Implementation of the ecosystem approach in the Adriatic through marine spatial planning




Investigation of hard-bottom habitats (Anthozoa and their taxonomy) in Boka Kotorska Bay

Final report

MONTENEGRO
MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM

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1 Framework

The work here underlined is based on the GEF Adriatic project. It is aimed at capacity building for the assessment of coralligenous communities in Montenegro, in order to propose a proper GES index based on the investigation of hard bottom habitats of Boka Kotorska, with a special attention to Integrated Monitoring Assessment Programs (IMAP) and to taxonomy and distribution of Anthozoa.

1.1 Scope of the work

- Conduct and supervise field and laboratory work for data, photographic and video documentation and sample collection;
- Suggest and apply proper methodologies for data collection and for their elaboration for GES assessment for hard bottoms with the definition of specific targets;
- Collect and organize photographic documentation for assessment and communication purposes;
- Provide a specific expertise on Anthozoa taxonomy as a tool for future scientific reports;
- Provide technical training on video and photography.

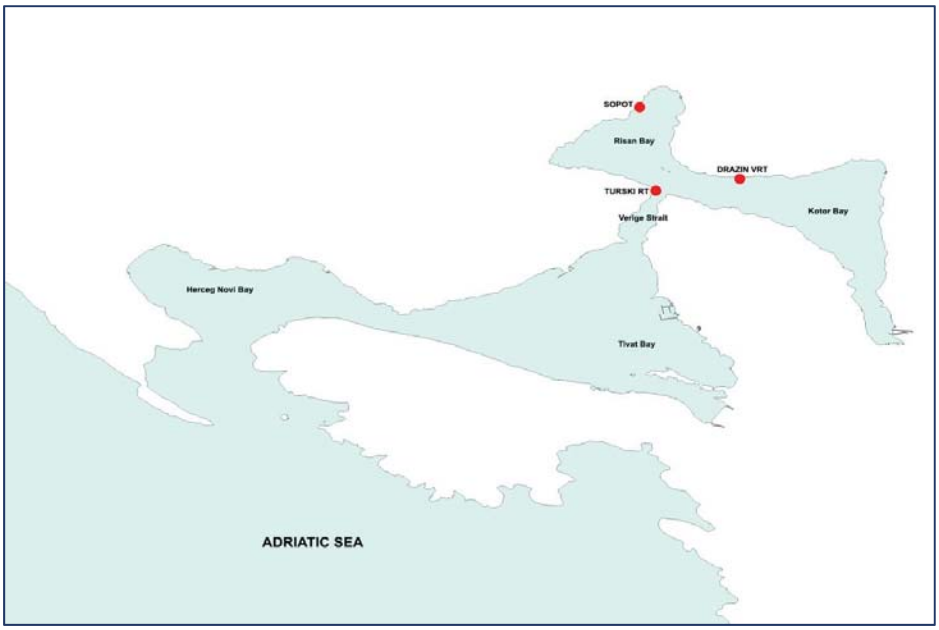
These activities have been discussed, defined and conducted in collaboration and with the support of the scientific team of Institute of Marine Biology of Kotor composed by Dr. Vesna Mačić and Dr. Slavica Petović.

1.2 Study area

Boka Kotorska Bay is considered the largest bay of the Adriatic Sea and Europe's southernmost fjord (Bosak *et al.,* 2012). The Bay, 87.3, km^2 and a coastal perimeter of 105.7 km, is divided into 4 smaller indentures: Herceg Novi Bay and Tivat Bay, the outermost ones, are connected with Risan Bay and Kotor Bay by a the Strait of Verige, only 350 m wide. The Bay is situated in a karstic mountainous setting that, at the back of Risan, reaches 1894 m^{asl} of Mount Orjen. In Boka Kotorska precipitations reach the maximum in Europe of 4584 mm per year (Magaš, 2002), with high variations throughout the year, with almost no rainfall in late spring and summer. A huge amount of freshwater flows into the Bay from the five small rivers, and also from numerous streams and karstic underwater springs (vrulja). The human impact on these water sources is considered low, less than the natural sources (Bosak *et al.,* 2012). In summary, the influence of geographical, orographical and hydrographic conditions of the Bay determine a very different situation from the open sea, influencing the abiotic and biotic factors (Badalamenti & Treviño-Otòn, 2012). In recent years a very rapid development of coastal settlements, aimed above all at tourism, with a consequent increase of seasonal anthropogenic pressure, and the increase in traffic of large cruise ships and small scale vessels (Mačić *et al.*, 2018) must be considered as potential elements of interference with the natural balance of the Bay.

