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MedMPAnet

ECOLOGICAL QUANTITATIVE DESCRIPTION OF BOKA KOTORSKA BAY MARINE AREA (MONTENEGRO)

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ECOLOGICAL QUANTITATIVE DESCRIPTION OF BOKA KOTORSKA BAY MARINE AREA (MONTENEGRO)

MedMPAnet project

Regional Project for the Development of a Mediterranean Marine and Coastal Protected Areas (MPAs) Network through the boosting of MPA creation and management

Study required and financed by:

MedMPAnet project

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Reference of the study:

MoU N°13/MedMPAnet/2012


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Acronym and abbreviations

ArcGIS	ESRI geographic information system (GIS) for working with maps and geographic information.
ASFA	Aquatic Sciences and Fisheries Abstracts
CAD	Computer-Aided Drafting
CPUE	Catch per unit effort
DIP	Diving Point
DTM	Digital Terrain Model
ESRI	An international supplier of Geographic Information System (GIS) software and geodatabase management applications
FAO	Food and Agriculture Organization
FLD	Fish Landing Point
FVC	Fish Visual Census station
GFCM	General Fisheries Commission for the Mediterranean
GIS	Geographic Information System
GPS	Global Positioning System
H&S	Health and Safety
HBQ	Hard bottom quadrat station
HP	Horse power
IBM	Institute of Marine Biology of Kotor
ISMAR	Marine Institute of the Italian CNR (National Research Centre)
MPA	Marine Protected Area
PD	Project Director
PM	Project Manager
RAC/SPA	Regional Activity Centre for Specially Protected Areas
SAP BIO	Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region
SPA/BD Protocol	Protocol Concerning Specially Protected Areas and Biodiversity in the Mediterranean
SPAMI	Specially Protected Areas of Mediterranean Importance
SSS	Side Scan Sonar
VVG	Van Veen grab station


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1. INTRODUCTION

Golder Associates S.r.l. (referred to as "Golder") has been appointed by the Regional Activity Centre for Specially Protected Areas (RAC/SPA) to complete a study in Boka Kotorska Bay, aimed at establishing a quantitative description of Kotor Bay marine area to strengthen the creation and management processes of Marine Protected Areas (MPAs) in Montenegro (Memorandum of Understanding N°13/MedMPAnet/2012).

1.1 Scope of work

The scope of work, defined in the RAC/SPA tender document, is focused on the items listed below:

- carry out an ecological study in the Boka Kotorska Bay, including mapping of marine habitats, geophysical survey, census and inventories of fish and invertebrates, coastal land use study, identification of priority areas for conservation and inventory of main sources of threats and impacts;
- produce GIS-based maps for Boka Kotorska Bay area;
- establish a preliminary description of small-scale fishery in the area;
- provide on-the-job training to the local experts on the many aspects of ecological quantification of Marine Protected Areas (MPAs) ecosystems.

These activities are addressed to support the planning, zoning and development of a MPA in Boka Kotorska Bay.

1.2 Study area

The Project area is located in the Boka Kotorska Bay, a semi-enclosed bay situated on the coast of Montenegro. The bay, which is the inner bay of a total of three bays, opens on the Adriatic Sea through the two other bays (Bay of Herceg-Novi and Bay of Tivat) and through the strait between Cape Ostro (Rt Ostro) and Punta Miriste.

The study area for the ecological and fishery survey occupies the entire Boka Kotorska Bay, including the narrow Verige Strait, which connects the Boka Kotorska Bay and the Bay of Tivat. The Boka Kotorska Bay, which has an area of 87.3 km^2 and has a coastline lenght of 105.7 km, comprises 4 smaller bays: Kotor Bay, Risan Bay, Tivat Bay and the open most Herceg Novi Bay. Within the Boka Kotorska Bay there are the two small islands of St. George (Sveti Djordje) and Our-Lady-of-the-Reef (Gospa od Skrpjela).

For coastal land use the study area is identified by a buffer of 1 km from the coastline of Boka Kotorska Bay including Verige Strait.

1.3 Team

The working team was composed by the following experts:

- Roberto Mezzalama, Senior Ecologist – Project Director (PD)
- Giovanni Torchia, Senior Marine Biologist – Project Manager (PM)
- Chedly Rais, Senior Marine Biologist – Advisor
- Fabio Badalamenti – Senior Marine Biologist – Advisor
- Fabio Morfea - Senior geophysical expert
- Massimo Dragan – Senior GIS analyst and information management specialist
- Cristian Villata – GIS specialist
- Chiara d'Angeli - GIS specialist
- Guido Di Bartolomei - H&S Coordinator
- Egidio Trainito - Professional underwater photographer and benthos expert
- Chiara Romano, Biologist – benthos expert
- Francesco Pititto – field work geophysical and biological expert
- Elisa Sizzano, Natural Scientist – Environmental Specialist
- Cecilia Amosso, Natural Scientist – Environmental Specialist

The local experts from the Institute of Marine Biology of Kotor that were involved during all the surveys (geophysical, biological and fishery) and in the first analysis of samples included:

- Vesna Mačić, local marine biologist expert senior;
- Anja Vulevic, local biologist junior;
- Marko Nikolic, local biologist expert junior;
- Sladjana Gvozdenovic, local biologist expert junior;
- Olivera Markovic, local biologist, fishery expert ;
- Mirko Djurovic, local biologist fishery expert.

Figure 1: Overview of the study area

2. METHODS

The following methodologies were applied during the study:

a) an initial desktop study;
b) a geophysical survey (including on-the-job training of the local expert) and data analysis;
c) a biological survey (including the beginning of fishery monitoring and on-the-job training of the local experts) and data analysis;
d) the coastal land use analysis;
e) the follow-up of the fishery survey by local experts and data analysis;
f) the GIS system preparation.

2.1 Desktop study

In order to establish a preliminary description of ecology and of small-scale fishery in the study area a literature research was performed. This analysis was conducted prior to the field survey, in order to identify the main gaps in knowledge and potential areas of special interest to be investigated more in-depth during the surveys.

The bibliographic research was carried out with the support of databases of peer-reviewed literature (e.g. Scopus, ASFA, Google Scholar); the following main data sources were considered:

- scientific literature and "grey" literature;
- previous ecological and fishery studies conducted in the study area;
- national and international environmental database (including data from FAO international projects);
- other relevant data and information already available to Marine Biology Institute of Kotor.

Moreover, the most recent satellite/aerial photo images (Bing Maps aerial imagery) and land use maps (Corine Land Cover 2006) were considered.

2.2 Geophysical survey

Key international experts:

- Fabio Morfea, geophysical expert;
- Francesco Pititto, marine biologist expert;
- Key national experts;
- Vesna Mačić, local marine biologist senior of the Marine Biology Institute (IBM) of Kotor.

Date: January 19th - 24th 2013.

Field work activities and tools:
Side scan sonar and single beam survey in the whole marine area was carried out. The C-MAX CM2 side scan sonar and an echo-sounder Navitronics (Reson) model Navisound 205 were used. All navigation data was recorded in PDS 2000 software for post-processing. Field activities were conducted using the vessel "Nemirna II" owned by IBM.

The frequency of 325 kHz was used and a 150 m lateral range was adopted to cover the whole study area. In addition, to further analyze the presence of threatened coastal habitats (e.g. seagrass meadows) the whole coastal perimeter of the bay was surveyed adopting a 100 m lateral range of the side scan sonar. Moreover, in one specific site in which presence of the sea grass *Posidonia oceanica* was known from past information, a small area was covered with a 50 m lateral range providing high resolution data of the distribution of the meadow and of some adjacent features (e.g. a freshwater pipe and some obstacles laying on the seabed).

A total amount of 69 navigation lines (Figure 2) were followed, for an amount of 177 km. The total area covered by the survey was 25,8 km^2.
A short field work report about the geophysical survey is available in **Appendix A**.

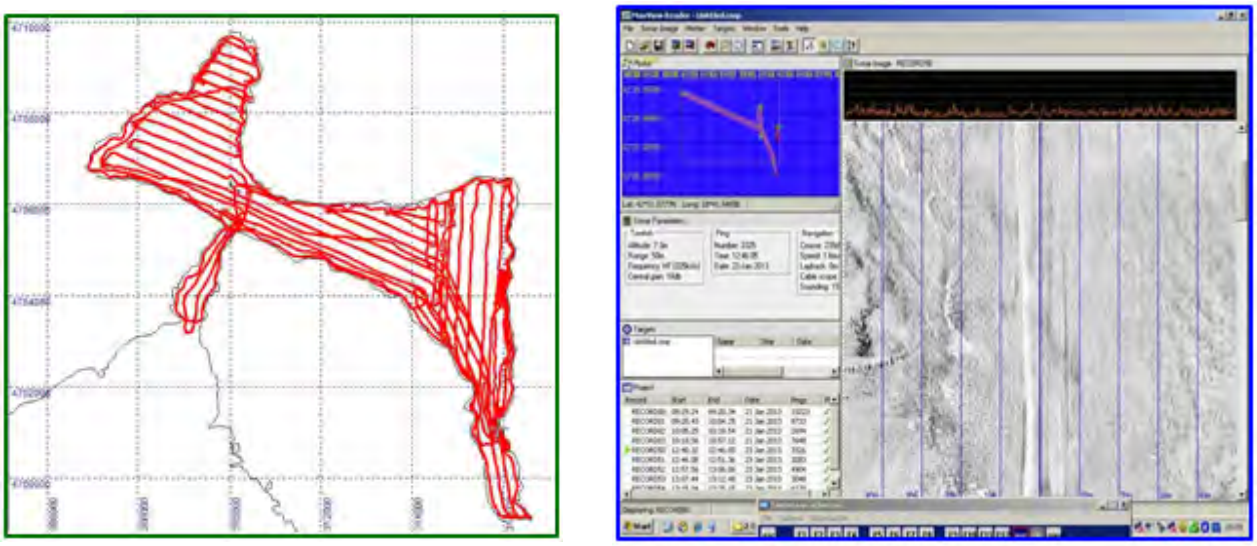

Figure 2: a. Survey lines of the geophysical investigation; b. The deeper limit of *P. oceanica* meadow identified by side scan sonar during the geophysical survey

Box 1 - The side scan sonar survey

The Side scan sonar records signals from the seabed to detect small to mid-scale features: seabed forms (e.g. ripple marks, pockmarks, etc.), textures, specific habitats (e.g. seagrass) with other types of natural morphologies and non-natural objects (e.g. archaeological artifacts, wrecks, small objects, etc.). The Echo-sounder collects depth data information along a grid of lines, using reflection of echoes generated by a transducer and geo-referenced by satellite positioning (GNSS-GPS).

Sonar imagery uses similarly reflected echoes from a linear transducer: signals are analysed for Amplitude Vs Time and result in a sonar image (sonogram) where different levels of energy (amplitude) measured by the transducer produce different 'colours' on the image, according to the characteristics of the seabed.

Sonar Imagery processing is performed by specific software that processes single line of data (sonogram) applying variable gain, equalization and image enhancement. Each line is exported in a raster image that is merged in a mosaic.

The mosaic is the basic layer over which features like seabed morphologies and marine habitats are analysed and identified. These results are used as baseline information for further ecological investigation (e.g soft bottom sampling, hard bottom visual census).

The field surveys performed afterwards supported the ground truthing of the side scan sonar data.

Data analysis

Data processing was done according to standard methods for each technique.

Bathymetry data were processed by controlling data graphically to eliminate erroneous measures (spikes, multiple echoes etc.). Afterwards the single line data was exported and collected in a x, y, z format and gridded with specific software, in order to calculate a regular Digital Terrain Model (DTM), from an irregular set of data. Once the DTM was generated, contouring was extrapolated from it and a bathymetric map was designed by CAD and GIS software.

The side scan sonar processing implied the use of Coda software that processes single lines of data (sonogram) applying variable gain, equalization and image enhancement. Each line was exported in a raster image and merged in a mosaic.

2.3 Biological survey

Key international experts

- Giovanni Torchia, marine biology expert;
- Egidio Trainito, marine biology expert and photographer;
- Francesco Pititto, marine biologist expert specialized in marine habitat mapping;
- Chiara Romano, marine biologist expert specialized in benthos
- Fabio Badalamenti marine biologist expert (involved in the planning and design of the survey).

Key national experts

- Vesna Mačić, local marine biologist expert senior (Institute of Marine Biology of Kotor - IBM);
- Anja Vulevic, local biologist expert junior;
- Marko Nikolic, local biologist expert junior;
- Sladjana Gvozdenovic, local biologist expert junior.

Date : April 5th – 12th 2013.

Field work activities and tools

Surveys were carried out using two vessels: the vessel “Nemirna II” owned by IBM and a smaller vessel rented at a local diving center (Figure 3).

The field activities were divided between two teams, fully equipped in order to work at the same time: one team was in charge of underwater towed camera surveys and sampling of soft bottom benthos by grab; the other team was in charge of diving activities, including direct scuba diving investigation on hard substrata, fish visual census and photographic survey.

Figure 3: a. The vessel Nemirna II rented from the local marine biological institute;
b. The support vessel rented from a local diving center

Positioning was assured by a Garmin GPS Map 70 and directly recorded in GIS, which was also used as navigation system and allowed NemirnaII's captain to visualize the transect to be carried out and the sampling points (Fig. 4).

Surveys with underwater camera were conducted along 26 transects/points based on side scan sonar data and on local expert' indications, in order to verify the interpretation of the side scan sonar data and to provide a representation of the different features present in the whole study area. A PANORACAM VVL-KS-B with a 360 degree rotary underwater camera was used. The position of the submersed camera was recorded as a *.shp* file by a GPS receiver and layback corrections. All videos were recorded and associated to the transect or point investigated.

Soft bottoms habitats have been investigated in 15 stations stratified per depth and seabed typologies (e.g. detritic, sandy, muddy) by collecting samples using a Van Veen Grab. Samples were rinsed and sieved with a 1 mm mesh. Remaining material was fixed in a 70 % alcohol solution. Part of the samples were sorted and identified at the Institute of Marine Biology of Kotor, directly involving local personnel as on-the-job training activities. The sorting and species classification were finalised at Golder laboratories.

The taxa identification was carried out using the most important taxonomic guides available in scientific literature. Special care was taken for species characteristics of biocenosis (Pérès and Picard, 1964, Bellan *et al.* 2007).

The following biodiversity indexes were calculated:

- Diversity (Shannon-Weaver, 1949);
- Evenness (Pielou, 1966);
- Species Richness (Margalef, 1958);
- Dominance (Simpson, 1949).

Figure 4: a. The navigation system with the photomosaic side scan sonar as basic map as;
b. The vessel Nemirna II during the biological survey

Hard bottom habitats were investigated by non-destructive, semi-quantitative methods, already successfully used in many Mediterranean studies (Bianchi *et al.*, 2003). For each site an amount of at least 10 random quadrates (50x50 cm) were photographed by scuba divers equipped with Nikon D3X, case Sea&Sea MDX PRO D3 and 2 flash Sea&Sea YS 250 PRO, which guarantee a high resolution of the photos (24 megapixel). Each photo was analysed using ESRi ArcGis 10.1 software that helps segmenting the different taxa and calculating the area occupied by each taxonomic unit found.

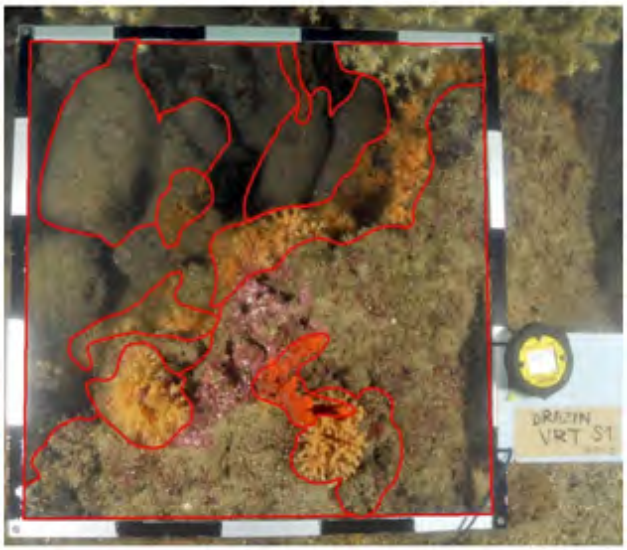

Figure 5: The analysis of the quadrat used to study the hard bottom assemblages

Fish assemblages in the study area were investigated through an underwater visual census, by scuba diving along random transects in 8 stations, chosen on the basis of side scan sonar data, local experts' indications and other available information from marine habitat mapping field work.

For each site, 25 m long random transects were followed by a marine biologist. A water space with a 5 m base (2,5 m on the right and on the left of the divers) by 2 m height was covered. Three transect replicate counts were carried out for each site. A PVC table was used to record all present species, their number and the size-class they belong to; three size-classes were used (La Mesa and Vacchi, 1996, 2003; Harmelin-Vivien *et al.*, 1985). The following abundance classes were adopted: 1, 2, 3-5, 6-10, 11-30, 31-50, 51-100, > 100).

Average values for each station and their associated standard deviations were calculated using Microsoft Excel formulas. Pearson's correlation analysis performed on SPSS was used to test association between fish parameters and other environmental variables. A Dendrogram Hierarchical Cluster analysis (between-group linkage method) was performed on SPSS statistic software in order to examine the fish assemblage. This procedure computes the smallest average distance between all group pairs and combines the two groups that are closest.

In addition to specific qualitative and quantitative data from the above-described "fish visual census", further qualitative data on fish assemblages inhabiting Boka Kotorska Bay was obtained by the following data sources:

- scuba divers' observations during photographic benthonic diving activities;
- interviews to local divers and fishermen
- fishery landing data (see chapter 2.5).

The integration of coastal land use, side scan sonar data, bathymetry and all the field surveys information was summarised in a biocenotic map (1:5.000 scale) for the whole study area.

For five ecologically valuable areas (one area colonized by *Posidonia oceanica*; two areas colonized by *Cymodocea nodosa*; one colonized by a mixed meadows with *Cymodocea nodosa*, *Nanozostera noltii* and *Zostera marina*; one interested by a considerable assemblage of the anthozoan *Savalia savaglia*) higher resolution maps (1:2.000 scale) were elaborated.Biocenotic maps were drawn according to the most relevant scientific literature (Pérès and Picard, 1964; Augier, 1982; Meinesz *et al*., 1983; Bellan-Santini *et al.*, 2002, Bianchi *et al.*, 2003b; Michez *et al.,* 2011). The symbols and conventions adopted comply with the accepted standard reported in Meinesz et al. (1983) and to the colour standard proposed by Tunesi *et al*. (2002).

A photographic survey was conducted in 8 stations and the photographic inventory of the ASPIM species (Annex II and III of the SAP BIO Protocol) was realized. A Camera Sony RX100 (equipped with Sea&Sea Digital Wide Conversion 0,56x, 2 flash Inon S2000, illuminator Light&Motion Sola 600) and a Camera Nikon D3X (equipped with Nikon AF-S 24-120, Nikon AF 18-35, Nikon AF Micro Nikkor 105 1:2,8, Nikon AF Micro Nikkor 60 1:2,8, case Sea&Sea MDX PRO D3 and 2 flash Sea&Sea YS 250 PRO) were used.

All the stations investigated during the biological survey are shown in the figure below.

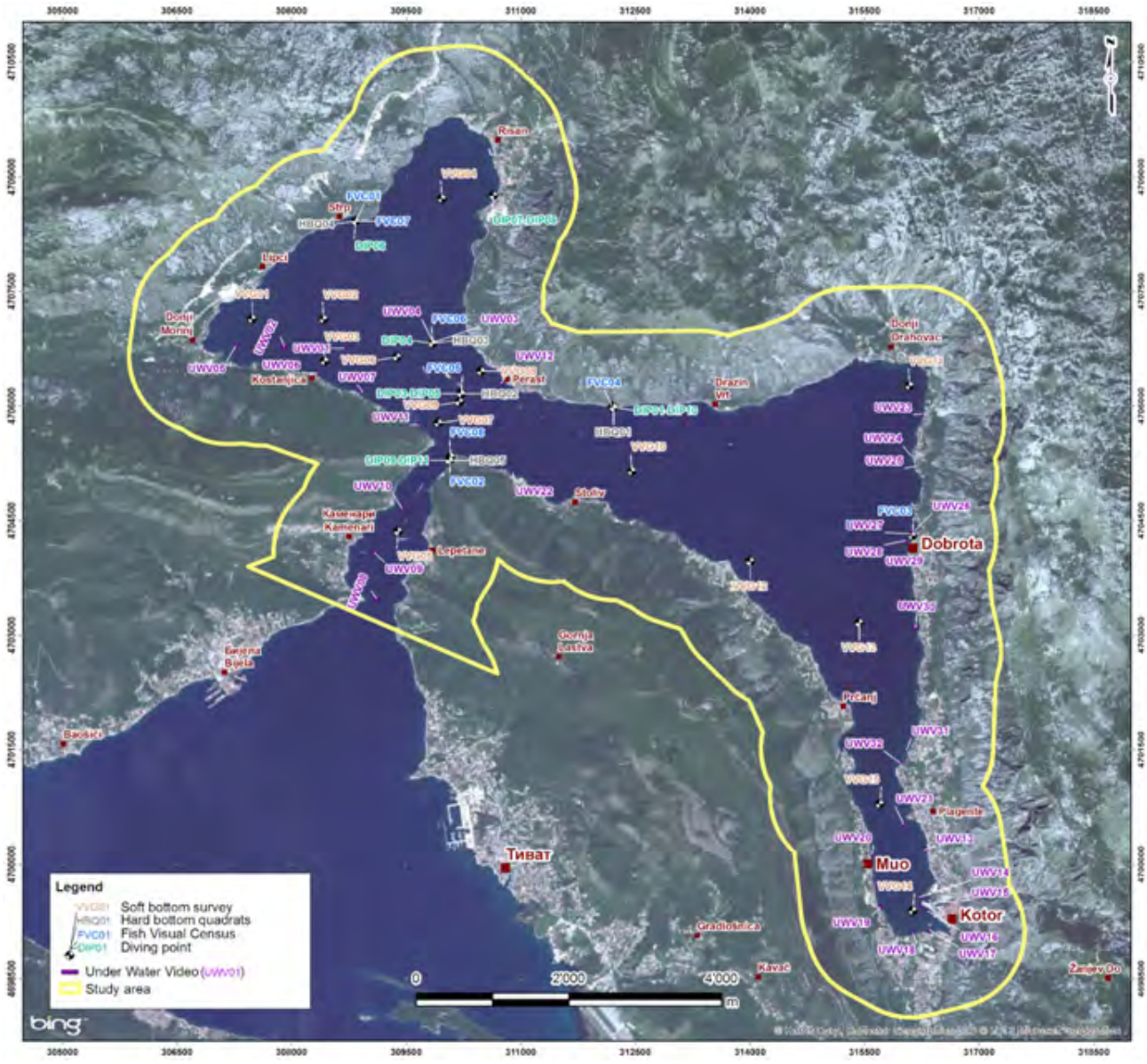

Figure 6: Study area and investigated stations

2.4 Coastal land use

A coastal land use analysis was carried out on a 1 km buffer drawn around the coast line of the Bay using GIS tools. The Corine land cover map Level III was updated and detailed using the Bing Maps aerial imagery (ArcGIS online) and a few ground-truthing surveys. A specific GIS layer concerning coastal land cover was produced.

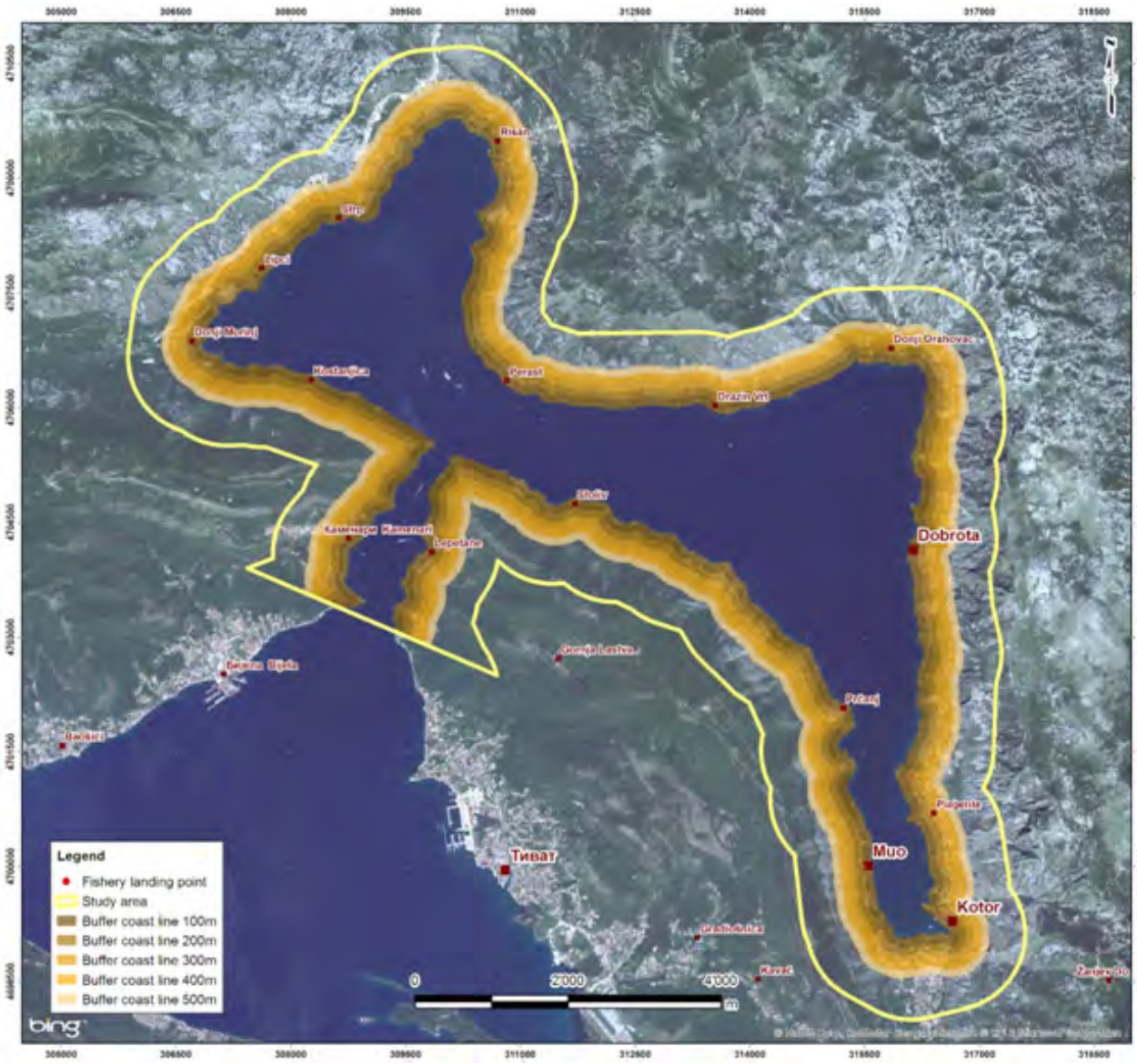

Figure 7: Study area costal buffer of 100m, 200m, 300m, 400m and 500m

2.5 Fishery study

Key experts

- Giovanni Torchia, coordinator;
- Olivera Markovic, local expect of the Institute of Marine Biology (IBM) of Kotor;
- Mirko Djurovic, local expect of the Institute of Marine Biology (IBM) of Kotor

Date : April 14th – May 16th 2013.

Field work activities and tools

The fishery landing survey was conducted in Boka Kotorska Bay during the period of April-May 2013. The fishery survey focused on the landing data form gillnet and trammel net, which are the most used fishing gears in Boka Kotorska Bay after the beach seine, and emerged as a gap during the desktop study. Landing data were collected using a special form (Appendix B) for a period of 10 days. On each sampling day the following data were recorded for each landing site: site, fishing area, depth, seabed type, vessel name, number of crew, fishing gear, gear characheristics and catch by species. Five different vessel crews where interviewed for a total of 16 interviews. A qualitative and quantitative data analysis was performed on the database with the use of pivot tables on Microsoft Excel. The CPUE was calculated dividing the weight (in kg) of fish caught and the number of individuals by the meters of net used and the number of fishing days (or by haul for beach seine net).

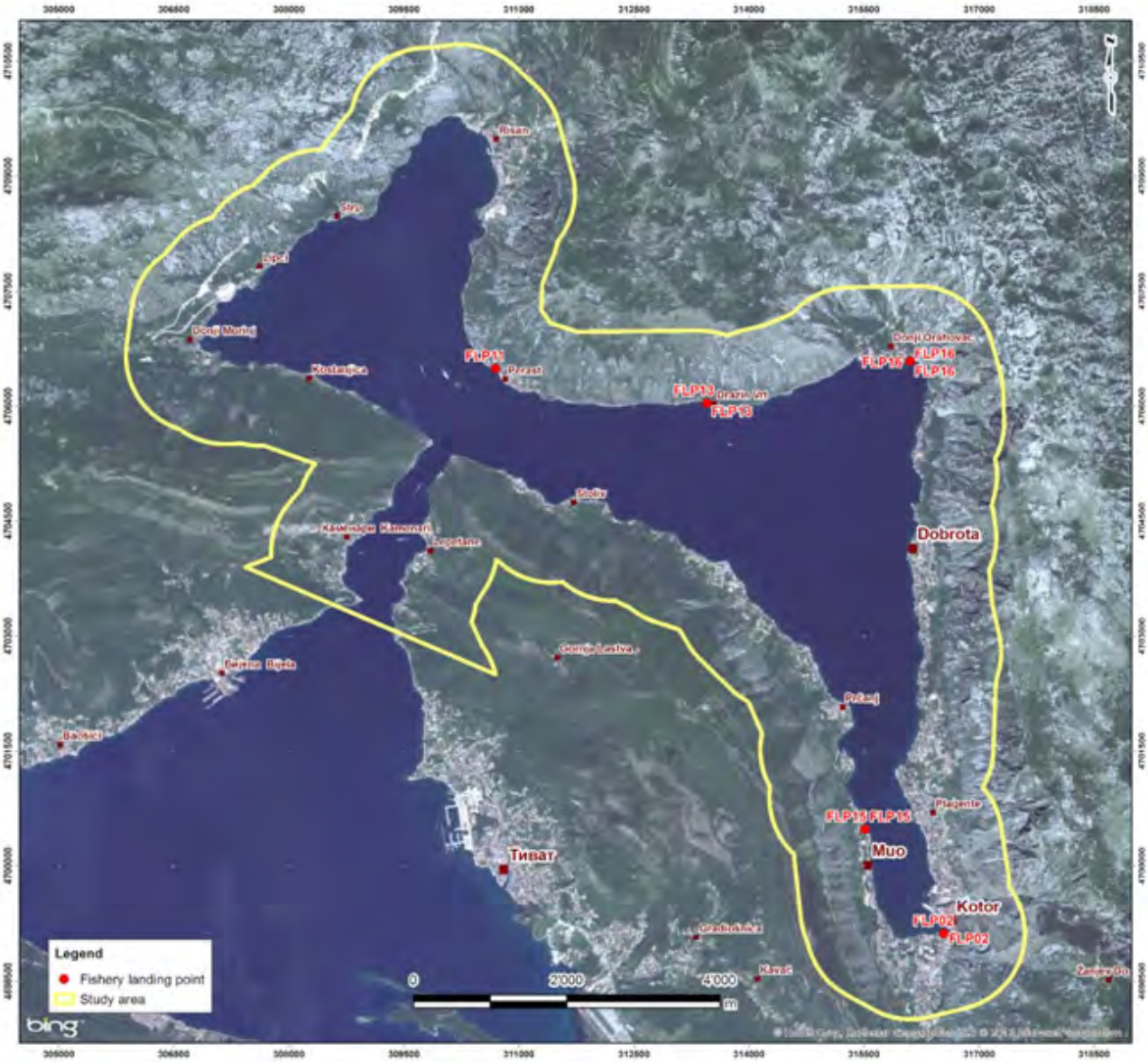

Figure 8: Landing points surveyed in Boka Kotorska Bay

2.6 GIS processing

The GIS project was developed with the software ESRI ArcGis 10.1 integrated by ArcGIS server. The process carried out to develop the GIS can be summarized in the following main steps: georeferentiation of the bibliographic data; geodatabase organization; import of tabular data, images, videos and photos from field work activities.

Fish species and benthonic species data were organized within a geodatabase in order to facilitate the research, data analysis and species selections.

Photos, videos and reports were stored as hyperlink within the geodatabase.

The geodatabase was structured according to the following structure:

- **Basic Geographic data**
- **Bibliographic data**
    1. Physical data
    2. Biological data
- **2013 Surveys**
    1. Geophysical survey
    2. Biological survey
    3. Fishery survey
    4. Coastal land use
- **Management**

3. RESULTS AND DISCUSSION

3.1 Desktop study

The bibliographic research resulted in the collection of 24 scientific papers and 12 reports (grey literature) relevant to the study. The table below summarises the results of the desktop study; the following paragraphs summarise the contents of the documents analysed.

Table 1: Bibliographic research contents

Subject	Number* of scientific papers	Number* of reports (grey literature)
Marine geomorphology	-	3
General marine ecology	4	4
Plankton	11	-
Benthos	6	3
Fish and fishery	4	6

**Some papers and reports cover more than one subject*

In addition, different relevant marine ecology databases were identified for the Kotor area. All the bibliographic data that could be georeferenced were added to the GIS project. Bibliographic references of the desktop study are available in separate sections of References (chapter 5).

3.1.1 General physical and oceanographic features of the study area

The Boka Kotorska Bay has an area of 87.3 km^2 and a coastline of 105.7 km. The Bay comprises 4 smaller Bays: Kotor Bay, Risan Bay, Tivat Bay and the openmost Herceg Novi Bay. The Bay is connected by shallow and narrow straits (e.g. the Verige S., 350m wide), and it is dominated by the mountains of the Dynarides Range, reaching almost 2.000 m (Mt.Orjen, that dominates to the NW the Bay of Risan, 1.894m). The Bay is considered a drowned valley shaped during the Pliocene period and later by tectonic down-warping.

Boka Kotorska Bay's geographical situation, orographical configuration and hydrographic characteristics influence the biotic and abiotic factors and determine a very specific environment, quite different from the open sea (Badalamenti and Treviño-Otón, 2012).

Precipitation in the Boka Kotorska reaches the point of the highest precipitation in Europe (4584 mm per year near Crkvice) due to the enormous mass of freshwater flowing into the basin of Risan, which is relatively small and closed (Parenzan and Stjepcevic, 1980). Precipitation varies greatly throughout the year. After the rainy season, that take place in autum, winter and early spring,, there is a period of summer drought, with no rainfall for 3-4 months (July-September).

Five small watercourses are present in the Boka Kotorska drainage area: Skurda, Ljuta, Siroka rijeka, Gradiosnica and Sutorina. Moreover, the whole area is characterized by karstic rivers and underwater springs, which influence temperature, salinity and species distribution. From November to April, when precipitation is higher, the sea surface of the Bays of Kotor and Risan, especially close to Orahovac and Morinj, shows very low salinity.

The lowest level of salinity (26.27 ppm) is found in the Bay of Risan at 11 m of depth. This low value is influenced by the great inflow from underwater sources/springs. The highest level of salinity (39 ppm) is found in the Bay of Kotor (Parenzan and Stjepcevic, 1980).

Throughout the year there is wide variation in surface water temperature in the Bay of Kotor. The mean maximum temperature is in July (26.9 °C) and the minimum in February (8.3 °C). Mean seafloor temperatures range from 19.5 °C to 14.4 °C (Parenzan and Stjepcevic, 1980). Sea currents are rather irregular and their directions and strength are influenced by winds, atmospheric pressure and mixing of fresh and sea water. In summer, the currents are weaker, while in other seasons they are considerably stronger (RAC/SPA draft rep).

Boka Kotorska Bay presents a well expressed karst entirety and aquifers discharging on the coast, as well as below the sea level. For example several authors reported springs and siphons on the northern bay, with the cities of Kotor to the SE and Risan to the NW,. Among them is the Sopot spring, just SE of Risan, which also springs at sea at a depth of 25-30m (Milanovic, 2007; Eusebio *et al.*, 2005; Bordin, 2007). Another spring was reported east of the Gospa od Skrpjela Islet, on the northern coast of the Kotor bay, between Perast and C.Drazin.

Bignami *et al.* (2008) during their oceanographic cruise found formations that may resemble submarine karst springs morphologies, (e.g. circular, sub-circular or elliptical depressions or pits, with maximum measured depths of 35m from a rather flat seafloor of 30m of depth) in Kotor Bay, Risan bay and the western Bays of Risan and Morinj.

An oceanographic campaign was conducted by ISMAR, with the oceanographic ship M/N Urania, in collaboration with the Centre of Marine Biology of Kotor in 2010. A multibeam survey was carried out in the Bay and the multibeam bathymetric map reveals the submarine karst morphologies.

3.1.2 Plankton

Many recent publications on phytoplankton assemblage in Montenegro's coast are available. Eleven scientific articles were reviewed during the desktop study: eight were based on studies performed specifically in the Boka Kotorska Bay while three refered generically to the Montenegro coast.

The study on the Montenegro coast covers phytoplankton assemblages (Drakulovic and Vuksanovic, 2010), temporal variability of Centropages typicus (Mazzocchi et al., 2007) and Cladocerans spatial and temporal distribution (Pestorić and Lučić, 2010).

Of the eight studies on the plankton in the Boka Kotorska Bay, five cover its phytoplankton dynamics and the water trophic state, two specific plankton taxa, respectively Cnidaria (Pestorić *et al.,* 2012) and *Pseudo-Nitzschia* (Bosak *et al.* 2010), and one the presence of anchovy eggs (Mandic *et al,* 2012).

The input of nutrients in spring and autumn is the main cause for the increased abundance of phytoplankton and chlorophyll a (Krivokapi *et al.,* 2009). Water streams and submarine springs are the main external sources of silicates and nutrients in the bay. Natural eutrophication (land–based nutrient input into the coastal area) is still dominant in this area.

According to the monitoring performed by Krivokapić *et al.* (2010) in one station in Boka Kotorska Bay, from March 2008 to February 2009, nutrient salts varied widely, with maximum values 23.91 µmol/l for nitrates, 1.52 µmol/l nitrites and 1.53 µmol/l for phosphate. Chlorophyll a concentration ranged from 0.12 to 11.13 mg/m^3. Based on the concentration of chlorophyll a, nitrates, nitrites and phosphates the area is defined as mesotrophic.

Based on the chlorophyll a concentration and the criteria of Hakanson (1994), the area could be described as eutrophic to hypereutrophic during winter, while during summer the inner part of Boka Kotorska Bay is characterized by low concentrations of nutrients, high transparency and absence of phytoplankton blooms (Krivokapi *et al.*, 2009), which suggests summer oligotrophication, as in other eastern Adriatic nutrient enriched environments.

However, for Drakulović *el al.* (2010) the Boka Kotorska Bay area seems to be already exposed to increased human impact considering the abundance of phytoplankton cells and the presence of species preferring nutrients resulting from their study.

3.1.3 Benthos

Five scientific papers and four reports were reviewed for the benthonic assemblage. Only one of the scientific articles is focused specifically on the Boka Kotorska Bay, in particular on the distribution of Fucus virsoides (Macic, 2006). The other article studies the distribution of benthic species in the Adriatic sea in general (Kruzic and Benkovic, 2008; Despalatović *et al.,* 2010; Nikolić *et al.,* 2010). Two reports from grey literature concern biocoenosis present in the Boka Kotorska Bay (Parenzan and Stiepcevic, 1980; Badalamenti and Treviño-Otón 2012) while the other three concern Bryozoa, Cirripedia (Igić., 2007, 2011) and Bivalvia of the Adriatic Sea (Legac, Hrs-Brenko, 1999).

The first attempt to describe the unique biocoenosis of the Boka Kotorska Bay was made by Parenzan and Stiepcevic, 1980. In this report the authors highlight the extraordinary abundance and biodiversity of the benthic fauna. As a result of the study, 17 different biocoenosis were identified in the area, including one characterized by *Cladocora caespitosa*.

More recently the results of the study performed in the Boka Kotorska Bay by Badalamenti and Treviño-Otón (2012) confirmed that the benthic assemblages of the infralittoral represent a unicum, because of the large percentage of soft bottom assemblages and the presence of coralligenous assemblages. In particular, at Dražin Vrt a coralligenous assemblage was found between 12 and 30 m of depth. Large colonies of *Cladocora coespitosa* reefs were present and were associated with a rich assemblage of large-sized sponges and cnidarians, notably massive colonies of the false black coral, *Savalia savaglia*, the gorgonian *Lofogorgia cfr sarmentosa* and of the yellow cluster anemone *Parazoanthus axinellae* (Badalamenti and Treviño-Otón 2012).

The morphology and growth of coral banks in the Adriatic Sea are positively affected by the sea currents, sedimentation and temperature (Kruzic and Benkovic, 2008). Strong sea currents as well as suspended sediments increase the availability of food resources (zooplankton, dissolved and particulate organic matter). Suspended sediments and organic components can reduce light penetration and can kill corals by burying them, or not allowing the zooxanthellae to photosynthesize. However, sediment removal from the oral disc, conducted by the *C. caespitosa* polyp, demonstrates that this species is well adapted to high sedimentation rates. The wide range of seasonal water temperatures in the Mediterranean Sea regulates the carbonate deposition pattern banding in corallites, which enhance the annual linear growth rate.

A recent scientific article on the distribution of *Fucus virsoides*, an endemic algae of the Adriatic Sea, indicates the presence of the alga in 14 localities in Boka Kotorska Bay. Four of the identified growing sites have recently disappeared, probably because of anthropogenic influence (e.g. habitat disturbance, organic wastes, temperature and salinity increase) (Macic, 2006).

The presence of the invasive red alga *Womersleyella setacea* (Rhodophyta, Ceramiales) was recorded in the Boka Kotorska Bay for the first time in 2003 (Nikolić *et al.*2010).

3.1.4 Fish and fishery

The Badalamenti and Treviño-Otón (2012) report presents the fish species recently found in the area and some general considerations on local fishery.

Three FAO reports on fishery, also including Montenegro, were analised (FAO, 2011, 2012a, 2012b), as well as an additional report focusing on the Adriatic demersal stocks (Vrgoc *et al.,* 2004). An indicationextracted from a draft report written by Djurović and Marković on fishery activities in Montenegro was given by RAC/SPA and considered (RAC/SPA draft rep). Four scientific articles describe the importance of the Boka Kotorska Bay as a nursery ground for two fish species important for local fishery: *Sardina pilchardus* (sardine) (Pešić *et al.*, 2010, 2006) and *Engraulis encrasicolus* (anchovy) (Mandić *et al,* 2011, 2012).

Fish

Badalamenti and Treviño-Otón (2012) detected 38 fish species along the Montenegro coast, but only 13 were found in Boka Kotorska Baythrough a visual census assessment. The three most abundant species in the Boka Kotorska Bay were *Boops boops*, *Chromis chromis* and *Symphodus ocellatus*.

A low species diversity, between 4.7 species/250m^2 and 9.3 species/250m^2, was found inside the Boka Kotorska Bay (Badalamenti and Treviño-Otón, 2012) compared to similar studies along the Mediterranean coast (15 species/250m^2 in García-Charton *et al.* 2004 and 15.1 species/250m^2 in Treviño-Otón & García-Charton, unpublished data 2009). The abundance and size of species with high commercial value was also remarkably low (*Epinephelus spp*., *Diplodus spp*., *Sparus aurata* , *Dentex dentex*).

