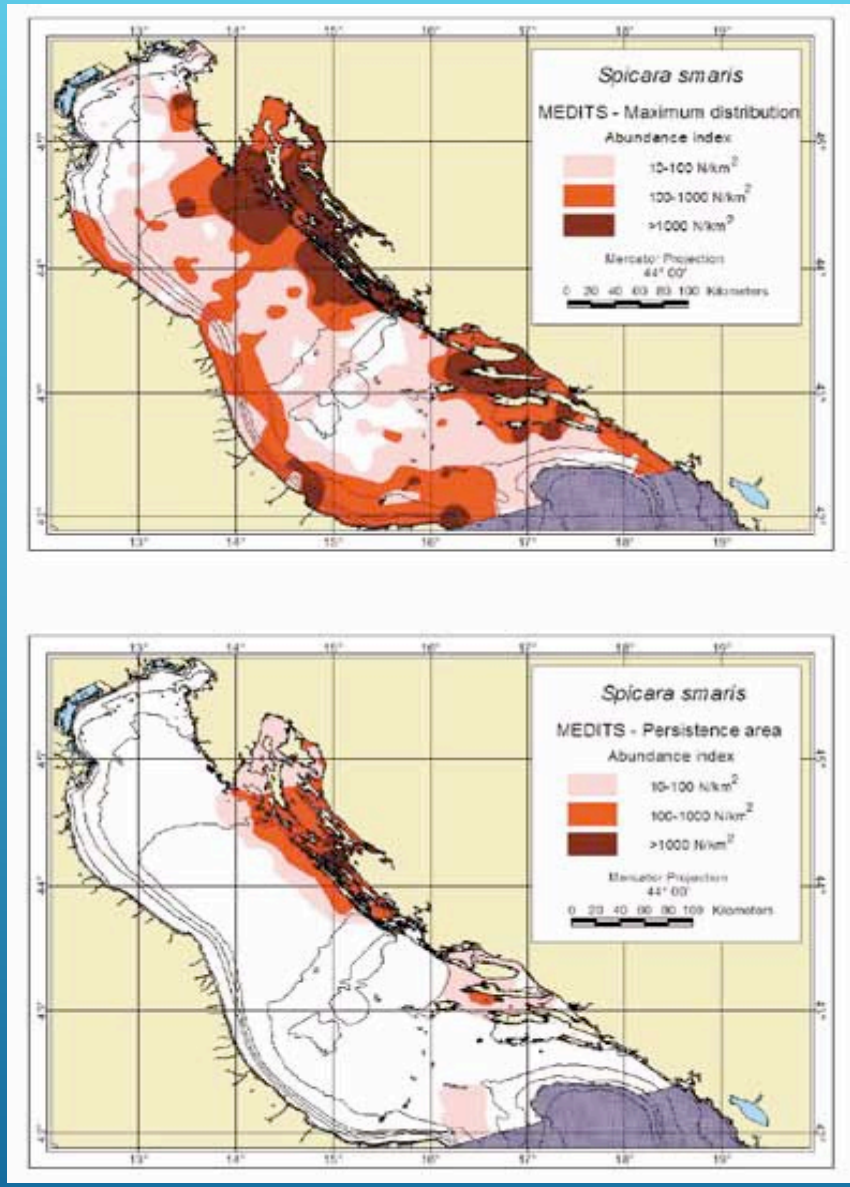
Gira oblica, (*Spicara smaris* (Linnaeus, 1758))

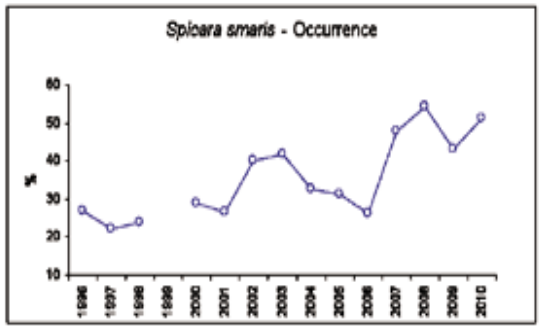
EN: Picarel; IT: Zerro; SL: Girica

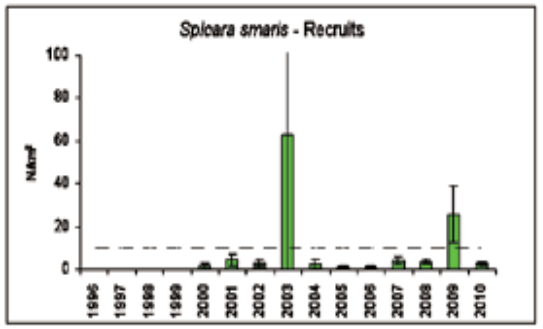


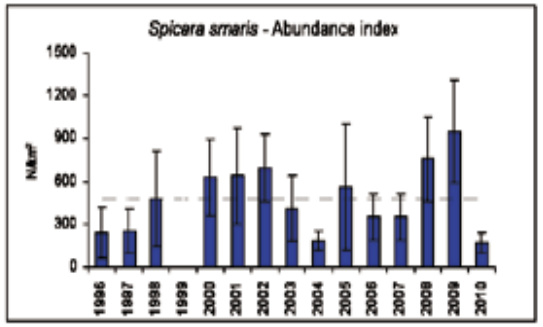
Picarel is widely distributed in the whole basin, except only restricted areas in the northern-most part of the Adriatic and deepest areas in the central part where it is not found.

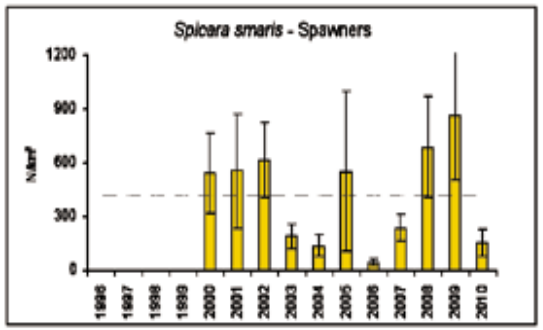
Greatest abundance is steadily caught on coastal and relict sand bottoms of the channel area of eastern Adriatic.

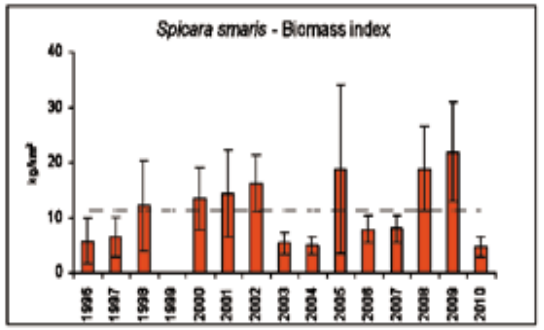


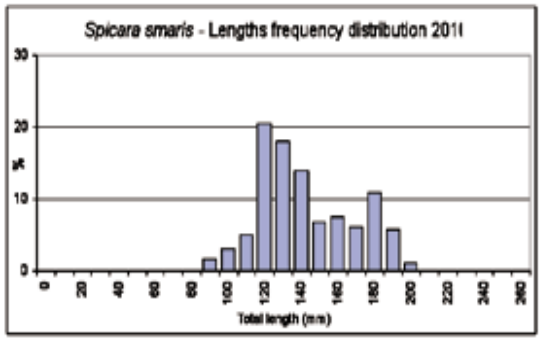








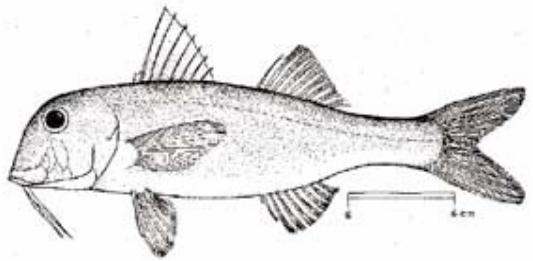




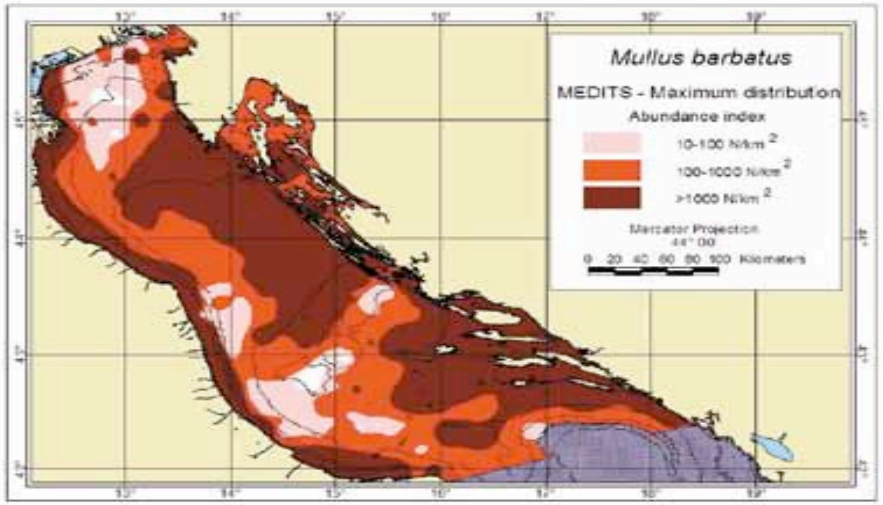
Frequency of occurrence shows big fluctation
In investigation period with generally increasing trend.
Medium value of occurrence is 35,5%.
Abundance and biomass indices fluctauated strongly without obvious trend and this fluctuation are mainly due to the fluctuation of spawners. Medium value of abundance was 476 speciemns per km2 and abudance indeks 11,3 kg per km2. Recruits represent very small fraction in the catches (due to the sampling period previous to recruitment period).
Length frequency distribution in 2010 showed dominance of adult individuals in the catches.

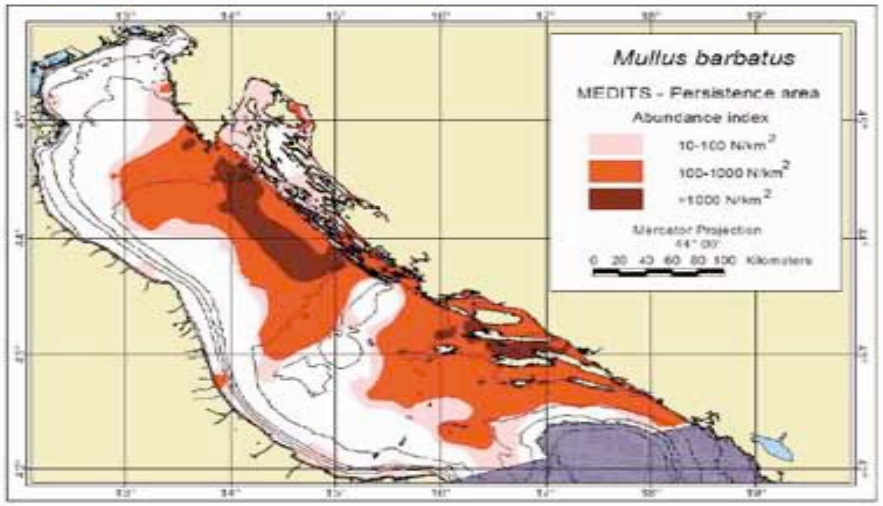
Trlja blatarica, (*Mullus barbatus* Linnaeus, 1758)

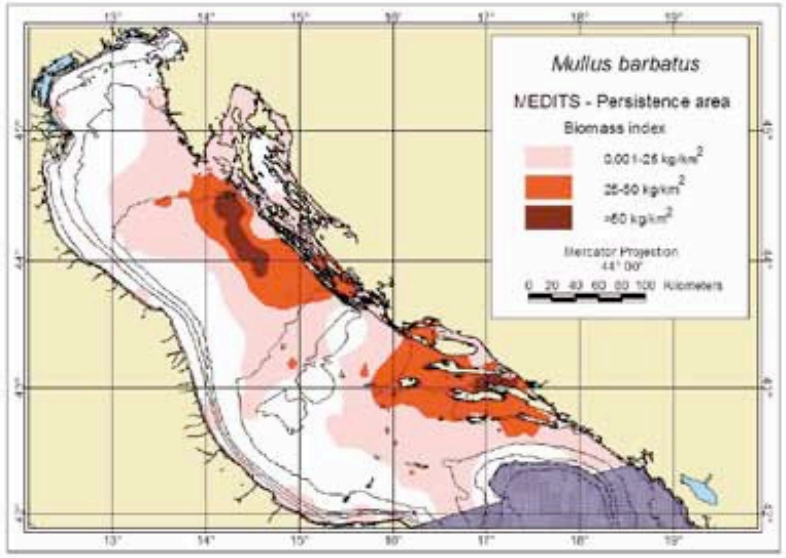
EN: Red mullet; IT: Triglia di fango; SL: Bradač

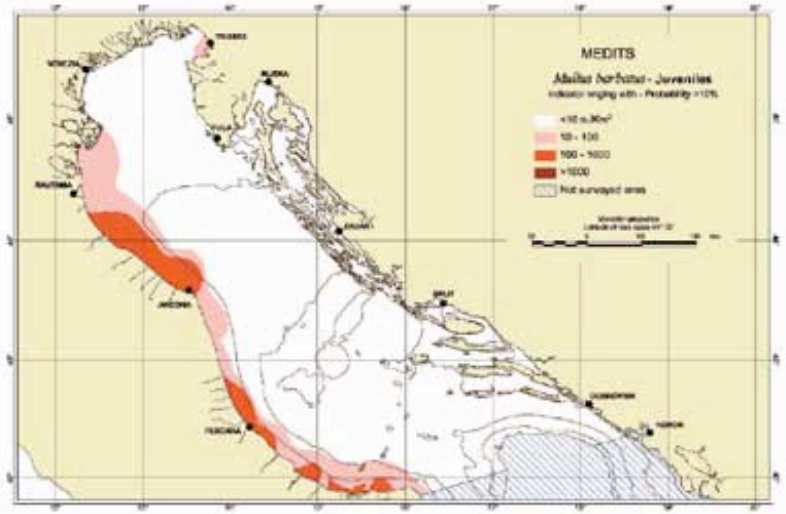


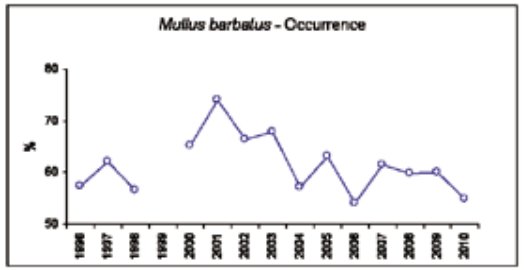
It is a migratory species widely distributed throughout the whole Adriatic. Density of the population (expressed in terms of abundance and biomass) during MEDITS survey (spring and early summer) is highest along the eastern adriatic coast. Juveniles are distributed along western shallow coastal water.