In agreement with the researchers of the Institute of Marine Biology of Kotor, three sites were chosen to carry out the assignment (Map 1): Drazin Vrt, Sopot and Turski rt (in the Verige strait). At the same time, the three localities fulfill three objectives:

- they represent different examples of typical bio-constructions in the Bay;
- offer biotic features of absolute value both for the Adriatic Sea and the entire Mediterranean;
- hold populations of rare and protected Anthozoa.



Map 1. Position of the monitored sites in the Bay

2 Coralligenous Communities: A Clarification on Definitions

The coralligenous communities were defined in 1964 by Peres & Picard as: "*Stands based on concretionary Melobesiae and with rich fauna (Gorgonians, large Bryozoa, Alcyonaria) ...; they constitute the coralligenous biocoenosis itself*".

Authors identified their two major characteristics:

- *They are linked to a hard substrate (original or resulting from a concretion);*
- *They are clearly sciaphilic and predominantly vegetal.*

Peres & Picard placed the biocenosis of the coralligenous in the circalitoral zone, schematically between 40 and 200 m.

A synthesis of the evolution of the definition of coralligenous habitats can be found in Ballesteros, 2006: "*There is no real consensus among scientists studying benthic communities in the Mediterranean Sea about what a coralligenous habitat is. In this review a coralligenous habitat is considered to be a* ***hard substratum of biogenic origin that is mainly produced by the accumulation of calcareous encrusting algae growing in dim light conditions****. Algae and invertebrates growing in environments with low light levels are called sciaphilic in opposition to photophilic, that is, growing at high light levels. All plants and animals thriving in coralligenous habitats are, thus, sciaphilic. Although more extensive in the circalittoral zone, coralligenous habitats can also develop in the infralittoral zone, provided that light is dim enough to allow growth of the calcareous algae that produce the calcareous framework*".

It looks like the scientific community currently agrees that the definition of coralligenous habitats assumes the **presence of a more or less thick basal layer often formed by sets of calcareous encrusting algae that can offer the substrate to more or less erect invertebrate populations, which may also be absent**. The importance of algal concretion is considered such that some researchers believe that the complexity of algal construction should be used as one important indicator of the quality of the coralligenous environment (Andromède Océanologie, 2013).

The knowledge on the benthic communities in Boka Kotorska has been summarized in RAC/SPA – UNEP/MAP, 2014 on the basis of previous literature and of the field report by Golder/RACSPA, 2013. In the biocenotic maps, coralligenous habitats are highlighted and their coverage is indicated at 2% of the Bay bottom surface. In Badalamenti & Treviño Oton, 2012 the presence of Cladocora reefs and Coralligenous assemblages is indicated in the site Drazin Vrt with low frequencies. In the same report authors examine the data by Stjepčević & Parenzan 1980 (based on surveys conducted in 1970) that indicated a "very wide distribution of Cladocora in the Kotor and Risan Bays". Badalamenti & Treviño Oton conclude: "*In our survey inside the Bay we did not find a correspondence with the data shown by Stjepčević and Parenzan. It remains to be established whether this difference is due to a) inaccurate estimations in the 1970 survey, when diving technologies were less sophisticated, b) mechanical damage caused by fishing gears, aquaculture development, anchoring and mooring activities, increased shipping traffic or a combination of all of these factors*".