Table 2: Fish species found in Boka Kotorska Bay

Family	Species
Centracanthidae	*Spicara smaris*
Labridae	*Labrus merula*
	Symphodus cinereus
	Symphodus doderleini
	Symphodus mediterraneus
	Symphodus ocellatus
	Symphodus tinca
Pomacentridae	*Chromis chromis*
Serranidae	*Serranus hepatus*
	Serranus scriba
Sparidae	*Boops boops*
	Diplodus annularis
	Diplodus vulgaris

(*Source: Badalamenti and Treviño-Otón, 2012*)

Fishery

In Montenegro four main fishery ports are present. These ports are located in Bar, Budva, Herceg Novi and Kotor (inside the Boka Kotorska Bay). They are used mainly by trawlers, seiners and boats for small-scale coastal fishing. It is estimated that about 70 trawlers of small/ medium size are harbored in Montenegro's ports, however it is sometimes difficult to distinguish between professional and recreational fishing (Badalamenti and Treviño-Otón 2012).

The fish is sold usually in market stalls and in restaurants, since these ports are not characterized by organized landing sites or fish auction markets (RAC/SPA draft rep).

In the Adriatic Sea the main commercial fish species are: European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), breams (*Pagellus spp*.), whiting (*Merlangius merlangus*), anglerfish (*Lophius budegassa* and *Lophius piscatorius*), commons sole (*Solea vulgaris*), horned octopus (*Eledone cirrhosa*) and musky octopus (*Eledone moschata*), common cuttlefish (*Sepia officinalis*), European squid (*Loligo vulgaris*), Norway lobster (*Nephrops norvegicus*) and deep-water rose shrimp (*Parapenaeus longirostris*) (Vergoc *et al.*, 2004).

In the Boka Kotorska bay, as in the whole coastal area of Montenegro, small-scale coastal fishing is present. The fishing activity of this bay is mainly targeting pelagic fishing, since the catch by trawl nets is forbidden in the bay because the area is known as natural spawning and nursery ground for small pelagic fishes (RAC/SPA draft rep.). Fishing gear used in small-scale coastal fishing includes: gillnets, trammel nets, traps for fish and crustaceans, floating (surface) and bottom long-lines, harpoons and angles for squids.

One layer gillnets and three layer trammel nets are probably the most commonly used fishing gear along the eastern Adriatic coast (RAC/SPA draft rep.). Very few data are available about the catches of these artisanal fisheries. A list of more common species caught by gill and trammel net is available in the extracts from the RAC/SPA draft report: *Boops boops*, *Sarda sarda*, *Pagellus erythrinus*, *Trachurus trachurus*, *Scomber japonicus*, *Lichia amia*.

Of particular importance in Boka Kotorska bay is the fishing of sardines (*Sardina pilchardus*) and anchovies (*Engraulis encrasicolus*) that in this area have important spawning and nursery grounds. Juvenile anchovies and sardines are caught using beach seines of small mesh size (5-6 mm) and artificial light. This type of traditional fishing has been performed for centuries in the Boka Kotorska bay, but no data on quantities of fish catched or fishing effort are available (RAC/SPA draft rep.). The more common species caught by different types of beach seine net are the following: *Boops boops*, *Sardina pilchardus*, *Engraulis encrasicolus*, *Trachurus trachurus*, *Scomber japonicus*.

3.1.5 Threats

The predictable increase in population and tourism in the area could be an important threat to Boka Kotorska Bay's delicate ecosystem. Although natural eutrophication (land–based nutrient input into the coastal area) is still dominant in the area, some evidence of human impact have been already noticed in phytoplankton abundance and composition (Krivokapi *et al.*, 2009; Krivokapić *et al.*, 2010; Drakulović *el al.*, 2010).

Moreover, higher contents of lead, cadmium, arsenic and mercury in sediments were recorded in Boka Kotor compared to reference points located at the open sea (Joksimovic and Stankovic 2010). These results can be explained with pollution from industry and from a large medical complex situated in the coastal area.

According to Badalamenti and Treviño-Otón (2012) the main human activities and threats to the coastal and marine environment are fishing and, to a much greater extent, tourism. The development of tourism and the general increase in human pressure along the coast will likely result in future pollution from untreated sewage. Another possible threat to marine environment in the area is the dumping of soil from road construction or improvement.

The coralligenous assemblages are one of the characteristic features of the Boka Kotorska bay. The major threat to the coral banks in the Adriatic Sea are global warming, human pressure like pollution and coastal development, and the alien invasive green algae *Caulerpa racemosa* (Kruzic and Benkovic, 2008).

The invasive red alga *Womersleyella setacea* could be another potential threat to Boka Kotorska Bay's biodiversity. This species was recorded in the Bay in 2003 for the first time (Nikolić *et al.*2010). *W. setacea* is thought to inhibit recruitment of corallines and other algae (e.g. Cystoseira spp.) (Ballesteros et al., 1998, 2009; Ballesteros, 2006). Studies confirm that the presence of this invasive species changes the assemblage structure and reduces species richness in coralligenous communities, particularly decreasing the diversity and abundance of other turf algae (Piazzi *et al.,* 2007).

Also the small scale fishery present in the Boka Kotorska Bay could be seriously impacted by the rapid expansion of tourism and the future plans for tourism infrastructure (Badalamenti and Treviño-Otón 2012). Presently the main threat to fishery stocks is represented by overfishing and illegal fishing methods like fishing with explosives and fishery of date. Both these destructive practices are reported in the Bay with a considerable intensity. According to Badalamenti and Treviño-Otón (2012), they are responsible for the low abundance and small size of fishes and barren habitats dominated by sea urchins.

3.2 Ecological study

3.2.1 Marine geomorphology

The single beam bathymetry and the side scan sonar mosaic are available for the whole study area (Appendix C) and are loaded as layers of the GIS.
Bathymetry and side scan sonar data are two essential elements of the biocoenoses maps, as they have been used to outline and complete the maps.
However on the basis of these two outputs (side scan sonar mosaic and the bathymetric data) some general comments on the morphology and features of Boka Kotorska Bay can be made:

- the coastal rocky bottom has a high slope and generally soft bottom starts very close to the shoreline, between 15 and 25 m of depth, soft bottoms cover a considerable part of the bay;
- below 30-40 m of depth, the seabed has a relatively low slope;
- the seabed of several deep areas is characterized by the presence of depressions;
- small scattered rocky bottom spots are found in several areas;
- there are several obstacles and objects laying on the seafloor;
- areas with signs of anchorage of very big cruises are evident;
- many very small objects and hard substrata are widespread in the soft bottoms of the Bay, therefore it is not possible to map them at the 1:5000 resolution of the map.

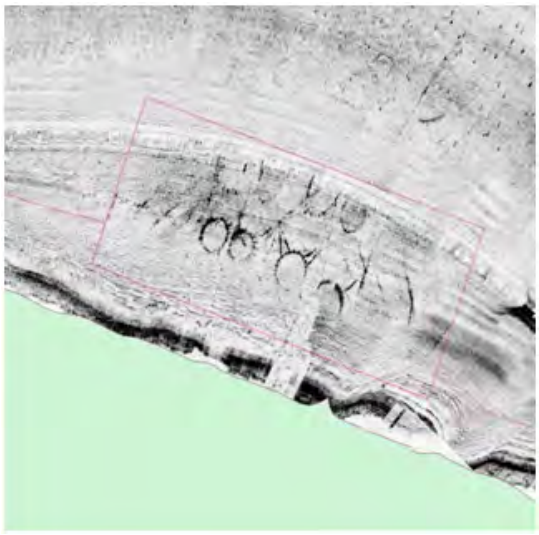

Figure 9: The SSS signal of an aquaculture farm near Verige

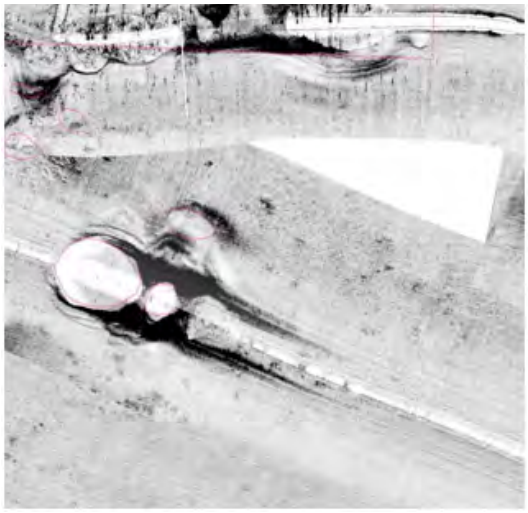

Figure 10: Soft Bottom depressions with possible presence of living Cladocora aggregations

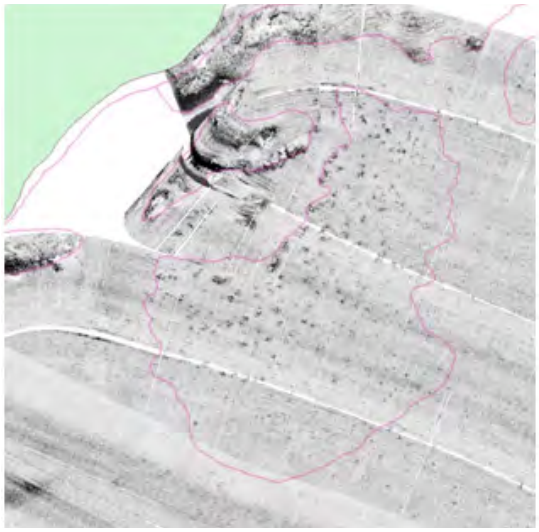

Figure 11: Mosaic of VTC and dead *Cladocora caespitosa*

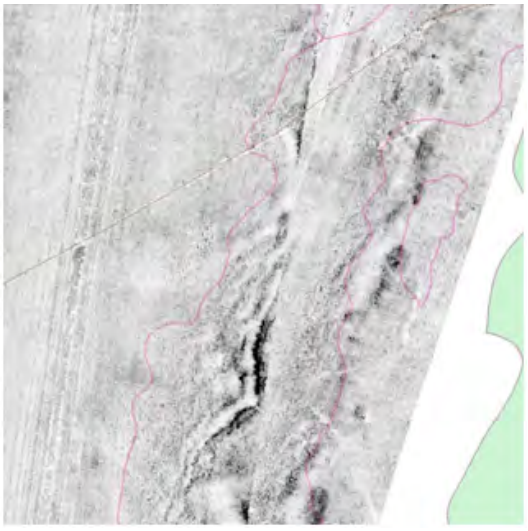

Figure 12: Particular of the *Posidonia oceanica* meadow (the straight line represents a pipeline on the seafloor)

3.2.2 Coastal land use

The analysis of the coastal land use was performed in a buffer of 1 km around the coast line. According to the Corine Land Cover classification (2006), corrected and reviewed through aerial photos and a few ground truthing surveys, the majority of this area is covered by forest and semi natural areas (76%), followed by artificial surfaces (20%) and agricultural areas (3%).

Table 3: Total area (km²) and percentage of the area covered by different land cover types in within 1 km from the coast line

LABEL1	LABEL2	LABEL3	Area (km²)	% Area
Artificial surfaces	Urban fabric	Discontinuous urban fabric	8.54	20
		Subtot. Artificial surfaces	8.54	20
Agricultural areas	Heterogeneous agricultural areas	Complex cultivation patterns	0.14	0
		Land principally occupied by agriculture, with significant areas of natural vegetation	1.24	3
		Subtot. Agricultural areas	1.38	3
Forest and semi natural areas	Forests	Broad-leaved forest	9.83	23
		Coniferous forest	0.42	1
		Mixed forest	0.01	0
		Subtot. Forests	10.25	24
	Scrub and/or herbaceous vegetation associations	Natural grasslands	0.54	1
		Transitional woodland-shrub	6.33	15
		Subtot. Scrub and/or herbaceous veg.	6.87	16
	Open spaces with little or no vegetation	Bare rocks	2.82	7
		Sparsely vegetated areas	12.07	29
		Subtot. Open spaces with little or no vegetation	14.89	35
		Subtot. Forest and semi natural areas	32.01	76
		TOT.	41.94	100

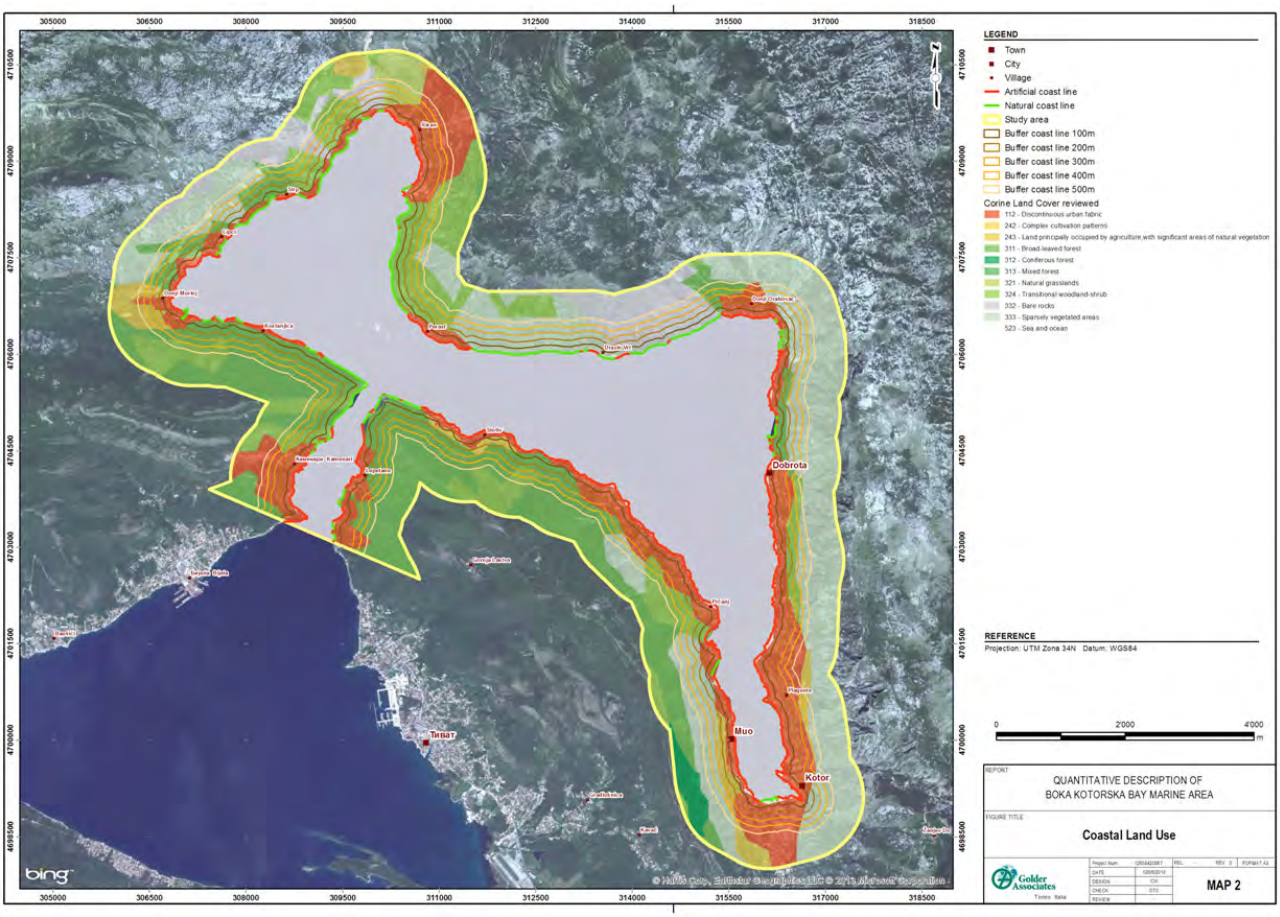

Figure 13: Land use in the coastal study area

In the study area forest and semi natural land cover types are dominated by open spaces with little or no vegetation (15% of the area), mainly characterized by sparsely vegetated areas (12%). Forests, mainly classified as broad-leaved forests, cover in total 10% of the coastal area and are concentrated in the south western portion of the Boka Kotorska Bay, on less steep terrain. Scrub and/or herbaceous vegetation associations cover 7% of the study area.

Sparsely vegetated areas and scrub and/or herbaceous vegetation associations can be the result of anthropogenic disturbance, xeric conditions, or a combination of the two. Mediterranean scrublands (maquis) are dense thickets of evergreen sclerophyll shrubs and small trees. On shallow soils or in steep areas, shrubland is the mature vegetation type. In other cases, shrubland is the result of degradation of former forest by logging, disturbance by major fires or overgrazing.

Forest communities prevail on deeper soils or where there has been less interference with the natural climax vegetation. Forests are often found in riparian areas, where they receive more water during summer. Tree species naturally present in this area are *Ceratonia siliqua* (locust), *Olea europaea* (olive), *Quercus coccifera* (cermes oak), *Pinus brutia* (calabrian pine), and *Pinus pinea* (pine).

In the coastal area artificial surfaces are concentrated mainly in the immediate vicinity of the coast, also because of the acclivity. Within the 1 km buffer, artificial surfaces cover 20% of the area, however in the first 100m from the coast line the portion of land covered by urban fabric is 68%.

The percentage of artificial surfaces constantly decreases considering the 200 m buffer (55%), 300m buffer (46%), 400m buffer (39%) and 500 m buffer (33%). On the other hand, forest and semi natural areas, including forests, scrub and/or herbaceous vegetation associations and open spaces with little or no vegetation, increase with the distance from the coast.

The majority of the artificial surfaces are situated along the Kotor Bay and at the end of the Risen Bay, in the northern and southern portion of the study area respectively. On the two sides of the strait, artificial areas are also present in correspondence with the cities of Kamenari and Lepetane. All artificial surfaces are classified as "discontinuous urban fabric".

The percentage of coastline considered "artificial" from photo interpretation is 69%. This data is very similar to the percentage value of urban fabric land use type in the first 100m from the coast (68%) and it is clearly related to it, helping to understand the high urbanization levels of the coast in Boka Kotorska Bay. "Natural" coastline is concentrated in the north east portion of the bay, between Orahovac and Morinj, and at the entrance of the strait towards the bay, where human settlements are less abundant.

Agricultural areas are scarce and heterogeneous around Boka Kotorska Bay, mainly classified as "land principally occupied by agriculture, with significant areas of natural vegetation". The agricultural land use type is distributed around the bay and is concentrated mainly up-country behind the cities of Morinj, Risan and Kotor. Its percentage value increases slightly but steadily with the distance from the coast line, from 0.9% in the first 100 m from the coast to a maximum of 3.2% in the 1 km buffer.

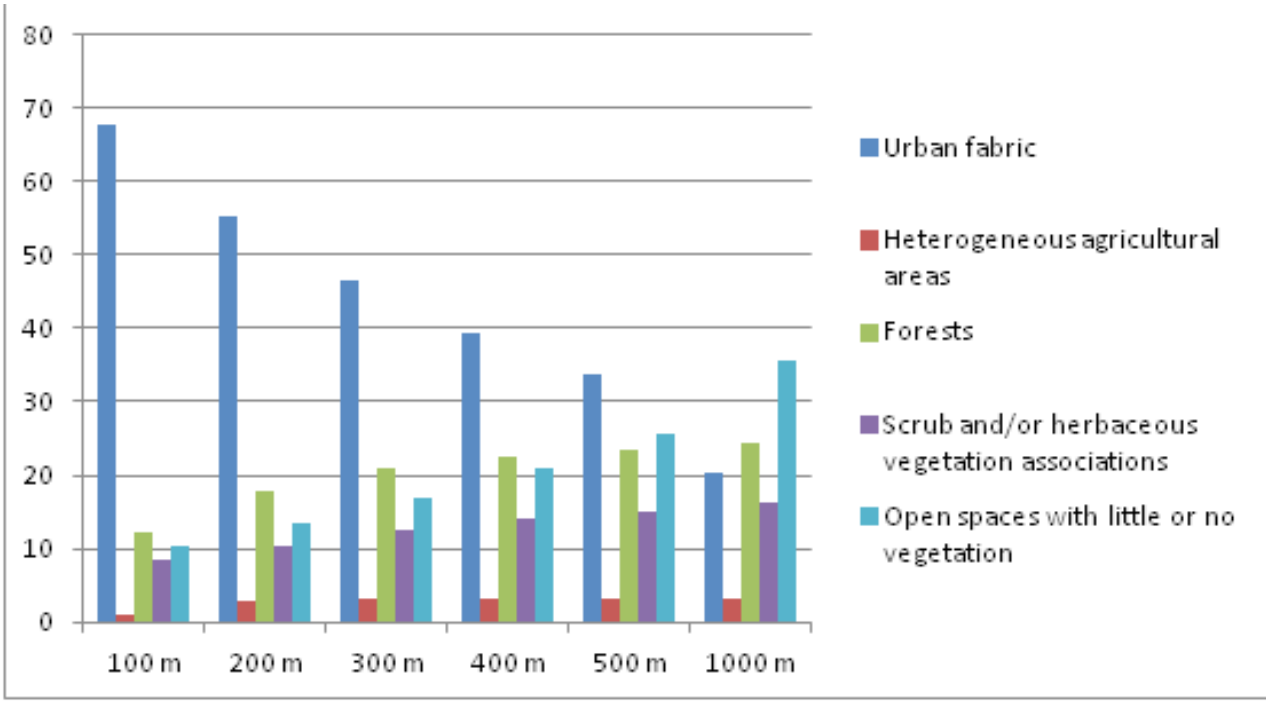

Figure 14: Percentage of the area covered by different land cover types within 100m, 200m, 300m, 400m, 500m and 1000m from the coast line

3.2.3 Macrobenthos assemblages (soft bottom and hard bottom)

Data on the seabed assemblages stem from three main sources: i) soft bottom survey (Van Veen Grab sampling); ii) the analysis of hard bottom quadrat photos; and iii) the visual observation during divings.

The taxa observed in Boka Kotorska Bay by the present study were 226 in total (Table 4); 150 on hard bottom and 77 on soft bottom. Mollusca is the most abundant phylum with a total of 46 taxa, followed by Anellida (38 taxa) and Porifera (37 taxa). Porifera, Briozoa, Tunicata, Chlorophyta and Rhodophyta were exclusively found on hard bottom while Anellida dominate on soft bottom (Table 5).

On the basis of the macrobenthos species identified and the side scan sonar mosaic, the habitats of the bay were classified and mapped. In total 21 benthic habitats (including mosaic of habitats and facies) were defined. Details on habitats are given in Paragraph 3.2.4.

Table 4: Macrobenthos taxa found in Boka Kotorska Bay

Taxa	Specie	Taxa	Specie
ANNELIDA	*Ampharetidae 1*	MAGNOLIOPHYTES	*Zostera marina*
ANNELIDA	*Bispira volutacornis*	MOLLUSCA	*Acanthocardia paucicostata*
ANNELIDA	*Capitellidae 1*	MOLLUSCA	*Alvania* cf. *lineata*
ANNELIDA	*Chaetozone* sp.	MOLLUSCA	*Antalis inaequicostata*
ANNELIDA	*Cirratulidae 1*	MOLLUSCA	*Aporrhais pespelecani*
ANNELIDA	*Dorvilleidae 1*	MOLLUSCA	*Arca noae*
ANNELIDA	*Eunice* sp.	MOLLUSCA	*Azorinus chamasolen*
ANNELIDA	*Eunicidae 1*	MOLLUSCA	*Barbatia barbata*
ANNELIDA	*Filograna* sp.	MOLLUSCA	*Bittium reticulatum*
ANNELIDA	*Flabelligeridae 1*	MOLLUSCA	*Bursatella leachi*
ANNELIDA	*Glycera* sp.	MOLLUSCA	*Calliostoma ziziphynum*
ANNELIDA	*Lacydoniidae 1*	MOLLUSCA	*Chiton corallinus*
ANNELIDA	*Lanice conchilega*	MOLLUSCA	*Corbula gibba*
ANNELIDA	*Lumbrineris* cf. *tetraurata*	MOLLUSCA	*Cratena peregrina*
ANNELIDA	*Lumbrineris latreilli*	MOLLUSCA	*Cuspidaria cuspidata*
ANNELIDA	*Lumbrineris* sp.	MOLLUSCA	*Dicata odhneri*
ANNELIDA	*Maldanidae 1*	MOLLUSCA	*Dischides politus*
ANNELIDA	*Marphysa bellii*	MOLLUSCA	*Euspira macilenta*
ANNELIDA	*Nematonereis unicornis*	MOLLUSCA	*Felimare picta*
ANNELIDA	*Nephtydae 1*	MOLLUSCA	*Flabellina affinis*
ANNELIDA	*Onuphiidae 1*	MOLLUSCA	*Flabellina ischitana*
ANNELIDA	*Onuphis conchylega*	MOLLUSCA	*Gastrochaena dubia*
ANNELIDA	*Oweniidae 1*	MOLLUSCA	*Geitodoris portmanni cfr.*
ANNELIDA	*Paraonidae 1*	MOLLUSCA	*Hexaplex trunculus*
ANNELIDA	*Pilargidae 1*	MOLLUSCA	*Kurtiella bidentata*
ANNELIDA	*Polynoidae 1*	MOLLUSCA	*Lithophaga lithophaga*

Taxa	Specie	Taxa	Specie
ANNELIDA	*Protula* sp.	MOLLUSCA	*Mactra corallina*
ANNELIDA	*Sabella spallanzani*	MOLLUSCA	*Myrtea spinifera*
ANNELIDA	*Sabellidae* sp.	MOLLUSCA	*Nassarius pygmaeus*
ANNELIDA	*Serpula vermicularis*	MOLLUSCA	*Nucula nitidosa*
ANNELIDA	*Serpulidae 1*	MOLLUSCA	*Nucula nucleus*
ANNELIDA	*Sigalionidae 1*	MOLLUSCA	*Nucula sucata*
ANNELIDA	*Spionidae 1*	MOLLUSCA	*Nuculana pella*
ANNELIDA	*Sternaspis scutata*	MOLLUSCA	*Parvicardium minimum*
ANNELIDA	*Sthenolepis* sp.	MOLLUSCA	*Pecten jacobaeus*
ANNELIDA	*Syllidae 1*	MOLLUSCA	*Pectinidae* sp.
ANNELIDA	*Terebellida n.i.*	MOLLUSCA	*Pinna nobilis*
ANNELIDA	*Terebellidae 1*	MOLLUSCA	*Pitar rudis*
BRYOZOA	*Beania magellanica*	MOLLUSCA	*Platydoris argo* cfr.
BRYOZOA	*Bryozoa n.i.*	MOLLUSCA	*Rissoa splendida*
BRYOZOA	*Bugula* sp.	MOLLUSCA	*Serpulorbis arenarius*
BRYOZOA	*Frondipora verrucosa*	MOLLUSCA	*Tellina distorta*
BRYOZOA	*Lichenopora radiata*	MOLLUSCA	*Tellina tenuis*
BRYOZOA	*Myriapora truncata*	MOLLUSCA	*Thuridilla hopei*
BRYOZOA	*Porella compressa* cfr.	MOLLUSCA	*Thyasira flexuosa*
BRYOZOA	*Reteporella* cfr. *grimaldi*	MOLLUSCA	*Timoclea ovata*
BRYOZOA	*Schizobrachiella sanguinea*	MOLLUSCA	*Tritonia nilsodhneri*
BRYOZOA	*Schizomavella mamillata*	NEMERTINA	*Nemertina unid.*
CEPHALOCHORDATA	*Branchiostoma lanceolatum*	PHAEOPHYCEAE	*Cystoseira barbata*
CHLOROPHYTA	*Cladophora* sp.	PHAEOPHYCEAE	*Cystoseira corniculata*
CHLOROPHYTA	*Codium adherens*	PHAEOPHYCEAE	*Cystoseira spinosa*
CHLOROPHYTA	*Codium bursa*	PHAEOPHYCEAE	*Dictyota dichotoma*
CHLOROPHYTA	*Halimeda tuna*	PHAEOPHYCEAE	*Fucus virsoides*
CHLOROPHYTA	*Ulva sp.*	PHAEOPHYCEAE	*Sargassum* cfr. *vulgare*
CHLOROPHYTA	*Valonia macrophysa*	PHAEOPHYCEAE	*Zanardinia typus*
CNIDARIA	*Aiptasia mutabilis*	PLATYHELMINTES	*Vorticerum luteum*
CNIDARIA	*Alcyonium coralloides*	PORIFERA	*Acanthella acuta*
CNIDARIA	*Balanophyllia europaea*	PORIFERA	*Agelas oroides*
CNIDARIA	*Caryophyllia* cfr. *inornata*	PORIFERA	*Anchinoe fictitius*
CNIDARIA	*Caryophyllia* cfr. *smithii*	PORIFERA	*Anchinoe tenacior*
CNIDARIA	*Caryophyllia* spp.	PORIFERA	*Aplysina aerophoba* cfr.
CNIDARIA	*Cerianthus membranaceus*	PORIFERA	*Aplysina cavernicola*
CNIDARIA	*Cladocora caespitosa*	PORIFERA	*Axinella cannabina*
CNIDARIA	*Condylactis aurantiaca*	PORIFERA	*Axinella damicornis*
CNIDARIA	*Epizoanthus* cfr. *arenaceus*	PORIFERA	*Axinella verrucosa* cfr.
CNIDARIA	*Epizoanthus* sp.	PORIFERA	*Calyx niceaensis*
CNIDARIA	*Eudendrium* sp.	PORIFERA	*Chondrilla nucula*
CNIDARIA	*Hoplangia durotrix* cfr	PORIFERA	*Chondrosia reniformis*
CNIDARIA	*Hydractinia inermis*	PORIFERA	*Clathrina cfr. cerebrum*
CNIDARIA	*Hydrozoa n.i.*	PORIFERA	*Cliona celata*
CNIDARIA	*Leptogorgia sarmentosa*	PORIFERA	*Cliona schmidti*

Taxa	Specie	Taxa	Specie
CNIDARIA	*Obelia* sp.	PORIFERA	*Cliona* sp.
CNIDARIA	*Parazoanthus axinellae*	PORIFERA	*Cliona viridis*
CNIDARIA	*Phyllangia mouchezi*	PORIFERA	*Crambe crambe*
CNIDARIA	*Pymanthus pulcher*	PORIFERA	*Dictyonella incisa*
CNIDARIA	*Savalia savaglia*	PORIFERA	*Disydea avara*
CNIDARIA	*Scleractinia n.i.*	PORIFERA	*Disydea fragilis*
CRUSTACEA	*Alphaeus* cf. *glaber*	PORIFERA	*Geodia cydonium*
CRUSTACEA	*Alpheidae*	PORIFERA	*Haliclona fulva*
CRUSTACEA	*Amphipoda 1*	PORIFERA	*Haliclona mucosa*
CRUSTACEA	*Amphipoda 2 (damaged)*	PORIFERA	*Hexadella racovitzai*
CRUSTACEA	*Diogenidae 1*	PORIFERA	*Ircinia oros*
CRUSTACEA	*Eriphia spinifrons*	PORIFERA	*Ircinia variabilis*
CRUSTACEA	*Hyppolitidae 1*	PORIFERA	*Petrosia ficiformis*
CRUSTACEA	*Isopoda* sp.	PORIFERA	*Poecilosclerida* spp.
CRUSTACEA	*Liocarcinus* sp.	PORIFERA	*Porifera n.i.*
CRUSTACEA	*Maya squinado*	PORIFERA	*Sarcotragus cfr. foetidus*
CRUSTACEA	*Mysidacea* sp.	PORIFERA	*Sarcotragus spinosulus*
CRUSTACEA	*Palaemonidae 1*	PORIFERA	*Spirastrella cunctatrix*
CRUSTACEA	*Penaeidae 1*	PORIFERA	*Spongia officinalis*
CRUSTACEA	*Penaeidae 2*	PORIFERA	*Suberitidae n.i.*
CRUSTACEA	*Periclimenes amethysteus*	PORIFERA	*Tethya aurantium*
CRUSTACEA	*Periclimenes scriptus* cfr.	PORIFERA	*Tethya citrina*
CRUSTACEA	*Tanaidacea unid.*	RHODOPHYTA	*Asparagopsis taxiformis*
ECHINODERMATA	*Amphiura chiajei*	RHODOPHYTA	*Botryocladia* sp.
ECHINODERMATA	*Amphiura filiformis*	RHODOPHYTA	*Corallinales n.i.*
ECHINODERMATA	*Amphiuridae juv. unid.*	RHODOPHYTA	*Hydrolithon* sp.
ECHINODERMATA	*Antedon mediterranea*	RHODOPHYTA	*Jania rubens*
ECHINODERMATA	*Centrostephanus longispinus*	RHODOPHYTA	*Lithophyllum racemus* cfr.
ECHINODERMATA	*Echinaster sepositus*	RHODOPHYTA	*Lithophyllum stictaeforme*
ECHINODERMATA	*Holoturia tubulosa*	RHODOPHYTA	*Mesophyllum adherens*
ECHINODERMATA	*Labidoplax digitata*	RHODOPHYTA	*Mesophyllum expansum*
ECHINODERMATA	*Marthasterias glacialis*	RHODOPHYTA	*Peyssonelia* cfr. *polymorpha*
ECHINODERMATA	*Ophiotrix fragilis*	RHODOPHYTA	*Peyssonelia rosa-marina*
ECHINODERMATA	*Ophiotrix* sp.	RHODOPHYTA	*Peyssonelia rubra*
ECHINODERMATA	*Ophiura albida*	RHODOPHYTA	*Peyssonelia* sp.
ECHINODERMATA	*Ophiuridae juv. unid*	RHODOPHYTA	*Rhodophyta n.i.*
ECHINODERMATA	*Sphaerechinus granularis*	RHODOPHYTA	*Sphaerococcus coronopifolius* cfr.
ECHINODERMATA	*Trachytione elongata*	SIPUNCULA	*Sipunculidae unid.*
ECHIURA	*Bonellia viridis*	TUNICATA	*Diplosoma spongiforme*
MAGNOLIOPHYTES	*Cymodocea nodosa*	TUNICATA	*Halocynthia papillosa*
MAGNOLIOPHYTES	*Nanozostera noltii*	TUNICATA	*Microcosmus* sp.
MAGNOLIOPHYTES	*Posidonia oceanica*	TUNICATA	*Phallusia fumigata*

Table 5: number of taxa found on hard bottom and soft bottom and total number of taxa found in Boka Kotorska Bay

Taxa	Hard Bottom	Soft Bottom	TOT. Hard and Soft Bottom
ANNELIDA	8	30	38
BRYOZOA	10	0	10
CEPHALOCHORDATA	0	1	1
CHLOROPHYTA	6	0	6
CNIDARIA	22	0	22
CRUSTACEA	7	11	17
ECHINODERMATA	7	8	15
ECHIURA	1	0	1
MAGNOLIOPHYTES	4	0	4
MOLLUSCA	21	25	46
NEMERTINA	0	1	1
PHAEOPHYCEAE	7	0	7
PLATYHELMINTES	1	0	1
PORIFERA	37	0	37
RHODOPHYTA	15	0	15
SIPUNCULA	0	1	1
TUNICATA	4	0	4
TOT. Taxa	**150**	**77**	**226**

The stations on hard bottom showed in general a higher number of taxa compared to stations in soft bottom. The hard bottom data reported in Table 6 must be considered with caution because the quadrat survey was not performed in all hard bottom stations and in some stations more than one scuba diving survey was carried out at different depths.

In any case the stations DIP03-DIP05 situated in Sveti Dorde (83 taxa) and the stations DIP09-DIP11 in Verige (72 taxa), had the highest number of taxa. Considering soft bottom stations, VVG05 (37 m in the central part of the strait) was the one with more taxa (39 taxa), followed by VVG09 (37 m in front of Perast in the central part of the bay) (23 taxa).

The qualitative list of molluscs of the bay, which counts 46 species inventoried during the present study, can be further improved by adding additional 25 dead species sampled. These species were not inserted in the previous lists and tables because they could be associated with biocoenoses distributed in the bay in recent past and no longer present in the area.

Nevertheless these species were classified to add further information to the knowledge of the bay's ecology. The list is available in Table 7.

Table 6: Total number of taxa found in hard and soft bottom sampling stations

Taxa	Tot.
DIP01-DIP10	42
DIP03-DIP05	83
DIP04	49
DIP06	64
DIP07-DIP08	8
DIP09-DIP11	72
Posidonia meadow	4
Tot. Hard Bottom	**149**
VVG01	20
VVG02	5
VVG03	21
VVG04	15
VVG05	39
VVG06	8
VVG07	9
VVG08	10
VVG09	23
VVG10	14
VVG11	7
VVG12	21
VVG13	16
VVG14	11
VVG15	18
Tot. Soft Bottom	**77**
TOT Hard and Soft Bottom	**226**

Table 7: Boka Kotorska Bay sea shell found in sediment. (Identified by Mauro Doneddu)

Class	Species
GASTROPODA	*Acteon tornatilis*
	Aporrhaiidae
	Bittium scabrum
	Bolinus brandaris
	Calyptraea chinensis
	Cerithidium submamillatum
	Clelandella miliaris
	Eulima glabra
	Mangelia attenuata
	Mangelia unifasciata
	Raphitoma aequalis
	Ringicula auriculata
	Turritella turbona
BIVALVIA	*Anadara transversa*
	Chama gryphoides
	Clausinella fasciata
	Diplodonta rotundata
	Flexopecten glaber
	Lucinoma boreale
	Mimachlamys varia
	Modiolus adriaticus
	Plagiocardium papillosum
	Spaniorinus reconditus
	Tellina crassa
	Timoclea ovata

3.2.3.1 Soft bottom benthos species: the analysis of the grab samples

The 77 taxa sampled on soft bottom in the 15 stations investigated have been used to classify the biocoenoses of muddy and sandy bottoms of the bay (see paragraph 3.2.4). Table 8 reports the number of specimens sampled in each station and the ecological indications given by some of the classified species.

Table 8: Species sampled in soft bottom by grab with ecological indication and number of specimens for each station

Phylum/SubPhylum	Species	Ecol. Indic.*	VVG01	VVG02	VVG03	VVG04	VVG05	VVG06	VVG07	VVG08	VVG09	VVG10	VVG11	VVG12	VVG13	VVG14	VVG15
ANNELIDA	Ampharetidae 1											1					
ANNELIDA	Capitellidae 1						1					3					
ANNELIDA	*Chaetozone* sp.														1		
ANNELIDA	Cirratulidae 1											1					
ANNELIDA	Dorvilleidae 1						2										1
ANNELIDA	*Eunice* sp.		9				3				2						
ANNELIDA	*Marphysa bellii*	Vas. Tol.	3				12										
ANNELIDA	*Nematonereis unicornis*	Lre	9				25			2	1						
ANNELIDA	Eunicidae 1		5				1							1			
ANNELIDA	Flabelligeridae 1														1		
ANNELIDA	*Glycera* sp.		1			1					1						1
ANNELIDA	Lacydoniidae 1					1	3					2		1	3		1
ANNELIDA	*Lumbrineris latreilli*	Lre, DL pref.	2				1										
ANNELIDA	*Lumbrineris* cf. *tetraurata*						1										
ANNELIDA	*Lumbrineris* sp.		4		1	5	7			1			1	4	1	1	2
ANNELIDA	Maldanidae 1		1				1				4	1	1	2	1		
ANNELIDA	Nephtydae 1			1	3		1	1			4		1	2	5		5
ANNELIDA	Onuphiidae 1					2				3							
ANNELIDA	*Onuphis conchylega*						2				16						
ANNELIDA	Oweniidae 1						2			2	1						
ANNELIDA	Paraonidae 1		1		4		7	1				3		3	1		
ANNELIDA	Pilargidae 1						1					1					
ANNELIDA	Polynoidae 1												1	1			
ANNELIDA	Serpulidae 1									1							
ANNELIDA	*Sthenolepis* sp.															1	2
ANNELIDA	Sigalionidae 1				1		2				4	2		3		1	1
ANNELIDA	Spionidae 1		2				1			1	1						
ANNELIDA	*Sternaspis scutata*	VTC excl.									1			1		3	
ANNELIDA	Syllidae 1		2		1		6				1			1	1		
ANNELIDA	Terebellidae 1		1	3	1	2	2	1						1	1	3	
NEMERTINA	Nemertina unid.											2	1	2			1
SIPUNCULA	Sipunculidae unid.						4										
CRUSTACEA	Palaemonidae 1				11									1			
CRUSTACEA	Palaemonidae 2																
CRUSTACEA	*Alphaeus* cf. *glaber*		1				13							1			9
CRUSTACEA	Alpheidae								3								3
CRUSTACEA	Hyppolitidae 1		2		1												
CRUSTACEA	Amphipoda 1				1		3		1					1			
CRUSTACEA	Amphipoda 2 (damaged)				4				2			2					
CRUSTACEA	Diogenidae 1				1											1	
CRUSTACEA	Penaeidae 1																3
CRUSTACEA	Penaeidae 2						1										
CRUSTACEA	*Tanaidacea unid.*						1					1		1		1	
CRUSTACEA	*Isopoda unid.*				1						1		1				

Phylum/SubPhylum	Species	Ecol. Indic.*	VVG01	VVG02	VVG03	VVG04	VVG05	VVG06	VVG07	VVG08	VVG09	VVG10	VVG11	VVG12	VVG13	VVG14	VVG15
CEPHALOCHORDATA	*Branchiostoma lanceolatum*									1							
ECHINODERMATA	*Amphiura chiajei*	Vas. Tol.	1		2	1	7	1				2		3	1		
ECHINODERMATA	*Amphiura filiformis*	Lre															4
ECHINODERMATA	Amphiuridae juv. unid.						1	2									
ECHINODERMATA	*Ophiotrix fragilis*	DE, Lre															1
ECHINODERMATA	*Ophiura albida*	DC pref., SV	1														
ECHINODERMATA	Ophiuridae juv. unid											4					
ECHINODERMATA	*Labidoplax digitata*	VTC excl.					1	1							1		
ECHINODERMATA	*Trachytione elongata*	VTC, Vas. Tol.			1	1	2										
MOLLUSCA	*Barbatia barbata*					1								1			
MOLLUSCA	*Acanthocardia paucicostata*	VTC excl.										1					
MOLLUSCA	*Parvicardium minimum*	Mixt.									3			1			
MOLLUSCA	*Corbula gibba*	Lre, FMI		2	9		1	16	14								
MOLLUSCA	*Cuspidaria cuspidata*										1			7	4	1	4
MOLLUSCA	*Myrtea spinifera*	Lre			2												
MOLLUSCA	*Mactra corallina*						2										
MOLLUSCA	*Kurtiella bidentata*	VTC excl.			1				5								
MOLLUSCA	*Nucula nitidosa*	Ind. Inst.,			7	2											
MOLLUSCA	*Nucula nucleus*	VTC, SV	11	1			3				1						
MOLLUSCA	*Nucula sucata*	VL, Vas. Str.				2	1										3
MOLLUSCA	*Nuculana pella*					2		1		2					1		
MOLLUSCA	*Azorinus chamasolen*	Mixt.							2								1
MOLLUSCA	*Tellina distorta*	FMI excl.			1	1			1								
MOLLUSCA	*Tellina tenuis*	SFHN					1							3		2	
MOLLUSCA	*Thyasira flexuosa*	Vas. Str., VTC pref.														1	
MOLLUSCA	*Pitar rudis*	DC pref.					1		1		1	1					1
MOLLUSCA	*Timoclea ovata*	Mixt., Lre					2										
MOLLUSCA	*Aporrhais pespelecani*	Mixt., DC, DL				1											
MOLLUSCA	*Rissoa splendida*									3							
MOLLUSCA	*Euspira macilenta*	Lre	1	1											1		
MOLLUSCA	*Nassarius pygmaeus*		1														
MOLLUSCA	*Alvania* cf. *lineata*						1										
MOLLUSCA	*Antalis inaequicostata*	Mixt.	1		2	3	1			3					2	1	
MOLLUSCA	*Dischides politus*	FMI, Ind. Inst.			10	3	2		3		2		1		3		1

Legend *		Legend *	
DC	Coastal Detritic Bottoms	Vas. Str.	Muddy Bottoms only
DE	Muddy Detritic Bottoms	Vas. Tol.	Muddy Bottoms tolerant
DL	Deep-sea Detritic Bottoms	VL	Deep-sea Muddy Bottoms
FMI	Instable Soft Bottoms	VTC	Coastal Terrigenous Muds
Ind. Inst.,	Indicator of Instability	excl	Exclusively
Lre	Large Ecological Distribution	pref	Preferentially
Mixt.	Mixticole		
SFHN	Shallow Water Sands		
SV	Muddy Sands		

The average number of species per station was 15.5 ± 8.1, the highest number of species was found in station VVG05 (39 species) and the lowest in VVG11 (7 species). The number of individuals found in each station varied between 129 in VVG05 and 7 in VVG11, with an average of 38.1 ± 29.2.