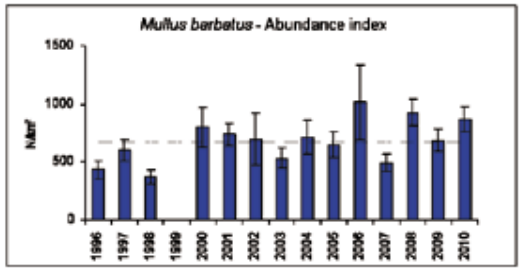




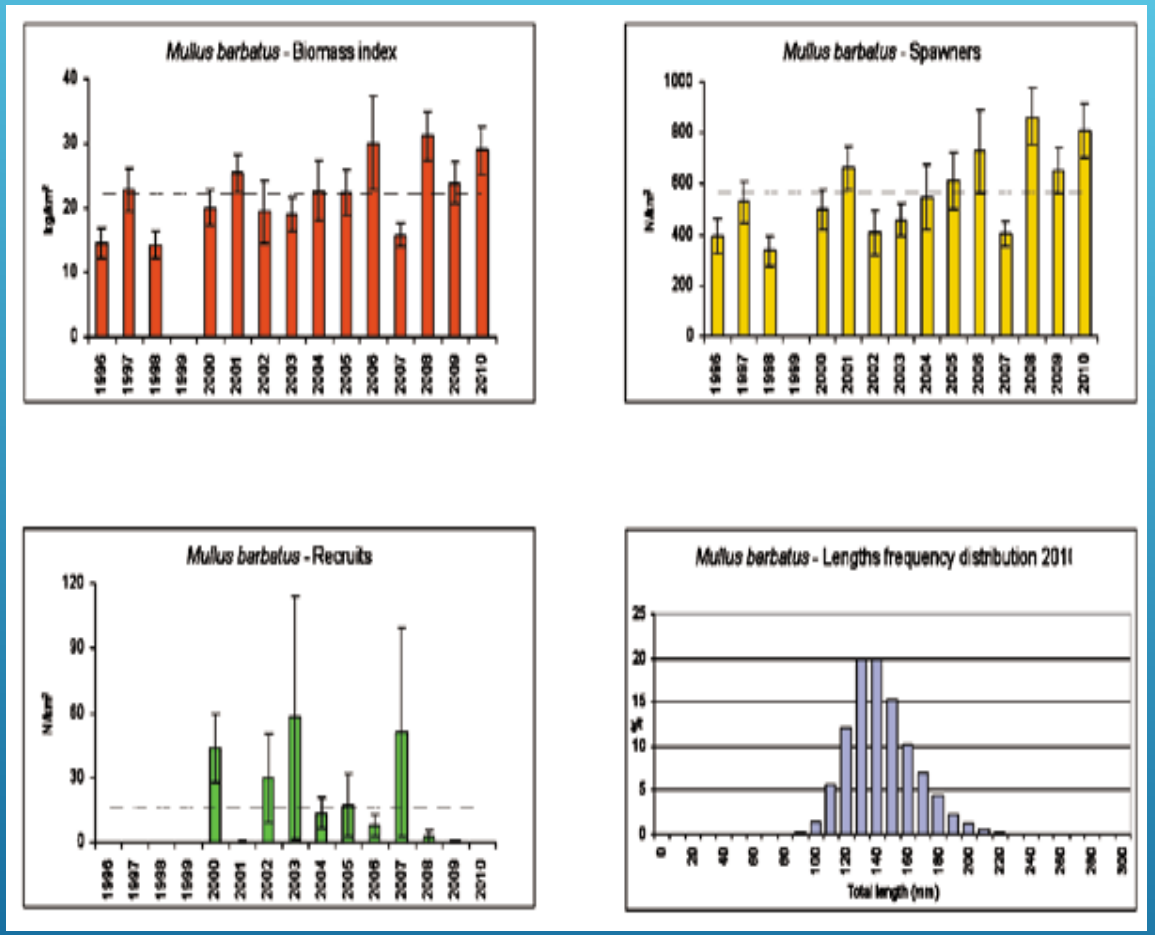








Frequency of occurrence shows fluctuation between years, but in the last 10 years trend of occurrence is decreasing. Medium value of occurrence in investigation period is 61.5%. Regarding abundance and biomass indices population shows fluctuations, but generally trends are increasing. Medium biomass indeks is 22.2 per km2.



Abundance indeks is 682 specimens per km2. Spawners dominate in the population and farction of recruits is small with big difference from year to year. Reasons for this situation are that sampling is organisd before the peak of recruitment (autumn) and the juveniles are distributed in the shallowest coastal waters out of area of investigation.
The same situation is evident also from legth frequency data: length frequency ditribution in 2010 showed that adult specimens dominate in the population, while fraction of juveniles was very low.

RED MULLET - *Mullus barbatus*

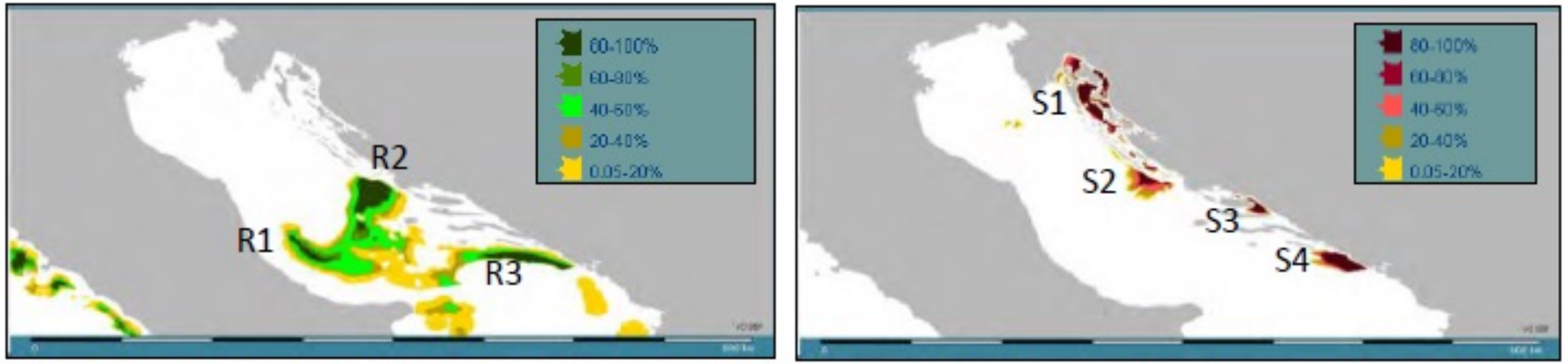


Fig 2.2.5.1.7. Position of persistent nursery (left) and persistent areas of potential spawners (right) in GSA 17

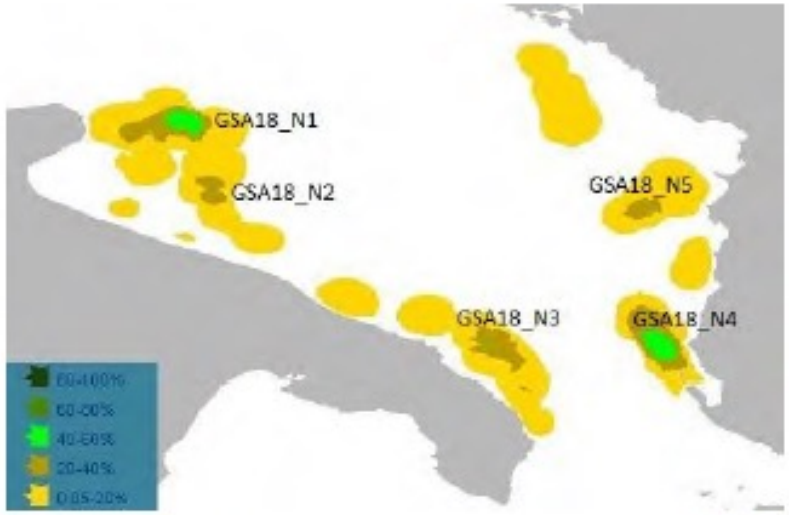
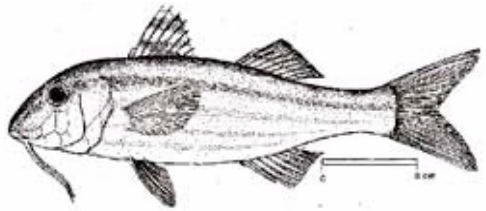
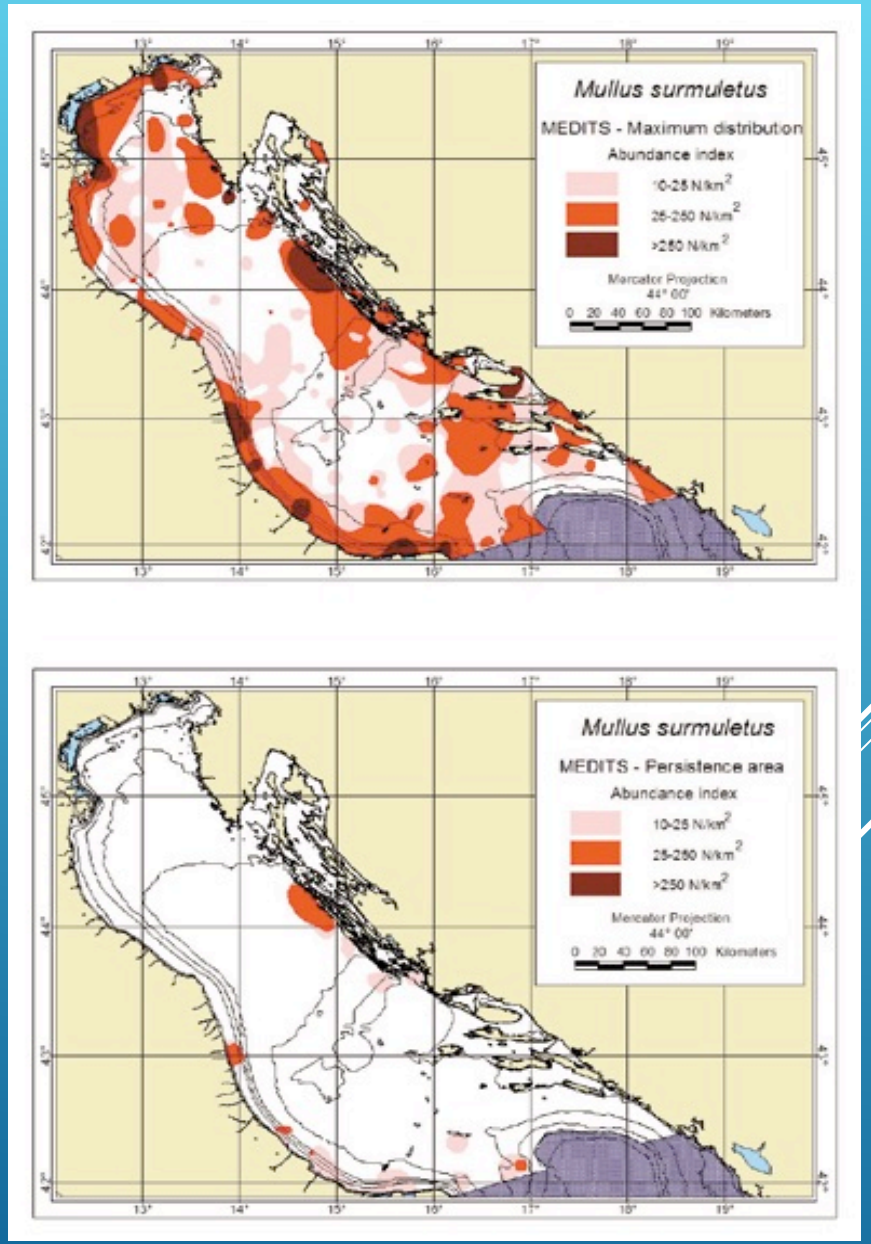