None of the descriptions of the benthic assemblages here outlined indicates the presence of calcareous encrusting algae as a basal substrate of the so called coralligenous assemblages. Thus none of the descriptions indicate the presence of coralligenous assemblages *sensu stricto* and therefore **the hard bottoms indicated as coralligenous in Boka Kotorska should be assigned to another category of benthic formations.**

Recently, Corriero *et al.*, 2019 described a bioconstruction along the Adriatic Apulian coast, north of Monopoli, mainly formed by two non-symbiotic scleractinians (*Polycyathus muellerae* and *Phyllangia americana mouchezi*) and affirmed: *"Although the bioconstruction described here is contiguous and taxonomically similar to coralligenous communities, it appears consistently different from a structural point*

of view, being mainly built by scleractinians, organized into an in-place and interlocking meshwork that provides rigidity to the reef... while the contribution of the algal component appears negligible. For these reasons, this bioconstruction deserves in all respects the definition of "coral reef". The similarities between the Apulian Mesophotic Coral Reefs with the bioconstructions present in Boka Kotorska will be highlighted in this report. Therefore, as a conclusion, the definition of Boka Kotorska's bioconstructions as coralligenous assemblages is to be considered inappropriate and will not be used later in this report, and it will be replaced by the terms **coral blocks**, or **coral herms,** or **biogenic blocks.**

The terminology "coral reef" will not be used to outline the bioconstructions in Boka Kotorska, first of all because coral reef, in the common use of the term, indicates a bioconstruction generated by symbiotic scleractinians, secondly because they are very fragmented and lack the spatial continuity of the typical reef.

3 Methods

The assignemet was carried out following these methodologies:

- consultation of the available literature about general environment and benthic communities in Boka Kotorska and about Anthozoa; consultation of literature on coralligenous assemblages assessment; definition of the sites for field work;
- field work for the collection of geographical data, proper documentation and samples, including on-the-job training;
- laboratory work aimed at the treatment of samples for identification;
- final rendering of collected photographs, measurements, rendering of panoramic images;
- choice of a proper methodology for GES assessment;
- data analysis and processing within the chosen methodology for GES assessment.

3.1 Literature

The consulted literature is listed in the Bibliography section of this report. On 10th September the need for scientic papers and for grey literature was discussed and defined with the researchers of IBM of Kotor, as well as the definition of the sites to be investigated and of the main goals of the monitoring activities.

3.2 Field work

The activities took place between September 11 and 17, 2019 using the boat Nemirna II° owned by IBM and positioning was performed through boat navigation instruments.

The three sites were investigated by non destructive, semi quantitative methods as successfully used in many Mediterranean studies and recently in the protocols the Marine Strategy developed in Marine Protected Areas. For each site a video or photo transect was performed and for each site at least 30 photographs were collected with frame area references.

For transect and area referenced images, a SONY α6000, APSC, 24 megapixel, was used equipped with 16-35 mm lens or Sigma 19 f2.8 in Sea&Sea MDX a6000 underwater housing with wet wide angle lens Nauticam WW1 which provides 130° of angle of view. Such a wide lens has been a forced choice on account of the water turbidity to reduce the distance from the subjects and eliminate flare and backscatter as much as possible.

For frame area and specimens measurement, two laser gauges have been used, measuring respectively 22 cm and 10 cm.

For macro images, the same set has been used but with 30 f3.5 macro lens. In the two cases, 2 strobes Inon S2000 have been used with diffuser domes to eliminate flare and backscatter as much as possible.

For laboratory photographs, a Nikon D3X, 24 megapixel, equipped with Nikkor 50 micro 2.8 f, and dedicated Nikon strobe have been used.

For video (in format XAVCS 50p = HD 1920x1080 50p), in Drazin Vrt and Sopot, the same set has been used as for transects and metric referenced images. In Turski rt, Olympus TG5 was used in dedicated housing (HD 1920x1080 25p) and GoPro video camera. No additional lights were used to avoid flare and loss of contrast on account of water turbidity.