A comparison between the species richness of each station was made and biodiversity indices were assessed for each station. The results are shown in Table 9.

Table 9: Biodiversity indices calculated for the soft bottom taxa assemblages identified in the sampling stations

Stations	Species N.	Ind. N	Margalef Index	Pielou Index	Shannon Index	Simpson Index
VVG01	20	59	4.66	0.86	3.72	0.09
VVG02	5	8	1.92	0.93	2.16	0.14
VVG03	21	65	4.79	0.86	3.77	0.08
VVG04	15	28	4.20	0.95	3.70	0.06
VVG05	39	129	7.82	0.85	4.48	0.07
VVG06	8	24	2.20	0.61	1.83	0.44
VVG07	9	32	2.31	0.80	2.55	0.22
VVG08	10	19	3.06	0.96	3.18	0.07
VVG09	17	45	4.20	0.82	3.34	0.14
VVG10	15	27	4.25	0.96	3.74	0.05
VVG11	7	7	3.08	1.00	2.81	0.00
VVG12	21	41	5.39	0.93	4.07	0.05
VVG13	16	28	4.50	0.92	3.70	0.06
VVG14	11	16	3.61	0.95	3.28	0.06
VVG15	18	44	4.49	0.90	3.77	0.07

Species richness (Margalef, 1958) index takes into account the ratio between the total number of identified species and the total number of counted individuals in the community, hence being directly proportional to the number of species and their distribution. This index shows values ranging between 7.82 in VVG05 and 1.92 in VVG02 (average 4.03 ± 1.43).

Diversity Index (Shannon-Weaver, 1949) takes into account both the number of species in the sample and the number of individuals per species. This index shows values between 4.48 in VVG05 and 1.83 in VVG06 (average value 3.34 ± 0.70). In the Mediterranean Sea it generally ranges from 1.5 to 3.5 – the upper part of the interval indicating well structured communities. Therefore the results indicate that communities in the study area are quite rich in species and well structured.

Pielou's Index assesses animals' distribution in the communities and assumes high values when species distribution is uniform in the sample, ranging between 0 and 1. In the study area the index ranges between 1 in VVG11, where 7 individuals of seven different species were found, and 0.61 in VVG06 (average 0.89 ± 0.09). In general, apart from VVG06, rather high values are present. The high value of station VVG11 is related more to the low number of species (with one individual each) than to a well distributed and structured community; considering the very low number of individuals it is difficult to evaluate its biodiversity.

Dominance Index (Simpson, 1949) measures the prevalence of a few species in the communities and has an inverse trend in comparison with Pielou's index. In the sampling locations the index was always quite low, indicating well structured and balanced communities. The only exception was the sampling point VVG06 with a value of 0.44.

In general the data on biodiversity indeces reveal that the stations VVG06, VVG07 and VVG02, located in the western part of the bay, score among the lowest values, while the station VVG05 located in the Verige strait has the highest scores.

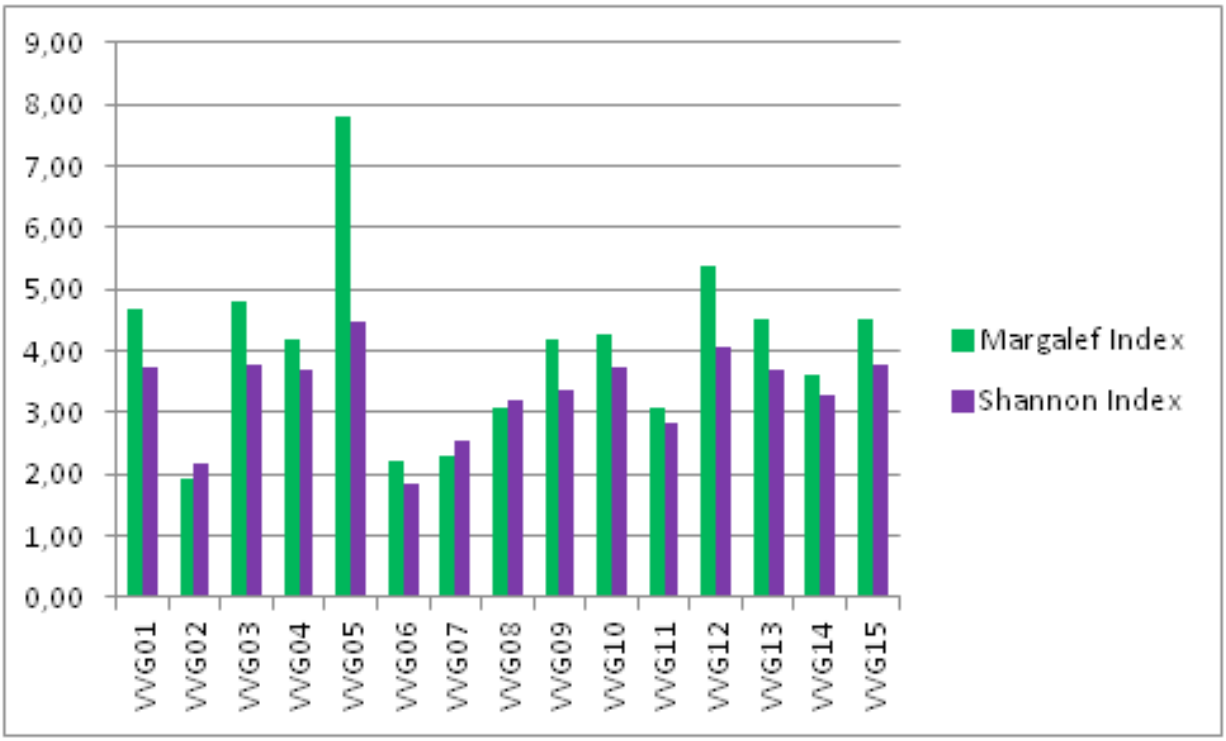

Figure 15: Species richness index (Margalef, 1958) and diversity index

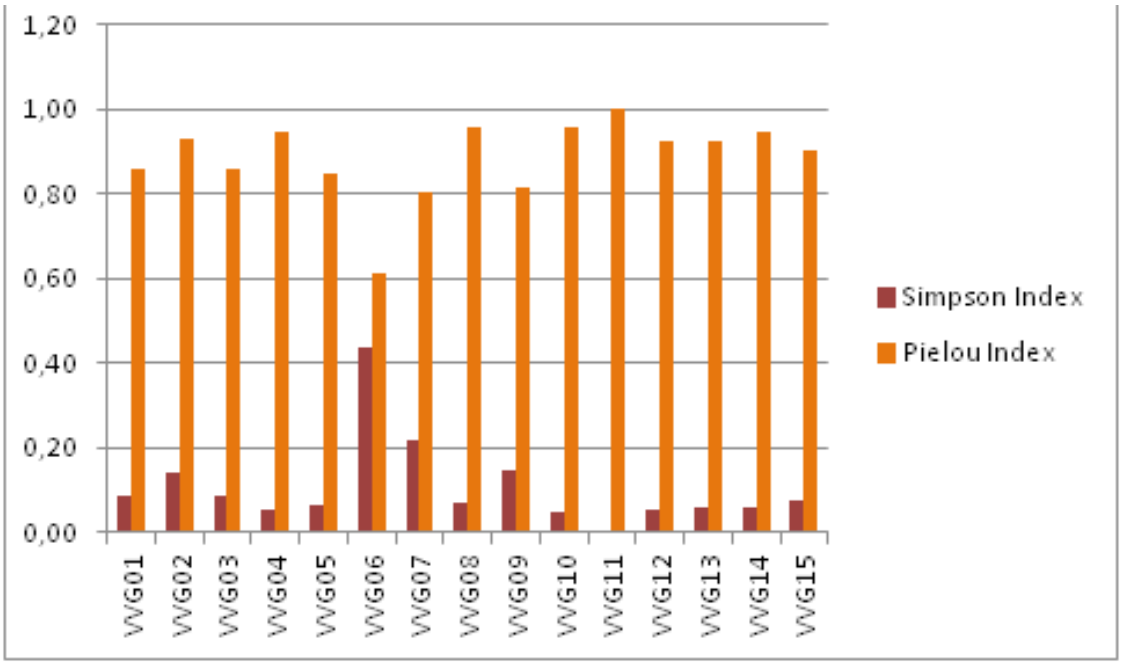

Figure 16: Dominance index (Simpson, 1949) and Pielou's index for the soft bottom sampling stations

Table 10: Biocenosis and depth for each soft bottom sampling station

VVG	Class	Biocenosis	Depth m
VVG01	DE	Biocenosis of muddy detritic bottoms	-14
VVG02	VTC	Biocenosis of coastal terrigenous muds	-30
VVG03	VTC	Biocenosis of coastal terrigenous muds	-26
VVG04	VTC_I	VTC with indication of instable conditions	-18
VVG05	VTC	Biocenosis of coastal terrigenous muds	-36
VVG06	VTC	Biocenosis of coastal terrigenous muds	-32
VVG07	VTC	Biocenosis of coastal terrigenous muds	-36
VVG08	MS_VTC	Mosaic of MS and VTC	-28
VVG09	C_VTC	Mosaic of C and VTC	-38
VVG10	VTC	Biocenosis of coastal terrigenous muds	-36
VVG11	FMI	Biocenosis of Instable soft bottoms	-24
VVG12	VTC_I	VTC with indication of instable conditions	-24
VVG13	VTC_I	VTC with indication of instable conditions	-30
VVG14	VTC_I	VTC with indication of instable conditions	-16
VVG15	VTC_I	VTC with indication of instable conditions	-22

3.2.3.2 Hard bottom benthos populations: the analysis of the quadrats

The macrobenthos assemblages of 5 stations were studied in detail using the quadrats method. The photos of each quadrat and the tables with data of the analysis are available in APPENDIX F. As example two photos of quadrats are reported in Figure 17.

Algae, Cnidaria and Porifera are the most abundant taxa found in the studied hard benthic communities. Vegetated coverage range between 43 % of the quadrats in the Drazin Vrt site and 11 % of the examined surfaces in Sv. Dorde. It is important to note that no significant presence of Pheophyceae was recorded and that the vegetation present is mainly incrustant or with a small tallus.

In Drazin Vrt Cnidaria have the maximum coverage, colonizing about 30 % of the examined areas. This value is relatively high in comparison with other sites and is probably related to the presence of an important facies of *Savalia savaglia* and *Leptogorgia sarmentosa* species. Mininum value of Cnidarian surface coverage was recorded in Godspa od Skarpjela and in STRP (respectively 5 % and 6 %).
The surface covered by Porifera species range between 8 % in DrazinVrt and 41 % in Sv. Dorde.

In all sites a wide variety of species of different size and shape was found.
Other taxa (Mollusca, Briozoa, Tunicata, Echinodermata and Pisces) were recorded, but they cover a small portion of the quadrats.

In three of the sites (HBQ03, HBQ04 and HBQ05) coral rubble (area of accumulation) were found. Remarkably, in three of the five sites, garbage was photographed in the quadrats' area.

Table 11: Bottom cover percentage

	HBQ01 - DrazinVrt		HBQ02 - SV. Dorde		HBQ03 - Godspa od Skarpjela		HBQ04 - STRP		HBQ05 - Verige	
Bottom Cover Type	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Algae	43	35	11	7	26	28	25	22	29	14
Cnidaria	30	31	13	8	5	5	6	8	7	6
Porifera	8	8	41	12	9	8	21	22	17	17
Polychaeta							1	2		
Briozoa	0	0	0	1					1	1
Tunicata			0	1	1	1	0	1	0	0
Echinodermata						21	0	1		
Soft Bottom	11	22	30	18	55	12	28	16	40	13
Bare stones and pebbles									1	3
Organic detritus					4	1	1	2	1	4
Coral rubble					0	0	2	5	1	3
Garbage	5	9	0	1	0					
Surface not taken into account because not usable (dark or clear)	4	6	4	5			15	10	2	6

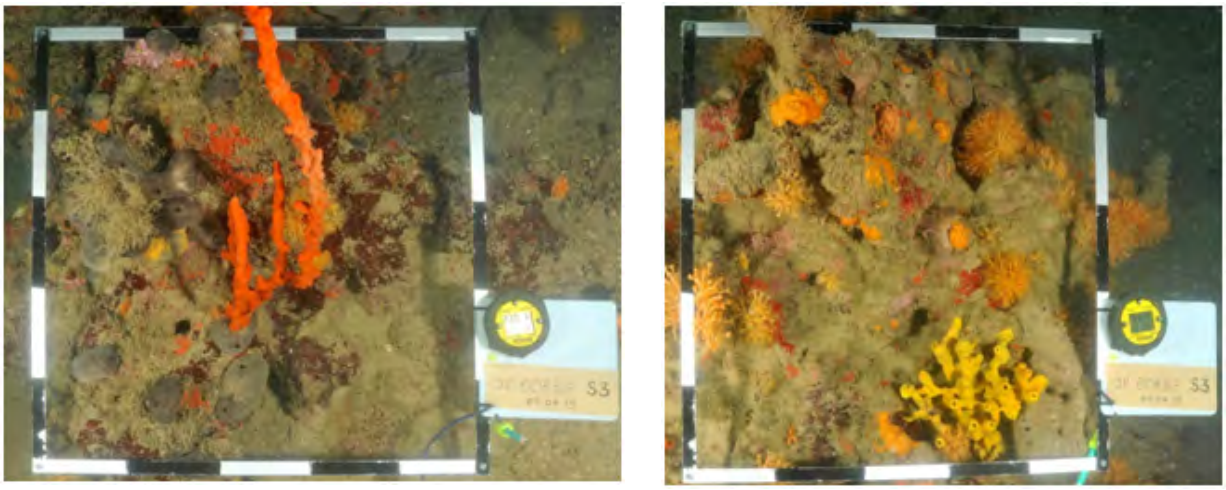

Figure 17: Examples of hard bottom quadrats

3.2.4 Inventory and spatial distribution of benthic habitats

The largest part of the seabed of the bay (more than 87% of the surface) is covered by the biocenosis of coastal terrigenous muds (VTC). Biocoenosis of Muddy Detritic bottoms (2%) and Muddy Sands cover other small portions of the seabed of the bay.

Photophilous algae are present in Kotor Bay only in limited portions of the shoreline and, due to the low water transparency, only in the first few meters of the upper infralittoral zone. Given the scale of the map (1:5000) is not possible to map the presence of photophilous Algae as a separate biocenosis.

Biocenosis of Sciaphilous algae is widely distributed in the inner part of the Bay. In most cases, given the complex geomorphology of the seafloor (e.g. hard and soft substrata, natural and artificial ones, slope of the seabed) this habitat is present in mosaic within other biocenosis. In the Northern and the Western part of the Bay, the seabed is characterized by natural substrata with high slopes, Sciaphilous algae colonize the first 8-10 m of the infralittoral.

Coralligenous habitats cover about 2% of the surface of the bottom. This important habitat is present in 5 localities (Strp, Perast, to the west of Perast, around the small islands of Sveti Dorde and Gospa od Skrpjela and Drazin Vrt).

Other small Coralligenous assemblages are located in the central and northern part of the bay. The Coralligenous assemblage is sometimes in mosaic with Sciafilous Algae or with VTC. The facies with *Savalia savaglia* and *Leptogorgia sarmentosa* (belonging to coralligenous) is present in the site of Drazin Vrt, where it covers an area of about 5,000 m^2 corresponding to about 0,02% of the seabed of the bay. The seagrass habitats cover 0,15% of the seabed. Seagrass are present in 4 coastal sites. One of these localities (Dobrota) is interested by the presence of *Posidonia oceanica* (about 21.000 m^2).

25 Deep holes with possible presence of living Cladocora aggregation are located mainly in the central part of the bay, close to the northern coast. A map of marine habitats of the bay (scale 1:5.000) is available in the GIS. The map is reported also in APPENDIX I at scale 1:15.000. Detailed maps at scale 1:2.000, relative to 5 localities, characterized by the presence of sensitive habitats, are available in the GIS (Figure 18).

Table 12: Biocenosis present in the area

Class	Habitats Description	Area m^2	Area%
BS	Biocenosis of Sciaphilous algae	135267	0.52
BS_C	Mosaic of BS and C	180060	0.69
BS_MS	Mosaic of BS and MS	3873	0.01
BS_VTC	Mosaic of BS and VTC	81329	0.31
C	Coralligenous biocenosis	153390	0.59
C_Sav-Lept	Mosaic of Facies with *Savalia savaglia* (dominant) and Facies with *Leptogorgia sarmentosa*	5109	0.02
C_VTC	Mosaic of C and VTC	156894	0.60
CYM	*Cymodocea nodosa* meadow	5170	0.02
CYM-NAN-ZOS	Mixed meadow composed by *Cymodocea nodosa*, *Nanozostera noltii* and *Zostera marina*	8280	0.03
DE	Biocenosis of muddy detritic bottoms	767970	2.94
DEP_CLA	Deep holes with possible presence of Cladocora species	47431	0.18
FMI	Biocenosis of Instable soft bottoms	529264	2.02
HP	*Posidonia oceanica* meadow	21000	0.08
HP_CYM	Mixed meadow composed by *Posidonia oceanica* and *Cymodocea nodosa*	1410	0.01
IP_BS_MS	Mosaic of Infralittoral stones and pebbles, BS and MS	970683	3.71
MS	Biocenosis of muddy sands in sheltered waters	8350	0.03
MS_VTC	Mosaic of MS and VTC	84457	0.32
PSA	Mosaic of Photophilous and Sciafilous Biocenoses	15833	0.06
VTC	Biocenosis of coastal terrigenous muds	11767389	45.01
VTC_CLAD	VTC with abundant presence of death Cladocora	188760	0.72
VTC_I	VTC with indication of instable conditions	10805314	41.33

Code	Human activities and infrastructures	Area m^2	Area%
AQ	Aquaculture farms	202700	0.78
ROPES	Ropes on the sea floor	1501	0.01

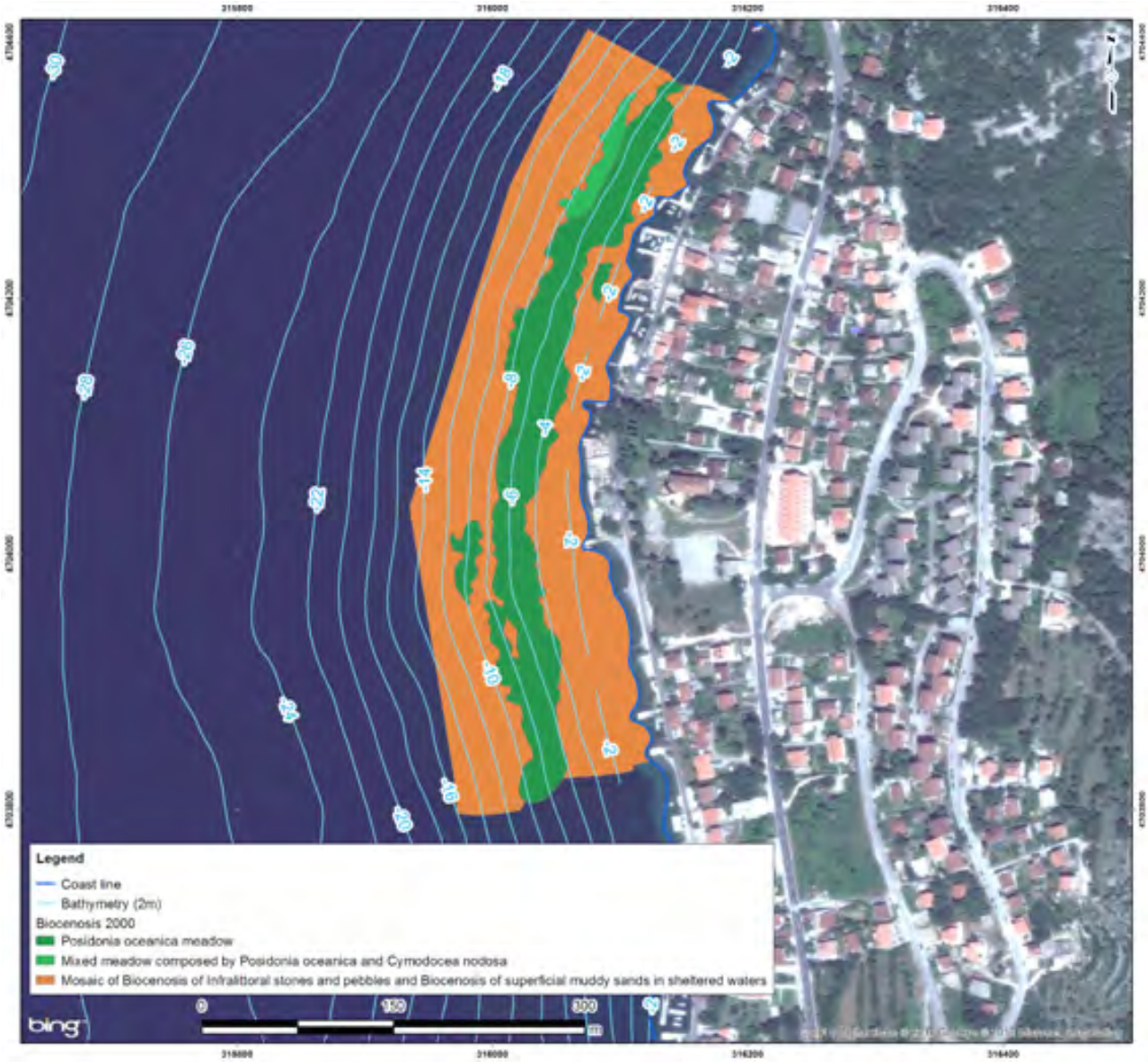

Figure 18: Example of detailed map 1:2000, available in the GIS

3.2.5 Fish population

A total of 59 fish species were identified as inhabiting the Boka Kotorska Bay. The qualitative general list was obtained using several data sources: fish visual census; scuba divers observation; fishery landing data; interviews with local fishermen (professionals and non professionals) (Table 13).

During the visual census a total of 23 species belonging to 7 families were identified and recorded. In addition, 12 other species were recorded outside the fish visual census transects survey. A total of 12 species, 10 of which not present in the visual census list or in the scuba divers observation, were reported during the fishery landing data survey. Finally other 15 species were added to the list thanks to interviews with local fishermen. Godidae is the most representative family with 11 species, followed by Labridae and Sparidae with 8 different species both. One species of the list (*Hippocampus hippocampus*) is included in Annex II of the SPA protocol; while the grouper *Ephinephelus marginatus* and the brown meagre *Sciaena umbra* are listed under Annex III.

Some species that are generally present as dominant species in the Mediterranean infra-littoral rocky bottom like *Coris julis, Thalassoma pavo, Apogon imberbis* seem absent (or perhaps are present but very rare) in the Boka Kotorska Bay.

Other species listed like the common sea bream (*Pagrus pagrus*) or the European seabass (*Dicentrarcus labrax*) are particularly abundant in specific periods of the year, respectively August-September and January-February. *P. pagrus* enter regularly into the Boka Kotorska Bay in abundant swarms at the end of the summer. Similar phenomena are described by local fishermen and scuba divers also for other Sparidae species.

The list below provides a general overview of the fish population of Boka Kotorska Bay. The following paragraph analyses the data from both the qualitative and the quantitative point of view, therefore it considers only the data obtained during the fish visual census.

Table 13: General list of fish inhabiting Boka Kotorska Bay

Family	Species	Visual Census	Scuba divers observation	Fishery landing data	Talks with local sea users
Blenniidae	*Parablennius gattorugine*		X		X
Blenniidae	*Parablennius rouxi*		X		
Callionymidae	*Callionymus cfr. risso*		X		
Carangidae	*Trachinotus ovatus*			X	
Carangidae	*Trachurus meditteraneus*			X	
Congridae	*Conger conger*				X
Clupeidae	*Sardina pilchardus*			X	
Engraulidae	*Engraulis encrasicolus*			X	
Gobiidae	Gobiidae sp.	X	X		
Gobiidae	*Gobius cfr. niger*		X		
Gobiidae	*Gobius cobitis*	X			
Gobiidae	*Gobius cruentatus*		X		
Gobiidae	*Gobius geniporus*		X		
Gobiidae	*Gobius* sp.		X		
Gobiidae	*Gobius vittatus*	X	X		

Family	Species	Visual Census	Scuba divers observation	Fishery landing data	Talks with local sea users
Gobiidae	*Gobius xanthocephalus*	X	X		
Gobiidae	*Pomatoschistus bathi*	X			
Gobiidae	*Thorogobius ephippiatus*	X			
Gobiidae	*Thorogobius macrolepis cfr.*		X		
Labridae	*Labrus merula*	X			X
Labridae	*Symphodus cinereus*	X	X		
Labridae	*Symphodus doderleni*	X			
Labridae	*Symphodus mediterraneus*	X	X		
Labridae	*Symphodus ocellatus*	X			
Labridae	*Symphodus roissali*	X			
Labridae	*Symphodus rostratus*	X			
Labridae	*Symphodus tinca*	X	X		
Merlucciidae	*Merluccius merluccius*			X	
Moronidae	*Dicentrarchus labrax*				X
Mugilidae	*Liza sp*				
Mugilidae	*Mugil sp*				X
Pomacentridae	*Chromis chromis*	X	X		
Pomacentridae	*Pomatoschistus cfr. quagga*		X		
Raijdae	*Raja sp*				X
Sciaenidae	*Sciaena umbra*				X
Scombridae	*Auxis rochei*			X	
Scombridae	*Sarda sarda*			X	
Scombridae	*Scomber japonicus*			X	
Scorpaenidae	*Scorpaena notata*		X		
Scorpaenidae	*Scorpaena porcus*	X			
Scorpaeninae	*Scorpaena scrofa*			X	
Serranidae	*Epinephelus marginatus*	X	X		
Serranidae	*Serranus cabrilla*	X			
Serranidae	*Serranus hepatus*	X	X		
Serranidae	*Serranus scriba*	X			
Sparidae	*Boops boops*	X	X	X	X
Sparidae	*Dentex dentex*				X
Sparidae	*Diplodus annularis*	X		X	X
Sparidae	*Diplodus puntazzo*				X
Sparidae	*Diplodis vulgaris*				X
Sparidae	*Pagellus erythrinus*			X	
Sparidae	*Pagrus pagrus*				X
Sparidae	*Sarpa salpa*				X
Syngnathidae	*Hippocampus hippocampus*				X
Trachinidae	*Trachinus sp*				X
Triglidae	*Trygloporus lastoviza*		X		X
Tripterygiidae	*Tripterygion delaisi*	X	X		
Tripterygiidae	*Trypterigion sp.*		X		
Uranoscopidae	*Uranoscopus scaber*				X
Zeidae	*Zeus faber*				X

3.2.5.1. Fish visual census stations

The census was performed in different areas at depths between -3 m and -27 m (FVC08 and FVC06 respectively).
Four types of stations were identified:

- Sponge, corals (Coralligenous formations) and mud characterise FVC07, FVC06 and FVC05;
- Mosaic with *Savalia savaglia* (dominant) and *Leptogorgia sarmentosa* (Coralligenous) characterize FVC04;
- Rocks, pebbles and dead Cladocora typify the stations FVC08 and FVC02;
- Posidonia meadow dominates in FVC03; and
- pebbles are the only sea bed typology in FVC01.

The presence of sponge and corals is positively correlated with the presence of mud on the sea floor (R=0.818; P<0.05) and both this parameters are positively correlated with sea depth (R=0.717; P<0.05).

Table 14: Environmental characteristics of survey point

	FVC01	FVC02	FVC03	FVC04	FVC05	FVC06	FVC07	FVC08
Depth (m)	5	15	8.5	16	24	27	18	3
S.savaglia facies	0	0	0	30	0	0	0	0
Sponge and corals	0	0	0	20	30	40	60	0
Mud	0	0	0	50	70	60	40	10
Pebbles	100	50	0	0	0	0	0	25
Dead Cladocora	0	30	0	0	0	0	0	55
Rocks	0	20	0	0	0	0	0	10
Posidonia meadow	0	0	100	0	0	0	0	0

3.2.5.2. Fish visual census data

A total of 678 specimens were identified, belonging to 23 species and 7 families. The most common species inhabiting the shallow water of the bay are the striped goby (*Gobius vittatus*), followed by the grey wrasse (*Symphodus cinereus*) and the brown comber (*Serranus hepatus*). These 3 species were found in the main part of the surveyed locations. Other rather common species inhabiting different habitats in the bay are the yellow-headed goby (*Gobius xanthocephalus*), the axillary wrasse (*Symphodus mediterraneus*), the damsel fish (*Chromis chromis*) and the painted comber *(Serranus scriba*).

Figure 19: *Serranus hepatus* and *Gobius vittatus,* two of the most common species of the bay

Table 15: Frequency of observed species

Family	Species (scientific name)	Species (common name)	% Freq
Gobiidae	*Gobius cobitis*	Giant goby	25,0
Gobiidae	*Gobius vittatus*	Striped goby	87,5
Gobiidae	*Gobius xanthocephalus*	Yellow-headed goby	62,5
Gobiidae	*Pomatoschistus bathi*	Bath's Goby	12,5
Gobiidae	*Thorogobius ephippiatus*	Leopard-spotted goby	12,5
Labridae	*Labrus merula*	Brown wrasse	25,0
Labridae	*Symphodus cinereus*	Grey wrasse	75,0
Labridae	*Symphodus doderleni*	-	25,0
Labridae	*Symphodus mediterraneus*	Axillary wrasse	62,5
Labridae	*Symphodus ocellatus*	Ocellated wrasse	12,5
Labridae	*Symphodus roissali*	Five-spotted wrasse	25,0
Labridae	*Symphodus rostratus*	Pointed- snout wrasse	12,5
Labridae	*Symphodus tinca*	Peacock wrasse	50,0
Pomacentridae	*Chromis chromis*	Damsel fish	62,5
Scorpaenidae	*Scorpaena porcus*	Black scorpionfish	25,0
Serranidae	*Ephinephelus marginatus*	Dusky grouper	12,5
Serranidae	*Serranus cabrilla*	Comber	12,5
Serranidae	*Serranus hepatus*	Brown comber	75,0
Serranidae	*Serranus scriba*	Painted comber	62,5
Sparidae	*Boops boops*	Bogue	12,5
Sparidae	*Diplodus annularis*	Annular seabream	25,0
Tripterygiidae	*Tripterygion delaisi*	Black-faced blenny	25,0

Considering the number of species, the most common families found were the Labridae (8 species) followed by the Gobiidae (6 species).

The most abundant species was *Chromis chromis* (Pomacentridae), while *Gobius vittatus* (Gobiidae) and *Serranus hepatus* (Serranidae) were also quite abundant.

The average species diversity observed (medium value among 8 stations) is 8,25 species/375 m^2. This value confirms the low fish diversity already observed by Badalamenti and Treviño-Otón (2012) inside the bay (4.7 species/250m^2 at Iza Perasta and 9.3 species/250m^2 at Dražin Vrt).

Available data for the Mediterranean Sea show a higher level of species diversity in other coastal area e.g. García-Charton *et al.* 2004 observed 15 species/250m^2 on average and Treviño-Otón & García-Charton (unpublished data 2009) detected 15.1 species/250m m^2.

Considering the number of individuals, on average 28.25 ind/125m^2 were found. The most common families found during the transect survey were the Gobiidae family (8.67 ind/125m^2) and the Pomacentridae family (7.33 ind/125m^2);

In order to obtain comparable data with other fish abundance values observed in the Mediterranean, the density can be related to 250 m^2; the average value observed in the bay is 56.5 ind./250 m^2 (total abundance), which is considerably low compared to the fish abundance observed in other areas.

Available data in literature differ between total and reduced abundances. Total abundance includes all the specie and reduced abundances excludes the shoaling species (e.g. *C.chromis*, *B. Boops*). Guidetti (2002) along the Apulian coast observed a total abundance of 818 ind./250m^2 and reduced abundance of 95 ind./250m^2; Bonaca and Lipej (2005) registered abundance of 91,2 ind./250m2 and reduced abundance of 72,3 ind./250m^2.

Of the fishes observed, 89% were classified as adult and only 11% as subadult. Only one individual (*Diplodus annularis*) was classified as juvenile. Sub-adult individuals were documented for 10 species of the 23 recorded. The species with the highest percentage of subadult were mainly Labridae: *Symphodus roissali* 54%, *Symphodus doderleni* 50%, *Symphodus tinca* 40%, *Symphodus ocellatus* 33%, *Serranus cabrilla* 33% and *Symphodus cinereus* 29% (Table 17).

Table 16: Transect survey: fish number and classes for each species

Family	Species	N. ind/125 m^2	% Juveniles	% Subadult	% Adult
Gobiidae	Gobidae n.c.	0.67	0.0	0.0	100.0
Gobiidae	*Gobius cobitis*	0.13	0.0	0.0	100.0
Gobiidae	*Gobius vittatus*	3.67	0.0	0.0	100.0
Gobiidae	*Gobius xanthocephalus*	1.92	0.0	10.9	89.1
Gobiidae	*Pomatoschistus bathi*	2.25	0.0	0.0	100.0
Gobiidae	*Thorogobius ephippiatus*	0.04	0.0	0.0	100.0
Labridae	*Labrus merula*	0.08	0.0	0.0	100.0
Labridae	*Symphodus cinereus*	0.88	0.0	28.6	71.4
Labridae	*Symphodus doderleni*	0.33	0.0	50.0	50.0
Labridae	*Symphodus mediterraneus*	0.67	0.0	6.3	93.8
Labridae	*Symphodus ocellatus*	0.13	0.0	33.3	66.7
Labridae	*Symphodus roissali*	1.63	0.0	53.8	46.2
Labridae	*Symphodus rostratus*	0.04	0.0	0.0	100.0
Labridae	*Symphodus tinca*	2.17	0.0	40.4	59.6
Pomacentridae	*Chromis chromis*	7.33	0.0	0.0	100.0
Scorpaenidae	*Scorpaena porcus*	0.08	0.0	0.0	100.0
Serranidae	*Epinephelus marginatus*	0.04	0.0	0.0	100.0
Serranidae	*Serranus cabrilla*	0.13	0.0	33.3	66.7
Serranidae	*Serranus hepatus*	2.67	0.0	6.3	93.8
Serranidae	*Serranus scriba*	0.42	0.0	0.0	100.0
Sparidae	*Boops boops*	1.25	0.0	0.0	100.0
Sparidae	*Diplodus annularis*	1.67	2.5	20.0	77.5
Tripterygiidae	*Tripterygion delaisi*	0.08	0.0	0.0	100.0
	Tot.	-	**0.1**	**10.6**	**89.2**

3.2.5.3. Fish assemblages per stations

The locations with the highest number of individuals were FVC03 (Posidonia meadow) and FVC04 (Coralligenus with the facies dominated by the false black coral *S. savaglia*), while FVC05 and FVC08 had the lowest number of individuals. The highest total number of species was recorded in FVC07 and FVC04: considering the mean values per transects FVC07 had the highest number of species (8.0 species), also FVC02 and FVC04 had quite high values (6.7 and 6.0 species respectively). The lowest total number of species was found in FVC05, FVC08 and FVC03. Considering species mean, the lowest values were found in FVC08 (3.3 species per transect) FVC06 (4.0 species per transect) and FVC05 (4.3 species per transect).

Table 17: fish assemblages features for stations

Stations	individuals/125 mq	species/125 mq	Tot. No species/Station
FVC01	26.00 ± 5.35	5.3 ± 0.5	8
FVC02	28.67 ± 17.25	6.7 ± 1.2	10
FVC03	47.33 ± 23.61	5.3 ± 1.2	6
FVC04	46.67 ± 10.87	6.0 ± 1.4	11
FVC05	12.33 ± 3.86	4.3 ± 0.5	5
FVC06	23.00 ± 11.52	4.0 ± 1.4	7
FVC07	25.33 ± 9.88	8.0 ± 1.4	13
FVC08	16.67 ± 3.40	3.3 ± 0.9	6

The highest presence of subadult was found in station FVC03 (Posidonia meadow) and FVC01 (shallow water station, hard bottom with pebbles) and FVC05 (coralligenous and mud). The number of subadult species per transect are positively correlated with the presence of Posidonia meadow (R=0.788; P<0.05).

Table 18: Fish assemblage classes summary for each survey point

	J				S				A			
Stations	Tot.	Mean	St.dev.	%	Tot.	Mean	St.dev.	%	Tot.	Mean	St.dev.	%
FVC01	0	0.00	0.00	0.00	22	7.33	6.34	28.21	56	18.67	3.86	71.79
FVC02	0	0.00	0.00	0.00	0	0.00	0.00	0.00	86	28.67	17.25	100.00
FVC03	1	0.33	0.47	0.70	33	11.00	4.55	23.24	108	36.00	25.73	76.06
FVC04	0	0.00	0.00	0.00	3	1.00	0.00	2.14	137	45.67	10.87	97.86
FVC05	0	0.00	0.00	0.00	11	3.67	0.47	29.73	26	8.67	3.40	70.27
FVC06	0	0.00	0.00	0.00	2	0.67	0.94	2.90	67	22.33	11.67	97.10
FVC07	0	0.00	0.00	0.00	1	0.33	0.47	1.32	75	25.00	9.42	98.68
FVC08	0	0.00	0.00	0.00	0	0.00	0.00	0.00	50	16.67	3.40	100.00

The cluster analysis conducted to compare the 8 investigated stations shows 3 main fish assemblages:

- Posidonia meadow fish assemblages (FVC03) ;
- fish assemblages associates to the *S. savaglia* facies (FVC04)
- fish assemblages of the area typified by other hard substrata (pebbles, dead Cladocora, rocky) with presence of muddy bottom or without muddy bottom, colonized or not by sponges and corals (excluding *S. savaglia*) (FVC01, FVC02, FVC05, FVC06, FVC07, FVC08).

The features of the 3 fish assemblages identified in the coastal area of the Boka Kotorska Bay are represented in the figures below. These assemblages can be considered representatives of the spring season while in other seasons the composition of fish population can be different.

The species *P. bathi* (38%), *S. roissali* (27%) and *D. annularis* (26%) dominate the population in the Posidonia meadow. The fish assemblages associated to the *S. savaglia* facies is dominated by *C. chromis* (60%) and *B. boops* (21%), followed by *G. vittatus* (6%) and *S. hepatus* (5%), while fish assemblage of the other areas (pebbles, dead Cladocora, rocky) is characterized by *C. chromis* (23%), *G. vittatus* (20%), *S. hepatus* (14%), S. tinca (13%) and *G. xanthocephalus* (12%).

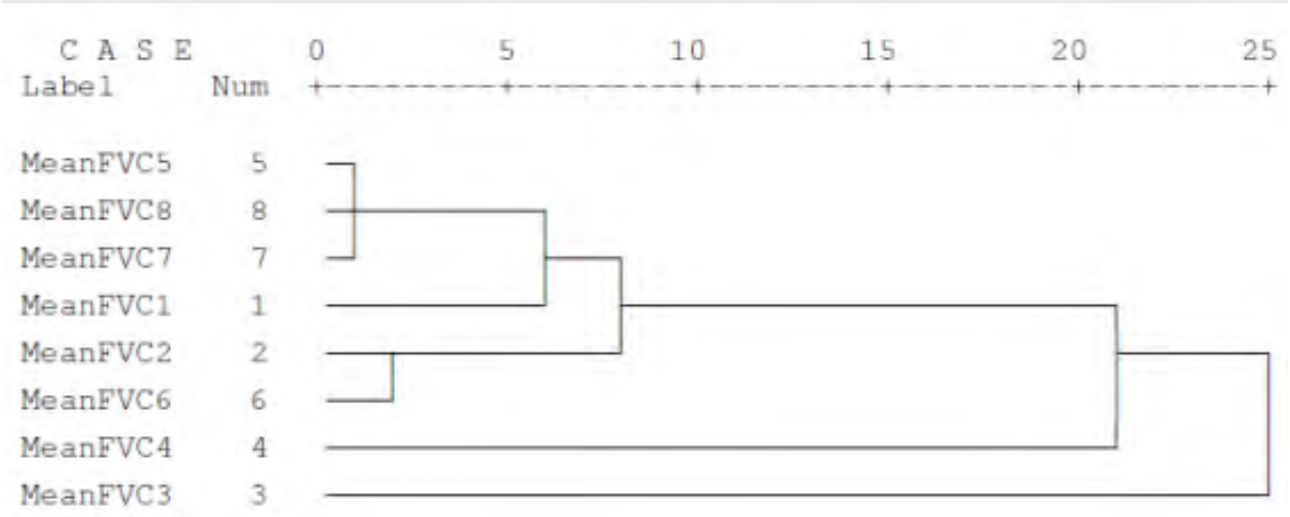

Figure 20: Dendrogram of fish assemblages for the stations

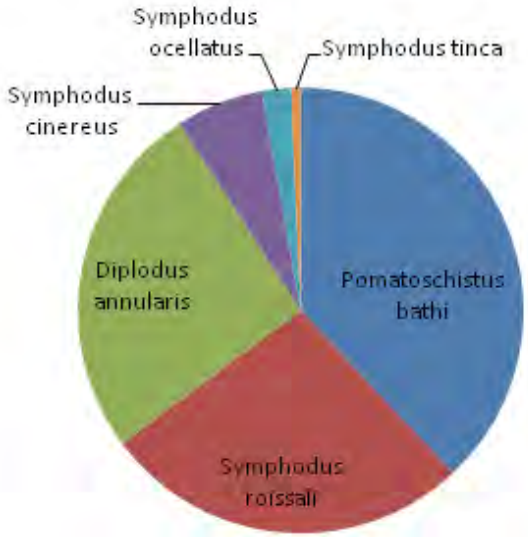

Figure 21: Posidonia meadow fish assemblages (FVC03)

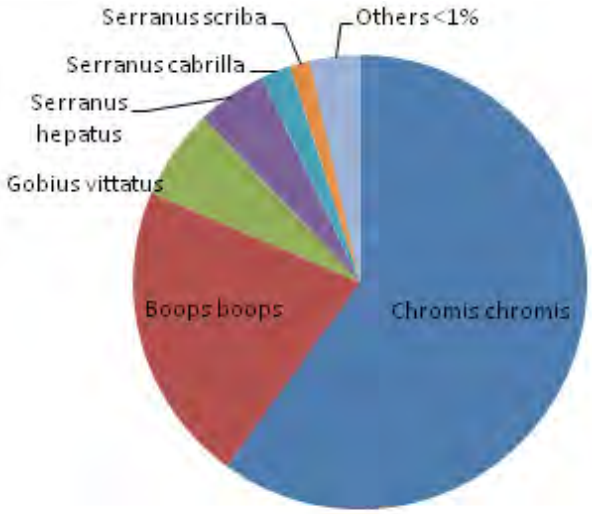

Figure 22: Fish assemblages associates to the *S. savaglia* facies (FVC04)

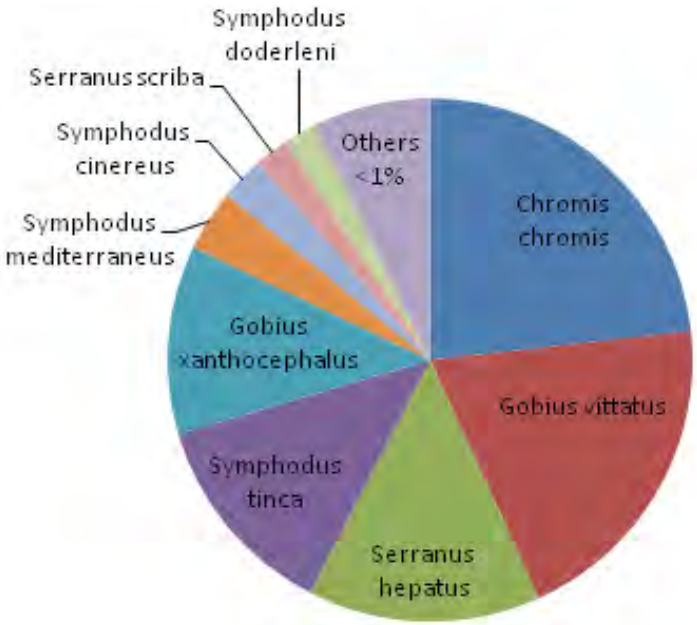

Figure 23: Other stations fish assemblage (FVC01, FVC02, FVC05, FVC06, FVC07, FVC08)

3.2.6 Species listed in the Annexes to the SPA/BD Protocol and other species of conservation interest

A total of 24 species listed in the Annexes to the SPA/BD[1] Protocol were recorded in the study area in addition to 27 other species of conservation interest (including the ones not directly observed during the survey but indicated by local fishermen).