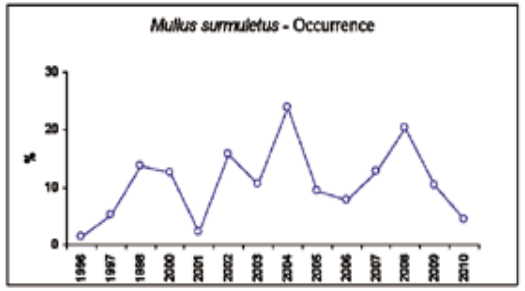
Fig. 2.2.5.1.8. Position of persistent nursery areas of hake in GSA18

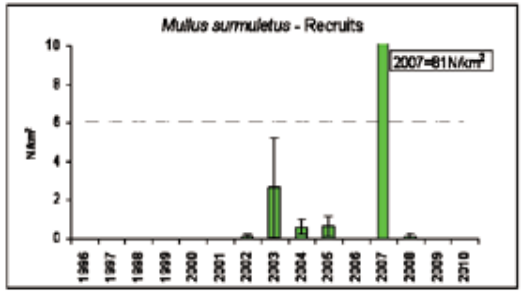
Trlja kamenjarka, (*Mullus surmuletus* Linnaeus, 1758) EN: Striped red mullet; HR: IT: Triglia di scoglio; SL: Progasti bradač

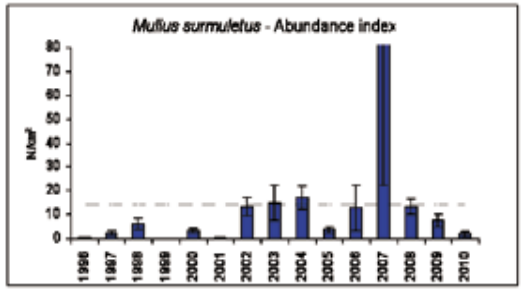


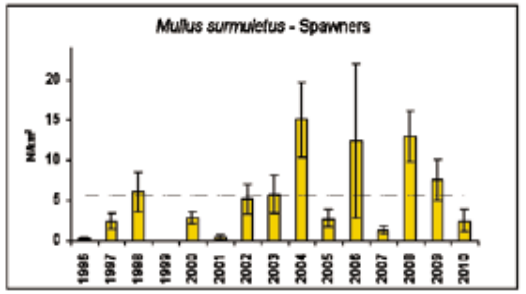
It is mainly distributed in the shallow coastal area along eastern and western coast on the rocky bottom.

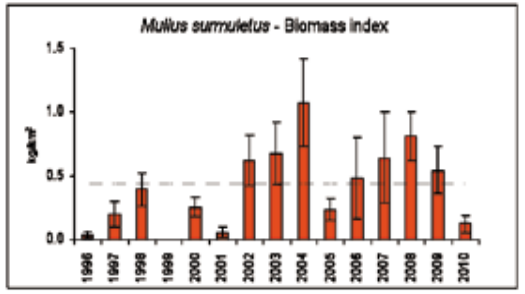


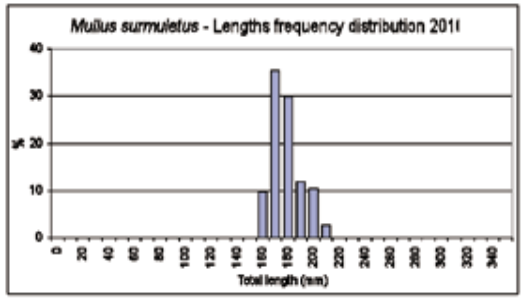










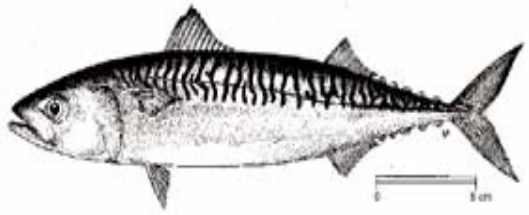


Frequency of occurrence fluctuated from year to year and mean value of occurence is 10.7%. Abundance and biomass indices generally kept on low values without obvious trend. Medium value of abundance indx is 14 speciemns per km2 and biomass 0.4 kg per km2.

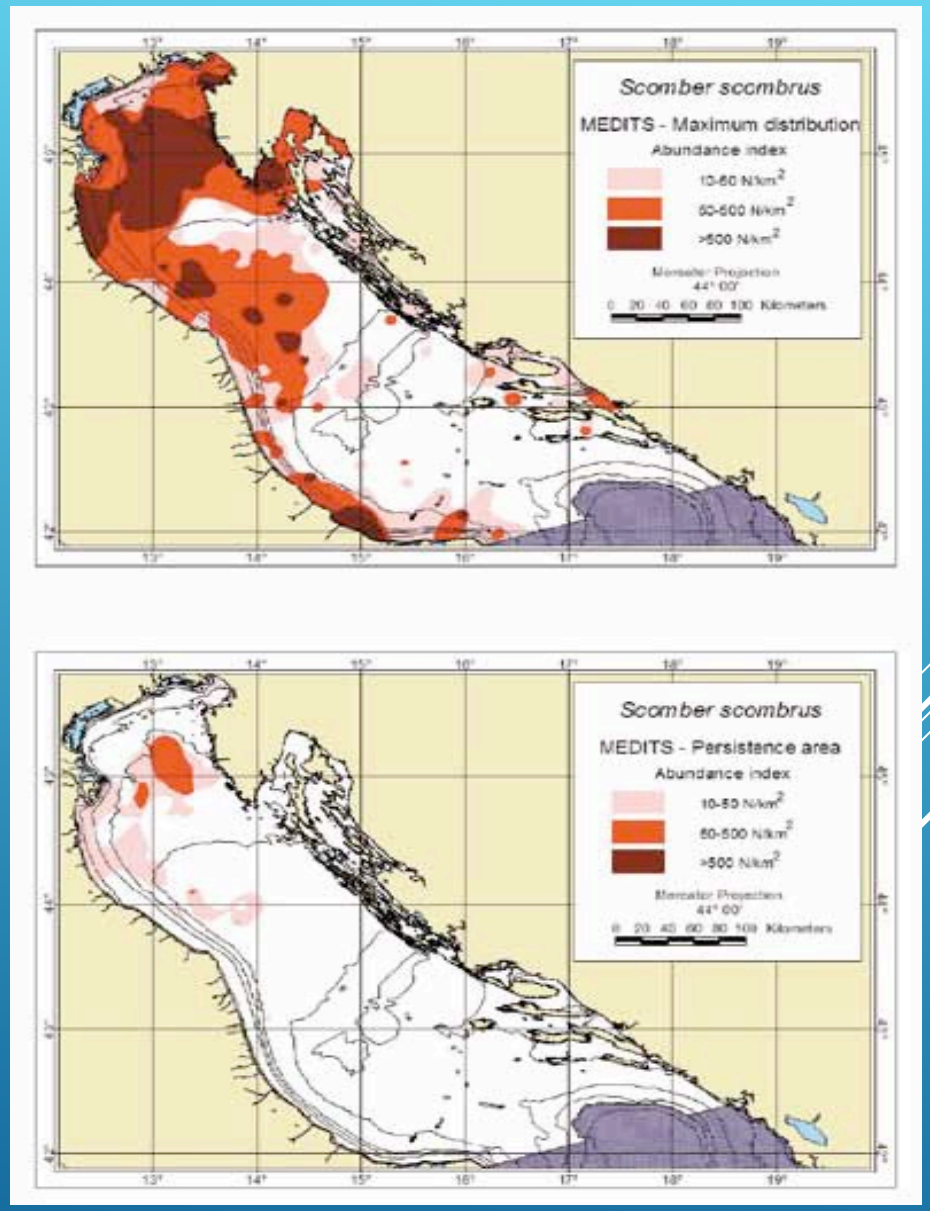
Due to fact that sampling was done before recruitmnt period and in the area in which recruits are not distributed, majority of the population are spawners, what is clear from abundance indices, as well as from length frequency distribution.

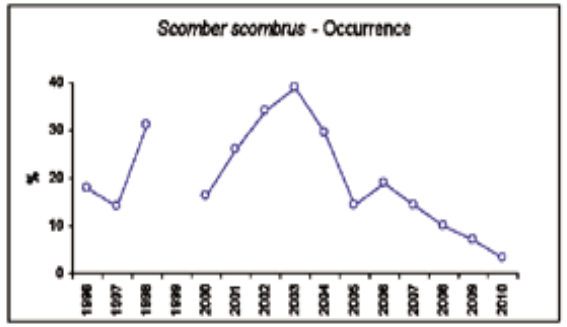
Skuša, (*Scomber scombrus* Linnaeus, 1766) EN:

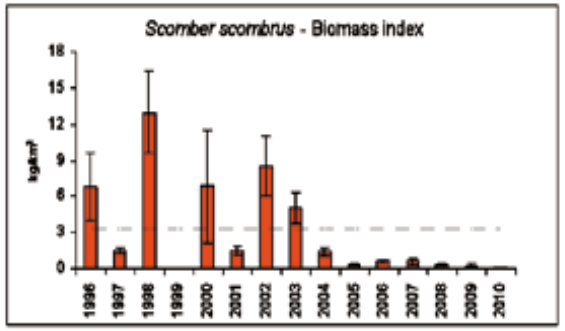
Atlantic mackerel; IT: Sgombro; SL: Skuša

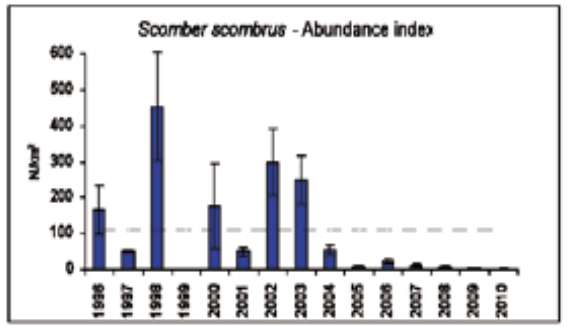


It is widely distributed in the whole northern basin and along coastal areas of the central basin. Greatest abundance is steadily found in the area off Delta of the Po river and open northern Adriatic.





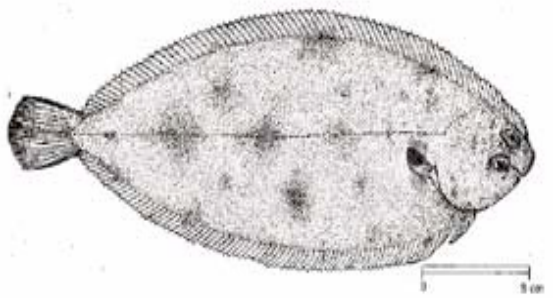




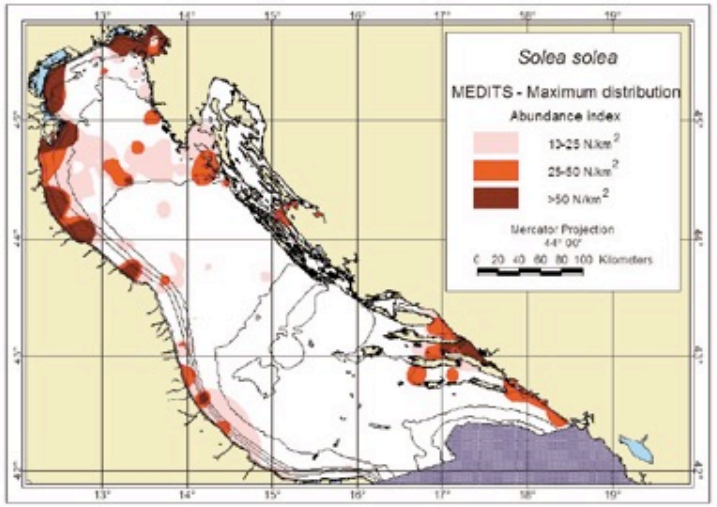
Frequency of occurrence showed interannual fluctuation with a clear decreasing trend in the last 8 years. Medium alue of occurrence was 19.7%. Similar decreaing trend were observed both in density and biomass indicators with medium value of abundance indeks 110.3 specimens per km2 and biomass indeks of 3.3 kg per km2.