Samples of scleractinia, alcyonacea and gorgonacea were collected by hand in connection with photographs and depth was recorded.

3.3 Laboratory work

Samples were first preserved alive in sea water for photography. Scleractinia were treated with hydrogen peroxid and/or sodium hypochlorite to clean corallites for morphological analysis. From the samples of *Spinimuricea klavereni,* the sclerites were estracted with 30% hydrogen peroxide and then photographed with a Nikon binocular CD-S1014917. Some samples were preserved in Ethanol 96%, changed after 24 h and then kept in freezer for future morphological and genetical analysis.

3.4 Photography and video rendering

Photographs have been treated on MAC OS 7.5 platform with Adobe Photoshop CS6® version 13.0.6. Measurements have been performed using Pixel Stitch 1.1®. Data regarding site, laser gauge, frame area have been added to the EXIF data of each processed image.

3.5 Methodology for GES assessment

The starting considerations for the individuation of a proper tool for the evaluation of the environmental conditions were the fllowing:

- the benthic assemblages in the three sites object of the investigation cannot be defined as Coralligenous assemblages *sensu stricto* (Corriero *et al.,* 2019)*;*
- the main characteristic of the assemblages are large populations of erect species settled both on hard and on mobile bottoms (Golder/RACSPA, 2013);
- the main erected specie are typical of mesophotic environments (Giusti *et al.,* 2015.; Topçu E. & Öztürk B., 2015 and 2016; Trainito & Baldacconi, 2016);
- the environmental conditions of elevated nutrient concentrations, elevate turbidity, poor light penetration in shallow depths and influences of freshwater inputs (Dautovic, *et al.,* 2012, Campanelli *et al.,* 2009);
- the evident anomaly compared to the classical Mediterranean zonation (Peres & Picard, 1964 and others);
- the evident analogy with mesophotic assemblages described for southern Adriatic Sea (Corriero *et al.,* 2019).

Despite the low depths of the monitoring sites (Drazin Vrt 10-25 m, Sopot 8-17 m, Turski rt 5-32 m), the environmental conditions are such as to create typically sciaphilous conditions even at the lowest depths, comparable to those of deep environments. The presence of populations of *Savalia savaglia*, of *Spinimuricea klavereni* and the bioconstructions of non-symbiont Scleractinia assimilate the habitats to those settled in mesophotic conditions.

These considerations suggested the use of the **MAES index** (Mesophotic Assemblages Ecological Status, Cánovas-Molina *et al.,* 2016) for the assessment for the purpose of GES evaluation (Borja, 2013).

The index is based on:

- the total number of taxa identified in the higher possible taxonomic detail, indicating those that, with their presence/abundance, manage to structure the habitat;
- specific abundance;
- percentage of coverage of the hard bottom and sedimentation value;
- density of the erected species (colonies/individuals per m^2);
- structure of the populations (average height of the main structuring species);
- state of health of the structuring species (percentage of epibiosis and/or necrosis and entanglement in fishing gears or other waste);
- type and abundance of anthropic waste that may be present (n° of waste per 100 m^2);

The collected data, both via video and photo transects by scuba diving, are used for calculating the MAES Index, applying the following formula:

$$MAES = ST + SCB + SE + SH + SEN + SL$$

where:

- ST = total number of recognizable megabenthos species;
- SCB = % coverage of the basal layer;
- SE = density of all erect species;
- SH = average height of the most abundant erect species;
- SEN = % of colonies of the most abundant erect species showing epibiosis and/or necrosis processes;
- SL = density of anthropic waste.

The index uses a seascape approach and takes into account the structure of the community, the conditions of the dominant erect species and the presence of visible signs of anthropic impact.

The MAES index fits to the environmental conditions of the examined sites in Boka Kotosrka also because the major obstacle for a good index response is

considered the difficulty of evaluating the development of the basal construction of encrusting algae, which in the present case is irrelevant.