Twenty-three benthonic species and one fish species were observed during the scuba diving surveys. Two fish species and one Mollusca were added to this number because indicated by local fishermen as inhabiting the bay.

Table 19: Species listed in the Annexes to the SPA/BD Protocol and rare species present in the study area

Taxa	Species	SPA/BD Protocol	Stations
Phaeophyceae	*Cystoseira barbata*	Annex II	DIP03-DIP05, DIP06
Phaeophyceae	*Cystoseira corniculata*	Annex II	DIP03-DIP05, DIP09-DIP11
Phaeophyceae	*Cystoseira spinosa*	Annex II	DIP03-DIP05, DIP09-DIP11
Phaeophyceae	*Fucus virsoides*	-	DIP06
Magnoliophytes	*Cymodocea nodosa*	Annex II	DIP07-DIP08
Magnoliophytes	*Nanozostera noltii*	Annex II	DIP07-DIP08
Magnoliophytes	*Posidonia oceanica*	Annex II	DIP01-DIP10, other locations
Magnoliophytes	*Zostera marina*	Annex II	DIP07-DIP08
Porifera	*Aplysina aerophoba cfr.*	Annex II	DIP01-DIP10, DIP03-DIP05, DIP04
Porifera	*Aplysina cavernicola*	Annex II	DIP01-DIP10, DIP03-DIP05, DIP04, DIP06, DIP09-DIP11
Porifera	*Axinella cannabina*	Annex II	DIP01-DIP10, DIP03-DIP05, DIP04, DIP06, DIP09-DIP11
Porifera	*Calyx niceaensis*	-	DIP09-DIP11
Porifera	*Geodia cydonium*	Annex II	DIP03-DIP05, DIP04, DIP06, DIP09-DIP11
Porifera	*Sarcotragus cfr. foetidus*	Annex II	DIP09-DIP11
Porifera	*Spongia officinalis*	Annex III	DIP01-DIP10, DIP03-DIP05
Porifera	*Tethya aurantium*	Annex II	DIP09-DIP11
Porifera	*Tethya citrina*	Annex II	DIP03-DIP05
Cnidaria	*Savalia savaglia*	Annex II	DIP01-DIP10, DIP06
Echinodermata	*Centrostephanus longispinus*	Annex II	DIP09-DIP11
Mollusca	*Dicata odhneri*	-	DIP09-DIP11
Mollusca	*Geitodoris portmanni cfr.*	-	DIP03-DIP05
Mollusca	*Lithophaga lithophaga*	Annex II	not observed
Mollusca	*Pinna nobilis*	Annex II	DIP07-DIP08, other locations
Crustacea	*Maya squinado*	Annex II	DIP03-DIP05
Pisces	*Epinephelus marginatus*	Annex III	DIP01-DIP10
Pisces	*Hippocampus hippocampus*	Annex II	not observed
Pisces	*Sciaena umbra*	Annex III	not observed

[1] *The SPA/BD Protocol of the Barcelona Convention has 2 annexes listing Endangered or Threatened Species (Annex II) and Species whose exploitation is regulated (Annexe III).*

Among the species present, 20 are included in Annex II (endangered or threatened species) of the SPA/BD Protocol and 3 in the Annex III (species whose exploitation is regulated) (Table 19).

The Photographic Atlas of the ASPIM species photographed during the biological survey is available in APPENDIX H. In particular the extraordinary abundance of some protected species needs to be underlined.

- The bivalve *Pinna nobilis*, which is present in all the investigated stations with sea grass. The bivalve is particularly abundant in the Posidonia meadow (which covers a total of 21.000 m^2 in the north western part of the bay) where it has been observed during the visual census with a density of 6.7±2.3 specimens /100 m^2.
- The coral *Savalia savaglia* which is present in 2 localities:

1. In Strp (DIP06) the number of colonies is significant, considering the rarity of the species across the Mediterranean Sea. The coral is present between 15 m and 19 m of depth.
2. In Drazin Vrt (DIP01-DIP10) the presence of the colonies is extraordinarily abundant. The area is extended over a surface of about 130 m x 30 m. The bathymetry ranges from 9 m to 17 m. The number of colonies of S. savaglia in this small coastal area can be estimated in about 200-300 specimens. The uniqueness of this area is related both to the abundance of this rare coral and to the superficial bathymetric distribution of the species which, in general, ranges from 20 m to more than 600 m depth (Ocaña and Brito 2004).

- The coral *Cladocora caespitosa*, which is present with very large, largely dead colonies and smaller living colonies. *C. caespitosa* has been observed during the 2013 survey in Godspa od Skarpjela, Sveti Dorde, Strp and Verige (DIP04, DIP03-DIP05, DIP06, and DIP09-DIP11). Badalamenti and Treviño Oton observed in 2011 some impressive *C. coespitosa* reefs also close to Dražin Vrt. During the 2013 survey the main part of the huge colonies found in Dražin Vrt was dead; several normal size colonies of the coral were found especially in the other surveyed stations.

  Massive *C. caespitosa* reefs were reported in the bay in the 1970 study made by Stjpčević and Parenzan (1980). Badalamenti and Treviño Oton (2012) and the present study (2013) reported a very wide distribution of Cladocora in the bay but did not find a correspondence with the data shown by Stjpčević and Parenzan.

  Several very large dead colonies of Cladocora were observed during the present survey. These dead colonies represent an excellent substrate for the colonisation and development of benthic communities. Local experts and reliable source also reported the presence of very large living colonies of Cladocora in the elliptical depressions or pits present in the flat seafloor of the bay. The turbidity of the deep water during the present survey didn't allow the exploration of these morphological submerged structures.

Some species, even if not included in the annexes of the SPA/BD Protocol are worth mentioning because considered rare species by many specialists. Four species belonging to these categories are described below:

***Fucus virsoides* - Strp (DIP06)**

A brown algae with relict stations for the Mediterranean Sea in the northern Adriatic Sea (Trieste Gulf). The species is considered endemic of the Mediterranean and the stations of Boka Kotorska are the southernmost of its known distribution.

***Calyx nicaeensis* - Verige (DIP09-DIP10)**

Sponge endemic of the Mediterranean Sea, it is considered rare with a scattered distribution, more frequent in the western portion of the Mediterranean Sea. It is found along the coast of Montenegro and in the present survey with two individuals.

***Geitodoris portmanni* - Sveti Dorde (DIP03-DIP05)**

A sea snail of the suborder Doridina, it is a rare species, endemic of the Mediterranean Sea and known in the Tyrrhenian and the Ionian Sea, but never found before in the Adriatic Sea. It lives in the lower part of stones and feeds on sponges.

***Dicata odhneri* – Verige (DIP09-DIP11)**

Sea snail of the sub order Aeolidiina, known in the Tyrrhenian Sea and the British islands. The present record is the first for the Adriatic Sea, another individual was found in the Trieste Gulf in 2011 (AMP Miramare - Morettin, Poloniato, pers. comm.). The species is very rare, of small dimension and its ecology is largely unknown.

The distribution of the abovementioned protected species or rare species or species of biogeographic interest according to the survey data is shown in Figure 31.

In addition to the species listed in the Annexes to the SPA/BD Protocol and rare species, the following species were also considered of conservation interest (biogeographical importance) and deserve to be mentioned:

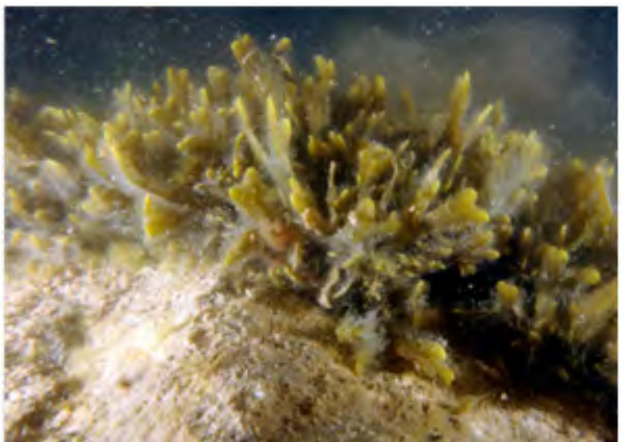

Figure 24: *Fucus virsoides*

Figure 25: *Calyx nicaeensis*

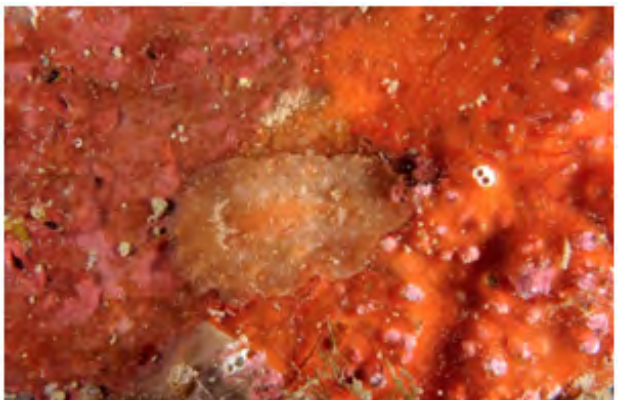

Figure 26: *Geitodoris portmanni*

Figure 27: *Dicata odhneri*

***Asparagopsis taxiformis* – Drazin Vrt (DIP01-DIP10)**

Red algae original from the Indo-Pacific Sea, very similar to *Asparagopsis armata*, was found for the first time in 1923. *A. taxiformis* is considered a species immigrated before the Suez Channel opening or originated in the west part of the Mediterranean, since the first record of this species dates back to 1813 along the Egyptian coast (Altamirano *et al.* 2008). Similarly, *A.armata* is an invasive species and its recent spreading acceleration in the Mediterranean basin is probably due to the global warming. In the Adriatic Sea the species is known along the Croatian coastline.

***Bursatella leachi* – Verige (DIP09-DIP11)**

Sea snail of circum-tropical origin, reported for the first time in the western basin of the Mediterranean in 1940. The first record for the Northern Adriatic Sea dates back to 1984 and it was afterwards found along the Croatian and Slovenian coast. Often sudden demographic explosions are reported in small areas with millions of individuals and high reproductive activity.

***Tritonia nilsodhneri* - Drazin Vrt (DIP01-DIP10)**

A sea snail of the suborder Dendronotina widely distributed from the western Atlantic to the Mediterranean Sea, where it was considered absent in Adriatic until the present record. This species lives associated with gorgonian species of the genus *Eunicella* and *Leptogorgia* and its color varies in relation to the host, therefore T. nilsodhneri is a cryptic species. It feeds on Eunicella and Leptogorgia polyps and lays its eggs. During the present study it was found on *Leptogorgia sarmentosa* with egg depositions.

Figure 28: *Asparagopsis taxiformis*

Figure 29: *Bursatella leachi*

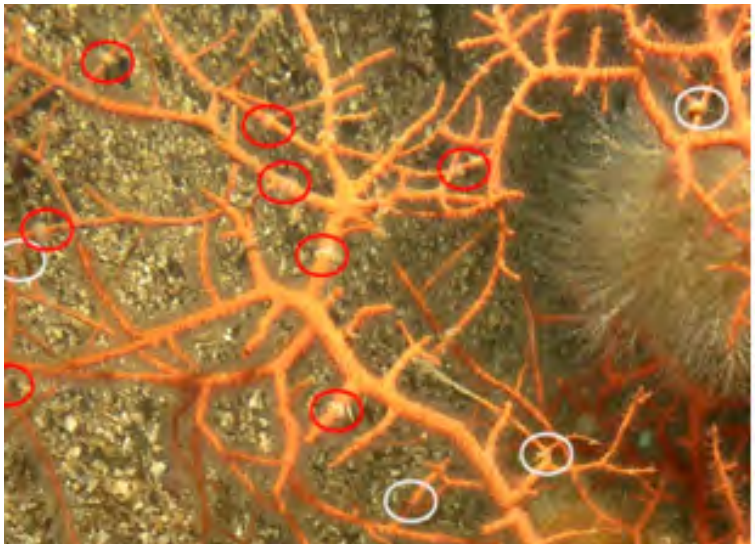

Figure 30: *Tritonia nilsodhneri* (*T. nilsodhneri* individuals are highlighted with white circle, eggs with red circles)

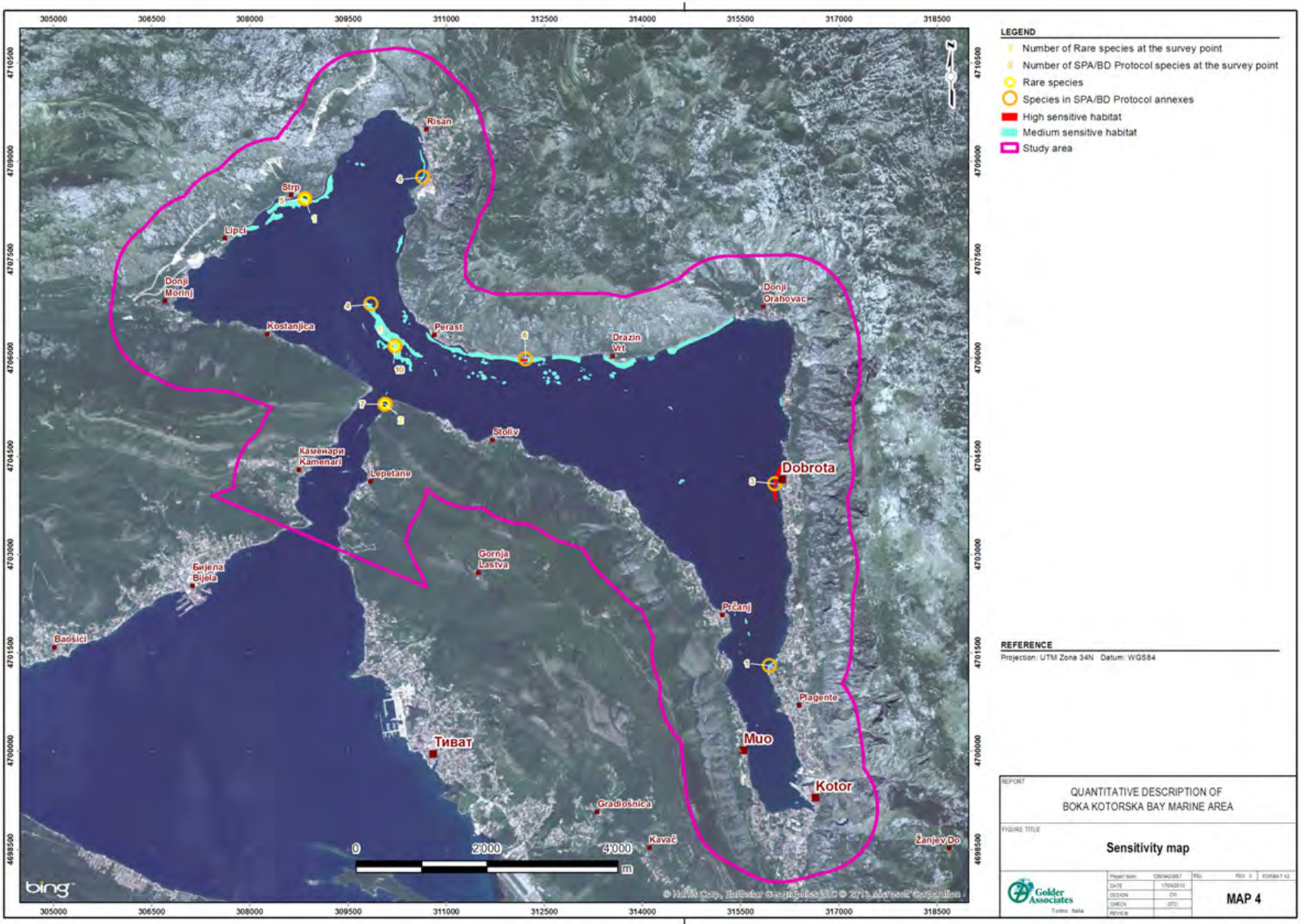

Figure 31: Species listed in the Annexes to the SPA/BD Protocol, rare species and sensitive habitats distribution

3.3 Fishery study

3.3.1 General features of small scale fishery

In Montenegro 70 vessels are registered for small–scale fisheries, 50 of these vessels are from the Boka Kotorska Bay (ports of Herceg Novi, Zelenika, Kotor and Tivat); among them Kotor port has the greatest number of registered vessels (17), according to the information collected. Most of the vessels in the small–scale fishing fleet are equipped with more than one type of fishing gear. In small-scale fisheries fishing days usually depend on weather conditions and catches are not recorded, therefore the level of exploitation is still unknown.

Gillnets and trammel nets are traditionally divided according to target species and mesh size. Fishing gear types that can be licensed according to the Law on Marine Fisheries and Mariculture are the following:

- gillnet for bogue ("bukvara")
- gillnet for Mediterranean sand smelt ("gavunara")
- gillnet for picarel ("girara")
- gillnet for picarel ("menulara")
- gillnet for crabs ("rakovica")
- gillnet for demersal fish ("prostica")
- gillnet for small pelagic fish ("vojga")
- gillnet for rays ("sklatara")
- gillnet for sharks ("psara")
- gillnet for bonito ("polandara")
- trammel net ("popunica")
- trammel net for flatfish ("listarice")
- trammel net for salema ("salpare").

According to the Law on Marine Fisheries and Mariculture, the height of all types of gillnets must not be above 4 meters regardless of the mesh size, except for gillnet called polandara, for which the height must not be above 22 m. The length of nets must not be above 160 m in the Boka Kotorska bay and 500 m in the open sea, except for polandara nets, for which the length must not be above 400 m. Fishing with bottom trawls, floating trawls and encircling large-scale fishing nets is prohibited in the Boka Kotorska Bay.

One layer gillnet is the most common type of fishing gear used in small–scale fisheries, followed closely by three layer trammel nets and beach seines. All the vessels using beach seines registered for small–scale fisheries (20 totally) in Montenegro are from the Boka Kotorska Bay. In summary the main gears used by small scale fishery in Boka Kotorska Bay are trammels, gillnets and beach seines.

In the following paragraphs a description of the catch of the three main small scale fishery gears is given; below a general description of local fishery general characteristics (gears and methods) is available. From the 14th of April to the 16th of May for a total of 10 days, 16 interviews to local fishermen were performed. In total five crews were interviewed in five different landing sites (Drazin rt,, Kotor, Muo-Peluzica, Orahovac and Perast). The following information on local fishery in the Boka Kotorska Bay can be extracted from the interviews:

Trammel and gillnet

Gillnets and trammel nets are stationary gears.

A set gillnet consists of a single netting wall kept more or less vertical by a floatline and a weighted groundline. The net is set on the bottom, or at a certain distance above it and kept stationary by anchors or weights on both ends. Gillnets are of special interest for artisanal fisheries because it is a low cost method. The size distribution of the catch is very much dependent on the mesh size used in the gillnet.

A trammel net consists of two/three layers of netting with a slack small mesh inner netting between two layers of large mesh netting within which fish will entangle. These nets are strings of single, double or triple netting walls kept more or less vertical by floats on the headrope and mostly by weights on the groundrope.

- According to the landing data trammels and gillnets (in the survey period – April-May) are mainly placed between 22 m and 33 m depth in the Bay;
- the crews of the fishing boat usually consists of two members;
- the boats have generally low horse power (7.22 – 9 HP);
- the length of nets is rather low, even though boats often carry more than one net;
- the fishing areas, when indicated, were usually just in front of the landing sites and on the muddy bottom;

- the same boat crew use different fishing gears and the ones used are:
  * gillnet for bogue (''bukvara'') of 100 m (mesh size 22 mm);
  * gillnet for bonito (''polandara'') of 200 m, 250 m or 400 m (mesh size 45 mm);
  * trammel net (''popunica'') of 120 m (mesh size 28 mm).
- Usually each boat uses 1-2 gillnets and 1-3 trammel nets at the same time and the total time spent at sea is around 10-12 hours per fishing day.

Beach seine

The gear is composed of a bunt (bag or lose netting) and long wings often lengthened with long ropes for towing the seine to the beach. The headrope with floats is on the surface, the footrope is in permanent contact with the seabed and the seine is therefore a barrier which prevents the fish from escaping from the area enclosed by the net. The coastal beach seine is designed primarily for night time, when it is used with artificial light. This type of traditional fishing has been used for centuries in the Boka Kotorska Bay.

- beach seine net is about 150 m (mesh size 6 mm, other used are 4.5-8 mm.);
- the law states that mesh size in any part of the net should not be less than 10 mm;
- According to landing data beach seines are usually set from a boat near the shore in shallow waters (10 m). Bibliographic data indicate that the beach seine fishery can be carried out on seabeds up to 30 m depth.

In the landing survey period (April-May) the most used fishing gears were the beach seine nets and the gillnet for bogue: beach seine nets were mentioned in 7 interviews and were used by two boats; the gillnet for bonito was mentioned in 6 interviews and was used by three different boat; the gillnet for bogue was used only by one boat and was mentioned in one interview. Similarly, the trammel net was used only by one boat and was mentioned in two interviews.

3.3.2. The catch

3.3.2.1. Qualitative data analysis

The catches of beach seine, trammel and gillnet (two types, one for bogue and another for bonito) were observed during the landing survey. 13 different alieutic species were detected.
Five species can be classified as demersal species (*Diplodus annularis*, *Merluccius merluccius*, *Pagellus erythrinus*, *Scorpaena scrofa* and *Sepia officinalis*); the others 8 are pelagic.

Table 20: Species detected during the landing survey

Family	Species (scientific name)	Species (English name)	Beach seine	Gillnets (2 types)	Trammel
Carangidae	*Trachinotus ovatus*	Pompano	X	X	
Carangidae	*Trachurus mediteraneus*	Mediterranean horse mackerel		X	X
Clupeidae	*Sardina pilchardus*	European pilchard	X		
Engraulidae	*Engraulis encrasicolus*	European anchovy	X		
Merlucciidae	*Merluccius merluccius*	European hake		X	X
Scombridae	*Sarda sarda*	Atlantic bonito	X	X	
Scombridae	*Scomber japonicus*	Chub mackerel		X	
Scombridae	*Auxis rochei*	Bullet tuna		X	
Sparidae	*Boops boops*	Bogue		X	
Sparidae	*Diplodus annularis*	Annular sea bream		X	X
Sparidae	*Pagellus erythrinus*	Common pandora		X	X
Scorpaenidae	*Scorpaena scrofa*	Red scorpinofish		X	X
Sepiidae (mollusc)	*Sepia officinalis*	Common Cuttlefish		X	X

The following 5 species should be added to the list according to the available data from desktop study (RAC/SPA draft report):

- the horse mackerel *Trachurus trachurus* (Carangidae);
- the leerfish *Lichia amia* (Carangidae);
- the Mediterranean sand smelt *Atherina hepsetus* (Atherinidae); and
- the mullets *Mugil* sp. and *Liza* sp. (Mugilidae).

According to the available information, these 18 species form the main part of the catch of small scale fishery in Boka Kotorska Bay.

3.3.2.2. Quantitative data analysis

Four species form more than 97% of the total catch in weight: *Engraulis encrasicolus* (70%), Sardina pilchardus (13%), *Trachinotus ovatus* (9%) and *Sarda sarda* (6%). The same species were also the most abundant in terms of individuals caught. All these species are pelagic.

The beach seine net and the gillnet for bonito had the highest catches in terms on total weight (91% and 7% respectively) but they were also the most used gear according to the landing survey data.

Engraulis encrasicolus and *Sardina pilchardus* are both small fishes with an average weight of 9 -14 g and are caught exclusively with the use of beach seine net, while *Trachinotus ovatus* and *Sarda sarda* had an average weight of 865 g and 1016 g each and are caught also with the gillnet for bonito (''polandara''). Beach seine net appears to be also the most selective fishing gear since only these four species of high commercial importance were caught with this fishing method.

In general all the individuals caught were of small or medium size.

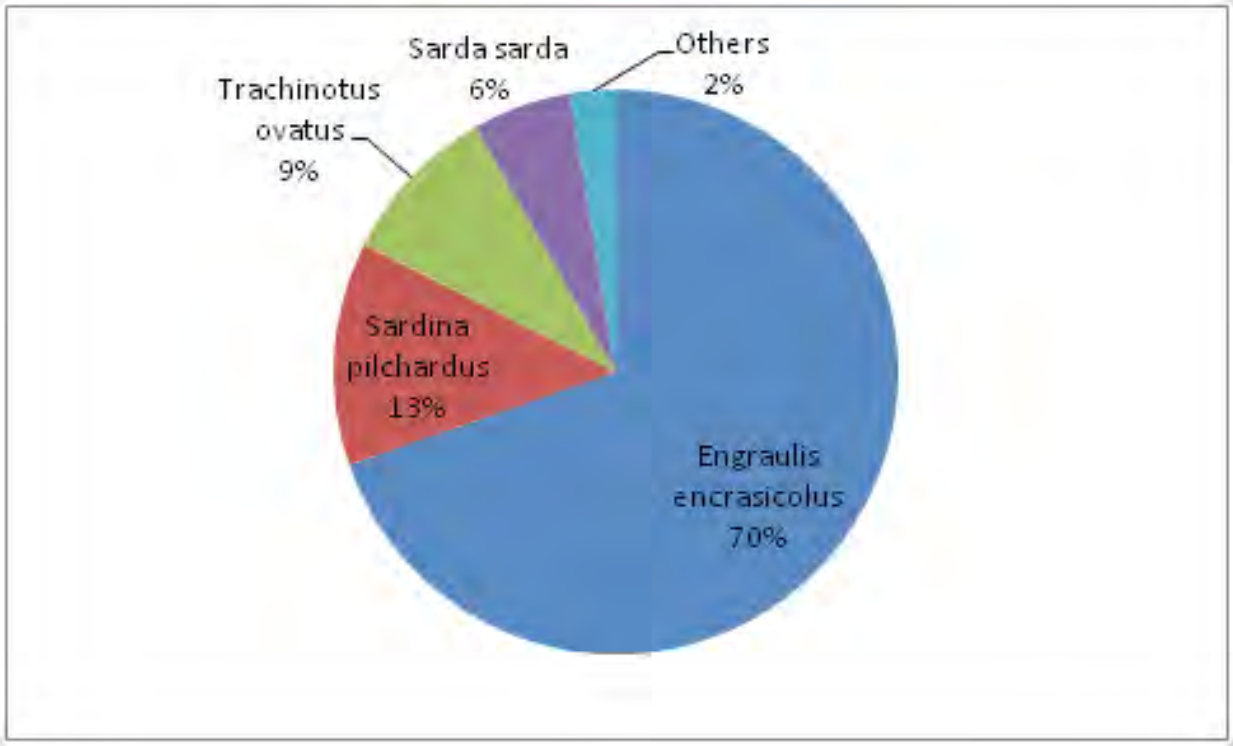

Figure 32: Biomass of species caught

Table 21: Landing raw data - biomass of fish caught by different fishing gears, total weight, total number of individuals and average fish weight

Species	Beach seine net kg for 7 fishing days	Gillnet for bogue kg for 1 fishing day	Gillnet for bonito kg for 6 fishing days	Trammel net Kg for 2 fishing days	Tot. (kg)	N. ind.	Mean weight (g)
Auxis rochei	0.0	0.0	0.5	0.0	0.5	1	500
Boops boops	0.0	1.6	0.0	0.0	1.6	34	47
Diplodus annularis	0.0	0.0	0.1	2.8	2.9	27	107
Engraulis encrasicolus	490.0	0.0	0.0	0.0	490.0	53400	9
Merluccius merluccius	0.0	0.0	1.9	0.6	2.5	8	313
Pagellus erythrinus	0.0	0.0	2.4	1.5	3.9	27	144
Sarda sarda	12.2	0.0	27.6	0.0	39.8	46	865
Sardina pilchardus	90.0	0.0	0.0	0.0	90.0	6550	14
Scomber japonicus	0.0	0.0	1.2	0.0	1.2	10	120
Scorpaena scrofa	0.0	0.5	0.0	0.9	1.4	5	280
Sepia officinalis	0.0	0.0	0.1	1.3	1.4	9	156
Trachinotus ovatus	50.0	0.0	15.0	0.0	65.0	64	1016
Trachurus mediteraneus	0.0	0.3	1.7	1.0	3.0	44	68
Total	642.2	2.4	50.5	8.1	703.2	60225	

The percentages of catch for the three main fishing gears used by small scale fishery are shown in Table 22.

According to the landing data, the European anchovy (*E. engrasicolus*), followed by the European pilchard (*S. pilcardus*) are the two dominant species (weight) in the catch with beach seine (Table 22). The available data (RAC/SPA draft report) for the years 2004-2005 and 2006-2007 show comparable percentages of species in the total catch but the report between anchovy and pilchard was inverted, with the following percentage: anchovy 37 %, European pilchard 59 % (other pelagic species contributed to 3.30% of the weight).

Gillnet catch is characterized by the Atlantic bonito *S. sarda* (52% of the weight) and the pompano *Trachinotus ovatus* (28%).

Trammel net catches dominated by the Sparidae annular seabream *D. annularis* (34%) and the common Pandora *P. erythrinus* (19%).

Table 22: Catch composition (in weight) for the 3 main small fishery gears

	% Beach seine (Biomass)	% Gillnets (Biomass)	% Trammel net (Biomass)
Auxis rochei	0.0	0.9	0.0
Boops boops	0.0	3.0	0.0
Diplodus annularis	0.0	0.2	34.6
Engraulis encrasicolus	76.3	0.0	0.0
Merluccius merluccius	0.0	3.6	7.4
Pagellus erythrinus	0.0	4.5	18.5
Sarda sarda	1.9	52.2	0.0
Sardina pilchardus	14.0	0.0	0.0
Scomber japonicus	0.0	2.3	0.0
Scorpaena scrofa	0.0	0.9	11.1
Sepia officinalis	0.0	0.2	16.0
Trachinotus ovatus	7.8	28.4	0.0
Trachurus meditteraneus	0.0	3.8	12.3

3.3.3 Catch Per Unit Effort

The catch per unit effort[2] (CPUE) of the beach seine observed during the landing survey corresponds to the medium value of 91,74 kg per haul (Table 23). Available bibliographic information (RAC/SPA draft rep.) indicates as CPUE for beach seine 156.44 kg per haul for the period of 2004-2005 and 141.92 kg per haul for the period 2006-2007.

The analyzed period is very limited (April-May) and catch has a seasonal variability, therefore the data must be considered with caution. In any case, according to available information, the trend seems to indicate a reduction of the catch since 2004.

Gillnets for bogue and for bonito have a yield of 1,2 and 1,67 kg/100 m of net respectively. The number of specimens caught each 100 m of net are respectively 19 ind./100 m net and 4 ind./100 m of net (Table 23). Data on the CPUE relevant to these gears in the Boka Kotorska Bay are not available from literature. Trammel nets have a medium performance of 1,13 kg/100 m nets and 8 ind. /100 m net.

CPUE observed in the bay are comparable with other data available for other Mediterranean regions.

Matic-Skoko *et al* (2011) registered in Vis (Croatia) average catch of 0.5 kg/32 m net (corresponding to 1,56 kg/100m); following fishery management measures the catch increased to 4,5kg/100m. As a general rule, the trammel net average catch rarely exceeds 2 kg/100m net (Guidetti *et al.,* 2010)

[2] The CPUE was calculated dividing the kg of fish caught and the number of individuals for the meters of net used and the number of fishing days

Table 23: CPUE for the different fishing gears

Fishing gear	Kg /100 m net (or haul)	N. ind./ 100 m net
Beach seine net	91.74*	8.573*
Gillnet for bogue (''bukvara'')	1.2	19
Gillnet for bonito (''polandara'')	1.67	4
Trammel net (''popunica'')	1.13	8

** Value are referred to one haul*

3.4 Geografic Information System

A Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.
GIS allows us to explore, analyze, question, interpret, and represent data in many ways that reveal relationships, patterns, and trends.

The advantages and functions of a GIS as a management supporting tool are multiples. Often considered as a simple drawing system, a GIS offers a way to easily view, query, analyze, interpret, and represent spatial data based on their attributes, location and topological relations. Maps, charts, tables and analytical reports can be derived from the data stored in a GIS as a means of documenting and explaining spatial patterns and relationships to assist in planning and decision-making processes.

A GIS was developed within the framwwork of the present Project using the software ESRI ArcGis 10.1. Data deriving from both bibliography and field work activities were georeferenced, exported as GIS features and uploaded into thematic geodatabases. The GIS is available in the attached DVD in APPENDIX J.

The GIS was also published as WebGIS (APPENDIX K includes a webGIS guide and the codes to access to the web page).

The KOTOR_BAY_GIS.mxd project contains all the GIS data, organized in order to reflect the geodatabases structure. Photos and videos were stored in separate folders and linked to the correspondent features in the GIS project. The following tables show the list of thematic geodatabases and GIS features.

Table 24: Content of the geodatabase Basic_Geographic_data

FEATURE NAME (in table of contents)	FEATURE NAME (in geodatabase)	DESCRIPTION	SOURCE
Administrative points	places	Administrative locations	Administrative points (http://www.geofabrik.de/)
Coast line	coast_line	Coast line	Local expert
Study area	study_area	Study area includying the Kotor Bay and 1 km buffer from coastal line	Present study
Corine Land Cover	clc2006_clip	Corine Lande Cover (vector data) clipped on an extended area around the study area	European Environment Agency (http://www.eea.europa.eu)
DEM (Aster)	ASTGTM2_N42E018_dem	Original Digital Elevation Model from Aster (Advanced Spaceborne Thermal Emission and Reflection Radiometer).	Aster (http://gdem.ersdac.jspacesystems.or.jp)
QA (Aster)	ASTGTM2_N42E018_num	Quality Assessment of Digital Elevation Model from Aster (Advanced Spaceborne Thermal Emission and Reflection Radiometer)	Aster (http://gdem.ersdac.jspacesystems.or.jp)

Table 25: Content of the geodatabase Bibliographic_data.gdb

FEATURE NAME (in table of contents)	FEATURE NAME (in geodatabase)	DESCRIPTION	SOURCE
Bathymetry by multibeam (Bignami *et al.* 2008)	Bignami_*et_al*_2008	Image with the bathymetry of part of the bottom of the bay	Bignami *et al. 2008*
Development of Marine and Coastal Protected Areas (BadalamentiF TreviñoOtónJ 2012)	BadalamentiF_ TreviñoOtónJ_2012	Stations location and data extracted from the previous study carried out in the bay (2011-2012) focused on benthos and fish assemblages	BadalamentiF TreviñoOtónJ 2012
Dredge transect (ParenzanP StiepcevicJ 1980)	ParenzanP_StiepcevicJ_1980	Stations location of the study carried out in the bay by Parenzan and Stiepcevicj in the seventies	ParenzanP StiepcevicJ 1980
Distribution of anchovy eggs in July 2006 (Mandić *et al.*, 2012)	Mandic_et_al_2012_ancho_ jul_2006_rev1	Image with the distribution of anchovy eggs in July 2006	Mandić *et al.*, 2012
Distribution of anchovy eggs in December 2006 (Mandić *et al.*, 2012)	Mandic_et_al_2012_ancho_ dec_2006_rev1	Image with the distribution of anchovy eggs in December 2006	Mandić *et al.*, 2012
Distribution of anchovy eggs in April 2007 (Mandić *et al.*, 2012)	Mandic_et_al_2012_ancho_ apr_2007_rev1	Image with the distribution of anchovy eggs in April 2007	Mandić *et al.*, 2012
Distribution of anchovy eggs in August 2007 (Mandić *et al.*, 2012)	Mandic_et_al_2012_ancho_ aug_2007_rev1	Image with the distribution of anchovy eggs in August 2007	Mandić *et al.*, 2012
Spawning habitat and biomass estimation of anchovy (Mandić *et al.*, 2011)	point_Mandic_et_al_2011	Mandić M., Đurović M., Slobodan R., 2011. Spawning habitat and biomass estimation of anchovy	Mandić *et al.*, 2011
Distribution of seaweed (Macic V., 2006)	Seaweed_distribution_ Macic_V_2006	Macic V., 2006. Distribution of seaweed Fucus virsoides J. Agardh in Boka Kotorska Bay (South Adriatic Sea)	Macic V., 2006
Bioconstructional features of the coral Cladocora caespitosa (Kruzic and Benkovic, 2008)	point_KruzicBenkovic_2008	Bioconstructional features of the coral Cladocora caespitosa (Kruzic and Benkovic, 2008)	Kruzic and Benkovic, 2008

Table 26: Content of the geodatabase 2013_Surveys.gdb

FEATURE NAME (in table of contents)	FEATURE NAME (in geodatabase)	DESCRIPTION	SOURCE
Unidentified Objects Line	UnidentifiedObjectsLine	Object of probable anthropic origin identified in the bay through side scan sonar survey	Single beam survey - present study
Bathymetry (2m)	Kotor_Bathym_2m	Bathymetry line	Single beam survey - present study
Unidentified Objects Poly	UnidentifiedObjectsPoly	Object of probable anthropic origin identified in the by through side scan sonar survey	Single beam survey - present study
Side Scan Sonar mosaic - Posidonia meadow	Photomosaic_2000	Mosaic of side scan sonar sonograms	SSS survey - present study
Fish Visual Census	Fish_Visual_Census	Fish visual census stations location and data	Biological survey - present study
Diving point	Diving_point	Diving point stations location and species observed	Biological survey - present study
Diving point photo	Diving_point_photo	Diving point stations location and photos	Biological survey - present study
Under Water Video	Under_Water_Video	Under water video transects locations and videos	Biological survey - present study
Soft bottom survey	Soft_bottom_survey	Soft bottom station locations (grab sampling points) and classified taxa	Biological survey - present study
Hard bottom quadrats	Hard_bottom_quadrats	Hard bottom study locations and quadrats photos	Biological survey - present study
Biocenosis 2000	Biocenosis2000	Map of biocoenoses - scale 1:2000	Biological survey - present study
Biocenosis 5000	Biocenosis5000	Map of biocoenoses - scale 1:5000	Biological survey - present study
Sumberged infrastructure	Sumberged infrastructure	Infrastructures identified in the Bay, scale 1:5000	SSS survey - present study
Fishery landing point	Fishery_landing_point	Fishery landing points location and landing data	Fishery landing survey
Coast line natural/ artificial	coast_line_artificial_natural	Coast line natural and artificial	Present study
Corine Land Cover reviewed	clc2006_clip_study_area_ reviewed	Corine Lande Cover (vector data) clipped on the study area reviewed after photo interpretation	Present study
Buffer coast line 100m	buffer_coast_line_100m	Buffer - 100m from the coast line	Present study
Buffer coast line 200m	buffer_coast_line_200m	Buffer - 200m from the coast line	Present study
Buffer coast line 300m	buffer_coast_line_300m	Buffer - 300m from the coast line	Present study
Buffer coast line 400m	buffer_coast_line_400m	Buffer - 400m from the coast line	Present study
Buffer coast line 500m	buffer_coast_line_500m	Buffer - 500m from the coast line	Present study
Buffer coast line 1000m	buffer_coast_line_1000m	Buffer - 1000m from the coast line	Present study
Fish farm location	Fish_farm	Fish farms location	Local experts
Side Scan Sonar mosaic - EST	Kotor_SSS_Mosaic_EST	Kotor_SSS_Mosaic_WEST	Kotor_SSS_Mosaic_ WEST_channel
Side Scan Sonar mosaic - WEST	Kotor_SSS_Mosaic_EST	Kotor_SSS_Mosaic_WEST	Kotor_SSS_Mosaic_ WEST_channel
Side Scan Sonar mosaic - WEST Channel	Kotor_SSS_Mosaic_EST	Kotor_SSS_Mosaic_WEST	Kotor_SSS_Mosaic_ WEST_channel

Table 27: Content of the geodatabase Management.gdb

FEATURE NAME (in table of contents)	FEATURE NAME (in geodatabase)	DESCRIPTION	SOURCE
Rare Biogeographical Species	Rare_Biogeographical_ Species	Distribution of rare species and species of biogeographical interest	Present study
Sensitive habitat	Sensitive_habitat	Medium and high sensitivity areas	Present study

*Table 28: Content of WEBSERVICE**

FEATURE NAME (in table of contents)	FEATURE NAME (in geodatabase)	DESCRIPTION	SOURCE
Bin Map Aerial	-	Bing Maps aerial imagery web mapping service	ArcGIS online
Bin Map Aerial Hybrid	-	Bing Maps aerial imagery with labels web mapping service	ArcGIS online
World Topo Map		Topographic map service	ArcGIS online

**These data refer to the ESRI online web service. It might be possible that opening the GIS Project the link will be missed. It can be easily restored using the ArcGIS online search tool.*

Queries on feautures attributes, geoprocessing tools, spatial analysis were used to support the preparation of the present report.

Giving some practical examples, through the "Join and Relates" tool it was possible to assign to a certain feature the attributes coming from a separate table or feature based on a common field or the spatial location. Geoprocessing tools such as "Buffer" were used to generate a buffer area at a determined distance from the selected feature, "Clip" to cut a feauture based on the shape of another feature, "Merge" to put together in a single feature data coming from different features of the same geometry type. Spatial analysis tool such as "Tabulate Area" were used to calculate cross-tabulated areas between two datasets and outputs a table.

Selection tools and so "Select by attributes" and "Select by location" were used, respectively, to select features by their attribute values and select feautures using the location of features in another layer. "Measure" tool was very useful to measure distances of features directly on the map, "Identify" tool to visualize the attribute table of a certain features by clicking on them, "Zoom" and "Pan" tools to explore the data, according to their extent and resolution.

This is not a comprehensive list of all the different analysis and elaboration that could be easily run on the available data using the ArcGIS instruments and tools. What is more, the KOTOR BAY GIS could also be implemented with new studies, forming a comprehensive and powerful management tool for Boka Kotorska Bay. Some screen-shot extracted from GIS are shown in the figures below.