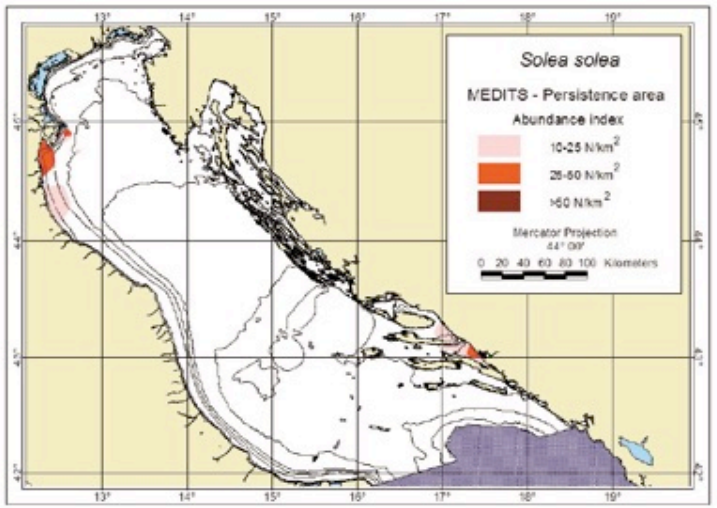
List, (*Solea solea* (Linnaeus, 1758))

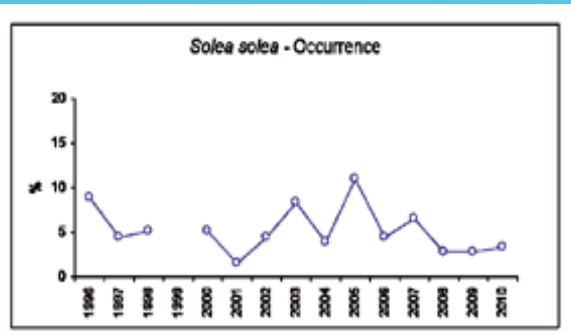
EN: Common sole; IT: Sogliola comune; SL: Morski list

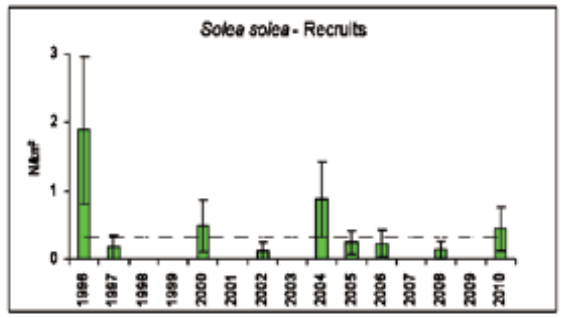


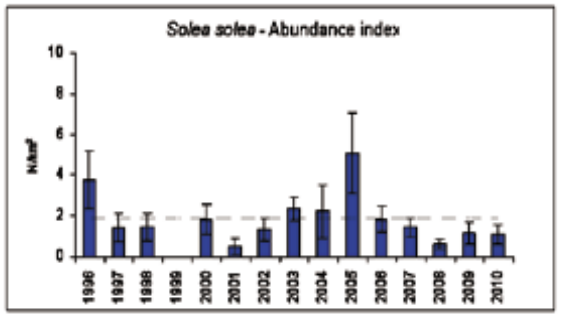
It is mainly found on muddy and sandy bottoms up to 50 m depth, mostly along coastalaraes near river mouths. Density of popualtion is biggest on the estuary of Po river and Neretva river, and in teh shalloweset northern Adriatic. But we sjoul keep in the mind that bottom trawl is not proper fishing gear for collection of this specie, especially in the spring and summer period.

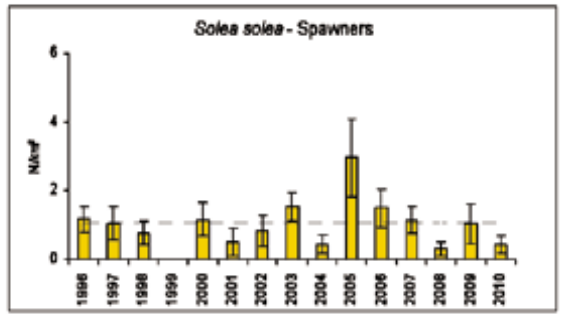


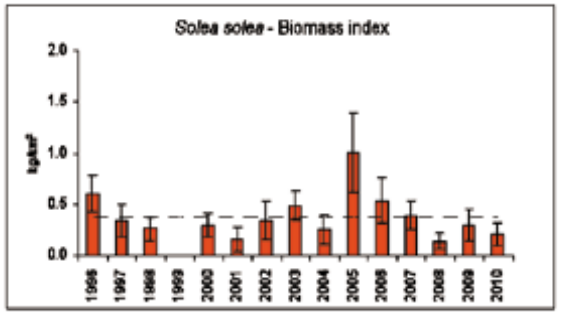


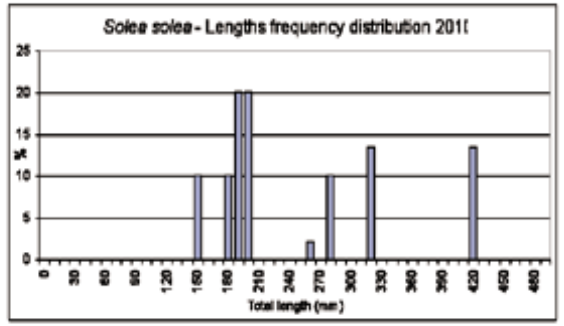










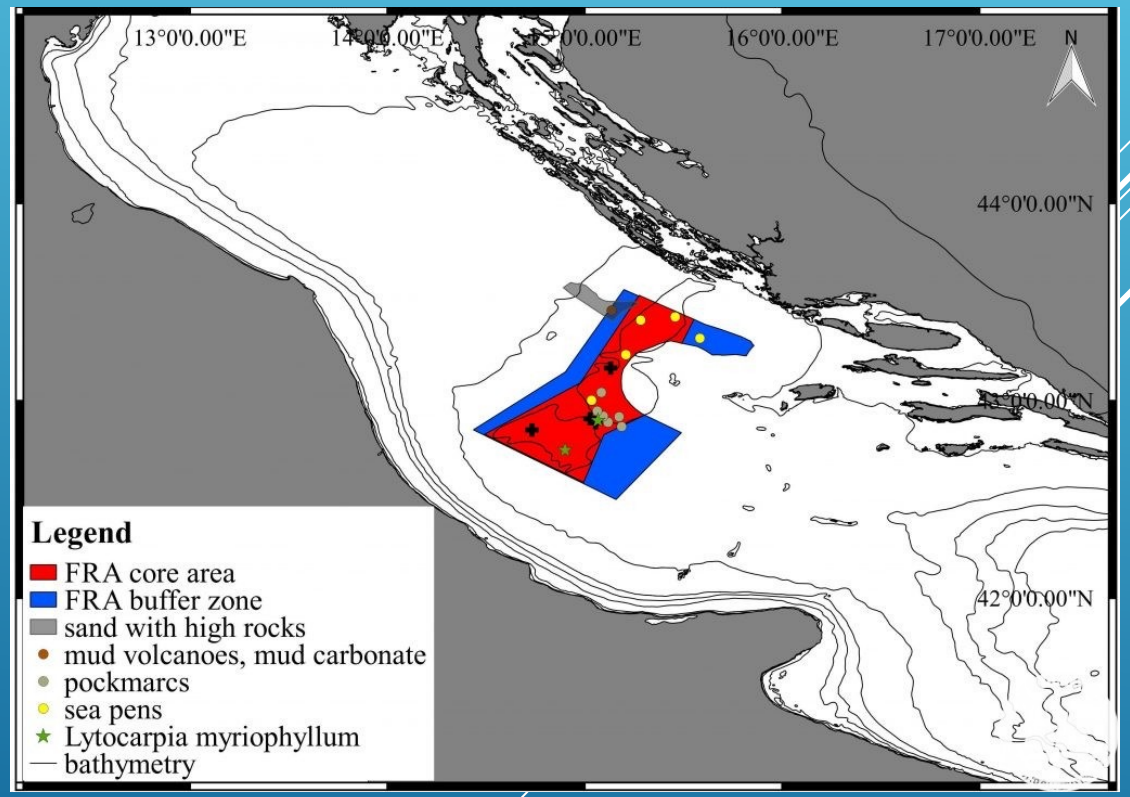


Frequency of occurrence is very low (mean value 5.2%) and varied without obvious trend. All abundance and biomass indices for whole population, as well as for spawners and recruits showed very low values, without clear trend in the investigation period. Medium value of biomass indeks is 0.4 kg per km2, and abundance of 2 specimens per km2.

The Jabuka/Pomo, with a maximum depth of 200-260 metres, contains unique geomorphological and oceanographic features. It is considered one of the most important Essential Fish Habitats of the Adriatic, hosting spawning areas and nursery of commercially important species such as hake and Norway lobster. Overfishing, especially by bottom-trawling, has caused the decline of fish stocks and threatens their essential habitats as those found in the Jabuka/Pomo Pit.

The protection by the GFCM of the Jabuka/Pomo Pit is a milestone decision showing that progress can be achieved even in areas heavily exploited by fisheries.

Despite being heavily overfished, the Mediterranean maintains a high recovery potential, as clearly proven by the Fish Recovery Area in Adriatic Jabuka/Pomo Pit, where a closure for demersal fisheries was introduced in 2017. Less than 2 years after its creation, the Jabuka/Pomo Pit FRA saw a dramatic increase in the biomass of hake and Norway lobster, and is now known as one of the best practices across the Mediterranean.



Advice at subregional level: Adriatic Sea

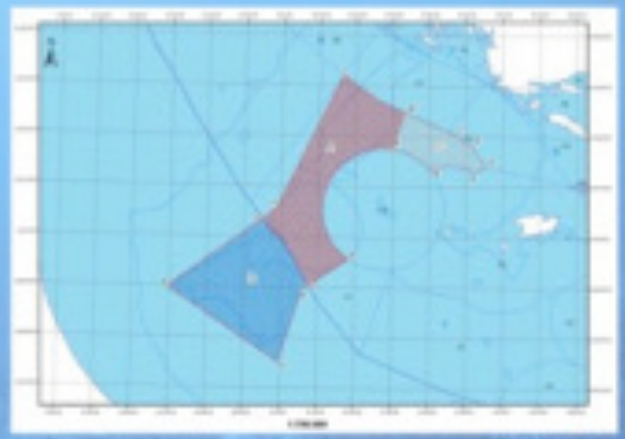
Demersal fisheries

- FRA proposal built upon a recommendation to improve the status of several stocks (notably hake)
- Jabuka/Pomo Pit: **key area** in terms of essential fish habitats for valuable species as well as vulnerable species and VMEs, also recognized by the WGSAD
- Submitted to SRC-AS and **technically validated by SAC**

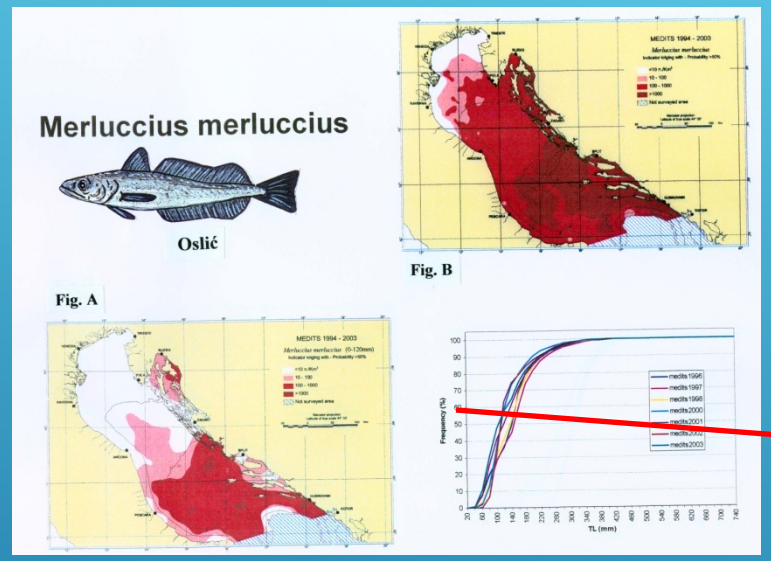
ADVICE:

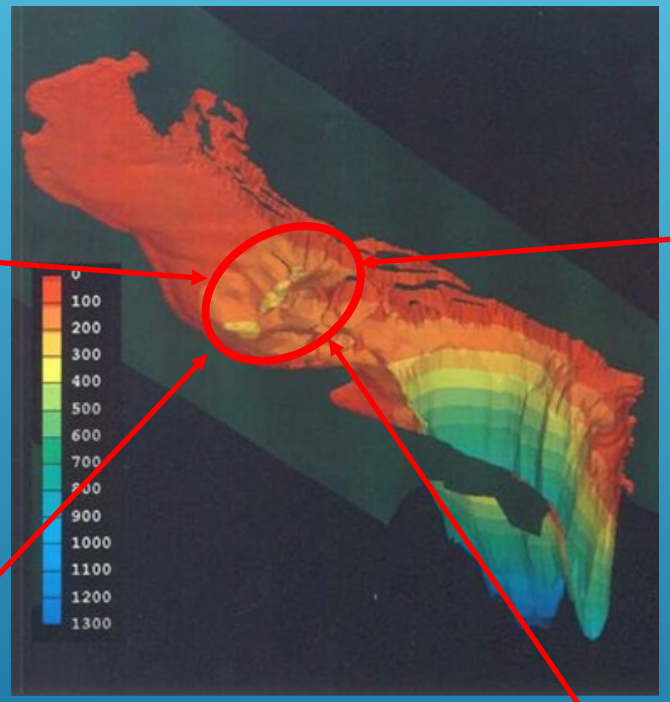
- consider the **establishment of a new GFCM Fisheries Restricted Area (FRA) in the central Adriatic Jabuka/Pomo Pit**, on the basis of the technical elements and coordinates provided in the validated proposal

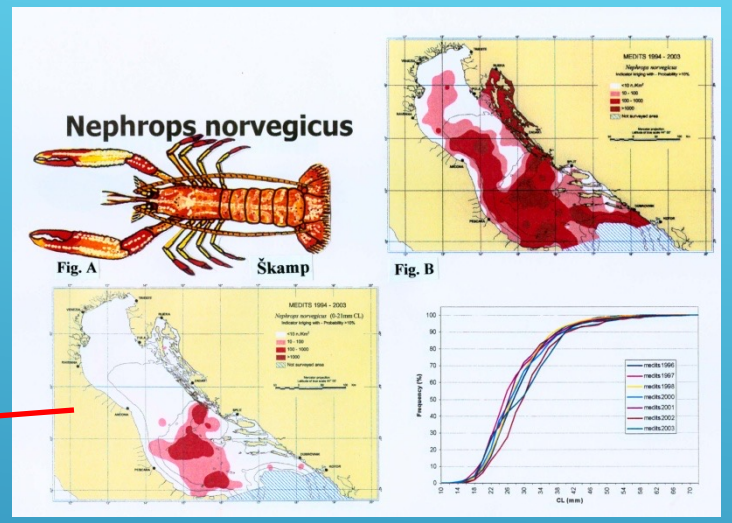
+ New EU Proposal on GFCM FRA in Jabuka/Pomo Pit