The MAES index was applied with satisfactory results on 7 sites along the Italian coasts (Cánovas-Molina *et al.*, 2016) and subsequently within the Marine Strategy in the Marine Protected Areas of Tavolara Punta Coda Cavallo and Capo Carbonara in Sardinia with results suitable for providing indications for management (Canessa, 2018).

The following Table 1 summarizes the elements and methods for calculating the MAES index.

Table 1. MAES metrics

Metrics	Score 1	Score 2	Score 3	References
% biotic cover in the basal layer	< 19	> 19 – < 30	> 30	Canovas-Molinas et al.. 2016
Density erected species (N°/area) Savalia savaglia	< 43.5	> 43.5 – < 69.6	> 69.6	Canovas-Molinas et al., 2016
Density erected species (N°/area) Spinimuricea klavereni	< 0.1	> 0.1 – < 0.5	> 0.5	Canovas-Molinas et al., 2016
Average height dominant erected species (h = cm) Savalia savaglia	< 0.1	> 0.1 – < 0.2	> 0.2	Topçu & Öztürk, 2015
Average height dominant erected species (h = cm) Spinimuricea klavereni	< 30	> 30 – < 60	> 60	Gaglioti et al, 2019; Pais *et al.*, 1992; Cerrano *et al.*, 2007; Trainito & Baldacconi, 2016.
% dominant erected species with epibiosis, necrosis	< 10	>10 – < 20	> 20	Carpine & Grasshoff,1975; Topçu & Öztürk, 2013-2015
Density marine litter (N°/area)	> 15.4	< 15.4 – > 9.6	< 9.6	Canovas-Molinas *et al.*, 2016; Topçu & Öztürk, 2015
% biotic cover in the basal layer	> 0.1	< 0.1 – > 0.6	< 0.6	Canovas-Molinas et al., 2016

Ecological status	Score	References
Bad	6 <> 9	Canovas-Molinas *et al.*, 2016
Moderate	10 <> 14	
Good	15 <> 18	

4 Field Work Results

4.1 Drazin vrt

This site has been the subject of previous investigations that have highlighted the singularity of the ecological conditions and consequently of the invertebrate populations (Badalamenti & Treviño-Oton, 2012; Golder/RACSPA, 2013), but their actual consistency and an in-depth taxonomic analysis of the constituent benthos were still to be determined.

4.1.1 Geographical and operational framework

The site is located at 18.71518° E and 42.48357° N (central point) and the monitored area is about 35 m from the coast line. A few meters high slope, vegetated by shrubs, ends on the coastal road of the Bay. East of the site there is a water pipe which occasionally drains at sea level. On the shoreline, blocks and pebbles are the resultant materials of the construction of the road and also occupy the first meters of the submerged area. Numerous materials of anthropic origin are observed on the slope and in the shoreline area.

The submerged area degrades rapidly and just a few meters from the shoreline the bottom reaches a depth of 5 m to degrade with greater steepness up to 15-25 m in the area where monitoring was carried out, 30-40 m from the coastline. In the first few meters the bottom is characterized by a stony ground with few metric blocks, covered with photophilic algae (mainly *Cystoseira corniculata*, *Padina pavonia*), which at around 10 m of depth ends on a mixed bottom of coarse sediments and bioconcretions, with few scattered rocky blocks. The coral blocks end at 25 m on a bottom covered with thin sediments. In the sedimentary areas there are clear signs of important sediment transports that interfere with the development of colonies of erect species.

Photo 1. The coast at Drazin Vrt

Photo 2. Anthropogenic litter at Drazin Vrt

Photo 3. Anthropogenic litter at low depth at Drazin Vrt

The area is characterized by submerged springs that were not active at the moment of this monitorig. When active, mainly in winter and early spring, they have been observed to generate swirling currents that probably affect the growth of erected species conditioning shape and orientation of the colonies (Golder/RACSPA, 2013).