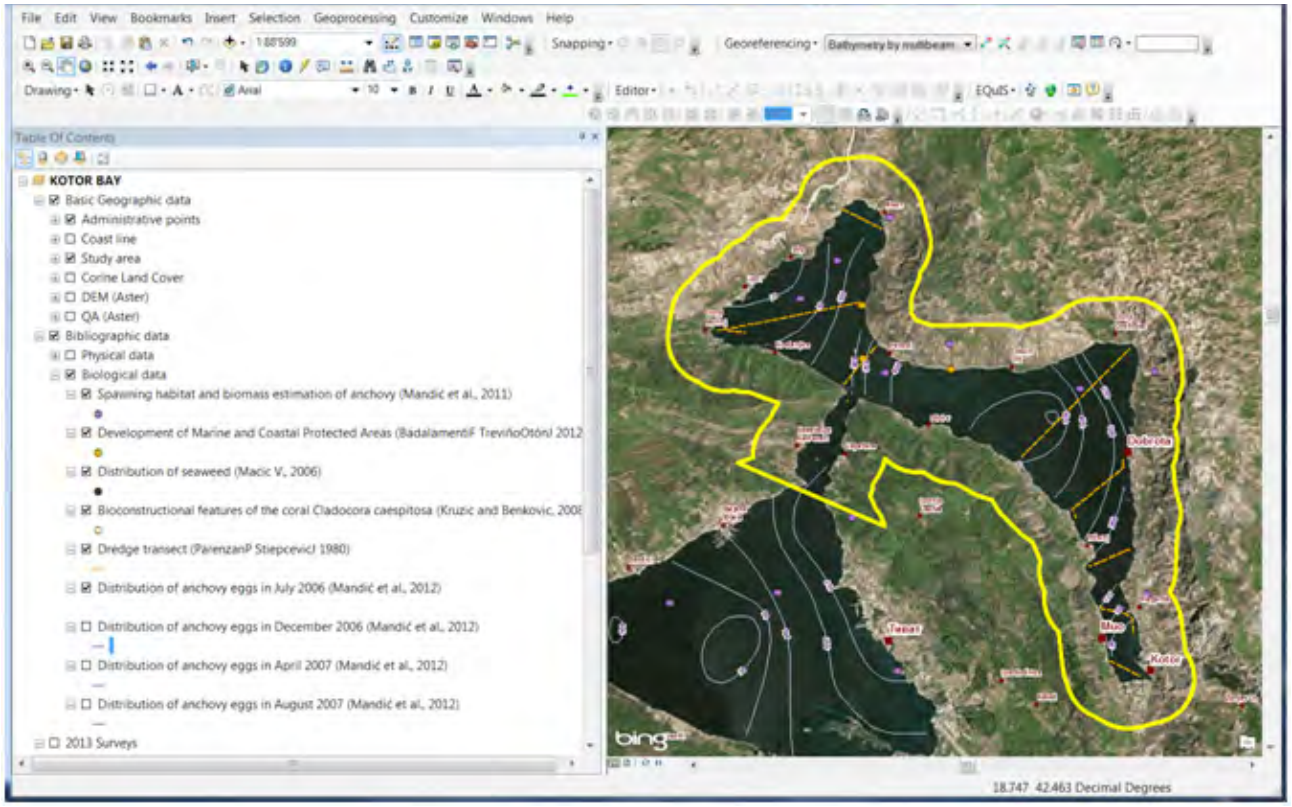

Figure 33: Example of some of the bibliographic datageoreferred and inserted in the GIS

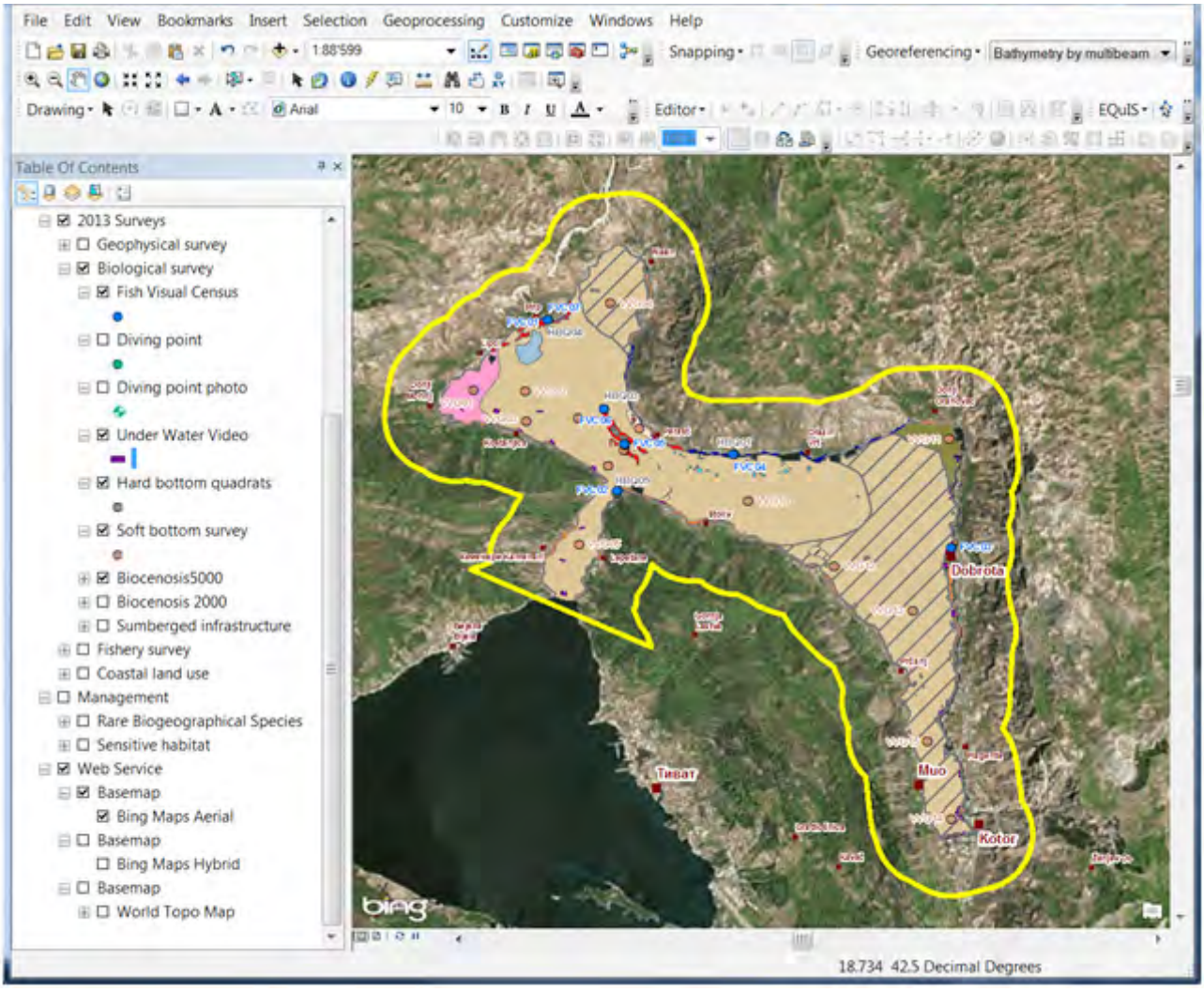

Figure 34: Example of localization of the stations of survey visualized with the biocoenotic map

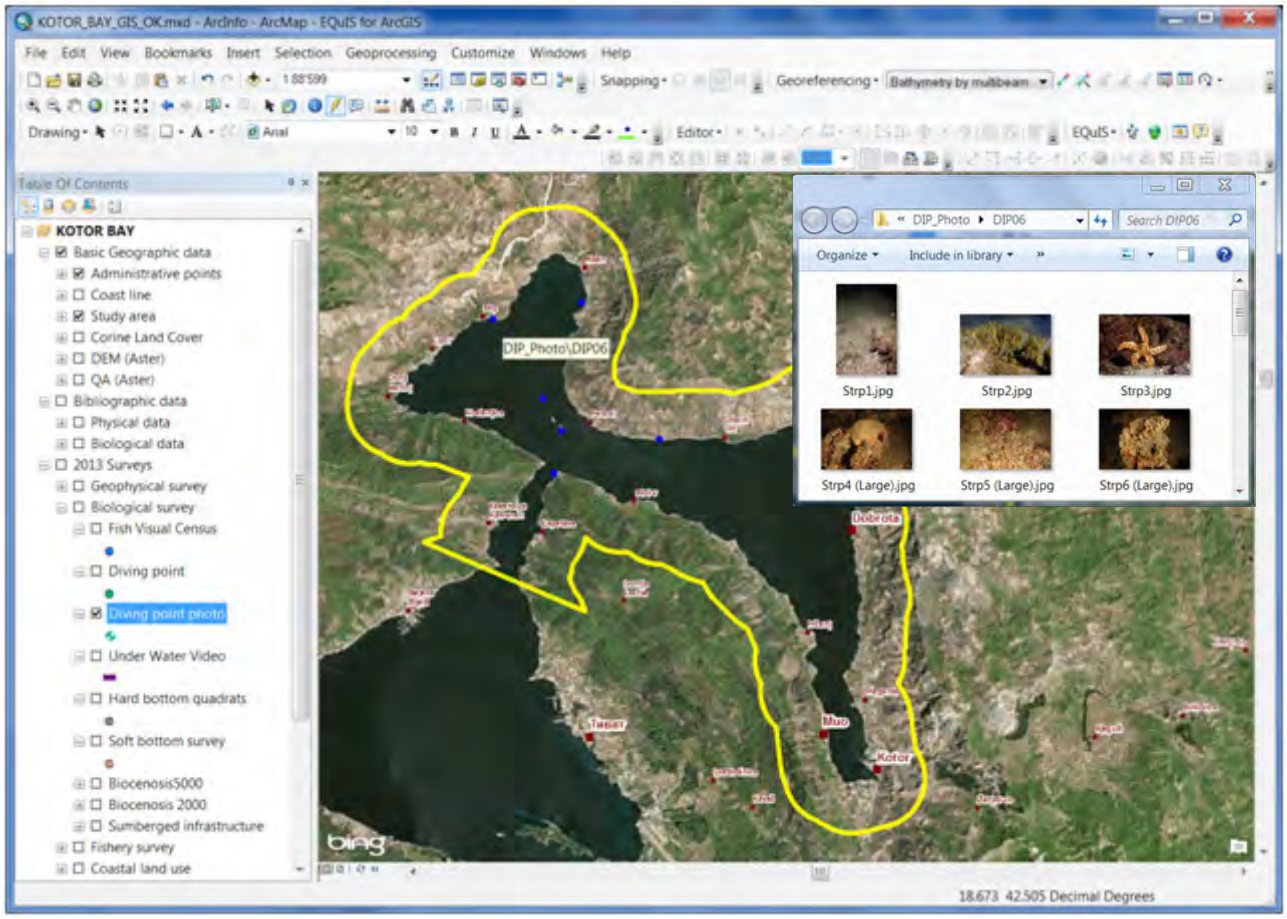

Figure 35: Example of diving points with iperlink to the photos of the station

3.5 On-the-job training to the local experts

The on-the-job training was performed during both field work missions: geophysical survey (January 19th - 24th 2013) and biological survey (April 5th – 12th 2013).

The recipients are listed below:

- Anja Vulevic, local junior biologist (Institute of Marine Biology of Kotor - IBM).;
- Marko Nikolic, local junior biologist expert (IBM).;
- Sladjana Gvozdenovic, local junior biologist expert (IBM);
- Vesna Mačić[3] , local senior marine biologist expert (IBM).

Several scientific and technical short training sessions were carried out at the beginning of each field work activity and during the activities surveys were suspended from time to time to explain the methods, the reasons and the expected results of each activity.

At the end of the last day of the biological survey, a final training session was held with all the local experts to discuss all the field work activities carried out, the preliminary data and the final expected results came up for discussion.

All the local experts attended the activities and training sessions with interest. In particular the participation and contribution and support of Vesna Macic was essential for the success of the job. Contact and exchange of technical and scientific information and data are continuing with local experts also after the finalization of the field activities.

The subjects of the training activities undertaken during the two field work sessions can be summarized as follows:

- Mob/demob of side scan sonar and positioning systems;
- The use of side scan sonar for the mapping of marine habitats (range, frequencies, interpretation of signal at video);
- Mob/Demob of underwater towed camera and positioning systems;
- How to carry out a survey using underwater towed camera;
- How to position different surveys by the use of open source and commercial GIS software;

Soft bottom sampling by Van Veen Grab:

* Collect, sieve and fix samples
* Sorting techniques using stereomicroscopy and taxonomic guides.
* Main taxonomical characters to identify polychaetes' family using simple guides;

- The use of camera and the best settings for underwater photo (preparation, regulation and use);

As additional contribution a few technical supports were given to local Marine Biology Institute, in particular the following activities can be underlined:

- Fixed NemirnaII's GPS communication cable to give local experts the possibility to further record field data (both position and bathymetry) in GIS;

[3] *Vesna Macic, who attended both field surveys and strongly supported the activities, at the same time was both recipient of the training and source of knowledge and data essential for the job activities.*

Figure 36: a. Training activity on sorting techniques using stereomicroscopy and taxonomic guides; b. Training activity on board of the vessel on the preparation of underwater camera

Figure 37: a. Training activity on GIS configuration to acquire position and other data directly in the field; b. On-job training: sampling by Van Veen Grab

4. CONCLUSIONS

4.1 General considerations

The activities undertaken improved the knowledge of the biology and ecology of the Boka Kotorska Bay and provided several tools for the management and monitoring of the bay, in particular:

- the maps of marine biocoenoses (1:5.000 and 1:2.000 scale);
- the inventory of 226 taxa of benthic organisms (251 taxa including the dead mollusks) and 56 fishes;
- a side scan sonar photomosaic map and bathymetric map of the seabed of the bay;
- an analysis of the coastal land use, and,
- a preliminary description of small-scale fishery in the area through a series of landing observations.

During the field campaigns, four local experts were trained on survey methodologies and species classification through practical lessons. A GIS database including all the geophysical and biological data collected during the survey and historical bibliographical data and information was generated. Inventory of benthos soft bottom species (77 taxa) and hard bottom species (150 taxa) was made. Sveti Dorde (mosaic of Coralligenous and Coastal Terrigenous Mud) and in Verige (Biocenosis of coastal terrigenous muds) have the highest biodiversity of benthic organisms. Also the station situated near Godspa od Skarpijela, showed relatively high biodiversity diversity, confirming the importance of islands in the ecology of the Bay.

21 differents benthic habitats were identified in the bay. The area is dominated by the biocenosis of Coastal Terrigenous Muds. Particular Coralligenous aggregations cover about 2% of the total surface of the seabed; the seagrass meadows are present in 4 sites and in total cover 0,15% of the seabed. 25 Deep holes with possible presence of *Cladocora* species were mapped in the central part of the bay.

Three different fish assemblages associated to three different habitats were defined. In general all the fish assemblages observed in the bay are characterised by a low fish density, the absence of widespread and common species (e.g. *Apogon imberbis, Coris julis, Thalassoma pavo, Muraena helena*), the reduced presence of species normally abundant in the coastal Mediterranean areas (e.g. *Sarpa salpa, Diplodus* spp.) and the abundance of Gobidae. These characteristics are probably due to the peculiar physical features of the area (e.g. wide thermic fluctuation, abundance of fresh water, limited extension of sea grass meadows, reduced wave motion).

The analysis of the coastal land use showed a high percentage of artificial coastal line (69%), confirmed by a comparable percentage value of urban land use areas in the first 100m from the coast (68%). This value of urban land use decreases proportionally with the distance from the shoreline. Fishery landing data give a first framework of the small scale fishery in the bay. The yields seem comparable to other Mediterranean Sea localities as far as weight is considered, but result particularly low in the number of caught species. The size of the fish is reduced. Key data and information useful to support the planning, zoning and development of a Marine Protected Area in Boka Kotorska Bay were collected and are described in detail in the following paragraphs.

20 species belonging to the Annex II and 3 species belonging to the Annex III of the SPA/BD Protocol were identified in the Boka Kotorska Bay. In addition 4 rare species and 3 species of biogeographic interest were observed in the bay. Two of these species have never been reported in the Adriatic Sea.

Six priority habitats were mapped in the Boka Kotorska Bay. The *Savalia savaglia* facies is worth a special mention. The small area in Dražin Vrt (about 5.000 m2) represents a unicum at a Mediterranean level thanks to the extraordinary density and abundance of *S. savaglia* colonies and the shallow water distribution of the species.

S. savaglia should be particularly protected not only for its specific rarity, endemism and vulnerability but also because it has a prominent role in sustaining high levels of biodiversity and ecosystem functioning in the surrounding benthos of the twilight zone (Cerrano *et al.,* 2010). In particular the *S. savaglia* facies and the role of *Cladocora* in the bay (including the historical regression of the species in the coastal areas) should be further investigated through special studies.

4.2 Areas supporting ecological process important for conservation purpose

The entire bay plays a key role as nursery for several species. Some studies are available for *Sardina pilchardus* (sardine) (Pešić *et al.,* 2010, 2006) and *Engraulis encrasicolus* (anchovy) (Mandić *et al,* 2011, 2012). The central and eastern part of the bay seems to have the higher concentration of eggs belonging to these pelagic species that represent 83% of the biomass caught by the fishing gears in the area; both of them are GFCM priority species[4].

According to the information collected on site, also other species in different periods of the years (e.g. *Pagrus pagrus* during summer months; *Dicentrarcus labrax* in February) enter with abundant swarms in the bay for reproduction. Juveniles were not observed during the surveys because the period of observation (April) did not correspond to the peaks of juveniles in the shallow water. Fish visual censuses carried out in late summer- autumn are expected to evidence significant fish recruitment.

The presence of the *Savalia savaglia* facies (Annex II of SPA/BD Protocol), as mentioned above, constitutes an extraordinary value for the bay. Long-living organisms like *S. savaglia*[5] producing three-dimensional hard skeletons can play an important role as habitat-modifiers (ecosystem engineers sensu).

The presence of elevated and complex tertiary substrates promotes benthic biodiversity and ecosystem processes. The high density of the colonies in the Dražin Vrt area needs special attention and protection measures.

The areas colonized by the particular coralligenous assemblages (in total about 2% of the seabed) characterized by the presence of *Cladocora caespitosa*, large-sized sponges (Axinella spp.) and cnidarians, notably the gorgonian *Leptogorgia sarmentosa* and of the yellow cluster anemone *Parazoanthus axinellae* form another hot spot of biodiversity. The key role of Cladocora in the ecosystem of the bay is evident.

Today the huge colonies observed are dead and *Cladocora* is present in the shallow water of the bay mainly with medium and small colonies. In any case the role of the dead *Clodocora* is fundamental as substratum for the development of benthic communities.

[4] The General Fisheries Commission for the Mediterranean (GFCM) established a list of 51 species considered of special importance for the fishery sector in the Mediterranean. This list is available at the following link: http://www.gfcm.org/gfcm/topic/166221/en#container

[5] Using 14C, a very slow radial growth rate (14 to 45 µm yr–1; Roark *et al.* 2006) has been calculated and the *S. savaglia* skeletons have been aged back at 2700 years

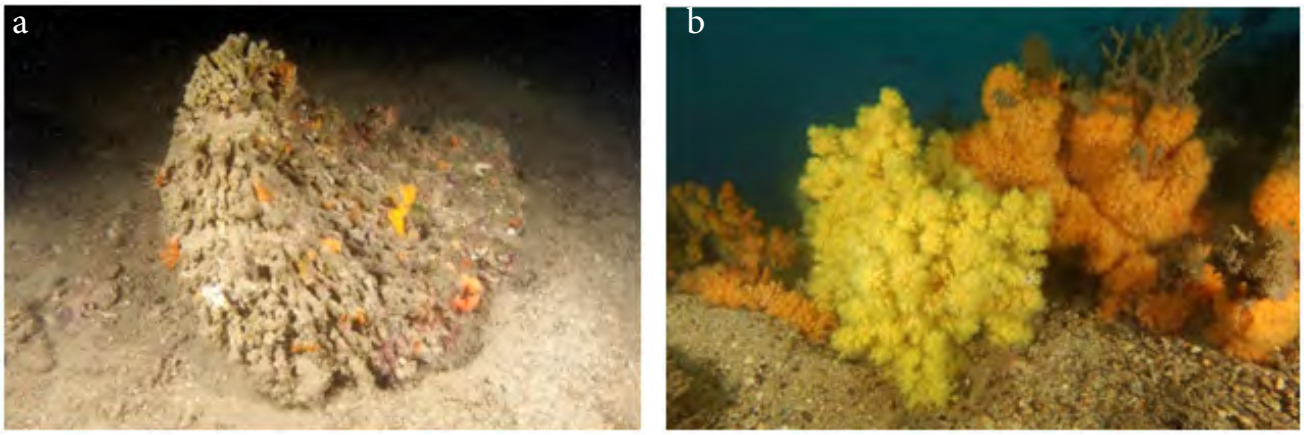

Figure 38: a. Dead Cladocora coloninized by benthonic species; b. *Savalia savaglia* colonies

Considering the reported presence of huge living colonies of Cladocora in the elliptical depressions or pits of the flat seafloor of the bay, special attention should be given to these morphological submerged formations.

In total we identified and mapped 25 small areas potentially interested by the presence of living very large Cladoora colonies. Moreover, both living and death Cladocora aggregations represent a powerful indicator of the evolution of benthic communities in the Bay. It is possible that *Cladocora* had its climax phase in the area hundreds to thousand years ago and currently lies in a recession phase due probably to environmental changes (e.g. sea level rise, increase in temperature and in water turbidity) the bay and the Mediterrranean in general are undergone.

An in-depth study focused on the assessment and datation of both living and death scleractinians (also in comparison with the close Croatian colonies) should be carried out in order to better understand the possible evolution of the benthic communities in the Boka Kotorska Bay.

Concerning marine plants, all the four Magnoliophyta listed under Annex II of the SPA/BD Protocol are present in the bay. The 4 areas interested by the presence of seagrass identified in the eastern and in the western part of the coast need special attention. In particular the area of Dobrota (about 21.000 m^2), colonized by *Posidonia oceanica*, and also characterized by a high density of the mollusk noble pen shell (*Pinna nobilis*), presents characteristic of a sensitive zone. It is also the only place in the bay colonized by Posidonia.

Special attention should be paid to the Verige Strait because of its fundamental functional role of connection with the other bays and with the open sea, and because of the high biodiversity value found in the soft bottom (sediment) and the hard bottom of this area.

The analysis of the map with the distribution of protected species and rare species Figure 31 reveals in particular the importance of the site of Sveti Djordje (10 species listed in the Annexes to the SPA/BD Protocol and 1 rare species), Drazin Vrt (6 species listed in the Annexes to the SPA/BD Protocol), of the coastal area in the Verige strait (7 species listed in the Annexes to the SPA/BD Protocol and 2 rare species) and Strp (5 species listed in the Annexes to the SPA/BD Protocol and 1 rare species).

Carrying out surveys for flag species such as cetaceans or marine birds was not included in the Terms of Reference of this assignment; however a recent publication reported the occurrence of a fin whale in the area (Joksimović *et al.*, 2013).

4.3 Main sources of threats and impacts

A joint analysis of the desktop study information and the results of the present study leads to the definition of the sources of threats listed in Table 24. In addition each source of threat is analysed considering its geographic extent, intensity and mitigation.

Increase in population/construction and tourism in the area

Description: in the area surrounding the bay, several construction sites were observed during the survey. The coastal analysis carried out within the present study showed a high percentage of artificial coastline and the concentration of the urbanization in the areas immediately close to the shoreline.

Geographic extent: the entire area seems subject to this impact, in particular the coastal area of the western part of the bay seems to have a higher number of construction sites.
Intensity: medium to high

Mitigation: limit and control construction activities and control tourism development. Develop regulations addressed to protect the sensitive species and habitats identified in the bay. Use the maps produced within the present study to support the establishing of legislative tools and regulation. Promote eco and soft tourism. Support private eco-tourism initiatives. Avoid uncontrolled sewage. Regulate and control soil dumping in the bay from road construction. Regulate recreational fishery.

Table 29: Main source of threats and relevant potential impacts

Source of threats	Potential impacts
Increase in population and tourism in the area	Increase of discharge in the bay (untreated sewage). Increase of coastal development, urbanization of the coast line. Dumping of soil from road construction or improvement. Eutrophication Increase of fishing pressure
Pollution from industry and other human activities situated in the coastal area.	Sediment pollution and water pollution with impact on ecosystem and fishery resources (e.g. nursery, spawing).
Uncontrolled scuba diving activities in sensitive areas	Impact on sensitive species and habitats
Presence of cruisers into the bay	Direct impact on gears used by small-scale fishery Impact on corralligenous assemblages through berths Impact on water quality
Global warming	Impact on shallow water gorgonian assemblages
Invasive species. The green alga *Caulerpa racemosa* and the red alga *Womersleyella setacea* (recorded in the Bay in 2003)	Potential impact to Coralligenous assemblages and inhibition to the recruitment of corallines and other algae (e.g. *Cystoseira* spp.)
Overfishing, illegal fishing methods like date fishery and uncontrolled recreational fishery	Impact on hard substrata habitats and fish assemblages (low abundance and small size of fishes)
Presence of plastic objects and debris on the coastal areas	Impact on coastal habitats through the physical covering of sensitive species and habitats

Pollution from industry and other human activities located in the coastal area

Description: It has been reported by local informant that in the past wastewater from the local hospital and other source of pollution was discharged in the bay. Today the presence of industries is very limited in the coastal area and wastewater discharges are more controlled; therefore the main sources of water pollution are probably represented by domestic sewage. Considering the sensitivity of the area special attention should be given to control all the possible discharges in the bay.

Geographic extent: the entire bay can be considered subject to this potential impact factor.

Intensity: medium

Mitigation: avoid uncontrolled sewages. Move and control existing industrial discharge in the bay (if any). Monitor the rivers flowing into the bay.

Uncontrolled scuba diving activities in sensitive areas

Description: touristic scuba diving activities seem more focused in the coast facing the open sea than inside the bay, mainly because of the limited visibility for several days of the year. Nevertheless some of the sensitive habitats described and mapped by the present study are sometimes targeted by scuba divers.

Geographic extent: mainly Drazin Vrt, Strp and the area surrounding the two islands of St. George (Sveti Djordje) and Our-Lady-of-the-Reef (Gospa od Skrpjela).

Intensity: medium to high

Mitigation: scuba diving activities inside the bay, in particular in the area of Drazin Vrt (*Savalia savaglia* facies) should be regulated and controlled.

Presence of cruisers into the bay

Description: the presence of huge cruisers into the bay has an impact both on the small fishery, because the ships cut and destroy the fishing gears along their route, and on the marine environment, because of the berth scouring of the seabed and the wastewater discharge into the water of the bay.

Geographic extent: The cruises seem to be used to anchor in the eastern part of the bay, close to Kotor.

Intensity: medium

Mitigation: Regulate the presence of the cruisers in the bay. Use the maps and the GIS produced in the present study to avoid impact on sensitive species and habitats and to define areas where anchoring is forbidden.

Global warming

Description: global warming seems to affect the coral colonies in shallow water more than other areas. The environmental features of these areas seem mainly linked with the presence of submerged cold springs.

Geographic extent: all the bay risks to be impacted by global warming. In particular the coastal areas of Drazin Vrt and Strp, characterized by corals distributed in shallow water could be more significantly impacted by global warming.

Intensity: medium

Mitigation: Monitoring activities at the moment is the only measure that can be suggested.

Invasive species

Description: In addition to the green alga *Caulerpa racemosa* and the red alga *Womersleyella setacea* mentioned in previous paragraphs, the species presented in the present report as of biogeographical interest like the red algae *Asparagopsis armata* and the sea snail *Bursatella leachi* require special attention.
C. racemosa was not observed in the bay but its presence is a potential risk.

Geographic extent: the entire bay

Intensity: medium

Mitigation: monitoring activities at the moment is the only measure that can be suggested.

Overfishing, illegal fishing methods like fishery of date and uncontrolled recreational fishery

Description: fishery is regulated in the bay (bottom trawls, floating trawls and encircling large-scale fishing nets are prohibited). However some illegal activities still seem to exist. Recreational fishery, especially during the period when of abundant swarm of fishes enter into the bay for reproduction, can impact the fish assemblages.

Geographic extent: the entire bay.

Intensity: low to medium.

Mitigation: Monitoring activities of artisanal fishery and recreational fishery and the application of further fishery regulations are recommended.

Presence of solid waste and debris on the coastal areas

Description: Solid waste and several debris were observed in all the sites investigated; in particular in some coastal sites rich in species and biodiversity (e.g. Drazin Vrt; Strp; Risan) a remarkable amount of debris on the seabed was found. The impact is double: mechanical covering of sensitive species and aesthetic impact.

Geographic extent: mainly the sites along the coastal route

Intensity: medium

Mitigation: information campaigns to raise awareness (e.g. display of photos), and removal of solid waste from shores could reduce this problem.

4.4. Recommendations for conservation and management

Based on the biological and ecological features of the Boka Kotorska Bay and taking into account the human activities occurring in the area as well as the identified main threats and sources of impacts, it is highly recommended to establish a marine protected area (MPA) covering the entire Bay and allowing the conservation of its natural heritage and providing the basis for the sustainable management of human activities. The main objectives of the MPA will be:

- Preservation of the species, assemblages and habitats of special conservation interest (in particular *Savalia savaglia* facies, Posidonia meadows, the coralligenous assemblages (*Cladocora caespitosa,* the large-sized sponges (*Axinella* spp.), the gorgonian *Leptogorgia sarmentosa* and the yellow cluster anemone *Parazoanthus axinellae*).
- Ensuring the sustainable management of two key fishery species for the area (the European sardine *Sardina pilchardus* and the European anchovy *Engraulis encrasicolus*) for which the entire Boka Kotorska Bay plays a key role as nursery.
- Sustainable development of sea watching activities (scuba diving, snorkeling, etc.)

It is recommended that the protection and management measures of the MPA be set according to a zoning scheme using two conservation levels:

A- Zones of high conservation interest: these zones cover the Bay areas with *Savalia savaglia* facies, coralligenous assemblages, Posidonia meadow, Pinna nobilis as well as areas with other species listed in Annex II to the SPA/BD Protocol. Areas of special functional role for the Bay, such as the Verige Strait, should be also considered as zones of high conservation interest. These zones will be «no-take zones» were all the human activities should be strictly regulated.

B- Zones with medium conservation measures: These will be the Bay areas that are not included under A (Zones of high conservation interest). Most of the human activities will be allowed except those having a negative impact on the marine environment of the Bay. In these zones regulation should include the control of anchoring, pollutant discharge (including solid waste and sewage), fishing, scuba-diving and coastal development.

Tentative preliminary zoning indications are presented in Figure 39. However, it is highly recommended that the zoning definition and the elaboration of the related regulation be carried out on the basis of the available scientific data, but within the framework of a consultation process involving all the stockholders (administrations, sea users, scientists, relevant NGOs, etc.).

The scientific data provided in this report shows that the Boka Kotorska Bay has the potential to be a candidate MPA for inscription on the SPAMI List. Indeed the area hosts species, assemblages and habitats of Mediterranean importance. It is also a nursery for many species including GFCM priority species. However, to be considered for the SPAMI List, the area should be granted a protection status recognized at national level. Furthermore a management plan should be developed and implemented not later than three years after the inscription of the MPA in the SPAMI List.

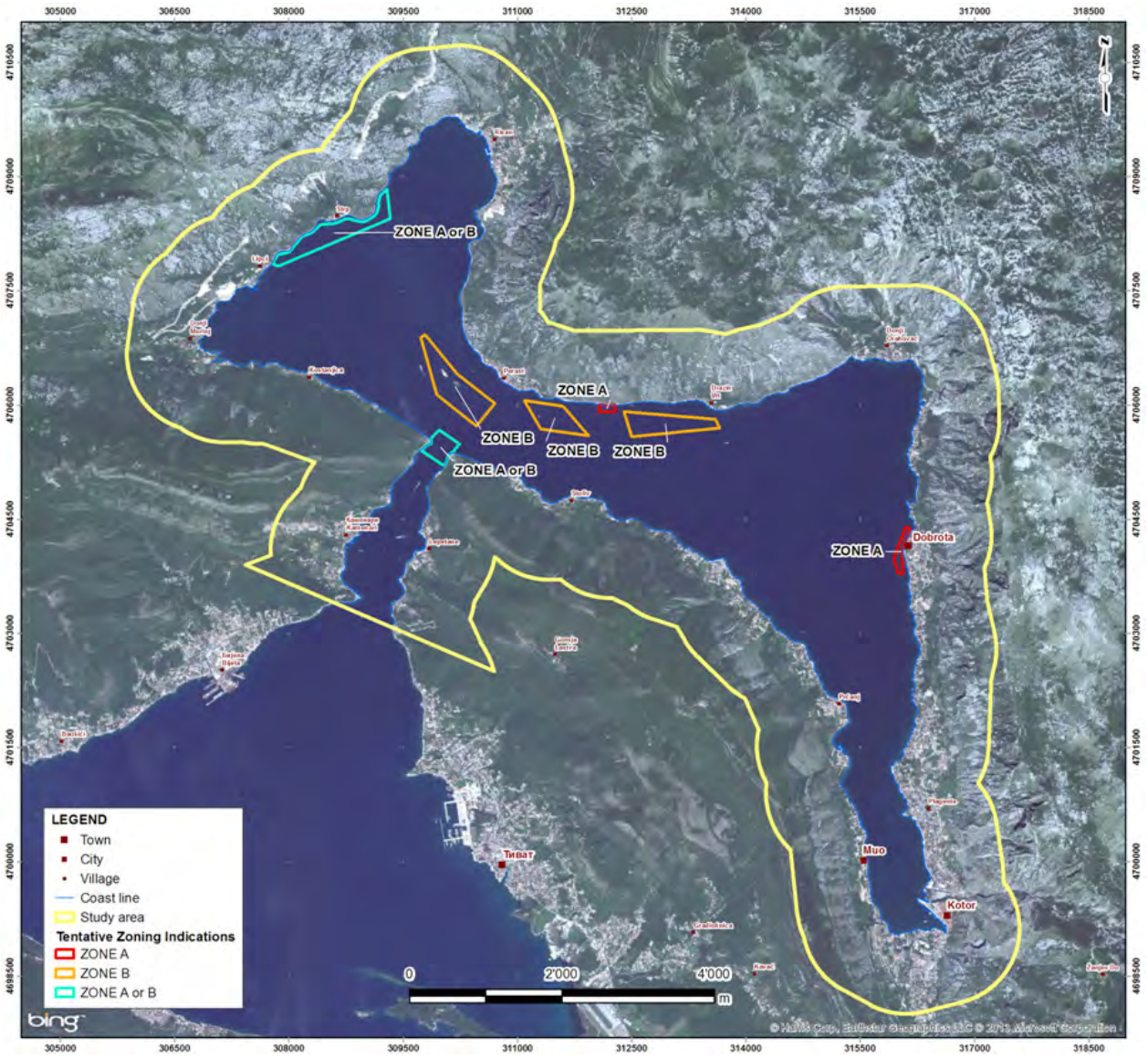

Figure 39: Tentative preliminary zoning indications

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APPENDIX A

Boka Kotorska Bay geophysical survey: short field work report

MEMORANDUM

TO Daniel Cebrian **DATE** 24/01/2013

CC Atef Limam

FROM Giovanni Torchia **PROJECT No.** 12508460716

KOTOR BAY GEOPHYSICAL SURVEY: SHORT FIELD WORK REPORT

The first field survey aimed at the seafloor characterization of the study area was carried out, between the 19th and the 24th of January 2013.

Two geophysical experts (Fabio Morfea and Francesco Pititto) carried out the survey, in collaboration with local expert, Dr. Vesna Mačić of the Institute of Marine Biology (IBM) of Kotor.

Field activities were conducted using the vessel “Nemirna II” owned by IBM (Figure 1).

Figure 1 - The vessel "Nemirna II"

The whole study area was surveyed using a C-MAX CM2 side scan sonar and an echo-sounder Navitronics (Reson) model Navisound 205, according to a route plan that assured the full coverage of the bay with the necessary data density. All navigation data was recorded in PDS 2000 software for post-processing phase.

Side scan sonar recorded signals from the seabed to detect small to mid-scale features: seabed forms (e.g. ripple marks, pockmarks, etc.), textures, specific habitats (e.g. Seagrass) with other types of natural morphologies and non-natural objects (e.g. archaeological, wrecks, small objects, etc.). Echo-sounder collected depth data information along a grid of lines, using reflection of echoes generated by a transducer and geo-referenced by satellite positioning (GNSS-GPS).

A total amount of 69 navigation lines (Figure 2) were travelled, for an amount of 177 km. The total area covered by the survey was 25,8 km^2.

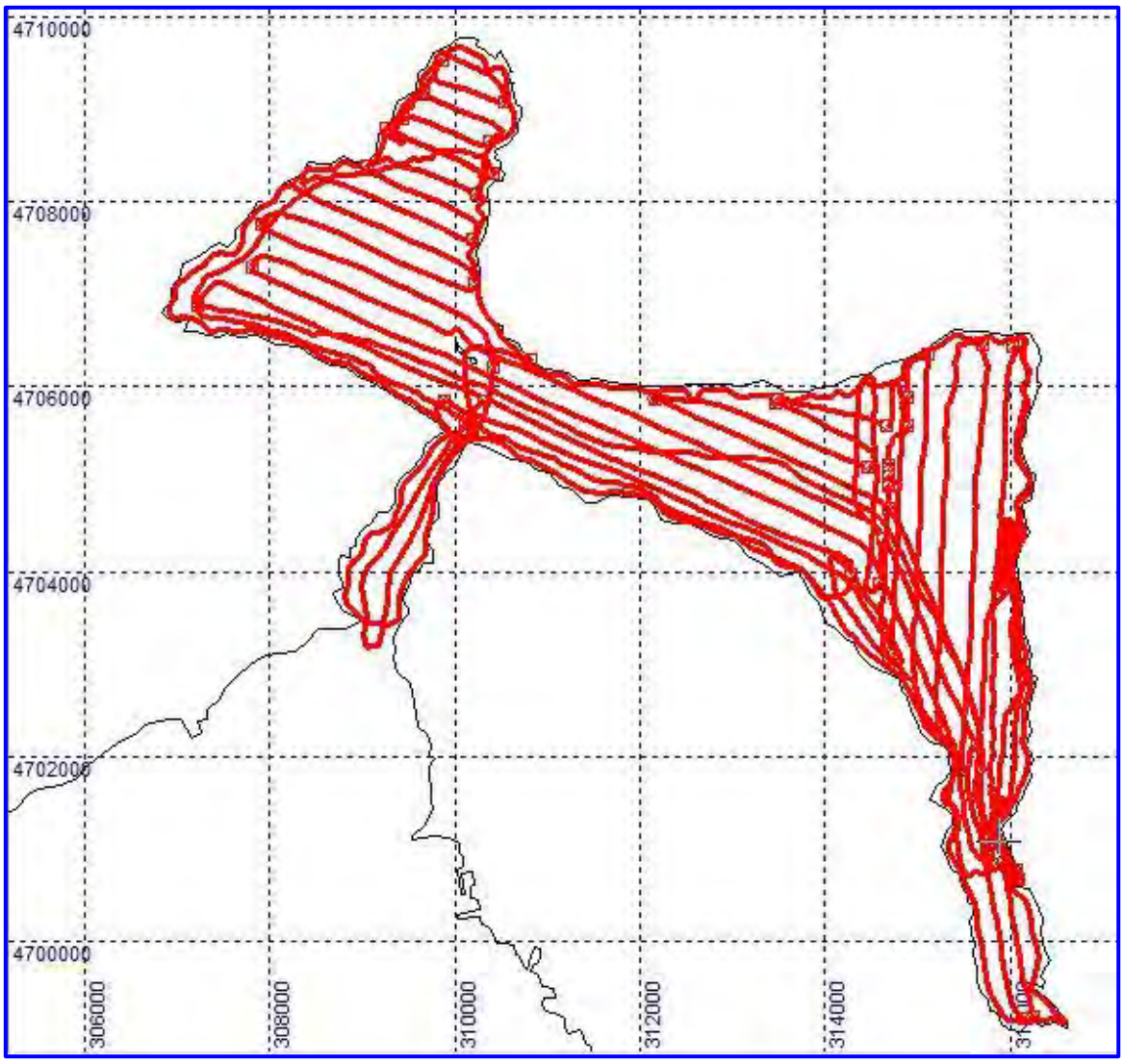


Figure 2 - Geophysical survey lines

In order to achieve a good resolution in recorded data a frequency of 325 kHz was used. As further improving of the presented technical proposal, a 150 m lateral range was adopted to cover the whole study area with. In addition, to in-deep analyze the presence of threatened coastal habitats (e.g. seagrass meadows) the whole coastal perimeter of the bay was travelled adopting a 100 m lateral range of the side scan sonar. Moreover, in one specific site in which presence of Posidonia oceanica was known from past information, a small area was covered with a 50 m lateral range giving an high resolution data of the distribution of the meadow and of some adjacent features (e.g. a freshwater pipe and some obstacles laying on sea bottom).

The following are preliminary and qualitative result:

- seagrass of Posidonia oceanica (Figure 3) and probably (to be confirmed by ground trothing) of Cymodocea nodosa have been identified in the bay;
- the coastal rocky bottom has a high slope and generally soft bottom starts very close to the shoreline, between 15 and 25 m depth, soft bottoms cover a consistent part of the bay;
- below the 30-40 m depth the bottom has a relatively low slope;
- in several areas the presence of deep holes has been recorded;
- small scattered rocky bottoms are present in several areas;
- there are several obstacles and object laying on the seafloor (Figure 4);
- areas with signs of anchorage of very big cruises were identified.