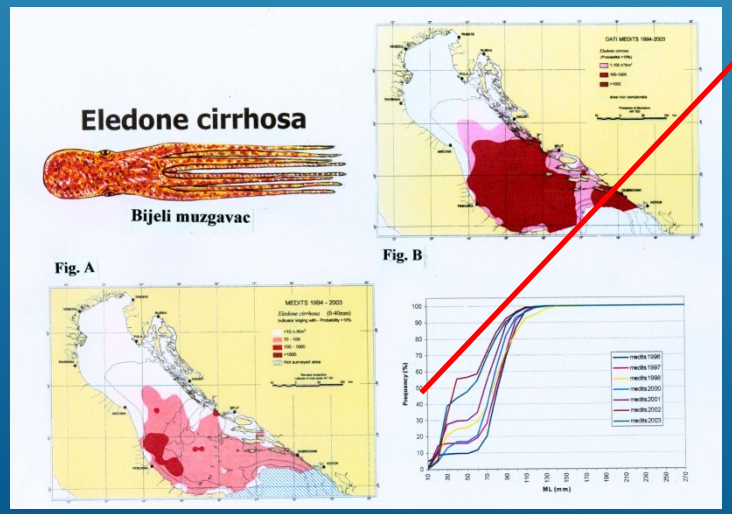


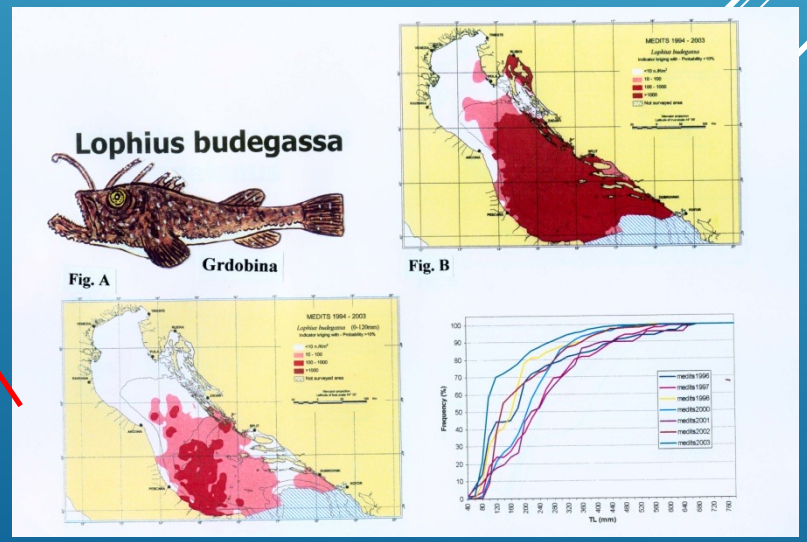
Preserving the Jabuka/Pomo Pit should be a priority for the conservation of biodiversity and management of resources of the Adriatic Sea.



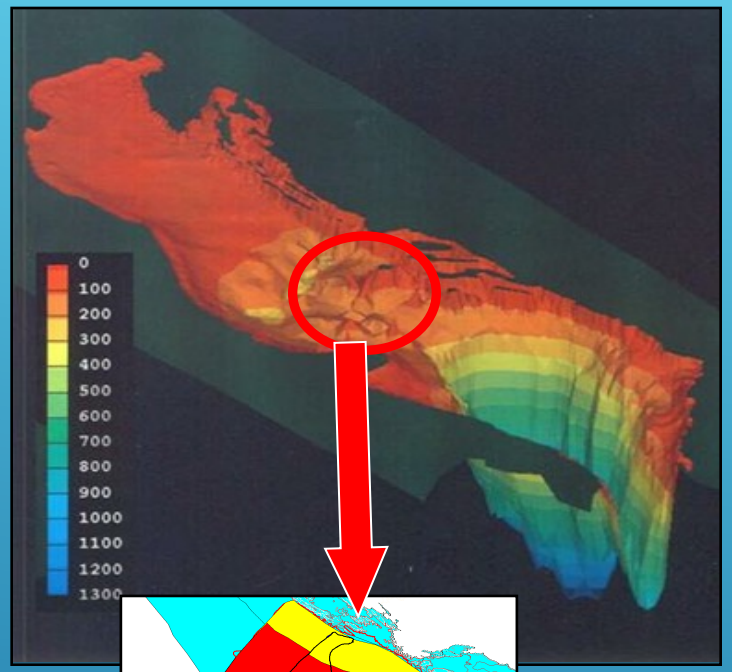


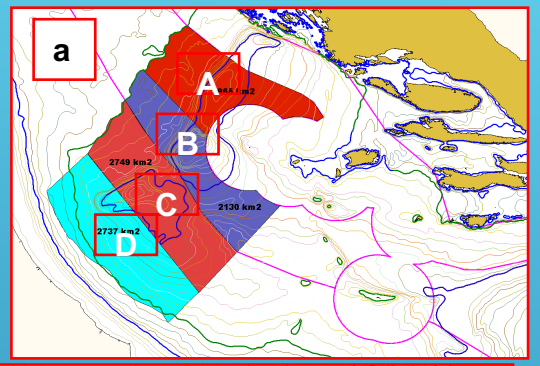


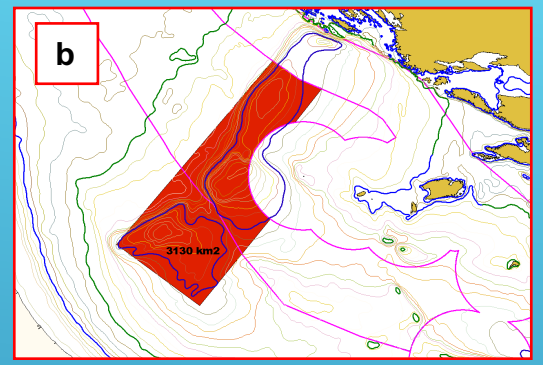


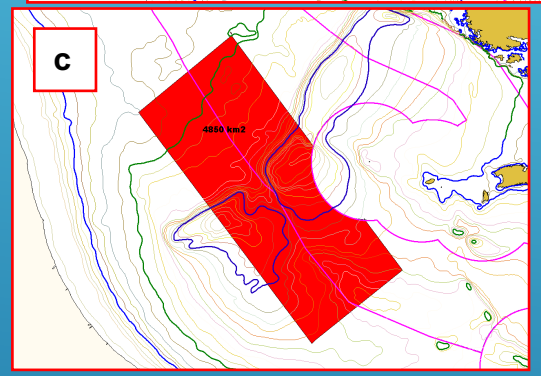


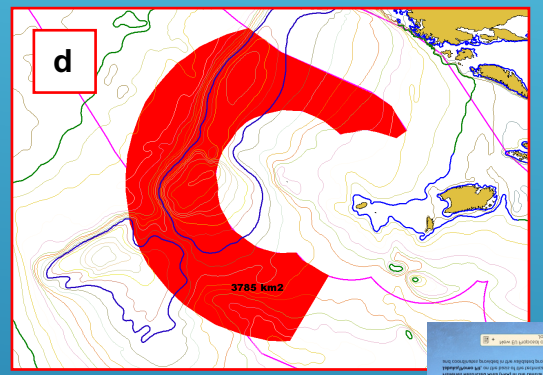
PRIJEDLOZI ZONA ZABRANE RIBOLOVA U JABUČKOJ KOTLINI

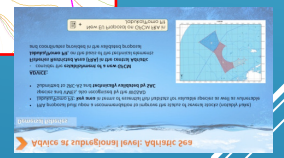


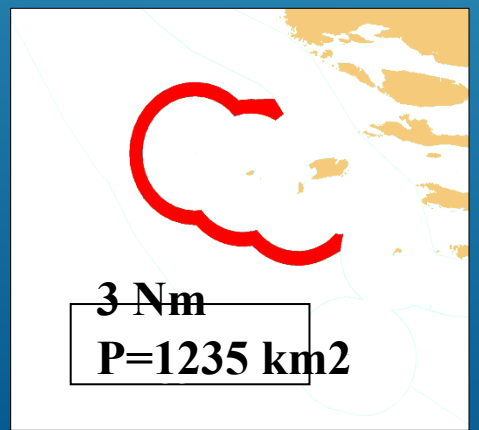


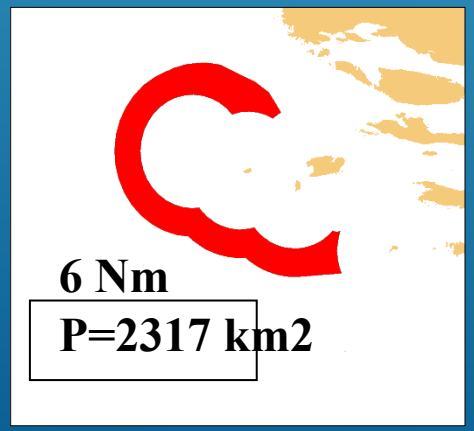












With its moderate slope and soft sea bottom, the Adriatic continental shelf (most of which is in the northern Adriatic Sea (NAS)) is particularly well suited for trawling for demersal fish and dredging for clams.

The bottom trawl fishery targets red mullet *Mullus barbatus*, European hake *Merluccius merluccius*, and Norway lobster *Nephrops norvegicus*.
Coastal small-scale or artisanal fisheries (extending to 50 km from the shore or out to 200 m) also occur, and some countries land significant catches, e.g., Croatia landed 1991 t year^{-1} during 2000–2010. Recreational fisheries also are important in Croatia, where catches averaged 3150 t year^{-1} during 2000–2010.

The Adriatic Sea is one of the largest and best-defined regions of shared fish stocks in the Mediterranean, which makes shared management of fisheries essential in order to ensure sustainability of the fisheries. The Adriatic Sea is one of the most productive and most exploited regions in the Mediterranean. Although it has a small surface area (5.5% of the Mediterranean area), it yields ~15% of total Mediterranean catches

The fisheries sector is diverse, is largely made up of small-scale fisheries, and has an important role in many national economies.

According to the European Fleet Register (2014), the Italian fishing fleet is composed of ~5000 motorized fishing boats, Croatia's fishing fleet includes just over 4000 vessels, and Slovenia's fleet consists of ~186 vessels. The largest percentage of the fleet (over 80%) is comprised of vessels shorter than 12 m, which also constitute the largest segment of the fleet capacity in terms of engine power as measured in kilowatts (i.e., ~50%).

Fleet capacity as described either by number of vessels or fishing power varies widely among national fleets. Italy has the highest catches (79% of the total catch in tonnes (metric tons), t), followed by Croatia (16%), Albania (2.6%), Slovenia (2%), and Montenegro (0.3%).

Currently, exploitation of fishery resources is heavy in the Adriatic, and although some stocks may be recovering, for others the situation remains critical. Conflicts with other sectors may arise, particularly with oil and gas developments, which could occupy large areas of the NAS in the next 20 years. Conflicts may also arise with the recreational fisheries sector and with the artisanal fishery sector, especially between different fishing-gear types.

Several factors have affected Adriatic fisheries, often interacting simultaneously. The population dynamics of
fisheries are based not only on resource availability but
are also strongly driven by market demand and prices
and other socioeconomic forces such as political changes (e.g., Croatia's entry into the European Union (EU)). The main legislative framework influencing the sector is the
Common Fisheries Policy (CFP), the EU instrument for the management of fisheries that sets the maximum quantities of fish that can be caught sustainably every year. National strategies (e.g., the National Strategic Plan for Development of Fisheries in Croatia) are also particularly important in shaping the future of commercialfisheries in the Adriatic.

The European Commission (EC) estimates that 88% of European stocks are overfished and 30% may not be able to replenish because they are outside safe biological limits (European Commission, 2009a).

More recently, Froese et al. (2018) indicated 69% of the 397 European stocks were subject to ongoing overfishing and 51% were outside safe biological limits, while Colloca et al. (2017) indicated >90% of the Mediterranean stocks lie outside safe biological limits.
These high fishing pressures not only affect the biological resources, but also have socioeconomic consequences. Overfishing, declines in the biomass and size of fish caught, low economic resilience, and fleet overcapacity inevitably debilitate the fishery sector (European commission, 2009b). Colloca et al. (2013) demonstrated that the current fishing regime, characterized by high fishing mortality combined with inadequate selectivity patterns, compromises stock productivity and fleet profitability

Adriatic Sea: Annual Catch Statistics

Total annual landings in FAO Area 37.2.1 (northern and central Adriatic, GFCM, 2018) fluctuated between 127,000 and 160,000 t from 1992 to 2013 and then increased to 185,000 t in 2016 (Figure 10.1). Italy accounted for most landings during this period, although landings in Croatia increased rapidly beginning in 2004. Four species accounted for 71% of the annual catch (2014–2016): sardines *Sardina pilchardus* (42%), anchovies *Engraulis encrasicolus* (19%), striped Venus clams *Chamelea gallina* (8%), and European hake (2%).

An analysis of Adriatic fishing effort on demersal fish during 1969–2013 highlighted three periods of effort (Bombace, 2017). During the first period (1969–1984) when fishing effort was in the range of 196,225–426,038 kW, catches increased and populations seemed to be in a steady state. A second period (1985–2003), when effort increased to 485,321 kW in 1991, was characterized by a continuous decline in catches and catch per unit effort.