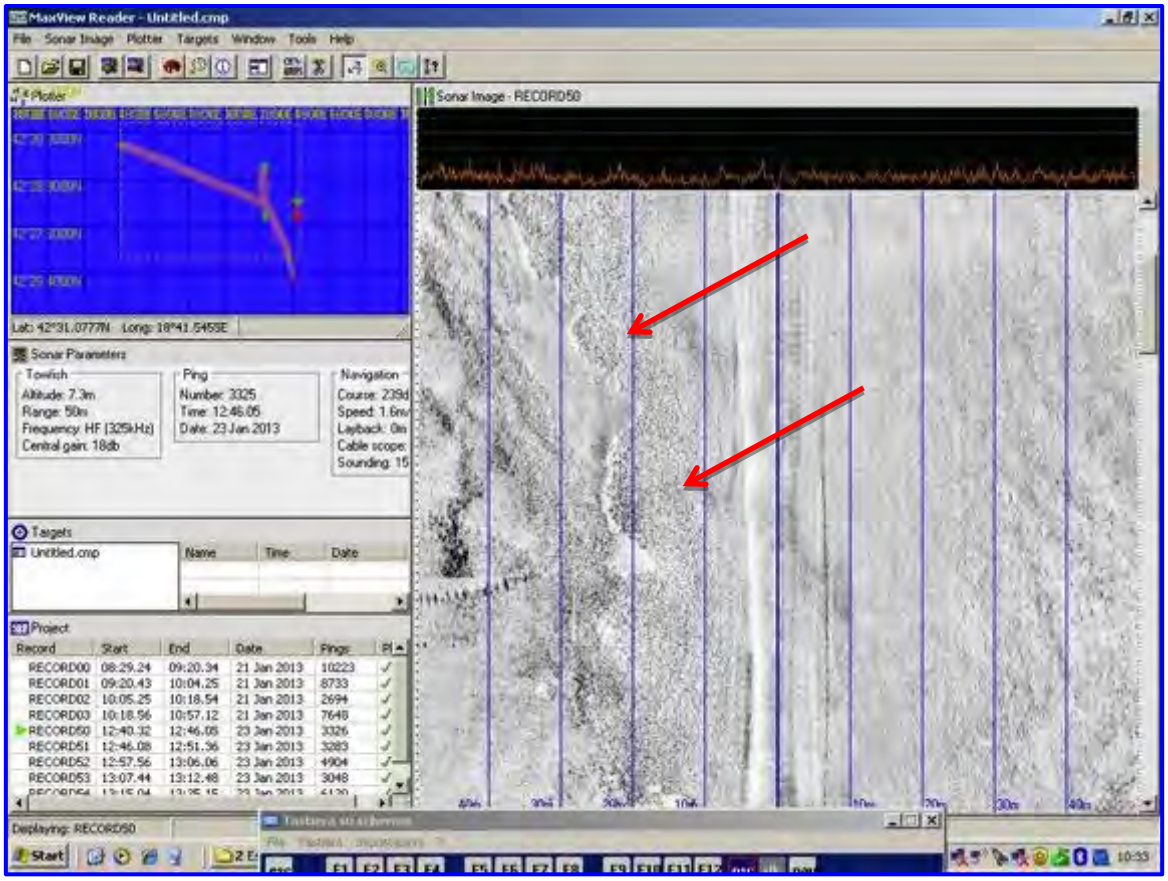


Figure 3 - Probable Posidonia oceanica meadow (as indicated by red arrows)

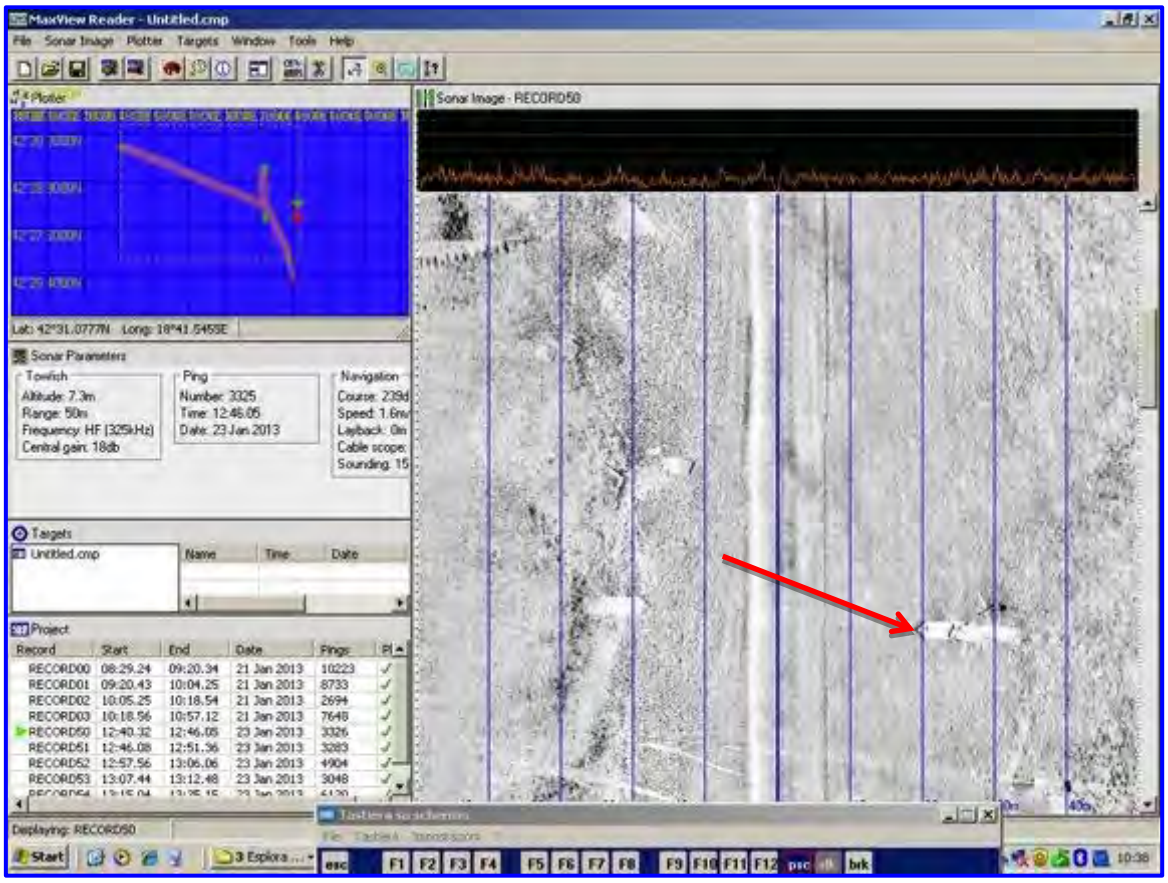


Figure 4 - Object on the seafloor (red arrow)

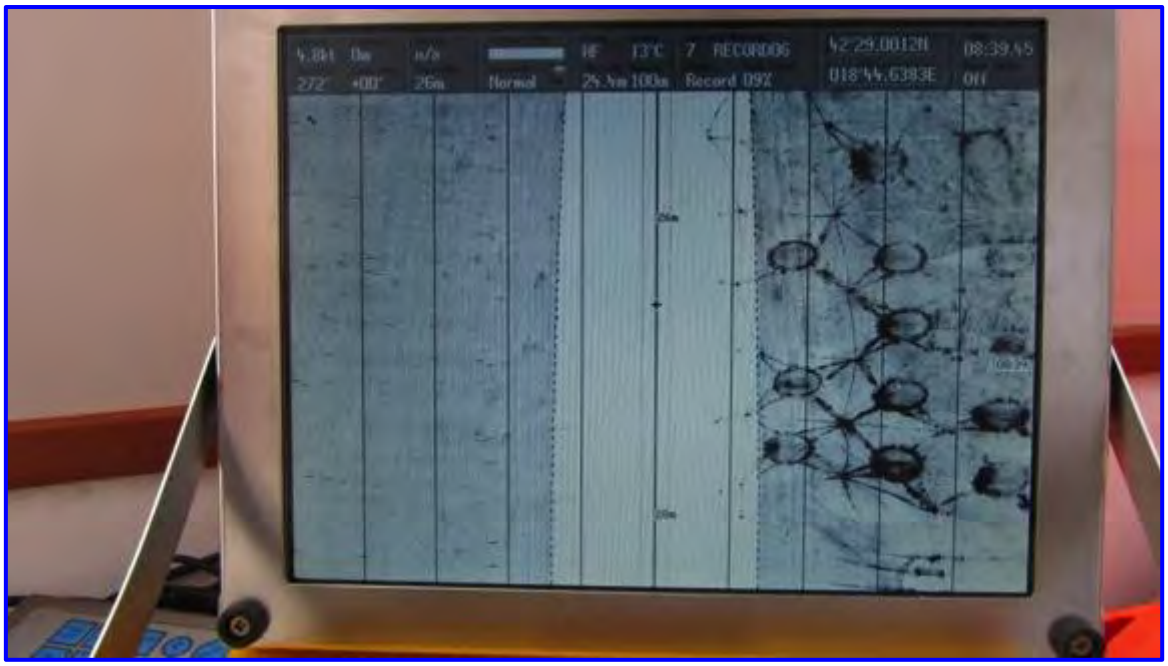


Figure 5 - The signal of a fish farm plant

Collected data will thus elaborated in order to plan all further surveys expected by this Project.

GOLDER ASSOCIATES SRL

Project Manager

APPENDIX B

Fishery landing data form

Fishery Survey

Interviewer

Vessel name

Crew N° HP

Fishing Area

Depth

Bottom type

Fishing Gears*

Mesh/Dimension

Lenght

Numbers

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

Note

Size Classes: S = Small M= Medium; L = Large;

APPENDIX C

Side scan sonar mosaic maps

311000 312500 314000 315500 317000 318500

4706000 4704500 4703000 4701500 4700000

Donji Orahovac
Perast
Drazin Vrt
Stoliv
Dobrota
Gornja Lastva
Prčanj
Plagente
Muo
Tиват
Kotor
Gradiošnica

bing

LEGEND

- Town
- City
- Village
- Study area

Side Scan Sonar mosaic - EST

Value
High : 255
Low : 0

REFERENCE

Projection: UTM Zona 34N Datum: WGS84

0 1'000 2'000 m

REPORT

QUANTITATIVE DESCRIPTION OF
BOKA KOTORSKA BAY MARINE AREA

FIGURE TITLE

Side Scan Sonar mosaic - EST

Golder Associates
Torino Italia

Project Num.	12508420857	REL. - REV. 0	FORMAT A3
DATE	26/06/2013		
DESIGN	CVI		
CHECK	GTO		
REVIEW	-		

MAP 5.1

306500 308000 309500 311000 312500

4709000 4707500 4706000 4704500 4703000

Risan
Strp
Lipci
Donji Morinj
Kostanjica
Perast
Drazin Vrt
Stoliv
Каменари Kamenari
Lepetane
Gornja Lastva
Бијела Bijela

bing

N

LEGEND

- Town
- City
- Village
- Study area

Side Scan Sonar mosaic - WEST Channel

Value

High : 255

Low : 0

REFERENCE

Projection: UTM Zona 34N Datum: WGS84

0 1'000 2'000 m

REPORT

QUANTITATIVE DESCRIPTION OF
BOKA KOTORSKA BAY MARINE AREA

FIGURE TITLE

Side Scan Sonar mosaic - WEST Channel

Golder Associates
Torino Italia

Project Num.	12508420857	REL. -	REV. 0	FORMAT A3
DATE	26/06/2013			
DESIGN	CVI			
CHECK	GTO			
REVIEW	-			

MAP 5.3

315500 315750 316000 316250 316500

4704500 4704250 4704000 4703750

Dobrota

bing

N

LEGEND

- Town
- City
- Village
- Study area

Side Scan Sonar mosaic - Posidonia meadow

Value

High : 255

Low : 0

REFERENCE

Projection: UTM Zona 34N Datum: WGS84

0 125 250 m

REPORT

QUANTITATIVE DESCRIPTION OF
BOKA KOTORSKA BAY MARINE AREA

FIGURE TITLE

Side Scan Sonar mosaic - Posidonia meadow

Golder Associates
Torino Italia

Project Num.	12508420857	REL. -	REV. 0	FORMAT A3
DATE	26/06/2013			
DESIGN	CVI			
CHECK	GTO			
REVIEW	-			

MAP 5.4

APPENDIX D

Diving Log-Book

DIVING LOG BOOK
BOKA KOTORSKA BAY – APRIL 2013

Total diving time: 8h 15'

06 April 2013

Hour: 15:45
Visibility (Secchi Disk): 2.5 m
Location: DIP01 - DRAZIN VRT
Depth: 19 m
Diving time: 57' 14°.

Anchoring a few meters from the shore, in line with a pipeline under the road, marine seafloor at about 9 m depth. Turbid water with visibility < 3m. Marine sediment characterized by coarse sand mixed with mud, scattered boulders and rock piles. Boulders and rocks have a 100% cover of muds that makes it difficult to identify benthos organisms. Coralligenous algae are visible in some spots on boulders and rocks.

At low depth (5 m) *Asparagopsis taxiformis*. *Aplysina aerophoba* (cfr) with a brown coat on part of the body. Rarely ramified.

At 9 m the first polyps of *Savalia savaglia* (of a whitish color) on *A. aerophoba* (cfr). On boulders colonies of orange Leptogorgia sarmentosa and individuals of Axinella cannabina not much ramified and dark red in color.

At about 12 m big colonies of *Savalia savaglia* in bushes (variegated yellow and white). From that point up to 17 m there are boulders, bushes of *Savalia savaglia* ramified colonies of *A. cannabina* and colonies of *L. sarmentosa*. Widespread colonies of rich orange *Parazoanthus axinellae*. The organisms concentration seems to be consistent with the presence of fresh water springs that cause water turbidity and that probably tend to have a direction but not continuous forming sometime vortexes. There is no *Cladocora coespitosa*. Small colonies of *Caryophyllia smithii* and *C. inornata* (cfr). Small Epinephelus marginatus (2) and Gobius vittatus.

Difficult situation both for current and turbidity, and optical effect due to freshwater mixing with saltwater.

07 April 2013

Hour: 12:00
Location: DIP02 - STRP
Depth: 31.4 m
Diving time: 21' 14

NO PHOTO

Anchoring on a SSS target at about 32 m depth. Almost no visibility, following the anchor chain we land on mud.

Hour: 14:25
Location: DIP03 - SVETI ĐORĐE
Depth: 25.7 m
Diving time: 36' 14°

Anchoring on a bottom of about 25 m with organic muddy sediment, visibility is acceptable (3-5 m). On the bottom low elevations are extensively colonized: the nature of the elevations is in some cases rocky, in

others it is probably a residual of *Cladocora concretions*. The colonies are mainly made of porifera cnidaria, briozoa and solitary tunicata with red inconstant algae in the substrate. The presence of live *Cladocora caespitosa* is limited to small colonies. Only part of the cover is recognizable because of the thick sediment layer that cover most of the elevations.

08 April 2013

Hour: 11:00
Location: DIP04 - GODSPA OD SKARPJELA
Depth: 32,8 m
Diving time: 41' 14°

Anchoring on one of the target on a bottom of about 33 m with muddy organic sediment, acceptable visibility on the bottom (2-3 m). The bottom is characterized by a ridge connected to the island, with a low inclination explored up to 20 m. From the bottom low elevations are extensively colonized: the nature of the elevations is clearly a residual of *Cladocora* concretions. The colony is mainly made of porifera, cnidarian, incrusting briozoa and single tunicate with red encrusting algae in the substrata. The presence of *Cladocora caespitosa* alive is limited to small colonies. Only part of the cover is recognizable because of the thick sediment layer that cover most of the elevations. Strong currents on the surface.

Hour: 12:45
Location: DIP05 - SVETI ĐORĐE
Depth: 21,6 m
Visibility: 3-4 m.
Diving time: 49' 14

Anchoring at about 22 m at a short distance from the previous day site on an hard bottom target. Soft muddy organic bottom with scattered blocks of dead cladocora from small up to 2 m high. The blocks are covered of organisms. The dive is performed on a transect perpendicular to the island with depth variations up to 5 m, there is a progressive reduction of rocky areas that become smaller and smaller and a clear progressive mutation of assemblage related to light penetration.

09 April 2013

Hour: 13:30
Location: DIP06 - STRP
Depth: 17.9 m
Diving time: 59' 14°

Very close to the shore, easily reachable from land. Anchoring on hard substrata of about 15 m, muddy and organic with scattered hard substrata and fresh water springs. Many cladocora fragments and likely many of the hard substrata are cladocora concrations. Most of the organisms are concentrated around freshwater springs that make the water turbid at intervals. Scattered waste. Explored in an area from 19 m and the surface, where in the tide zone *Fucus virsoides* individuals are found.

Hour: 15:50
Location: DIP07 - RISAN
Depth: 3.7 m
Diving time: 18'

Anchoring close to shore on a muddy organic sediment. At a mean depth of 3.5 m a mixed prairie of *Cymodocea nodosa*, *Nanozostera noltii* and *Zostera marina* is present. The first two species are much

covered by epiphytic organisms and mud. Wide spread presence of epiphytic algae. *Pinna nobilis* of small dimensions. The vegetated zone extends for about 10 m of length parallel to the coast line. Waste are scattered everywhere. Some small freshwater spring.

Hour: 16:25
Location: DIP08 - RISAN
Depth: 2-3.5 m
Diving time: 19'

Anchoring on the organic muddy sediment. At a mean depth of about 3.5 m there is a mixed prairie of *Cymodocea nodosa* and *Nanozostera noltii*, widespread presence of epiphytic algae covered in mud. *Pinna nobilis* of small dimensions. The vegetated zone extends for about 10 m of length parallel to the coast line. Waste are scattered everywhere. A lot of dead *Holothuria*, probably used and thrown by fisherman.

10 April 2013

Hour: 12:55
Location: DIP09 - VERIGE
Depth: 15.9 m
Diving time: 65'

Anchoring very close to shore, on the right side of the entrance channel of the last basin of Boka Kotorska Bay: current entering, the itinerary follows the slope in favor of the current. The sea bottom has a high slope an it is formed by muddy organic sediment with scattered hard substrata, some of small dimension, others higher than 2 m, likely formed by past cladocora concretions, in some cases it is possible to recognize dead corals more than 1 m in length. In some stretch there are rock piles usually of small dimension.

Below 16 m of depth rocks reduced and the bottom is almost exclusively organic sediment. Fishes seems to be present in higher number than in other site, both for number of species and abundance. Algae adapted to low light levels are prevalent, with a wide spread presence of *Corallianceae* in the substrata.

Hour: 15:35
Location: DIP10 - DRAZIN VRT
Depth: 20.5 m
Diving time: 46'
Visibility (Secchi Disck): 5 m

We go back to the first day diving point in order to verify the extension of the biocenosis and collect more data. The site is investigated for about 80 m in extension. The visibility is better compared to the first dive and the temperature is around 14 e 15 °C. Strong intermittent currents are present due to fresh water springs (the effect of upwelling waters is visible also from the surface).

The biocenosis with S*avalia savaglia, Leptogorgia sarmentosa, Parazoanthus axinellae, Aplysina cfr. cavernicola* and *Axinella cannabina* is practically continuous from 9 to 20 m depth on a rocky formation (probably a residual of cladocora reef) and on small rocks elevations covered by coarse sediment. In some places the movement of the sediment is evident (in correspondence to surface pipelines, for example). This could eradicate and/or submerge the ramifications of *Savalia savaglia*. At the end of the transect going back up towards the shore, the biocenosis changes with the presence algae and *Aplysina aerophoba/cavernicola*.

Up to 5 m of depth there is almost only freshwater at lower temperature. All around the area there are plastic waste (mostly plastic bottles).

11 April 2013

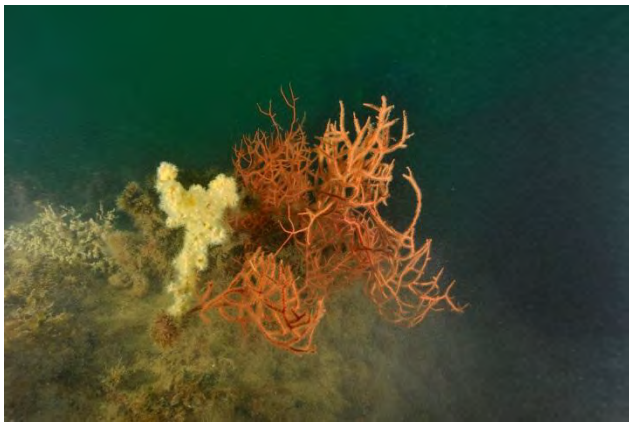
Hour: 10:15
Location: DIP11 - VERIGE
Depth: 14.0 m
Diving time: 78'

Anchoring very close to the shore and in line with many little water stream that end in the sea. The itinerary of the dive is along the slope in the opposite direction from the last one (going out). The sea bottom has a high slope and it is characterized by muddy organic sediment mixed with pebbles and blocks of dead cladocora formations partially in situ and partially collapsed. The main objective is to collect photographic documentation of most frequent fishes in the biocenosis observed and the area offers a good synthesis.

APPENDIX E

Photographic Atlas of stations

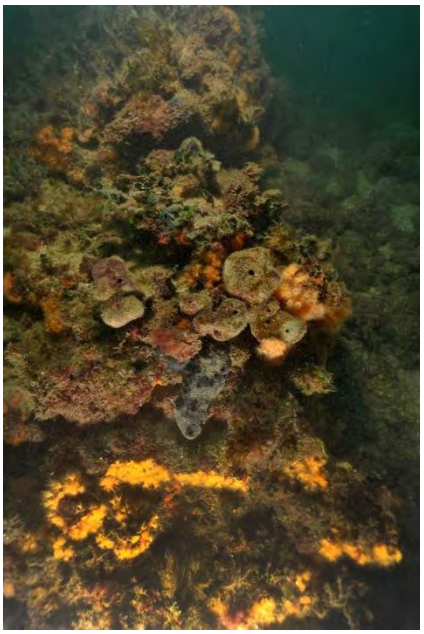
DIP01-DIP010 (Drazin Vrt)









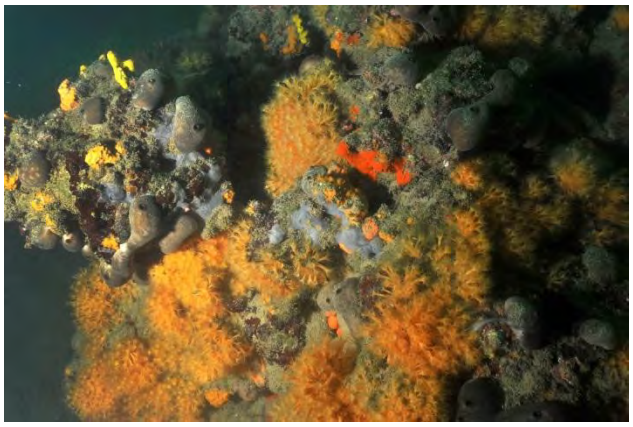



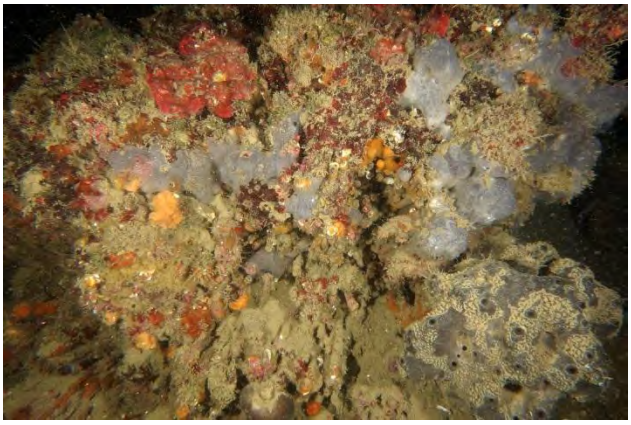






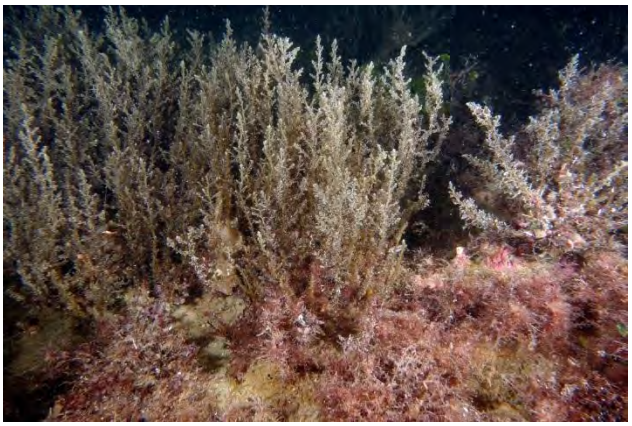

DIP03-DIP05 (Sveti Djordje)



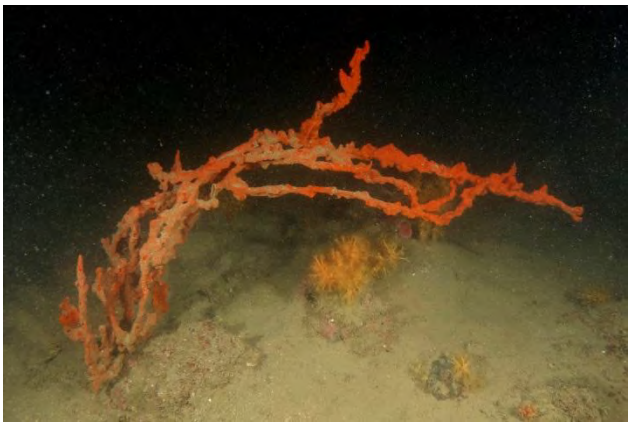




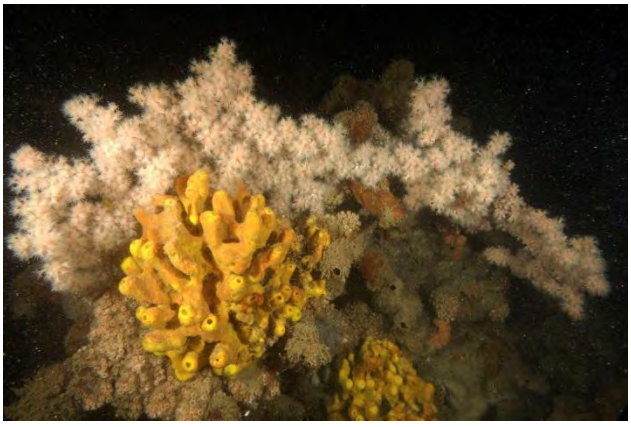


DIP04 (Gospa Od Skrpjela)

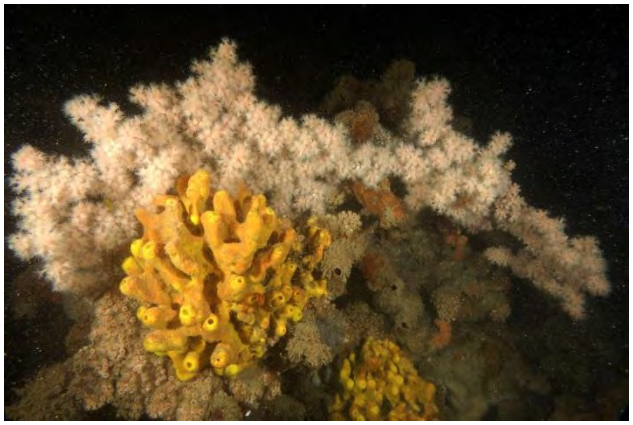


DIP06 (Strp)



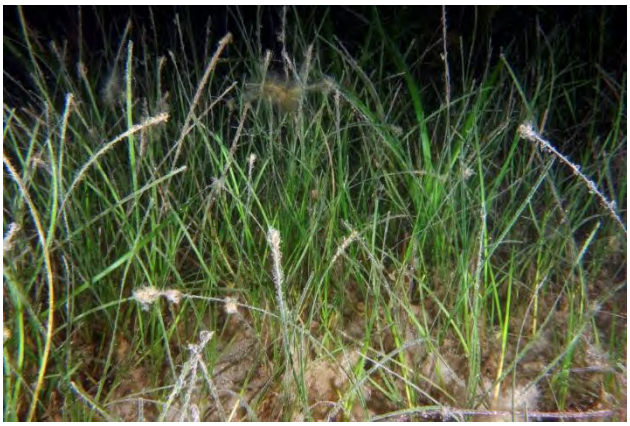









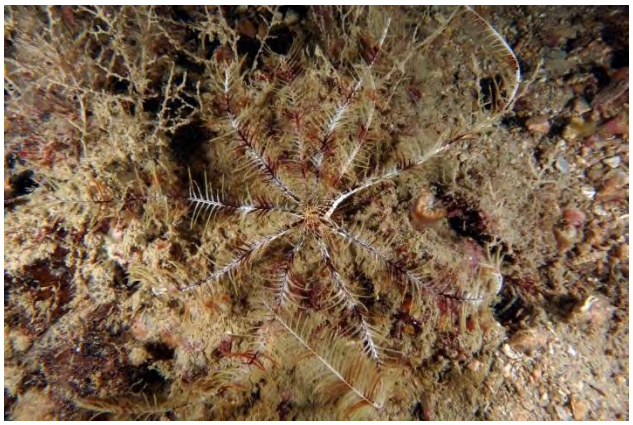

DIP07-DIP08 (Risan)

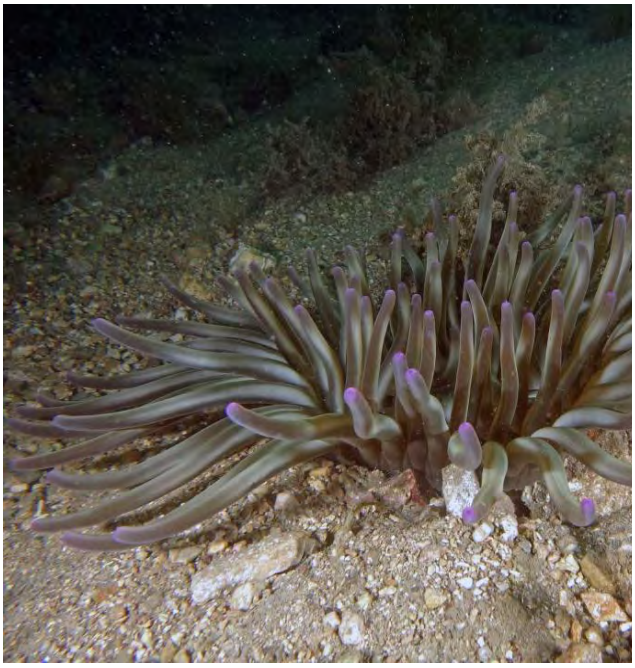


DIP09-DIP11 (Verighe)







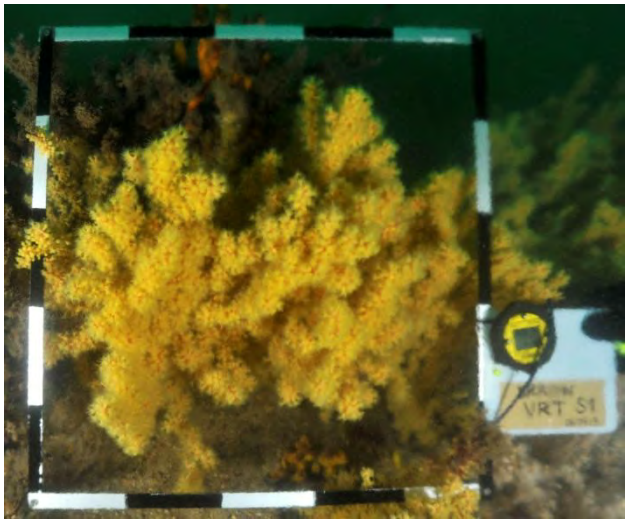



APPENDIX F

Photographic Atlas of hard bottom 50X50 cm quadrats

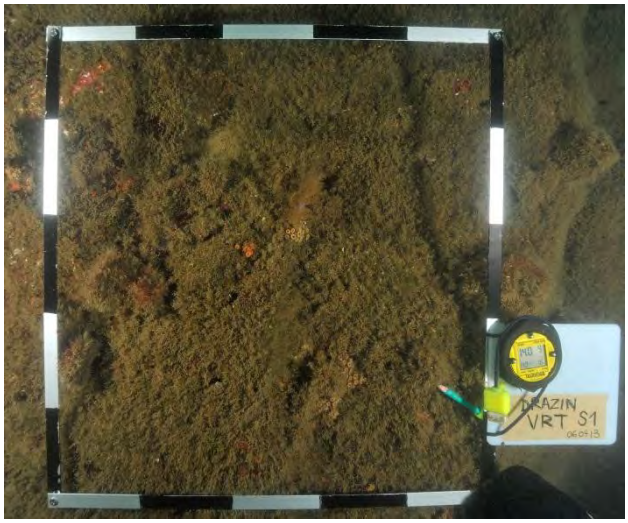
HSQ01 - Drazin Vrt

HBQ01 - DrazinVrt	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Algae	10.00	41.25	97.25	88.50	8.50	31.75	0.00	42.25	66.25
Cnidaria	75.00	5.50	2.75	2.50	4.25	61.25	69.00	14.00	33.75
Porifera	7.00	21.50	0.00	8.25	21.25	0.00	16.00	1.75	0.00
Briozoa	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00
Soft Bottom	0.00	0.00	0.00	0.00	66.00	0.00	15.00	16.25	0.00
Garbage	0.00	18.25	0.00	0.00	0.00	0.00	0.00	22.50	0.00
Surface not taken into account	8.00	16.50	0.00	0.00	0.00	7.00	0.00	3.25	0.00

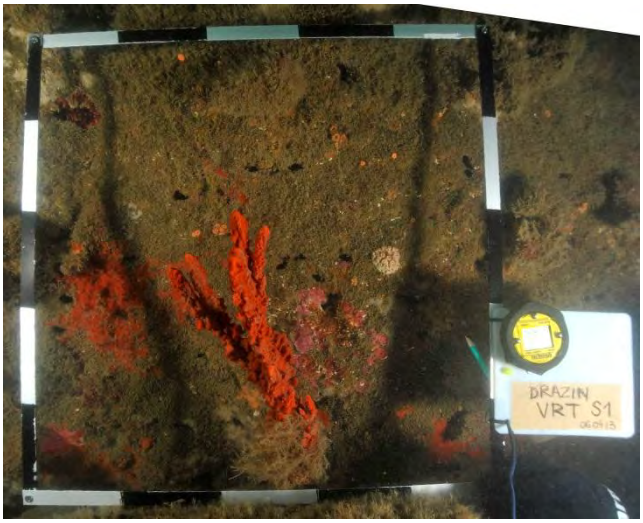


HSQ01-01

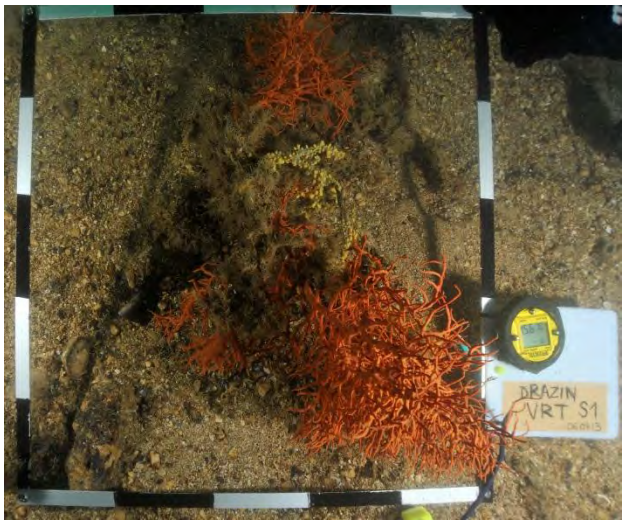
HSQ01-02



HSQ01-03



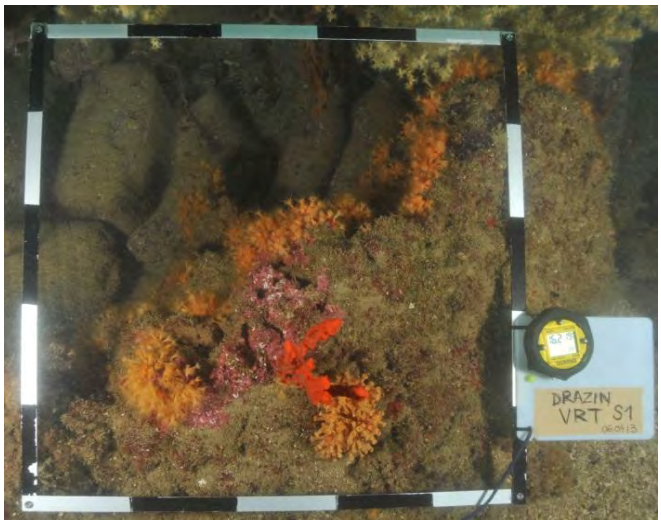
HSQ01-04



HSQ01-05

HSQ01-06

HSQ01-07



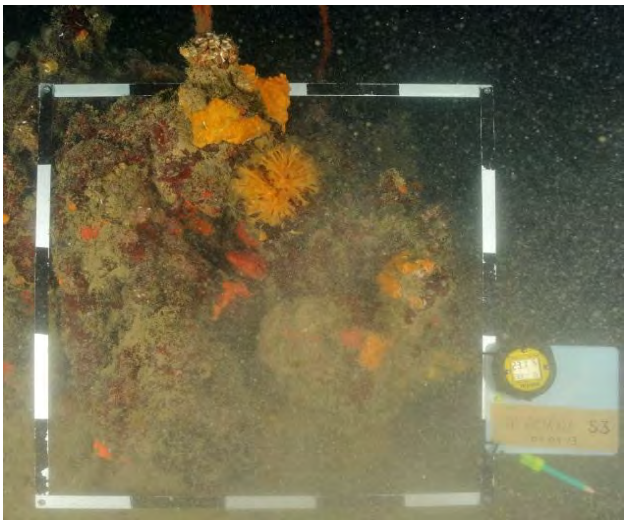
HSQ01-08

HSO01-09

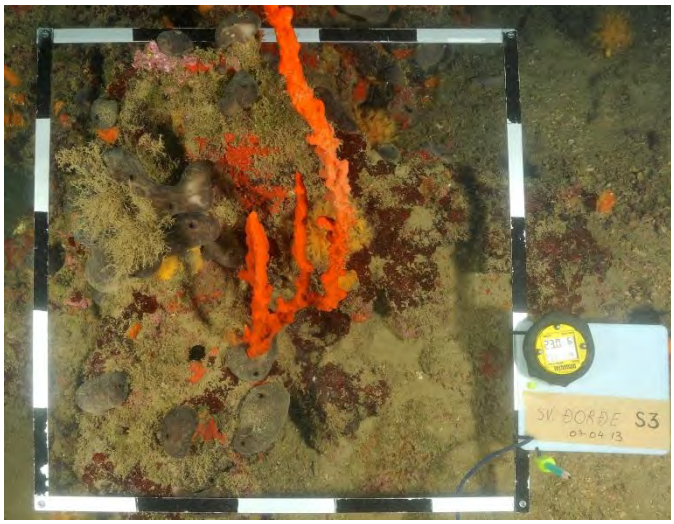
HSQ02 - Sveti Djordje

HBQ02 - SV. Dorde*	Q2	Q3	Q4	Q6	Q7	Q9	Q10	Q11	Q13	Q14
Algae	12.50	6.50	15.25	29.50	8.75	4.00	5.00	8.50	11.75	6.00
Cnidaria	6.25	8.50	1.50	11.75	10.75	16.50	28.25	18.50	22.25	8.50
Porifera	46.50	25.00	29.75	27.50	49.50	43.50	48.25	64.75	34.75	41.25
Briozoa	0.00	0.00	0.00	1.50	0.00	0.00	0.00	3.00	0.00	0.00
Tunicata	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	1.00	0.00
Soft Bottom	34.75	56.00	53.50	19.75	25.00	32.00	18.50	0.00	14.25	44.25
Garbage	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mollusca*	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Surface not taken into account	0.00	0.00	0.00	8.00	6.00	4.00	0.00	5.25	16.00	0.00

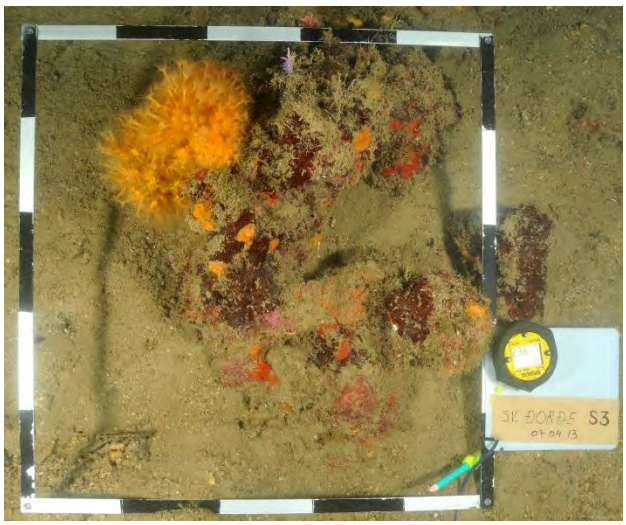
*** In order to analyse a comparable number of data, a maximum of 10 quadrats was analysed for each station. The quadrats used in the analysis were selected random. All the quadrats are showed below.**