The last period (2004–2013) was also characterized by a negative trend in catches even though fishing effort declined to 305,061–207,800 kW. A small recovery in catches was observed in the last 2 years (2012–2013). A more detailed focus on the last period highlighted a strong reduction of demersal catches (Bolognini et al., 2017). Considering differences between 2004 and 2012 in GSA 17, the reduction was 11,009 t (42%) and €70,495 million (36%). Only the last years of this period showed a slight recovery in catches, especially for European hake, sole (*Solea solea*), and penaeid shrimp or prawn (*Penaeus kerathurus*).

Species of small pelagic fish are widely distributed in the Adriatic Sea and play an important role in the commercial fisheries of all countries located along the coast, accounting for a large share of the total catches. The main species in capture fisheries are sardines, anchovies, and sprat, as well as Atlantic mackerel *Scomber scombrus* and chub mackerel *Scomber japonicus*. Their stocks are regularly assessed by the FAO-GFCM Working Group on Small Pelagics. Today, the two main countries contributing to total catches are Italy (targeting mainly anchovy) and Croatia (targeting mainly sardine).

The Croatian fishery saw a period of forced closure in the 1990s due to the war in former Yugoslavia. When the war ended, the fleet was renewed with the appearance of large purse seiners that now constitute the main component of their fishing fleet. Currently, the Italian share of anchovy and sardine accounts for ~30% of total national catches; in Croatia, small pelagic fish represent ~80% of the total national catches.
Pelagic catch dominated marine fish landings, particularly in the east coast fishery.

The annual sardine catch fluctuated between 20,000 and 40,000 t during 1992–2010 and increased to 80,000 t from 2010 to 2016. In contrast, annual anchovy catches increased from ~10,000 t in 1992–1994 to a peak near 60,000 t in 2006 and then declined to ~37,000 t in 2016. From the mid- 1980s the contribution of pelagic fish to total landings decreased remarkably because of a lack of proper management measures, which led to the successive downsizing of the anchovy and sardine stocks and, more recently, to economic changes (due to the war in former Yugoslavia) that took place in the eastern coastal countries.

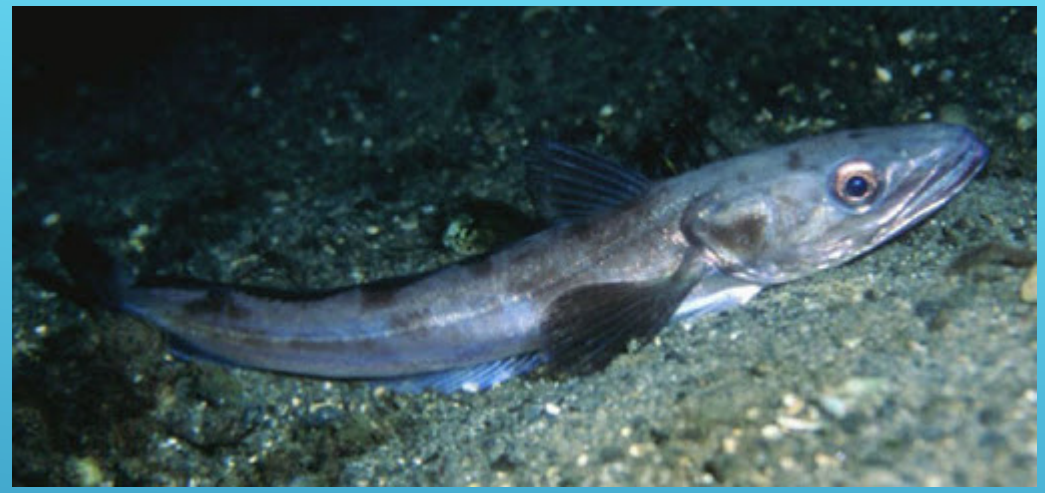
Demersal Fish

10.3.2.1. Adriatic Sea

Demersal fisheries involve trawlers operating on the continental shelf (NAS) and parts of the continental slope in the southern Adriatic. Of the 280 species identified during the Mediterranean International Trawl Survey

(MEDITS), 80–90 species are commercially important (Piccinetti et al., 2012). European hake and red mullet dominate the demersal fish catch (Figure 10.5). Decadal variations in annual hake landings featured biomass peaks in 1994 (~7500 t) and 2006 (~5500 t), lows in 2001 (~2600 t) and 2011 (~2270 t), and an increase during 2011–2016

Assessments of European hake show a sharp increase in recruitment in 2005 and thereafter a level similar to or higher than in past years. In 2008 a new, though lower, peak was observed. Total fishing mortality (F) decreased to 2004, then increased in 2005 and 2006. Catches, and thus F, were dominated by the trawl fishery. As GFCM considered the stock to be overfished, they recommended a sizable reduction of F (GFCM SAC, 2012).

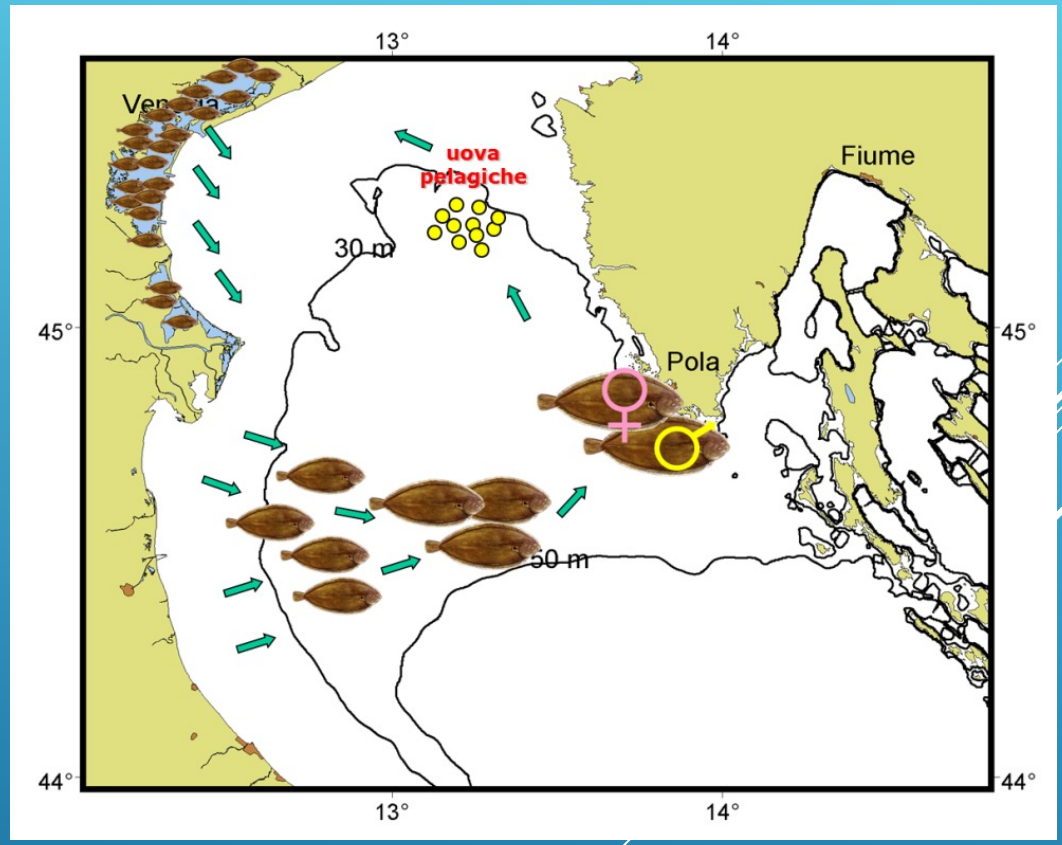


Annual sole landing increased from ~1000 t to > 2000 t, while annual sea-bream landings were <1000 t throughout

Adult red mullet are distributed along the central and eastern Adriatic, while juveniles are found in the western coastal area, where they remain until early winter when they move deeper. Annual landings declined from near 4000 t in 2005 to < 3000 t between 2010 and 2013, and then increased to > 4000 t in 2016. Spawning stock biomass decreased slightly from 9000 t in 2008 to 6300 t in 2011.

Total biomass decreased by 50% from 2008 (50,000 t) to 2011 (25,000 t) (GFCM-SAC, 2012). The GFCM recommended reducing fishing mortality on new recruits, which could be obtained by a longer closed season for trawling along the western Adriatic coast where, in autumn, age-0 recruits born in summer are concentrated.

The common sole is distributed in the northern and central Adriatic depending on age. Adults are present along the Istrian coast, while juveniles are present in Italian coastal waters, especially at the Po River mouth. Most of the population moves from north to south along the Italian coast, and probably from south to north along the eastern coast. Highest catches occur in the fall. Rapido trawl landings are traditionally dominated by small 0+, 1, and 2 year old fish. The stock in GSA 17 is subjected to overfishing, with the current *F* (as of 2011) higher than the GFCM reference point (GFCMSAC, 2012).A reduction of fishing pressure has been recommended (GFCM-SAC, 2012), while considering that the exploitation is mainly orientated towards juveniles and the success of recruitment seems to be strictly related to environmental conditions.



Catch of miscellaneous coastal fisheries (fishes other than sardines and anchovies) by Italy trended downward from ~8000 t in 1996 to a low of ~5000 t in 2009, and then increased to ~7700 t in 2016. In contrast, Croatian landings decreased from ~2100 t in 1992 to ~500 t in 2003 and then increased to ~2100 t from 2010 to 2016

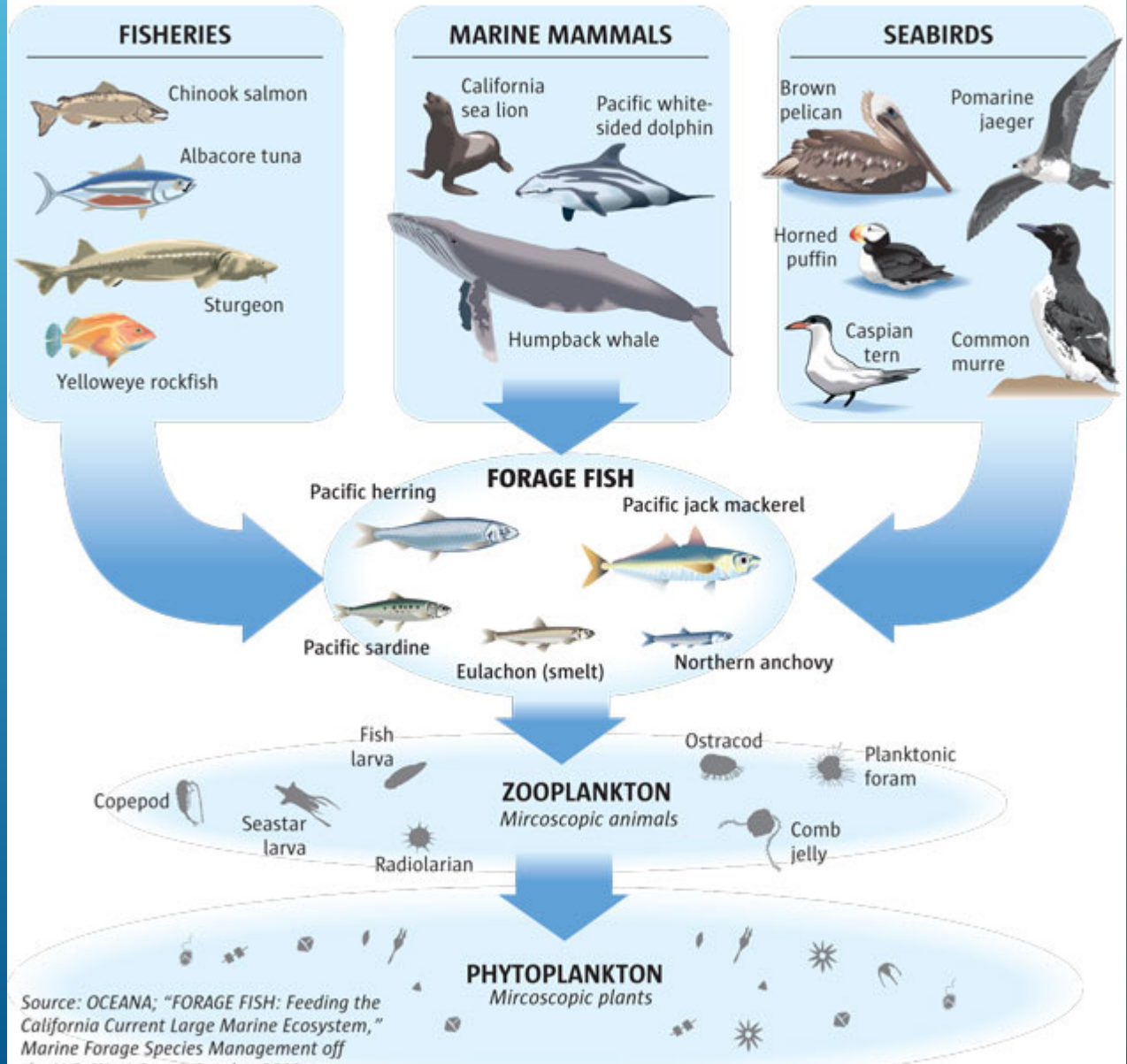
Landings of the elasmobranch fisheries in FAO Division 37.2.1 from 1992 to 2016 show a peak in landings of ~1176 t in 2005 followed by a decrease to 486 t in 2012 and an increase to 935 t in 2016 (Figure 10.7).
Smaller elasmobranchs, especially small sharks, rays, and skates are often commercially important species in trawls.

recent decades, sport and recreational fisherman have targeted large sharks in big game fishing (thresher shark *Alopias vulpinus*, blue shark *Prionace glauca*, and porbeagle *Lamna nasus*). In 1982, the houndshark (*Mustelus* spp.) catch was 1704 t, or ~64% of the total elasmobranch landings (2649 t; the maximum of the period). That year was exceptional, with the second-highest landings of smooth hounds *Mustelus* spp. (824 t) occurring in 2005. Rays accounted for high percentages of total landings in 1986 (1097 t; 58%) and 1987 (1071 t; 56%). Highest landings of dogfish *Squalus acanthias* (537 t) were reported in 1993, but then a significant decline of landings was observed, especially in 2003, when only 41 t were reported for the whole Adriatic.

The main change in composition and distribution of demersal fish resources has been the decrease of elasmobranch diversity and frequency of capture (Jukić- Peladić et al., 2001). Of greatest significance was the decline in long-lived and slowly growing species. For example, small species such as the spotted catshark *Scyliorhinus canicula* and the brown ray *Raja miraletus* were frequently collected in both surveys, while some larger sharks and ray species disappeared or were rarely found during MEDITS 1998.

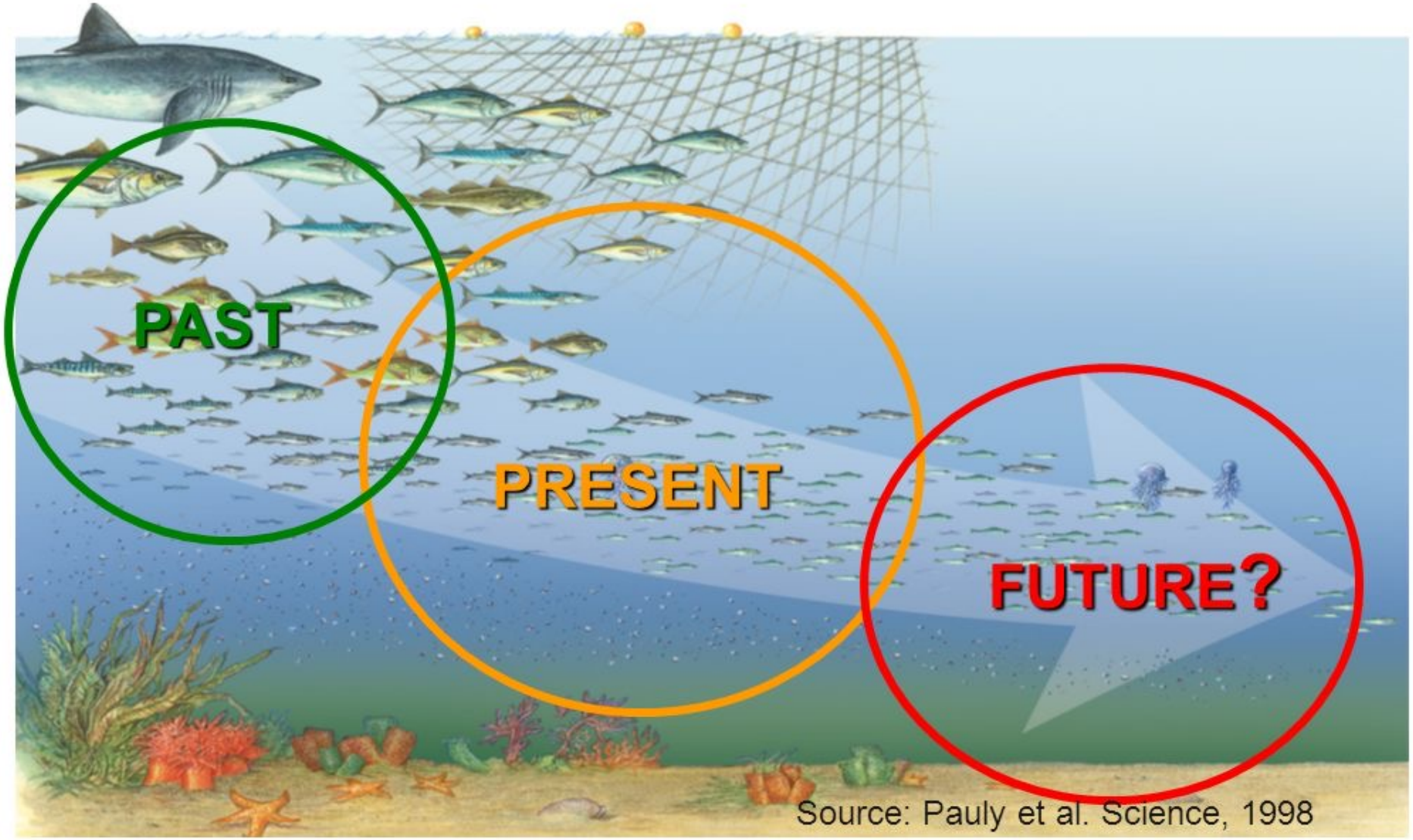
The ocean food web

Along the U.S. West Coast, most major fish, mammal and seabird species rely on forage fish for food – a group of about 30 species of small schooling fish. Scientists increasingly recognize that maintaining this small group of fish is key to ocean health.



Source: OCEANA; "FORAGE FISH: Feeding the California Current Large Marine Ecosystem," Marine Forage Species Management off

“Fishing down the food chain”



The large, long-lived fishes at or near the top of aquatic (especially marine) food webs, when exploited by multispecies fisheries, tend to decline faster than smaller, short-lived fishes with lower trophic levels. This results in the size and mean trophic level of exploited fish assemblages gradually declining, as does the mean trophic level of catches from an ecosystem exploited in this manner.

This reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish. This effect, also found to be occurring in inland fisheries, is most pronounced in the Northern Hemisphere.

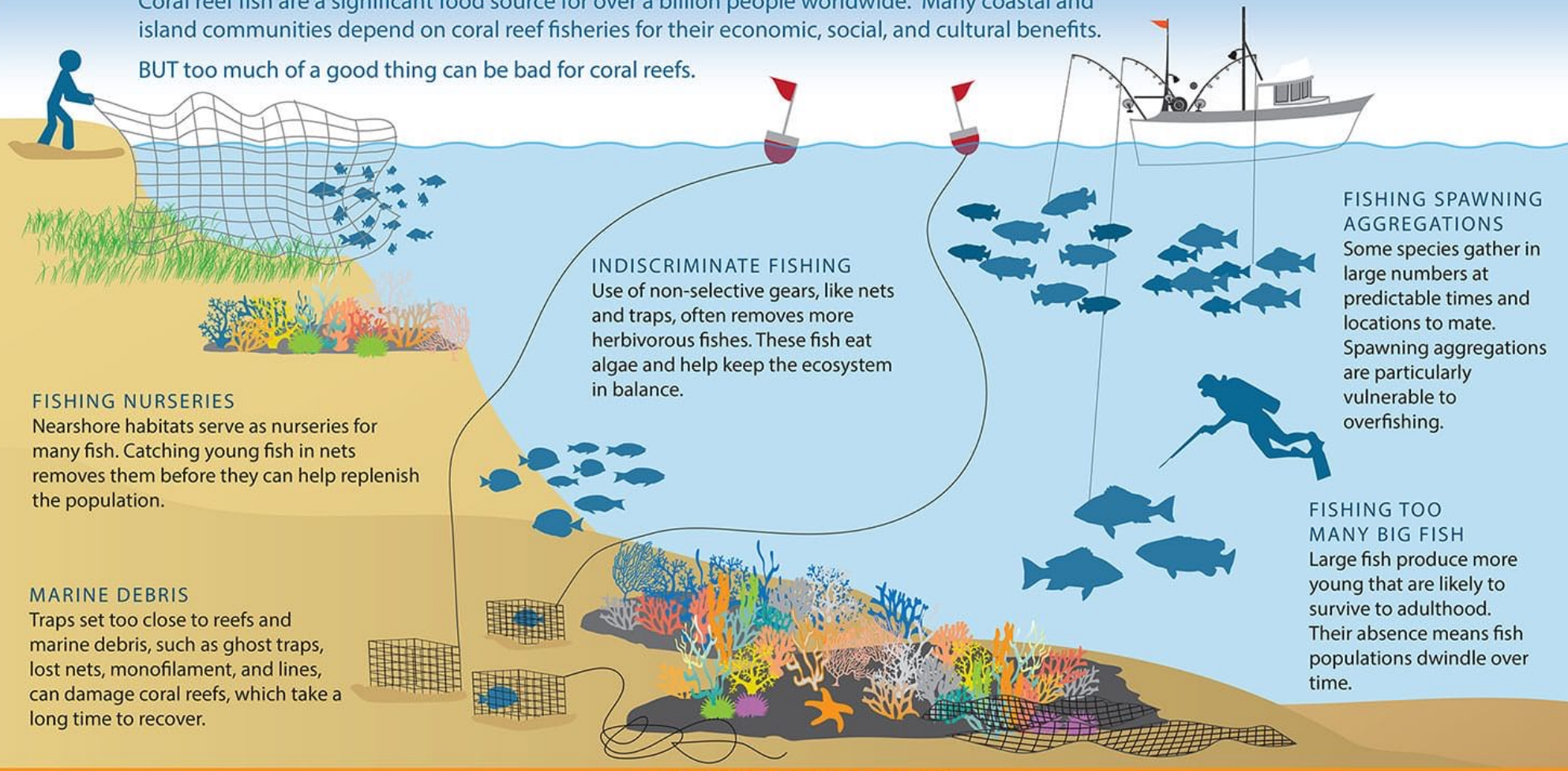
This phenomenon, now known as 'Fishing Down Marine Food Webs'
has been documented through detailed analyses of fisheries catch data from a wide range of ecosystems all over the world

Fishing down food webs (that is, at lower trophic levels) at first to increasing catches, then to a phase transition associated with stagnating or declining catches. These results indicate that present exploitation patterns are unsustainable.

THREATS TO CORAL REEFS OVERFISHING

Coral reef fish are a significant food source for over a billion people worldwide. Many coastal and island communities depend on coral reef fisheries for their economic, social, and cultural benefits.

BUT too much of a good thing can be bad for coral reefs.



FISHING NURSERIES

Nearshore habitats serve as nurseries for many fish. Catching young fish in nets removes them before they can help replenish the population.

MARINE DEBRIS

Traps set too close to reefs and marine debris, such as ghost traps, lost nets, monofilament, and lines, can damage coral reefs, which take a long time to recover.

INDISCRIMINATE FISHING

Use of non-selective gears, like nets and traps, often removes more herbivorous fishes. These fish eat algae and help keep the ecosystem in balance.

FISHING SPAWNING AGGREGATIONS

Some species gather in large numbers at predictable times and locations to mate. Spawning aggregations are particularly vulnerable to overfishing.

FISHING TOO MANY BIG FISH

Large fish produce more young that are likely to survive to adulthood. Their absence means fish populations dwindle over time.

HOW YOU CAN HELP

- Educate yourself on local fishing rules and regulations. Your state fishery agency or bait and tackle shop can help you learn more.
- Make sustainable seafood choices. Learn more at www. FishWatch.gov.
- Only take what you need. Catch and release fish that you don't plan to eat.
- Be a responsible aquarium owner. Know where your fish come from and DO NOT release unwanted fish into the wild.

Research into marine living resources expands knowledge and develops methods that can support management decisions for a sustainable utilization of fish and shellfish stocks

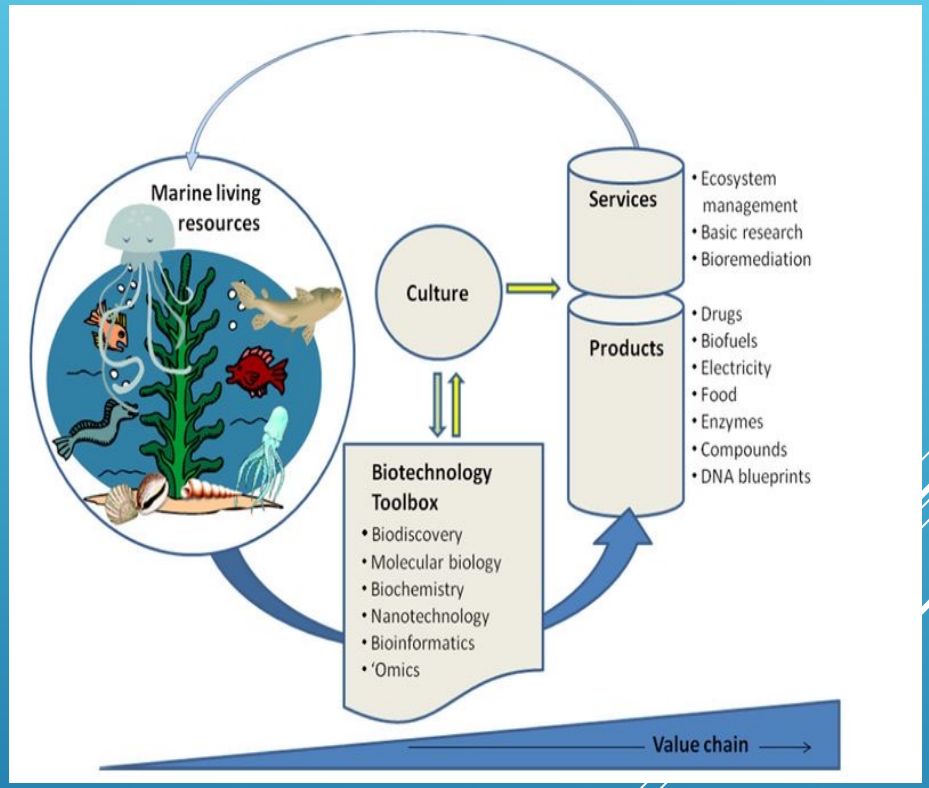
Main themes within marine living resources research

Surveying and fisheries monitoring methods and analysis

We are constantly developing methods to collect and process data to describe the current status of and trends in fish stocks based on the best available information. This involves work to assess the amount and distribution of fish and other commercially relevant marine species. For that end we develop methods and tools to monitor and analyse these stocks as well as the effort, distribution and catches in fisheries.