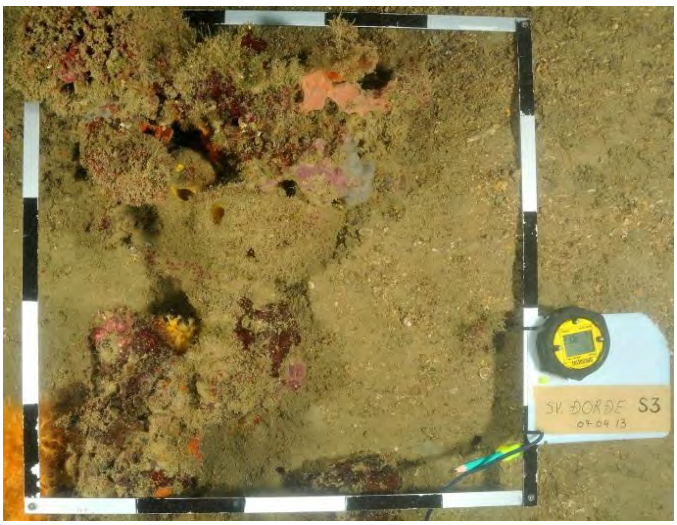
HSQ02-01



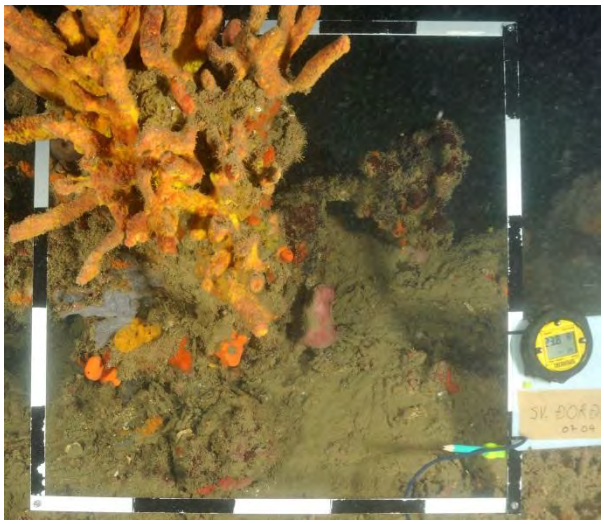
HSQ02-02



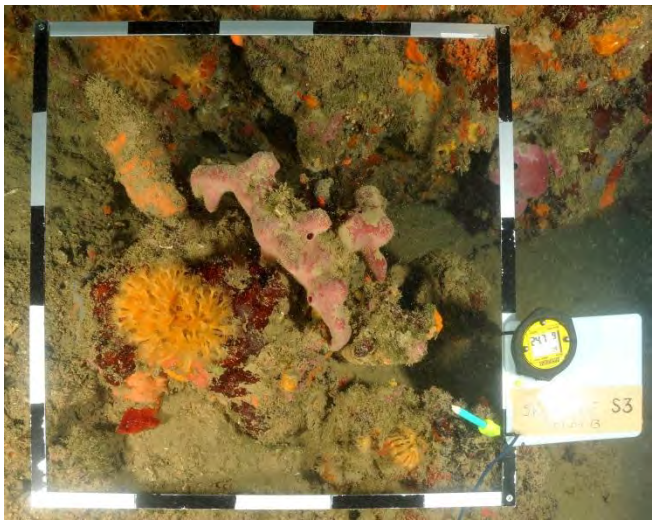
HSQ02-03



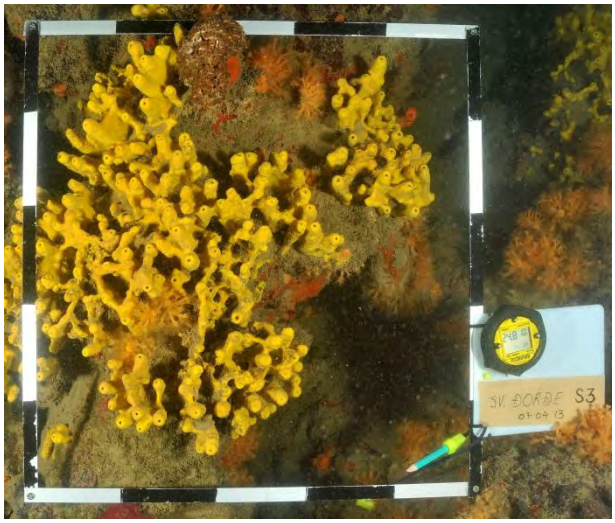
HSQ02-04



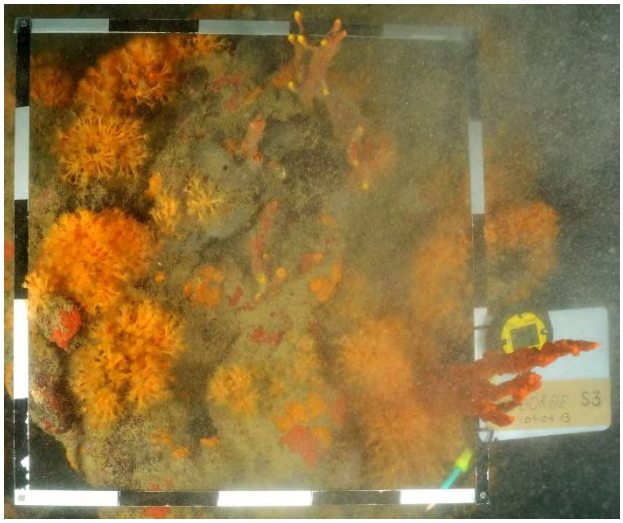
HSQ02-05



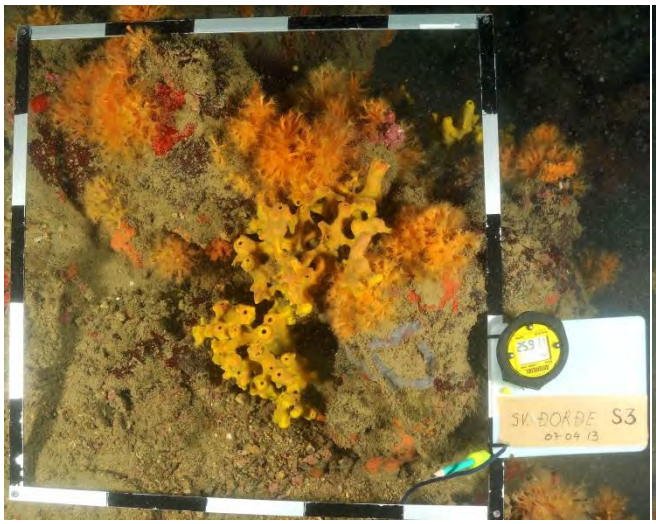
HSQ02-06



HSQ02-07



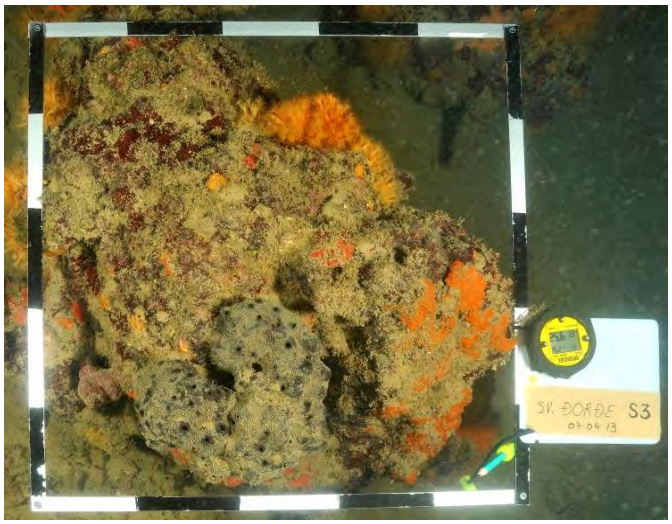
HSQ02-08



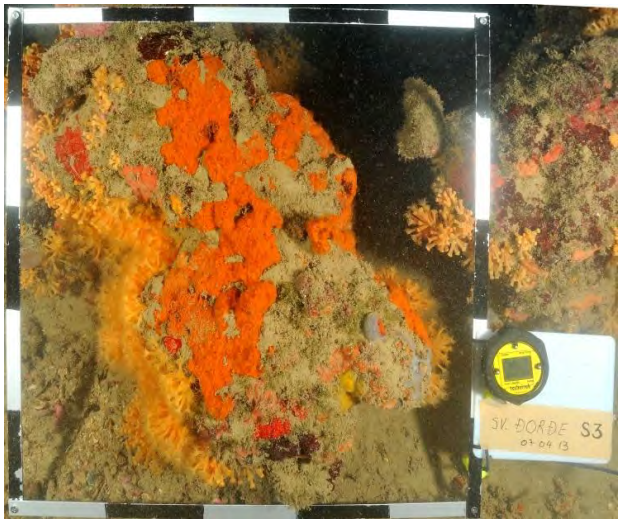
HSQ02-09

HSQ02-10

HSQ02-11

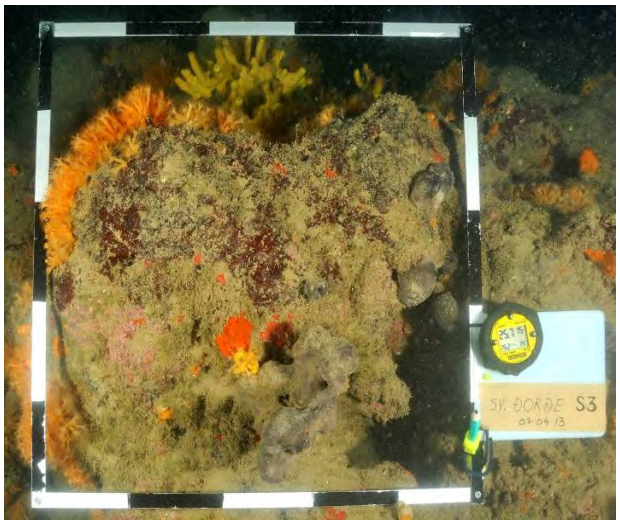


HSQ02-12

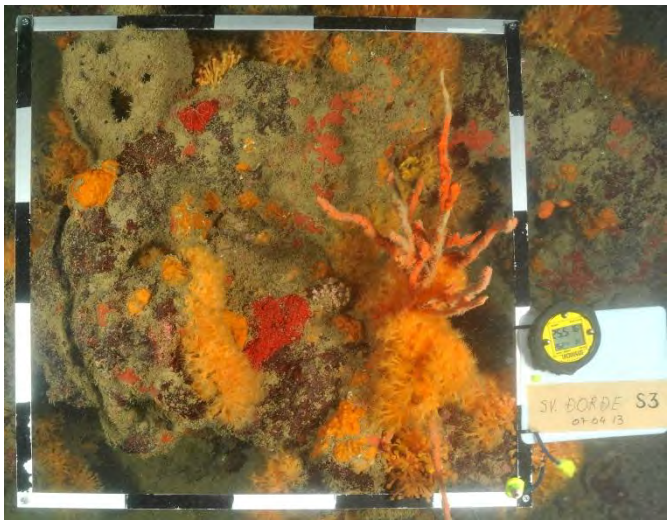


HSQ02-13

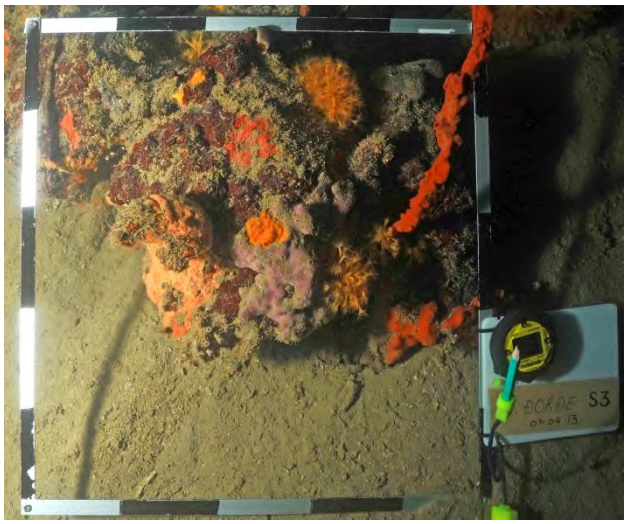
HSQ02-14



HSQ02-15



HSQ02-16



HSQ02-17

HSQ02-18

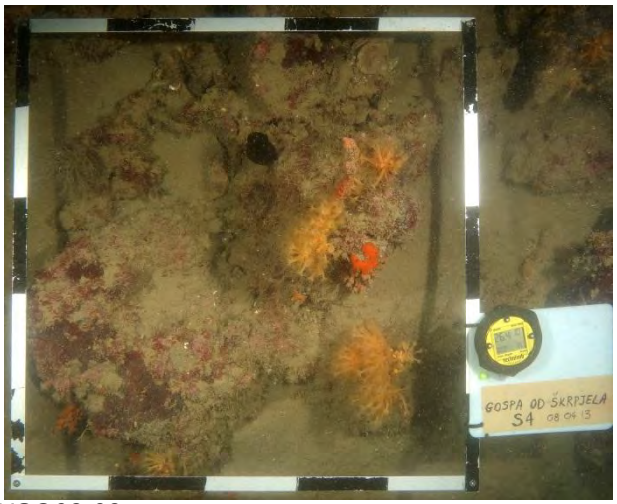
HSQ02-19

HSQ03 - Gospa Od Skrpjela

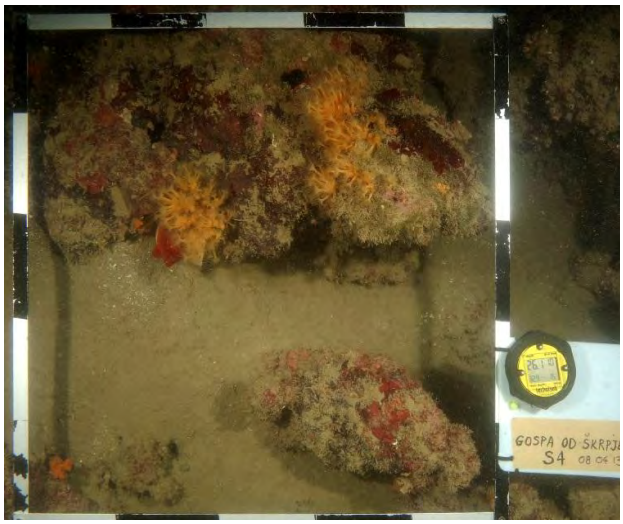
HBQ03 - Godspa od Skarpjela*	Q2	Q3	Q4	Q5	Q7	Q8	Q9	Q13	Q14	Q15
Algae	36.75	4.50	5.75	83.50	59.75	24.00	3.75	31.25	0.00	5.75
Cnidaria	8.75	7.00	9.00	2.25	0.00	3.00	0.00	7.50	0.00	15.75
Porifera	4.25	25.00	10.25	4.75	6.50	7.00	20.00	6.25	0.00	5.00
Tunicata	0.75	1.00	0.00	1.50	1.50	0.00	2.25	0.00	0.00	0.00
Soft Bottom	49.50	62.50	75.00	8.00	32.25	64.00	74.00	51.00	63.50	73.50
Coral rubble	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.50	0.00
Garbage	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
Pisces*	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Surface not taken into account	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00

*** In order to analyse a comparable number of data, a maximum of 10 quadrats was analysed for each station. The quadrats used in the analysis were selected random. All the quadrats are showed below.**

HSQ03-01



HSQ03-02

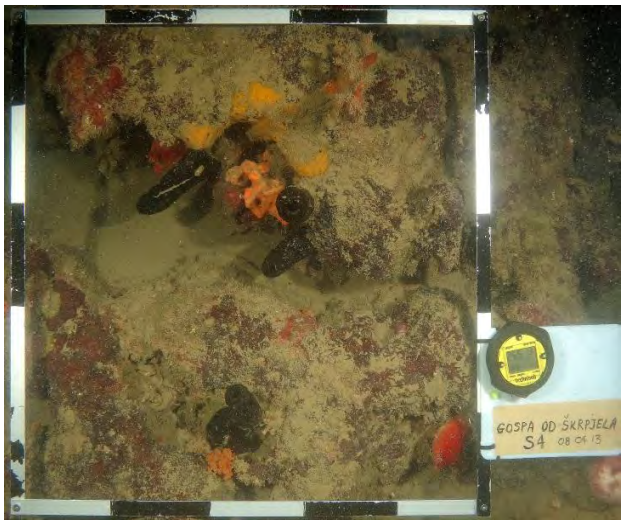


HSQ03-03

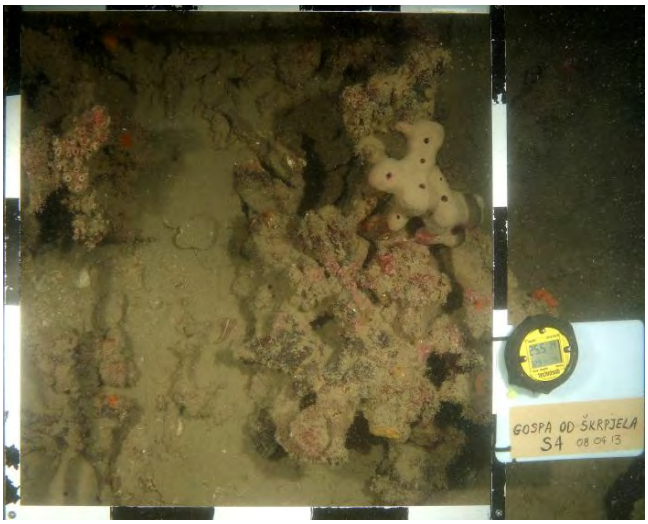
HSQ03-04

HSQ03-05

HSQ03-06

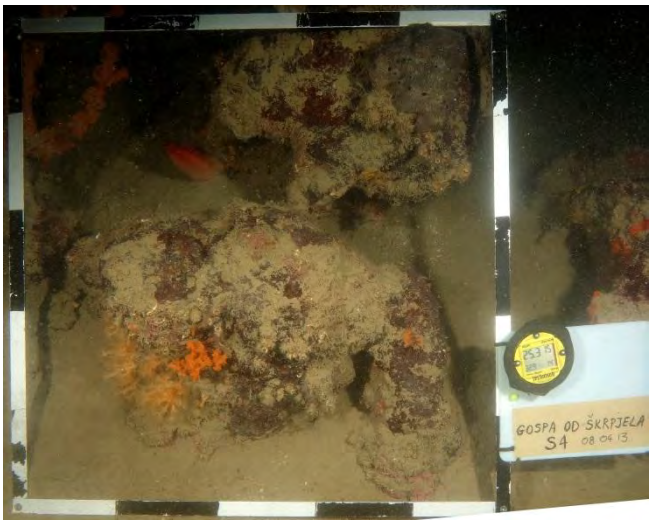


HSQ03-07

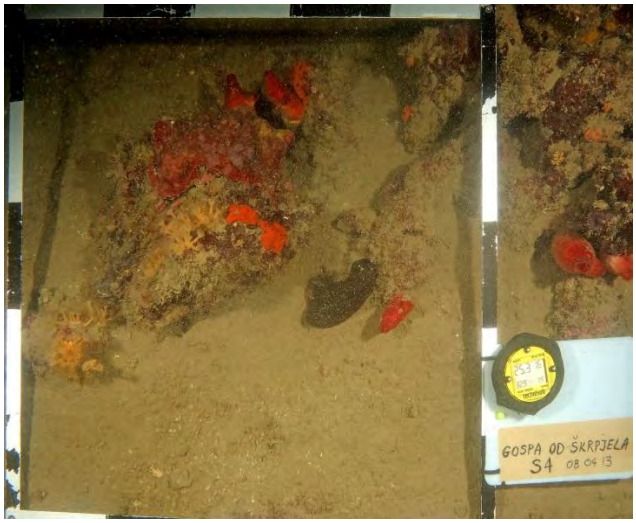


HSQ03-08

HSQ03-09

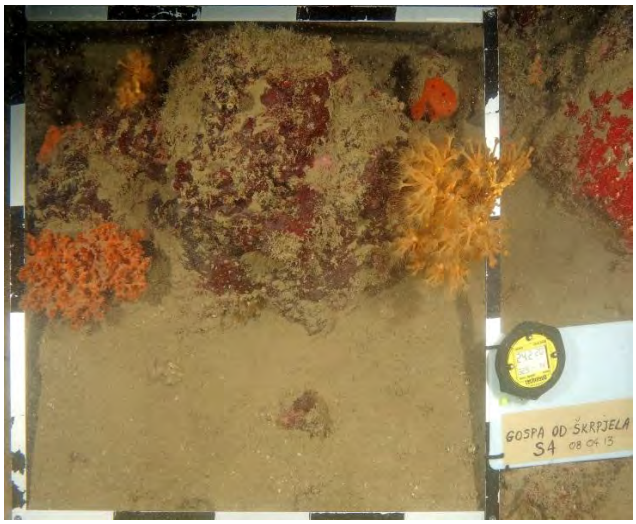


HSQ03-10

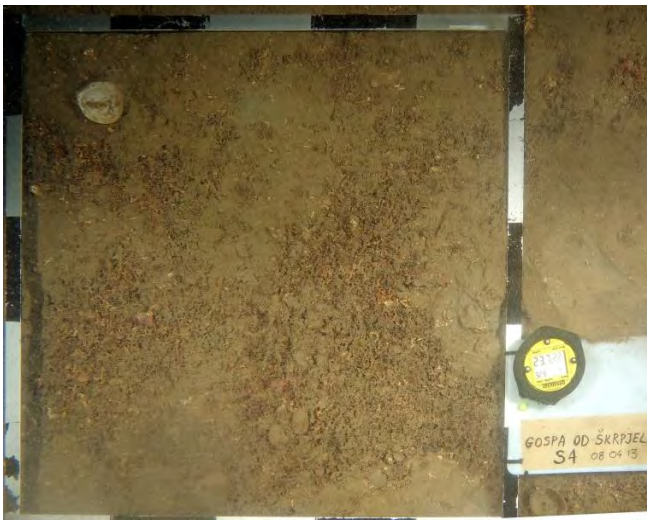


HSQ03-11

HSQ03-12

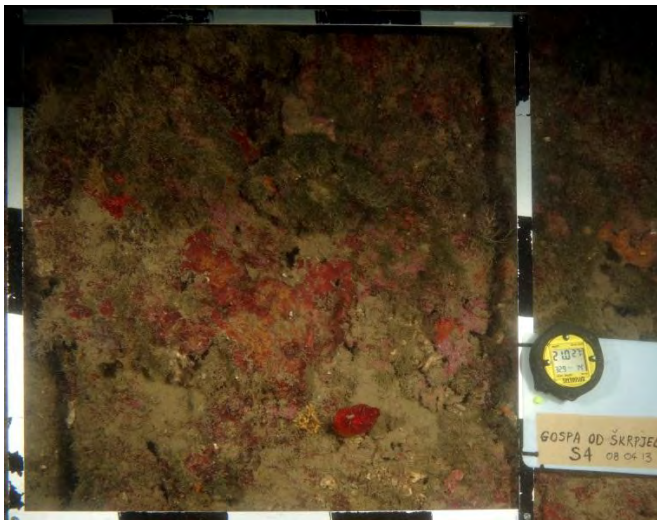


HSQ03-13



HSQ03-14

HSQ03-15

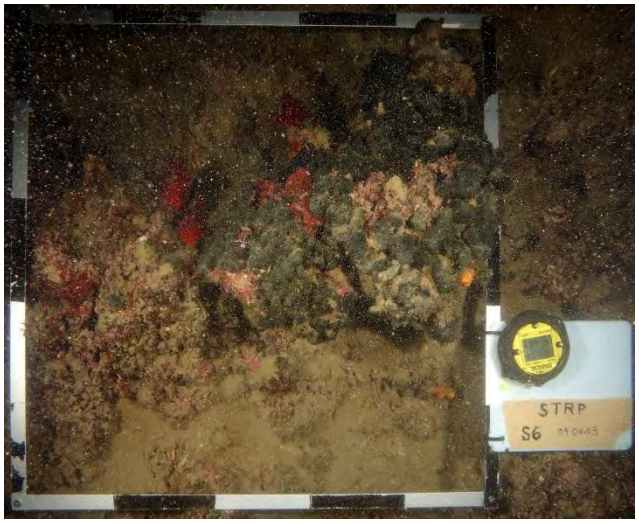


HSQ03-16

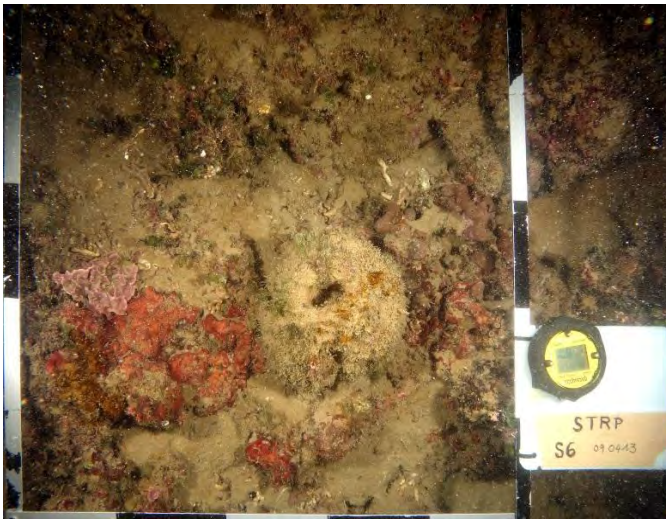
HSQ04 – Strp

HBQ04 – STRP*	Q2	Q3	Q6	Q7	Q8	Q11	Q12	Q13	Q15	Q16
Algae	15.00	26.00	34.50	36.00	43.25	0.00	68.25	3.00	0.00	24.25
Cnidaria	6.00	9.00	0.00	0.00	0.00	2.75	2.00	2.00	26.00	13.25
Porifera	18.00	4.00	0.00	6.00	3.75	49.00	26.75	66.00	12.00	25.50
Polychaeta	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tunicata	0.00	0.00	3.50	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Echinodermata	0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soft Bottom	28.00	22.50	27.50	37.00	45.00	37.25	3.00	0.00	44.00	37.00
Organic detritus	0.00	6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coral rubble	14.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polychaeta*	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Pisces*	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Surface not taken into account	19.00	23.00	26.00	21.00	8.00	11.00	0.00	28.00	18.00	0.00

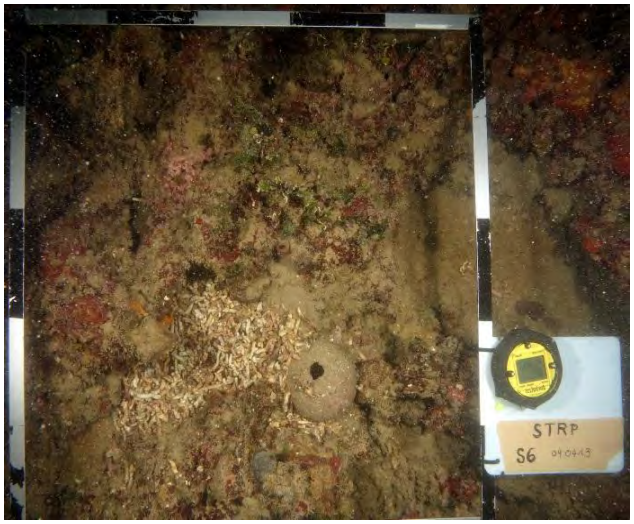
*** In order to analyse a comparable number of data, a maximum of 10 quadrats was analysed for each station. The quadrats used in the analysis were selected random. All the quadrats are showed below.**



HSQ04-01

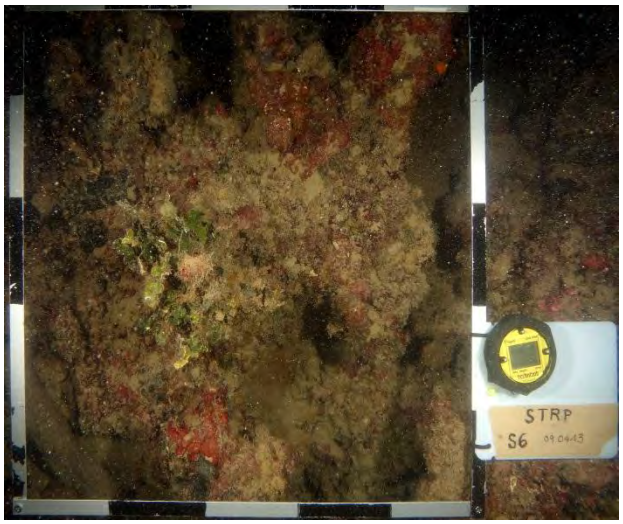


HSQ04-02



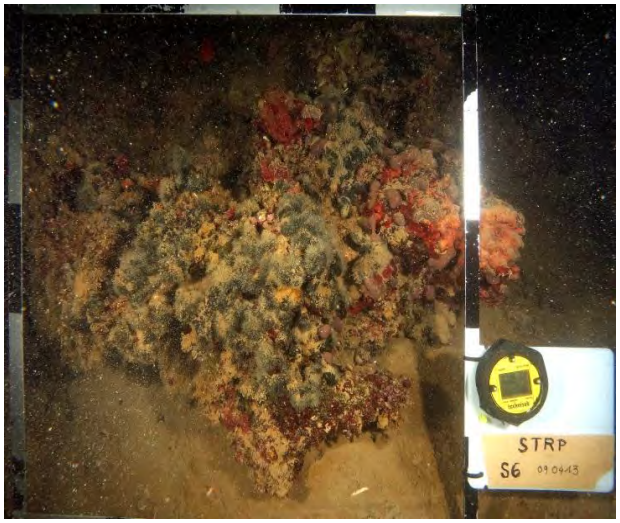
HSQ04-03

HSQ04-04

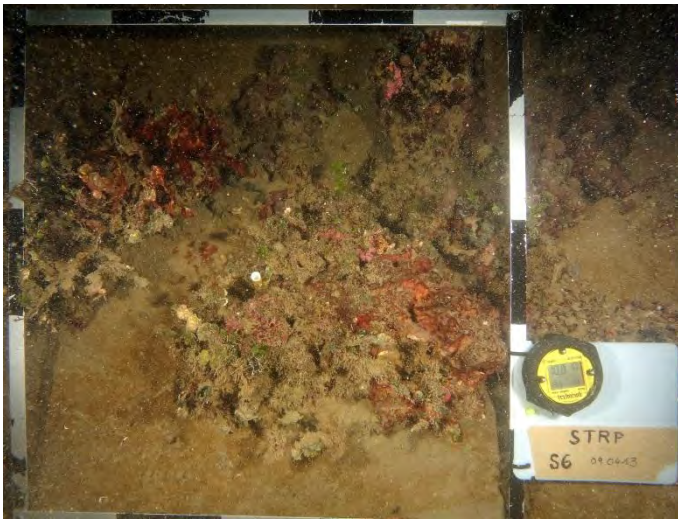


HSQ04-05

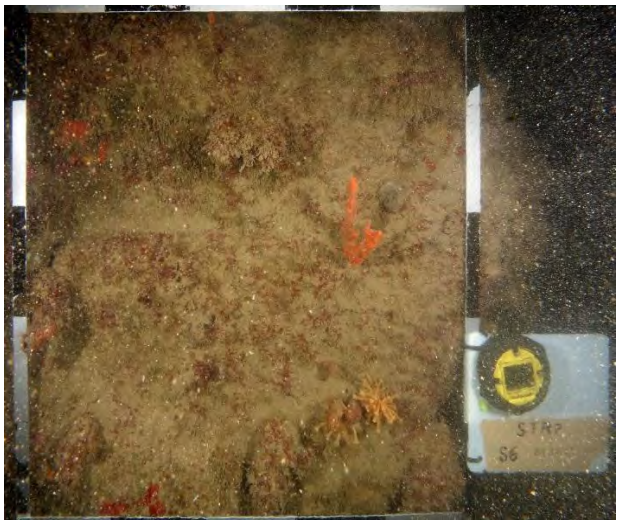
HSQ04-06



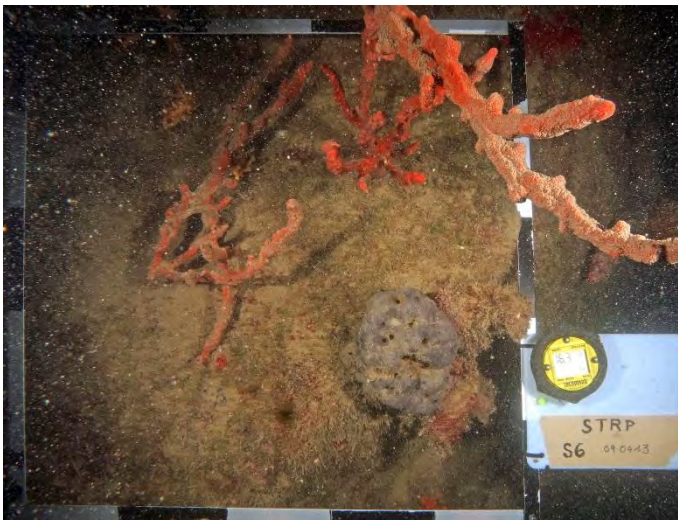
HSQ04-07



HSQ04-08

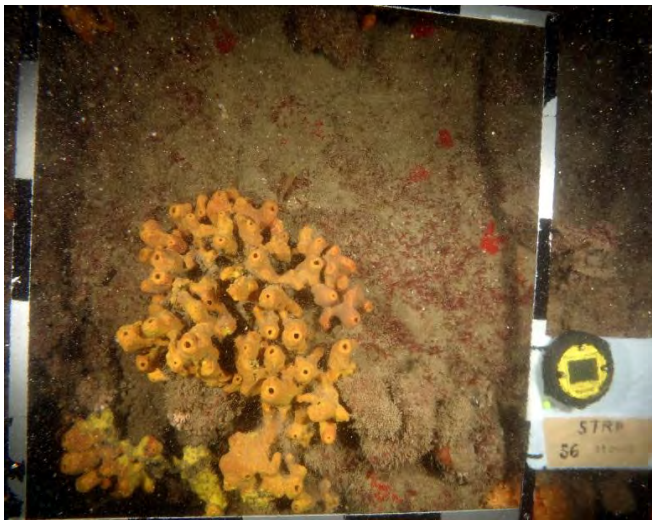


HSQ04-09

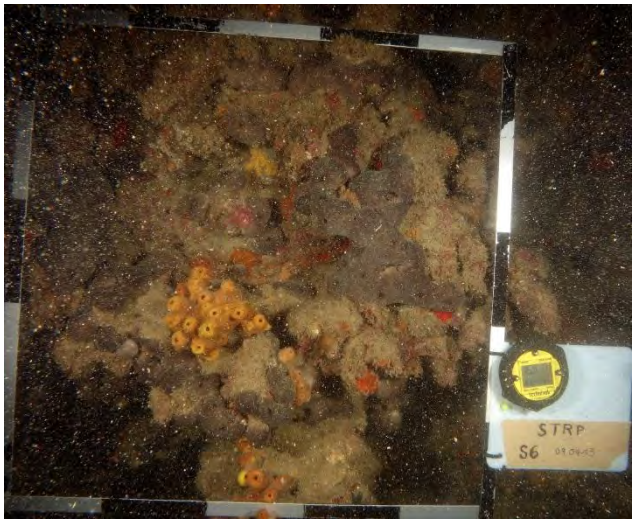


HSQ04-10

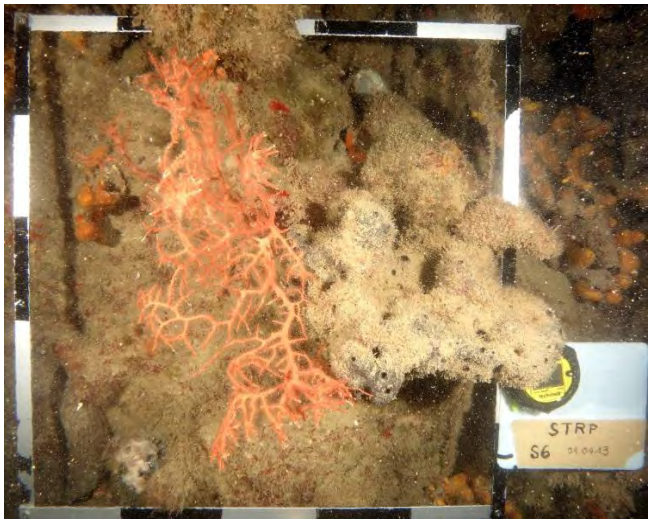
HSQ04-11



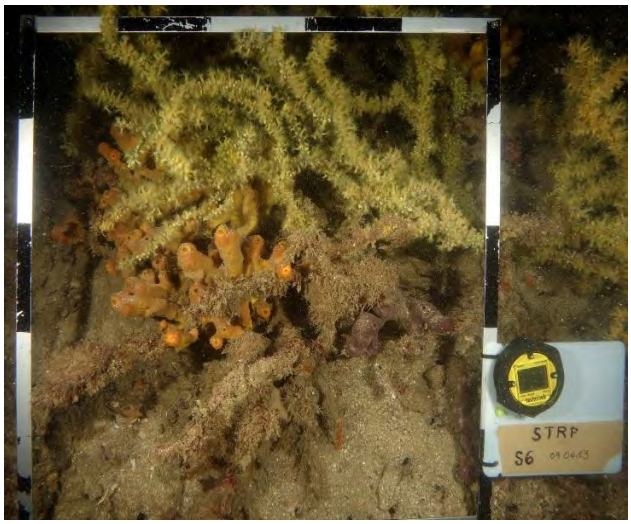
HSQ04-12



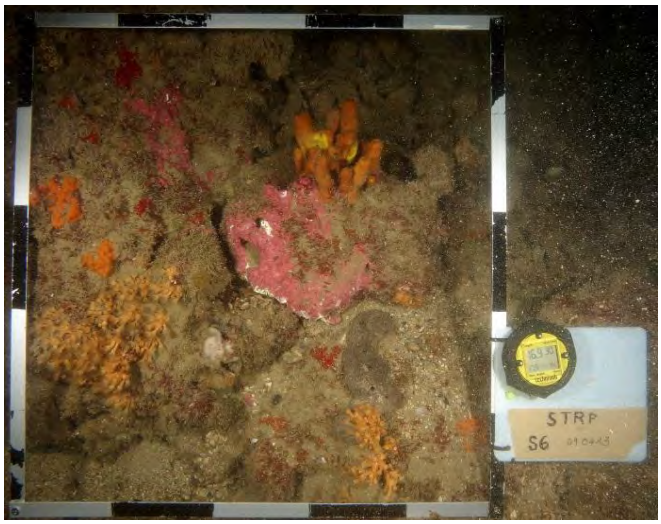
HSQ04-13



HSQ04-14



HSQ04-15

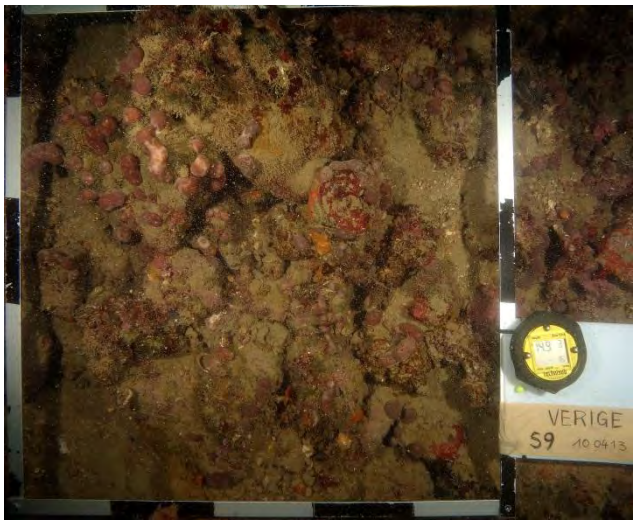


HSQ04-16

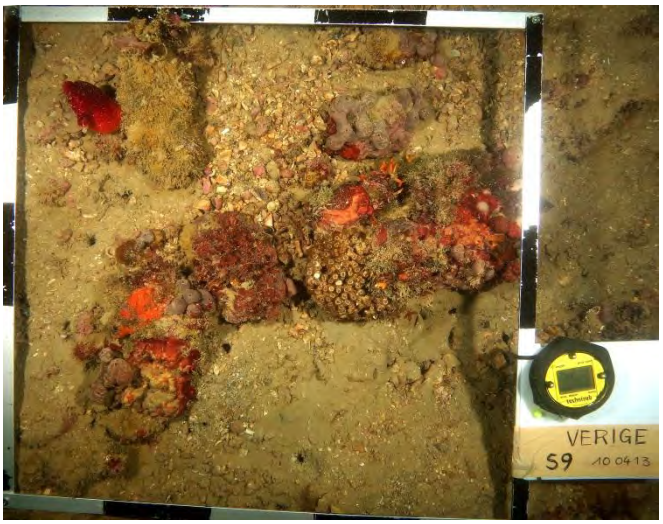
HSQ05 – Verige

HBQ05 – Verige*	Q1	Q2	Q4	Q5	Q6	Q7	Q10	Q11	Q13	Q14
Algae	18.00	11.75	34.00	51.25	44.75	14.00	19.50	42.00	34.50	16.00
Cnidaria	5.50	3.25	14.25	0.00	0.00	16.50	14.50	9.50	4.00	6.50
Porifera	28.50	16.75	29.75	13.75	5.00	0.00	9.00	3.00	8.50	54.75
Briozoa	0.00	3.25	0.00	0.00	2.00	0.00	0.50	0.00	1.00	0.00
Tunicata	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00
Soft Bottom	30.00	50.25	19.00	34.00	48.25	54.50	48.50	45.00	52.00	22.75
Nude stones and pebbles	0.00	0.00	0.00	0.00	0.00	6.50	8.00	0.00	0.00	0.00
Organic Detritus	0.00	13.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coral rubble	0.00	0.00	0.00	0.00	0.00	8.50	0.00	0.00	0.00	0.00
Pisces*	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Polychaeta*	0.00	2.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Surface not taken into account	18.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

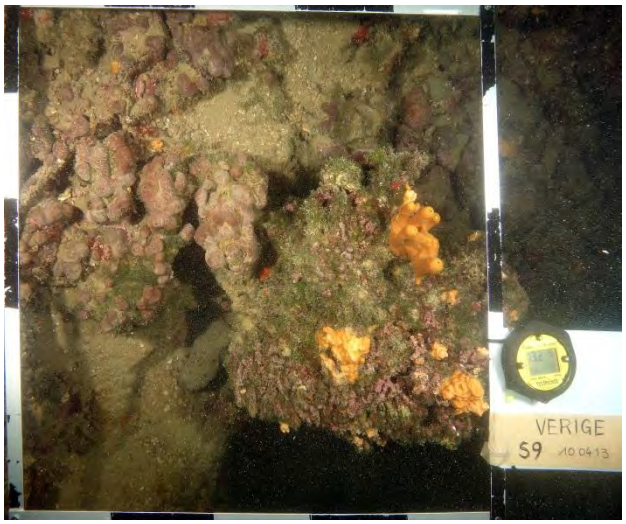
*** In order to analyse a comparable number of data, a maximum of 10 quadrats was analysed for each station. The quadrats used in the analysis were selected random. All the quadrats are showed below.**