Stock identification and vital statistics

We develop methods for a fast and precise processing of individual fish to identify their species and population affiliation. We examine the length, weight, sex and maturity and determine the age of the fish. The fish we measure come from sampling of catches from the fishery and from scientific surveys. Data is then converted into estimates of trends in stock size and biomass, and the average growth, reproduction and mortality rates of individual fish.



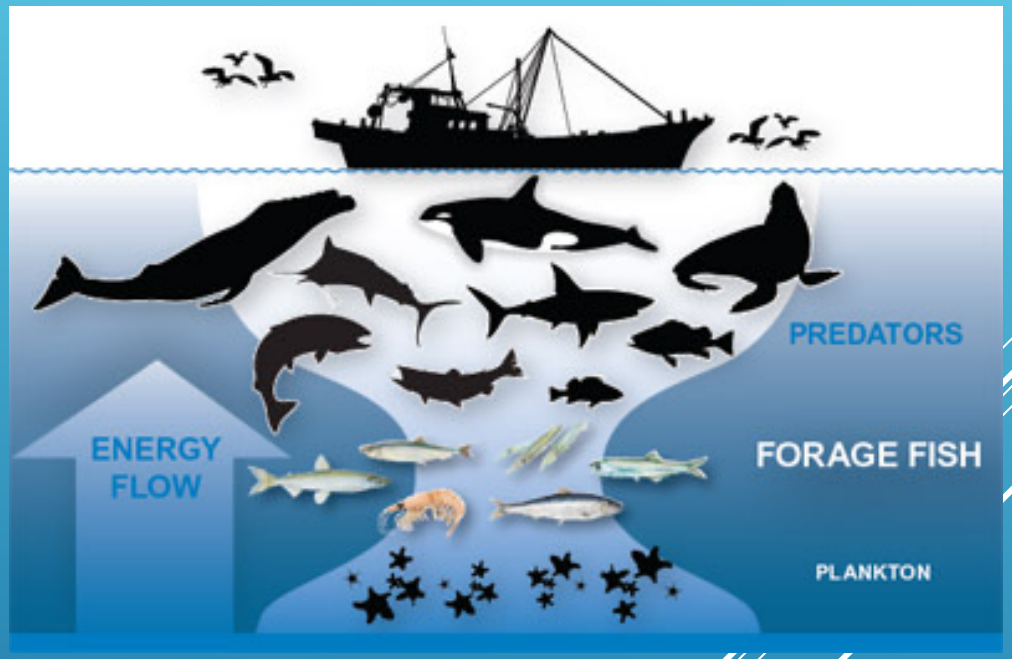
Data handling methods and statistical stock assessment models

Data from fisheries sampling and surveys are entered into data bases with public access. We construct and offer dedicated software to extract, combine, analyse and illustrate the extensive information that has been gathered by international scientific collaboration. Further, we develop novel but rigorous statistical models to analyse and predict population trends and their uncertainties, telling us to what extent these stocks can be exploited.

• Process-oriented models and analysis of fisheries management strategies

•

We develop process-based mathematical models that can describe the spatial behaviour and life cycle of individual organisms in the 3D marine environment taking into account both hydrographic and biological influences. In this way we can predict e.g. larval drift and population distribution of the fish stocks, spatial connectivity of stocks as well as growth and survival of individual fish, based on physiological relations. The work addresses the aspect of scaling from individual level dynamics to population level where a spatial structure emerges in the models from underlying biological and oceanographic processes.



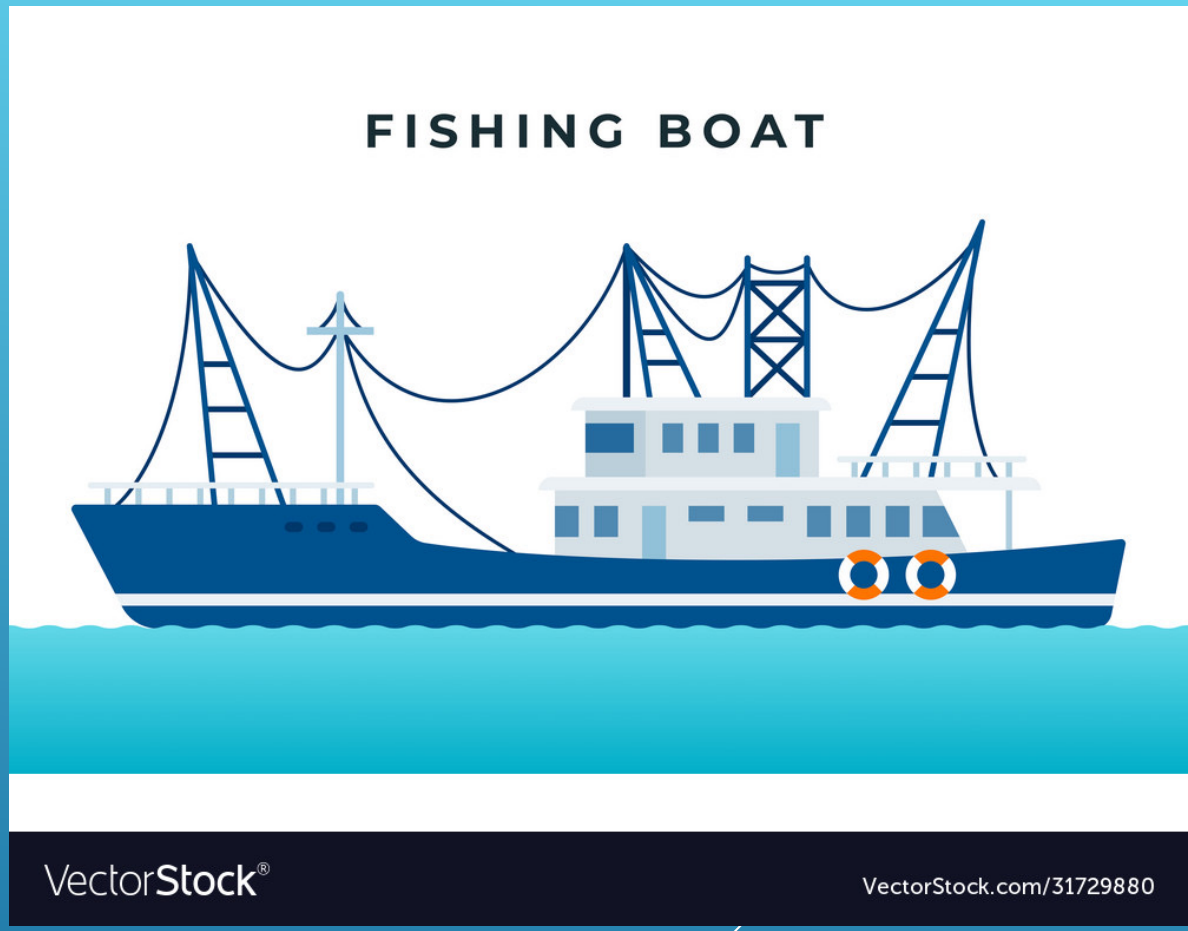
Why do we carry out research into marine living resources?

The overall goal of research into marine living resources is to help ensure the sustainable utilization of ecologically and commercially important fish and shellfish stocks. Fisheries are dependent on there being enough fish and shellfish in the sea, both now and in the future. So although predictions into the future are highly uncertain we have the goal to strengthen the scientific basis for fisheries advice and to contribute to management strategies that are robust to changes in the dynamics of the populations and their ecosystems.

The specific aim for the research area is therefore to increase our knowledge of the biological mechanisms behind population fluctuations, and to develop the appropriate mathematical and statistical models to be able to assess the development in the amount of fish in the different stocks in the sea, how they distribute and the level of exploitation they can sustain within a reasonable prediction horizon.

Even though survey technology is constantly developing, e.g. acoustic and visual methods like echo sounders, sonars and video cameras, you cannot count the number of fish in the sea like you count birds flying in the sky or deer in a field. Therefore, indirect methods have to be used to estimate the amount of fish in the different stocks in the sea. Here data from the fishery on removal of fish by the catches is extremely useful combined with independent surveys supplying trends and indices of population abundance and distribution.

When we combine these data with measurements of size and age of the fish we can follow the decline in numbers of fish in each year class and thereby estimate the annual mortality rate. This mortality is a combination of fishing mortality and mortality from natural causes like predation and death at spawning and old age. If we can estimate natural mortality we can also calculate fishing mortality and address the impact of fishery. Estimating fishing mortality is one of the fundamentals of the most advanced stock assessment approaches, the so called analytical assessment.

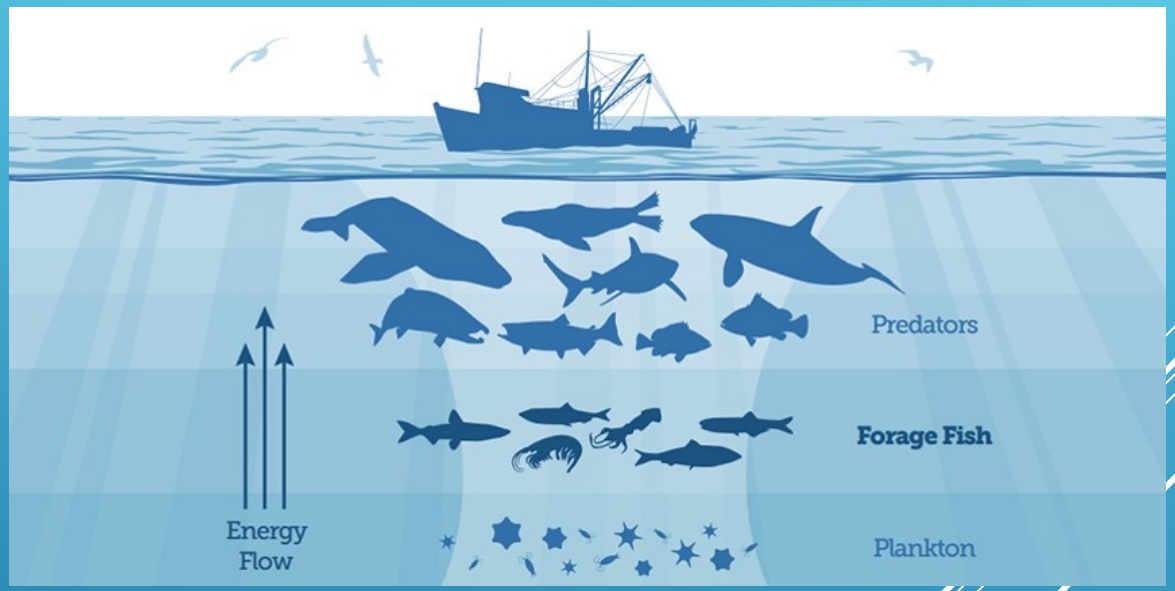


How do we carry out the research?

Data about fish stocks and quantities and species caught originates from landing statistics, fishermen's logbooks (which provide information on species, quantities and areas), samples from fisheries collected at different ports, and on board fishing vessels and from scientific expeditions. This data includes gender, age, size, maturity, genetics, etc. and is used to identify populations and their respective age compositions.

We apply all this information and data in formalised statistical models to estimate the fishing mortality, the biomass of the stock and the number of recruits in each new generation. We use a statistical approach since it gives us the opportunity to rationally select the best model setting for our analysis and provides us with uncertainty estimates of the above estimated parameters to judge whether estimated population changes are significant. The stock assessment models are made freely accessible and transparent in open source user friendly portals. It is the intension that anybody with an interest in fisheries is able to reproduce exactly what the scientists have built their fisheries advice on.

When the studied systems are highly complex, process-oriented models offer a simplified view of ecosystem dynamics. Since model parameters are highly uncertain and process representation is simplified, process-oriented models can only offer a semi-realistic description, where the approximate effects of biological end environmental mechanisms can be assessed. Such semi-realistic explorations are useful in many situations, where there is not sufficient data to support a data-driven assessment of the question of interest and this allows us to estimate the response-envelope of the ecosystem to anthropogenic drivers, e.g. climate change and changed fishing patterns. These models also guide the development of underlying biological models used in stock assessment work towards a more realistic process representation that makes better usage of biological knowledge and derived ecosystem properties.



What is the research used for?

The research into marine living resources is used to give advice on the development and current status of the individual stocks and how much can be caught in fisheries without endangering the recruitment of new generations to the population. Advice also considers a healthy ecosystem functioning such as there being enough fish in the stock to provide food for predators higher up in the food chain. Based on the scientific advice managers will negotiate and set TACs and fishing quotas as well as in other ways regulate the fisheries.