HSQ05-01



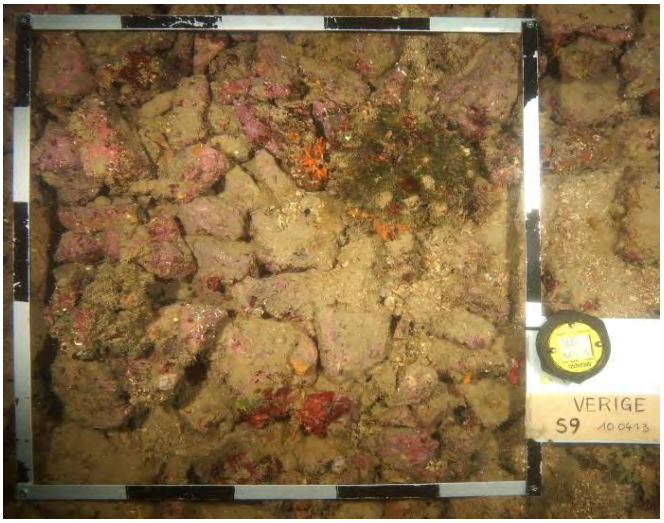
HSQ05-02



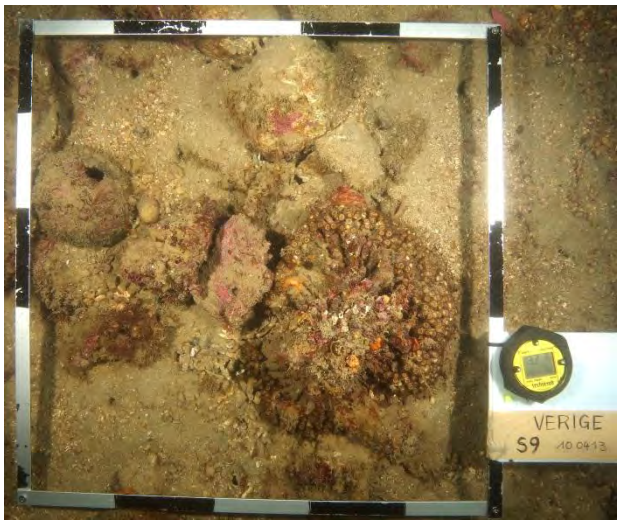
HSQ05-03

HSQ05-04

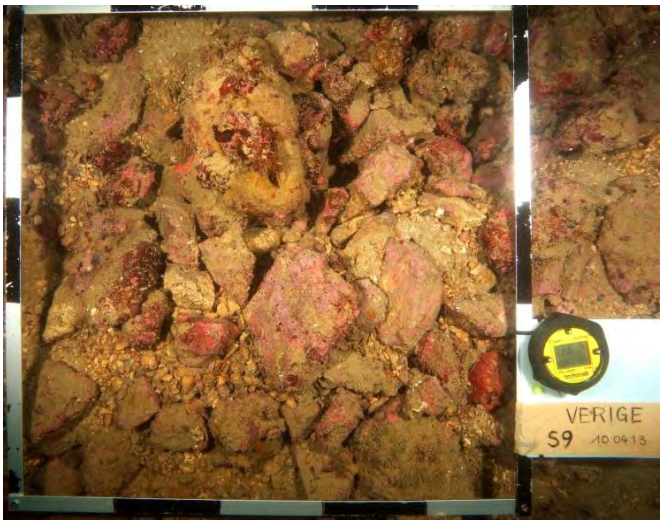
HSQ05-05



HSQ05-06

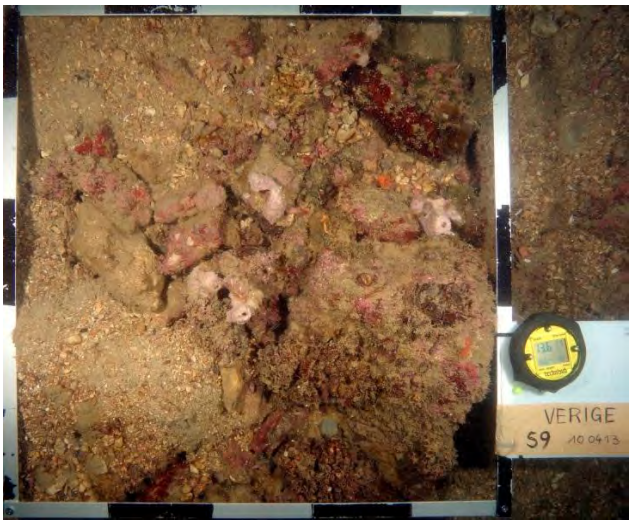


HSQ05-07

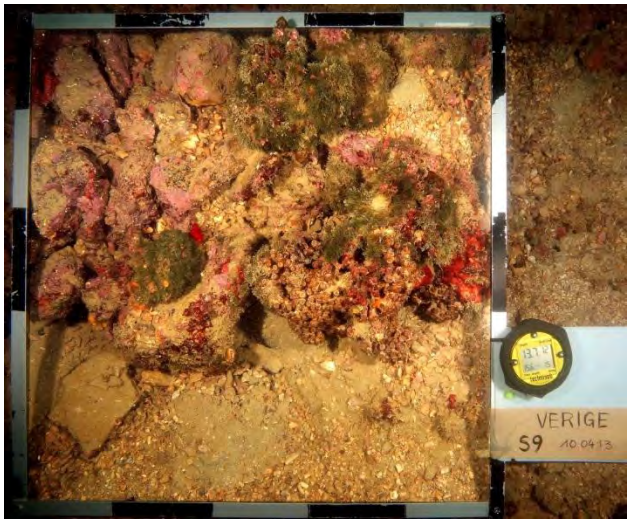


HSQ05-08

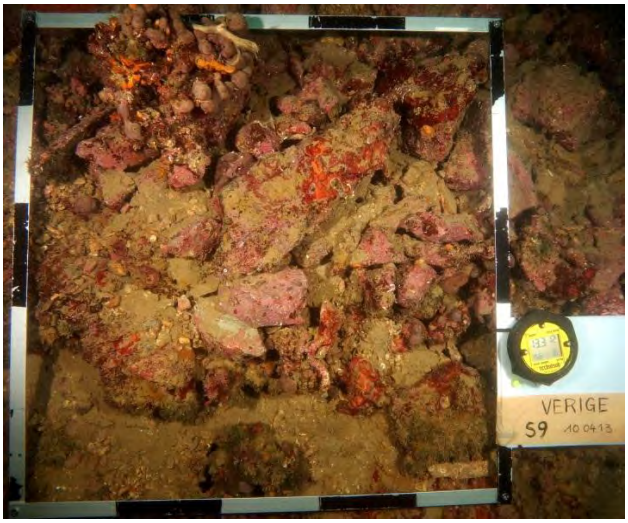
HSQ05-09



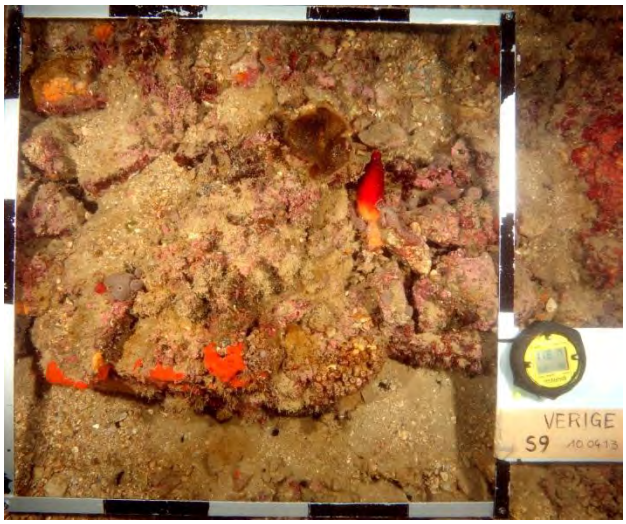
HSQ05-10



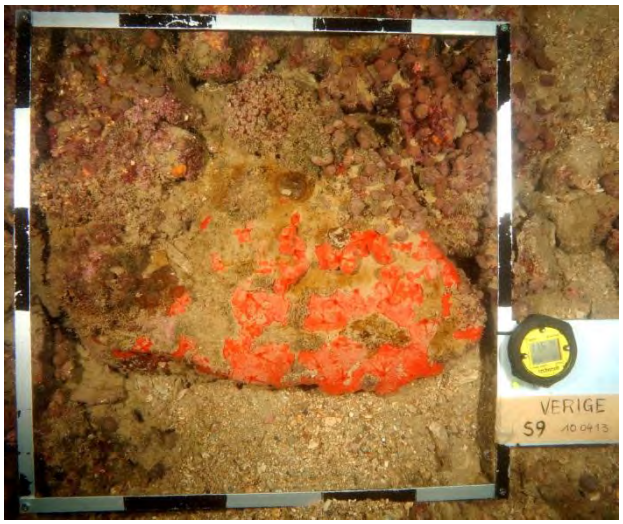
HSQ05-11



HSQ05-12



HSQ05-13



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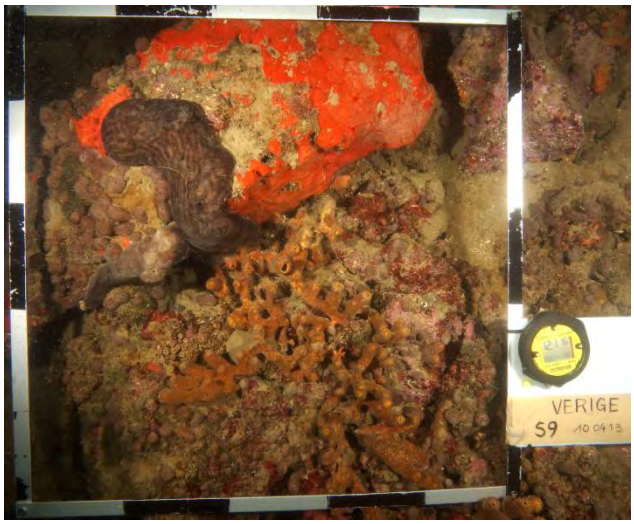
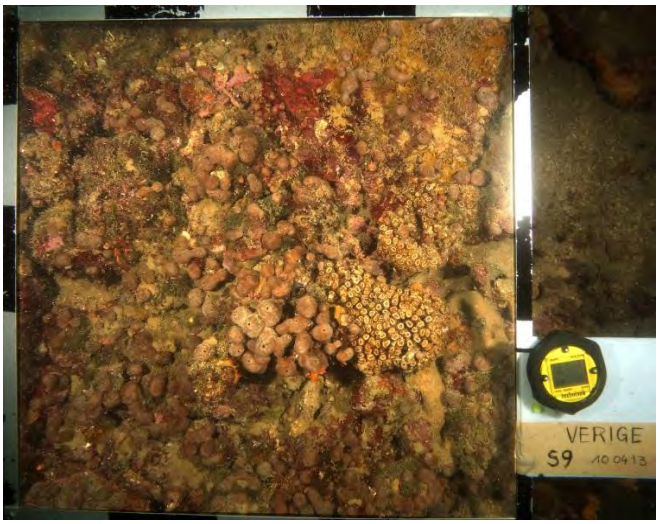


HSQ05-15



HSQ05-16

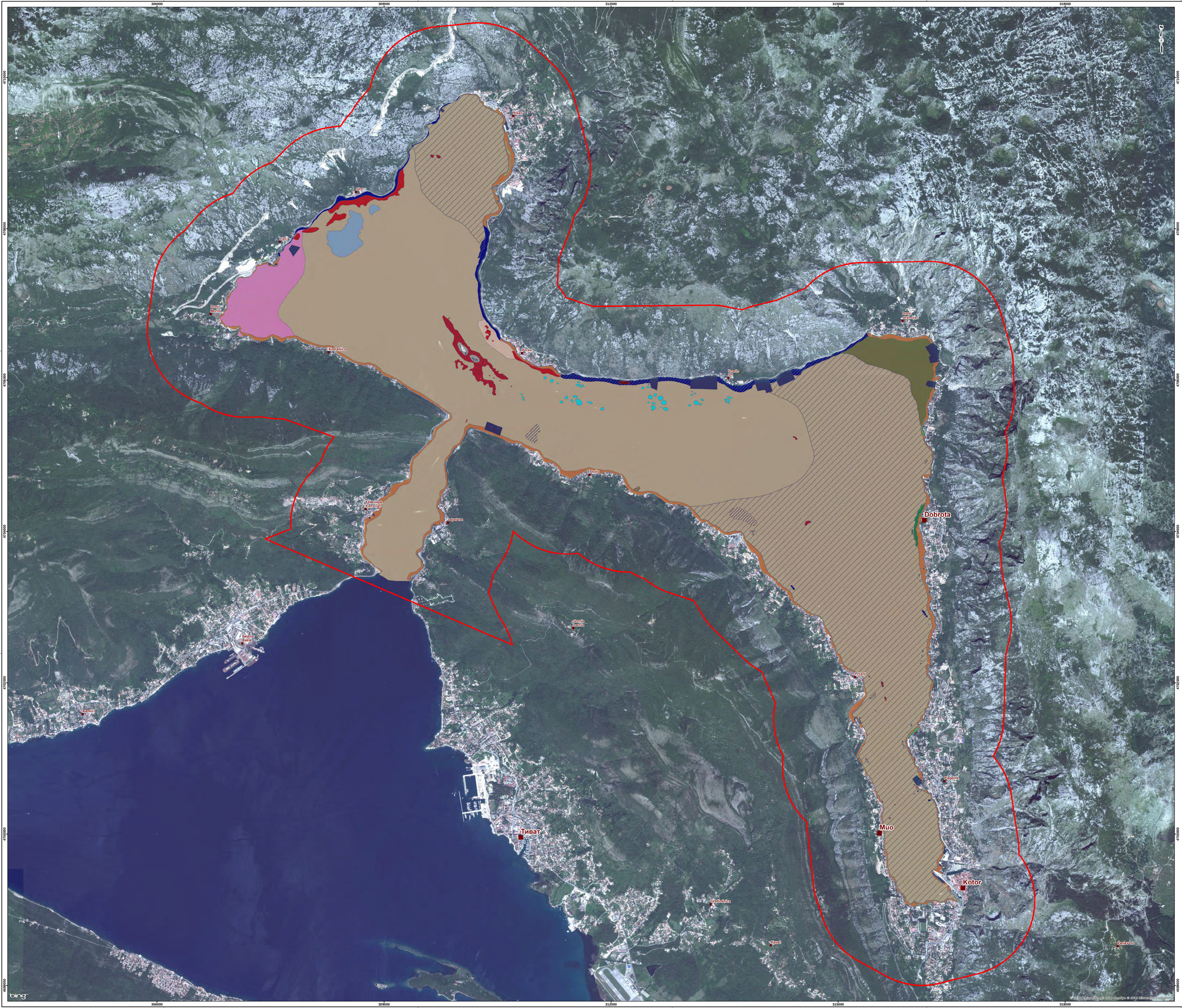
HSQ05-17

APPENDIX G

Map of marine habitats

306000 309000 312000 315000 318000

4710000 4708000 4706000 4704000 4702000 4700000 4698000



LEGEND

- Town
- City
- Village
- Study area

Biocenosis 5000

- Biocenosis of Sciaphilous algae (BS)
- Mosaic of BS and C
- Mosaic of BS and MS
- Mosaic of BS and VTC
- Coralligenous biocenosis (C)
- Cymodocea nodosa meadow (CYM)
- Mixed meadow composed by Cymodocea nodosa, Nanozostera noltii and Zostera marina (CYM-NAN-ZOS)
- Mosaic of Facies with Savaglia savaglia (dominant) and Facies with Leptogorgia sarmentosa (C_Sav-Lept)
- Mosaico of C and VTC
- Biocenosis of muddy detritic bottoms (DE)
- Deep holes with possible presence of Cladocora species (DEP_CLA)
- Biocenosis of Instable soft bottoms (FMI)
- Posidonia oceanica meadow (HP)
- Mixed meadow composed by Posidonia oceanica and Cymodocea nodosa (HP_CYM)
- Mosaic of Infralittoral stones and pebbles, BS and MS
- Biocenosis of muddy sands in sheltered waters (MS)
- Mosaic of MS and VTC
- Mosaic of Photophilous and Sciafilous Biocenoses (PSA)
- Biocenosis of coastal terrigenous muds (VTC)
- VTC with abundant presence of death Cladocora (VTC_CLAD)
- VTC with indication of instable conditions (VTC_I)

REFERENCE

Projection: UTM Zona 34N Datum: WGS84

0 400 800 1'200 1'600 2'000 m

REPORT

QUANTITATIVE DESCRIPTION OF
BOKA KOTORSKA BAY MARINE AREA

FIGURE TITLE

Marine biocenosis of the Boka Kotorska bay

Golder Associates
Torino,Italia

Project Num.	12508420857	REL.	- REV. 0	FORMAT A0
DATE	17/06/2013			
DESIGN	CVI			
CHECK	GTO			
REVIEW	-			

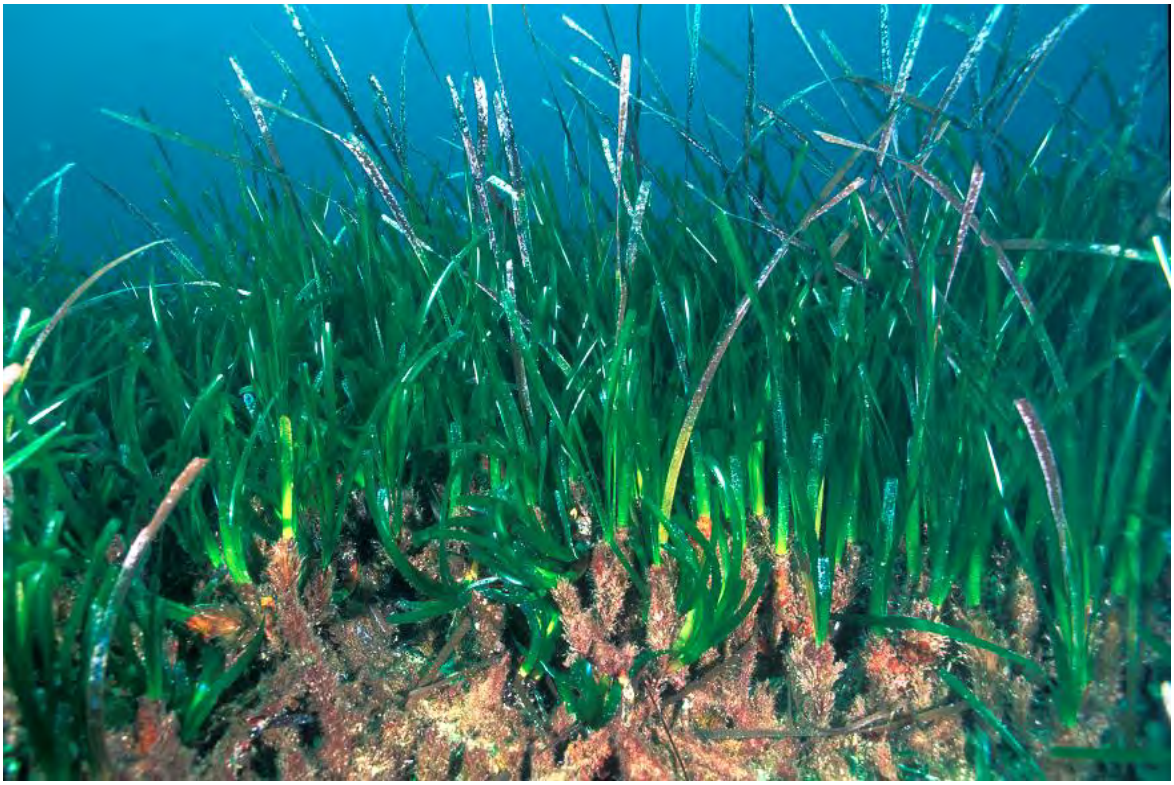
MAP 3

APPENDIX H

Atlas photos of endangered or threatened species following the Annex II of SPA/BD Protocol

Magnoliophyta

Cymodocea nodosa (Annex II)



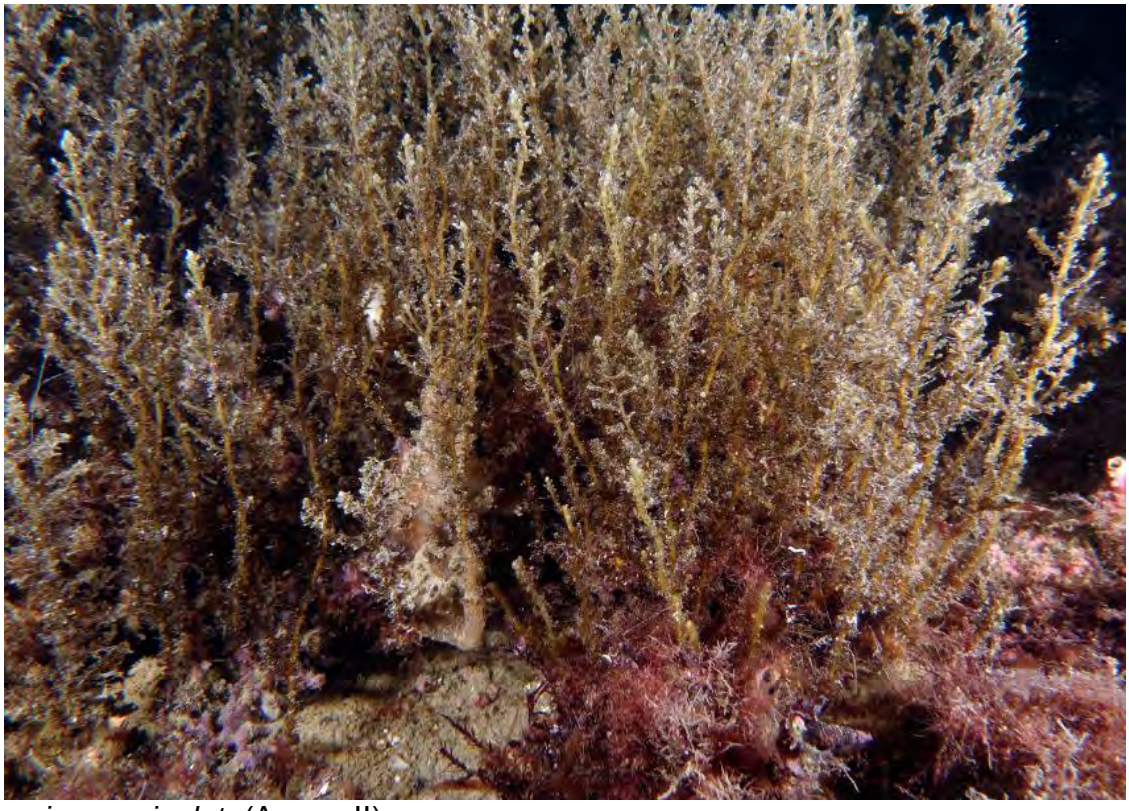
Posidonia oceanica (Annex II)

Zostera marina (Annex II)

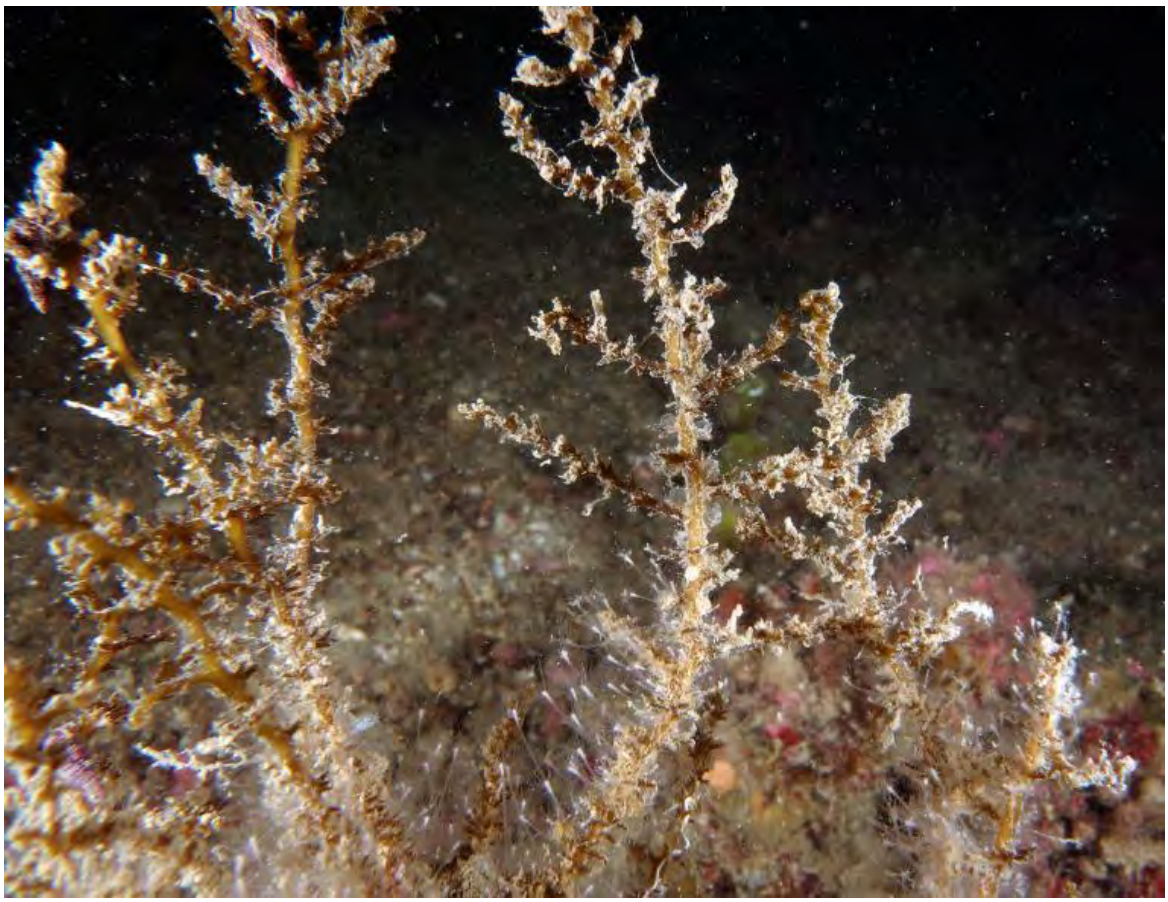
Nanozostera noltii (Annex II)

Heterokontophyta

Cystoseira barbata (Annex II) (photo by Vesna Mačić)



Cystoseira corniculata(Annex II)



Cystoseira spinosa (Annex II)

Porifera

Aplysina aerophoba (Annex II)

Aplysina cavernicola (Annex II)

Axinella cannabina (Annex II)

Geodia cydonium (Annex II)

Tethya aurantium (Annex II)

*Tethya citrina (*Annex II)

Spongia officinalis (Annex III)

*Sarcotragus foetidus (*Annex II)

Cnidaria

Savalia savaglia (Annex II)

Mollusca

Lithophaga lithophaga (Annex II)

Pinna nobilis (Annex II)

Echinodermata

Centrostephanus longispinus (Annex II)

Crustacea

Maya squinado (Annex III)

Pisces

Epinephelus marginatus (Annex III)

APPENDIX I

Filled-in fishery landing data forms

Fishery Survey N. 01

Site	Kotor Bay		Date	14.04.2013.	
Interviewer	Olivera and Mirko				
	Vessel name	77-KT			
	Crew N°	1	HP	4,45	
Fishing Area		Kotor Bay			
Depth	22 m		Bottom type	Mud	
	Fishing Gears*	Gillnet (''polandara'')	Mesh/Dimension	45 mm	
			Lenght	400 m and height of 18 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Sarda sarda*	Bonito	6,5	6	Medium	Gillnet	
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
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30							

Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 02

Site	Kotor Bay		Date	16.04.2013.	
Interviewer	Olivera and Mirko				
	Vessel name	77-KT			
	Crew N°	1	HP		
Fishing Area		Kotor Bay			
Depth	22 m		Bottom type	Mud	
	Fishing Gears*	Gillnet (''polandara'')	Mesh/Dimension	45 mm	
			Lenght	400 m and height of 18 m	
			Numbers	2	

Caught Species

	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Sarda sarda*	Bonito	3,2	3	Medium	Gillnet	
2	*Pagellus erythrinus*	Common pandora	0,5	1	Small	Gillnet	
3							
4							
5							
6							
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Note	
	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 03

Interviewer	Olivera and Mirko				
	Vessel name	35-KT			
	Crew N°	2	HP	7,22	
Fishing Area		In front of Drazin rt			
Depth	28 m		Bottom type	Mud	
	Fishing Gears*	Gillnet (''polandara'')	Mesh/Dimension	45 mm	
			Lenght	220 m and height of 12 m	
			Numbers	2	

Caught Species

	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Sarda sarda*	Bonito	6,2	5	Medium	Gillnet	
2	*Pagelus erythrinus*	Common pandora	0,9	2	Small	Gillnet	
3	*Auxis rochei*	Bullet tuna	0,5	1	Small	Gillnet	
4							
5							
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Note

Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 04

Interviewer	Olivera and Mirko				
	Vessel name	35-KT			
	Crew N°	2	HP		
Fishing Area		Drazin rt			
Depth	10 m		Bottom type	Mud	
	Fishing Gears*	Beach seine net	Mesh/Dimension	6 mm	
			Lenght	150 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Engraulis encrasicolus*	European anchovy	120	20400	Medium	Beach seine net	
2							
3							
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Note	
	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 05

Interviewer	Olivera and Mirko				
	Vessel name	3-KT			
	Crew N°	2	HP		
Fishing Area		In front of Orahovac			
Depth	10 m		Bottom type		
	Fishing Gears*	Beach seine net	Mesh/Dimension	6 mm	
			Lenght	150 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Sardina pilchardus*	European pilchard	50	3750	Medium	Beach seine net	
2							
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 06

Interviewer	Olivera and Mirko				
	Vessel name	3-KT			
	Crew N°	2	HP		
Fishing Area		In front of Orahovac			
Depth	10 m		Bottom type		
	Fishing Gears*	Beach seine net	Mesh/Dimension	6 mm	
			Lenght	150 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Sardina pilchardus*	European pilchard	40	2800	Medium	Beach seine net	
2	*Engraulis encrasicolus*	European anchovy	70	10500	Medium	Beach seine net	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 07

Interviewer	Olivera and Mirko				
	Vessel name	3-KT			
	Crew N°	2	HP		
Fishing Area		In front of Orahovac			
Depth	10 m		Bottom type		
	Fishing Gears*	Beach seine net	Mesh/Dimension	6 mm	
			Lenght	150 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Engraulis encrasicolus*	European anchovy	150	22500	Medium	Beach seine net	
2							
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4							
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 08

Interviewer	Olivera anad Mirko				
	Vessel name	62-KT			
	Crew N°	2	HP	9	
Fishing Area		Kotor bay			
Depth	25 m		Bottom type		
	Fishing Gears*	Trammel net (''popunica'')	Mesh/Dimension	28 mm	
			Lenght	120 m and height of 1.6 m	
			Numbers	3	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Scorpaena scrofa*	Red scorpionfish	0,9	3	Small	Trammel net	
2	*Diplodus annularis*	Annular sea bream	1	4	Small	Trammel net	
3	*Sepia officinalis*	Common cuttlefish	0,3	2	Small	Trammel net	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 09

Interviewer	Olivera and Mirko				
	Vessel name	56-KT			
	Crew N°	2	HP		
Fishing Area					
Depth	33 m		Bottom type	Mud	
	Fishing Gears*	Gillnet	Mesh/Dimension	45 mm	
			Lenght	250 m and height of 15 m	
			Numbers		

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Trachinotus ovatus*	Pompano	15	13	Medium	Gillnet	
2	*Sarda sarda*	Bonito	7,5	10	Medium	Gillnet	
3	*Merluccius merluccius*	European hake	0,6	4	Small	Gillnet	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 10

Interviewer	Olivera and Mirko				
	Vessel name	3-KT			
	Crew N°	2	HP		
Fishing Area		In front of Orahovac			
Depth	10 m		Bottom type		
	Fishing Gears*	Beach seine net	Mesh/Dimension	6 mm	
			Lenght	150 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Engraulis encrasicolus*	European anchovy	160		Medium	Beach seine net	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 11

Interviewer	Olivera and Mirko				
	Vessel name	35-KT			
	Crew N°	2	HP	7,22	
Fishing Area					
Depth	25 m		Bottom type		
	Fishing Gears*	Gillnet	Mesh/Dimension	45 mm	
			Lenght	220 m and height of 12 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Trachurus meditteraneus*	Mediterranean horse mackerel	1,7	40	Small	Gillnet	
2	*Scomber japonicus*	Chub mackerel	1,2	10	Small	Gillnet	
3	*Sarda sarda*	Bonito	3,9	5	Medium	Gillnet	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 12

Interviewer	Olivera and Mirko				
	Vessel name	3-KT			
	Crew N°	2	HP		
Fishing Area		In front of Orahovac			
Depth	10 m		Bottom type		
	Fishing Gears*	Beach seine net	Mesh/Dimension	6 mm	
			Lenght	150 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Sarda sarda*	Bonito	3,2	4	Medium	Beach seine net	
2	*Trachinotus ovatus*	Pompano	20	32	Medium	Beach seine net	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 13

Interviewer	Olivera and Mirko				
	Vessel name	35-KT			
	Crew N°	2	HP	7,22	
Fishing Area		Drazin rt			
Depth	5-10 m		Bottom type		
	Fishing Gears*	Beach seine net	Mesh/Dimension	6 mm	
			Lenght	150 m	
			Numbers	2	

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Sarda sarda*	Bonito	9	12	Medium	Beach seine net	
2	*Trachinotus ovatus*	Pompano	30	19	Medium	Beach seine net	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 14

Interviewer	Olivera and Mirko				
	Vessel name	56-KT			
	Crew N°	2	HP		
Fishing Area					
Depth	33 m		Bottom type		
	Fishing Gears*	Gillnet	Mesh/Dimension	45 mm	
			Lenght	250 m and height of 15 m	
			Numbers		

Caught Species

	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Pagelus erythrinus*	Common pandora	1	5	Small	Gillnet	
2	*Merluccius merluccius*	European hake	1,3	2	Medium	Gillnet	
3	*Sarda sarda*	Bonito	0,3	1	Small	Gillnet	
4	*Diplodus annularis*	Annular sea bream	0,1	1	Small	Gillnet	
5	*Sepia officinalis*	Common cuttlefish	0,1	1	Small	Gillnet	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 15

Interviewer	Olivera and Mirko				
	Vessel name	56-KT			
	Crew N°	2	HP		
Fishing Area					
Depth	25 m		Bottom type	Muddy	
	Fishing Gears*	Gillnet (''bukvara'')	Mesh/Dimension	22 mm	
			Lenght	100 m and height of 1.5 m	
			Numbers		

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Trachurus meditteraneus*	Mediterranean horse mackerel	0,3	2	Small	Gillnet	
2	*Scorpaena scrofa*	Red scorpionfish	0,5	2	Small	Gillnet	
3	*Boops boops*	Bogue	1,6	34	Medium	Gillnet	
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Note	Size Classes: S = Small M= Medium; L = Large;

Fishery Survey N. 16

Interviewer	Olivera and Mirko				
	Vessel name	56-KT			
	Crew N°	2	HP		
Fishing Area					
Depth	25 m		Bottom type	Muddy	
	Fishing Gears*	Gillnet (''bukvara'')	Mesh/Dimension	22 mm	
			Lenght	100 m and height of 1.5 m	
			Numbers		

	Caught Species						
	Scientific name*	Common name	Quantity kg	Quantity No	Dimension	Fishing Gear	Notes
1	*Trachurus meditteraneus*	Mediterranean horse mackerel	0,3	2	Small	Gillnet	
2	*Scorpaena scrofa*	Red scorpionfish	0,5	2	Small	Gillnet	
3	*Boops boops*	Bogue	1,6	34	Medium	Gillnet	
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Note	Size Classes: S = Small M= Medium; L = Large;

APPENDIX J

The GIS database

APPENDIX H

WebGIS guide

WEB GIS GUIDE

ACCESS

The WEB GIS is accessible on the internet at the following web page:

URL: http://web01.golder.se/KotorBay

External user: kotorbay

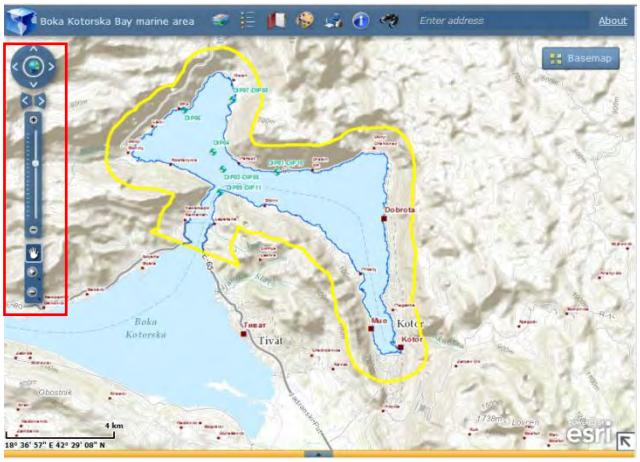
Pwd: J0kuLaht1

FUNCTIONALITIES

The funcionalities available in the WEB GIS are included in the set of bars/tools/widgets listed below

- Zoom/pan bar
- Layer list
- Legend
- Bookmark
- Draw
- Print
- Identify
- Attribute table
- Search
- Basemap

Zoom/pan bar



Moving the cursor on the zoom bar or clicking the bottoms "+" or "-" the zoom of the map can be changed. The scroll button of the mouse can be used as an alternative method to zoom in or zoom out.

Click on the "pan" button to explore the map mantaining the same level of zoom.

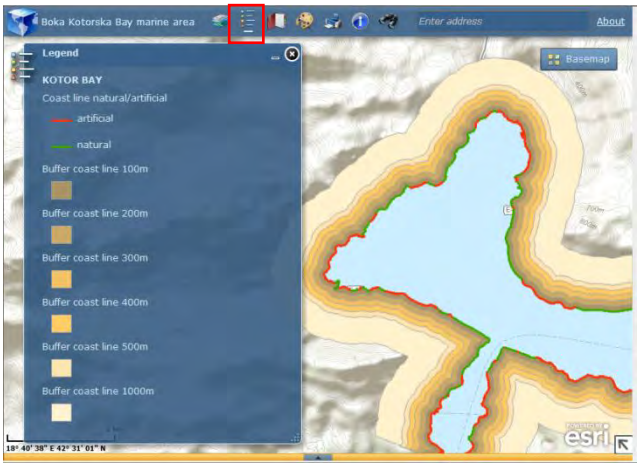
Clinck on the ”world” symbol to go back to the full extent of data.

Layer list

The Layer list widget shows the list of all layers included in the WEB GIS. Ticking or unticking a layer in the list makes it visible or invisible on the map.

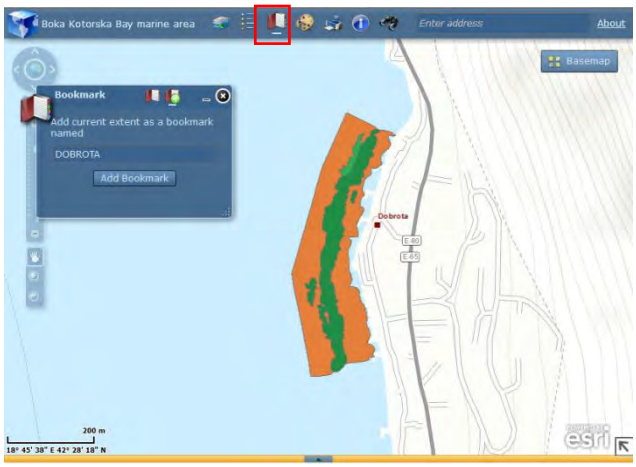
Legend

Click on the Legend symbol to open the Legend widget showing the symbolization of layers visible on the map.



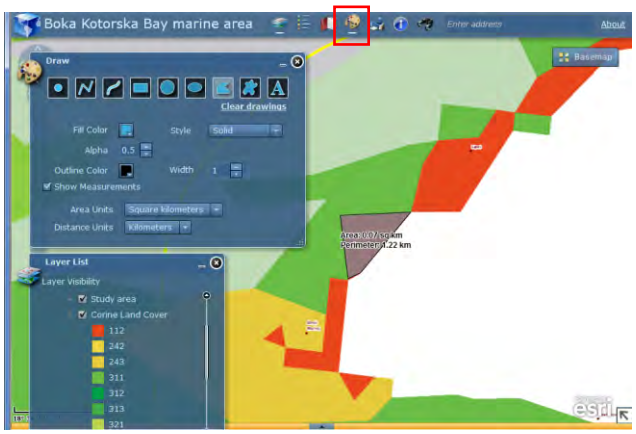
Bookmark

Click on the Bookmark symbol to open the the Bookmark widget which allows to save and assign a name to a certain map visualization.



Draw

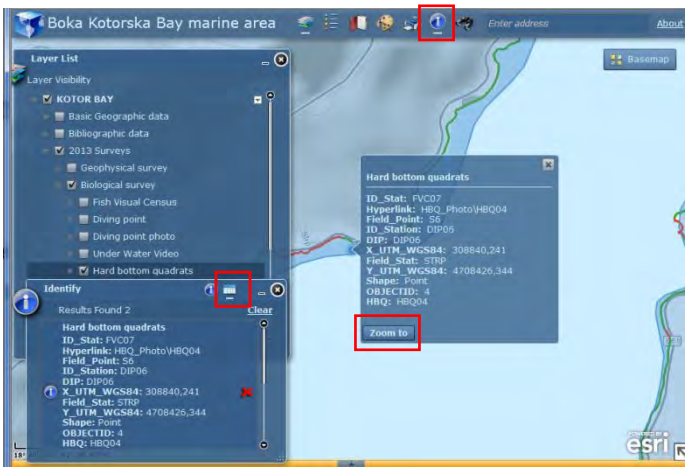
The Draw widget allows to draw graphic elements on the map, choosing between different predefined geometric shapes(points, lines, polygons, etc..). Tick the "Show measurements" box to visualize the correspondent areas or distances in the desired units.



Print

Print widget makes you printing the visualized map on a predefined printer assigning a certain title and subtitle.

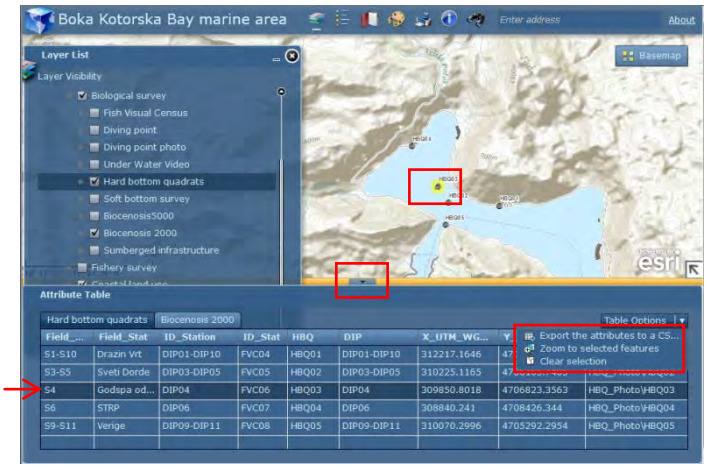
Identify



Using the Identify widget it is possible to visualize the information related to one or more selected features belonging to one ore more layers. The features can be selected by drawing a point, a line or a polygon. The identification is automatically made from all the layers visible on the map.

Once a selection is made, the Identify window appears, showing the results as well as the list of all fields contained in the associate table of all the selected features. Clicking on a certain result in the list it is possible to open its information on a separate window; the “zoom to” button makes it possible to zoom to the identified geometry.

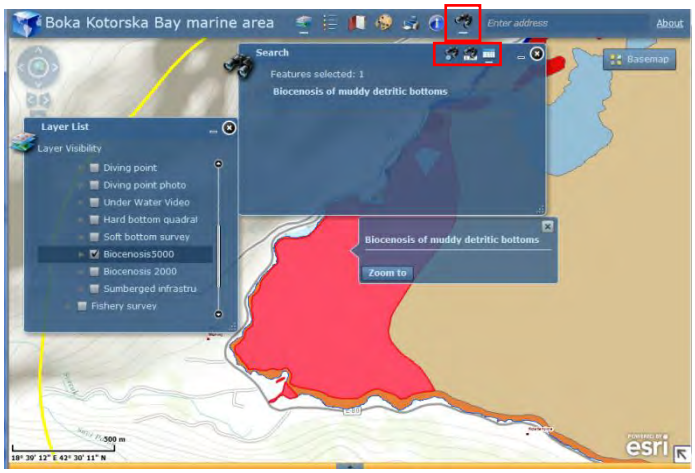
Attribute table



Click on the Arrow button on the map to expand the Attribute Table panel. It shows the data related to all features of all layers visible on the map. The records belonging to each different layer are listed in separated sheets.

Clicking on a certain record on the table the correspondent feature is highlighted on the map. Using the Table Options box it is possible to export the attribute table or to zoom to the selected features.

Search



The Search widget allows to look for features belonging to one of the following layers:

- Fish Visual Census
- Soft bottom survey
- SPAMI species
- Biocenosis 5000

Once a layer is selected from the drop-down menu, the features can be searched either by drawing a point, a line or a polygon or by attribute. Using the “by attribute” criteria the user can type a specific name and all the features with that specific name in the attribute table will be selected.

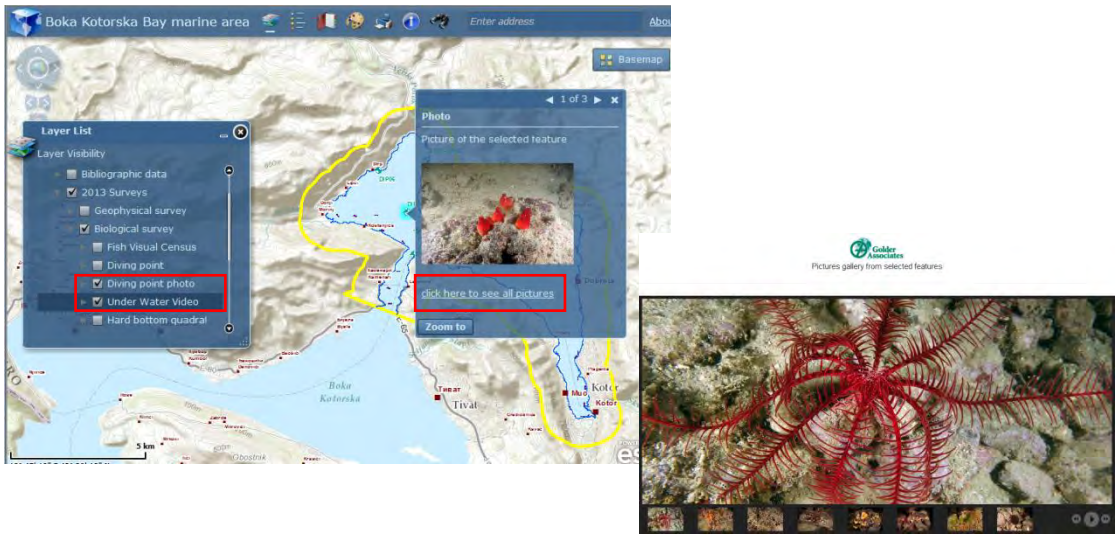
The features resulting from the search process are displayed in red on the map and clicking on the table button it is possible to have them listed. Each of the features can be selected from the list and displayed on a separate window where the zoom to features tool will be available.

Hyperlink

The Diving point photo layer and the Under Water Video layer (2013 Surveys – Biological survey) contain the hyperlinks respectively to the photos taken at each diving point and to the video made at each under water segment.

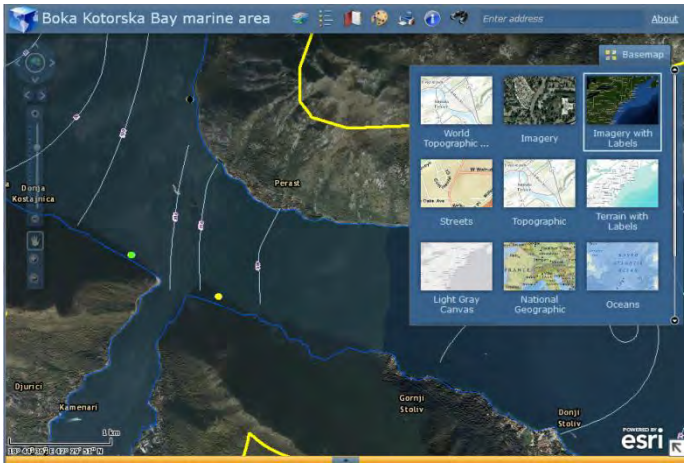
Click on a certain Diving point photo feature on the map to open the hyperlink. A window with a first picture appears on the map. Click to “click here to see all pictures” to see the entire pictures gallery referring to the selected diving point.

Similarly click on an Under Water Video feature to open the correspondent video.



Basemap

Many different basemaps available from ESRI online service can be selected using the Basemap widget



Regional Activity Centre
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