The non rectilinear transect DV01 was performed within the beginning and the end of the presence of *Savalia savaglia* colonies, corresponding to these coordinates:

- Starting point: 18.716222°E, 42.483211° N;
- End point: 18.713972°E, 42.483153° N.

The distance between these two strongholds is 185 m and the total lenght of the transect was 200 m, covering an area of 800 m^2 (200 x 4 m).

Along the transect three dives were performed with different purposes as outlined in the next **Table 2**. In the 3 dives, a total area of about 1,600 m^2 was surveyed.

Table 2. Dive roster – Drazin Vrt

Site	Date	Depth	Time	Activities
Drazin Vrt dive 1	12 09 2019	24.9	57	Photographic transect in the whole area. Videos for specific assemblages. Collection of samples
Drazin Vrt dive 2	12 09 2019	25.9	49	Photographic transect to obtain metric areas. Collection of samples
Drazin Vrt dive 3	16 09 2019	25.8	58	Photographic transect for deepening analysis and for communication material

4.1.2 Megabenthic assemblages

The transect DV01 is characterized by the alternance of sedimentary areas, scattered or grouped colonies of the Zoantharia *Savalia savaglia*, scattered coral blocks mainly formed by the Scleractinia, *Polycyathus muellerae*, scattered stony blocks. The biocenosis is also characterized by large sponges growing both on coral and stony blocks (*Acanthella cannabina* and *Aplysina aerophoba/cavernicola*), colonies of *Leptogorgia sarmentosa* and *Parazoanthus axinellae*. The encrusting calcareous algae component is irrelevant being present with very small and very sparse formations.

Savalia savaglia, the most common species, is distributed, in a range of 9-22 m depth, both in sedimentary areas and to a lesser extent on bioconcretions and even less on stony blocks. It is distributed in metric assemblages and with sparse colonies in a number counted/estimated to exceed 500 colonies (509). Counts are quite difficult for the species because, in the large assemblages, it is difficult to distinguish different colonies and anastomosis processes are largerly diffused. The average height of the colonies is 54 cm with a maximum of about 100 cm. The largest assemblage occupies an area of about 6.5 m^2. The assemblages do not show epibiosis or necrosis in the distal branches, while the lower part of the colonies in contact with the bottom shows the evident consequences of the high sediment transport that characterizes the area (due mainly to aerial and submerged springs), which is amplified by the accumulation of debris (mainly plastic bottles) at the base of the colonies. To confirm this, there are few colonies with large central stems.

In the transect, 6 patches of dead colonies of *Savalia savaglia* were counted (the largest covering an area of 3.8 m^2), only two with some distal branches still alive. The most plausible hypothesis is that these colonies were suffocated by a covering of sediments and debris (as observed in previous surveys) then moved by the bottom currents, generally leaving only the stems, then colonized by epibionts. This process is well known in the terrestrial environment for the active coastal dunes colonized by pioneer vegetation and exposed to the action of the wind. However, it is clear that this is a very different process from that well

known for Gorgonacea: i.e. necrosis of the distal parts and subsequent colonization by epibionts, generally due to variuos pathogens in conditions of prolonged periods of anomalous water heating (Huete-Stauffer *et al.,* 2011).

In the western side of the transect there are conspicuous and complex coral formations (with scarce erect species) where the main component is the scleractinia *Polycyathus muellerae* and a sparse presence of patches of *Phyllangia americana mouchezi*. Traces of mechanical damage (anchors?) are spread through the coral blocks and there are large areas of rubble mainly formed by dead corallites.

Cladocora caespitosa is present only at low depths (< 10 m) with small cushion-like colonies in association with emisciaphilic algae (*Halimeda tuna, Peyssonnelia squamaria*).

Photo 4. The main assemblage of *Savalia savaglia* (coverage area 6.5 m^2)

Photo 5. The main patch (3.8 m^2) of dead Savalia savaglia with few colonies still alive

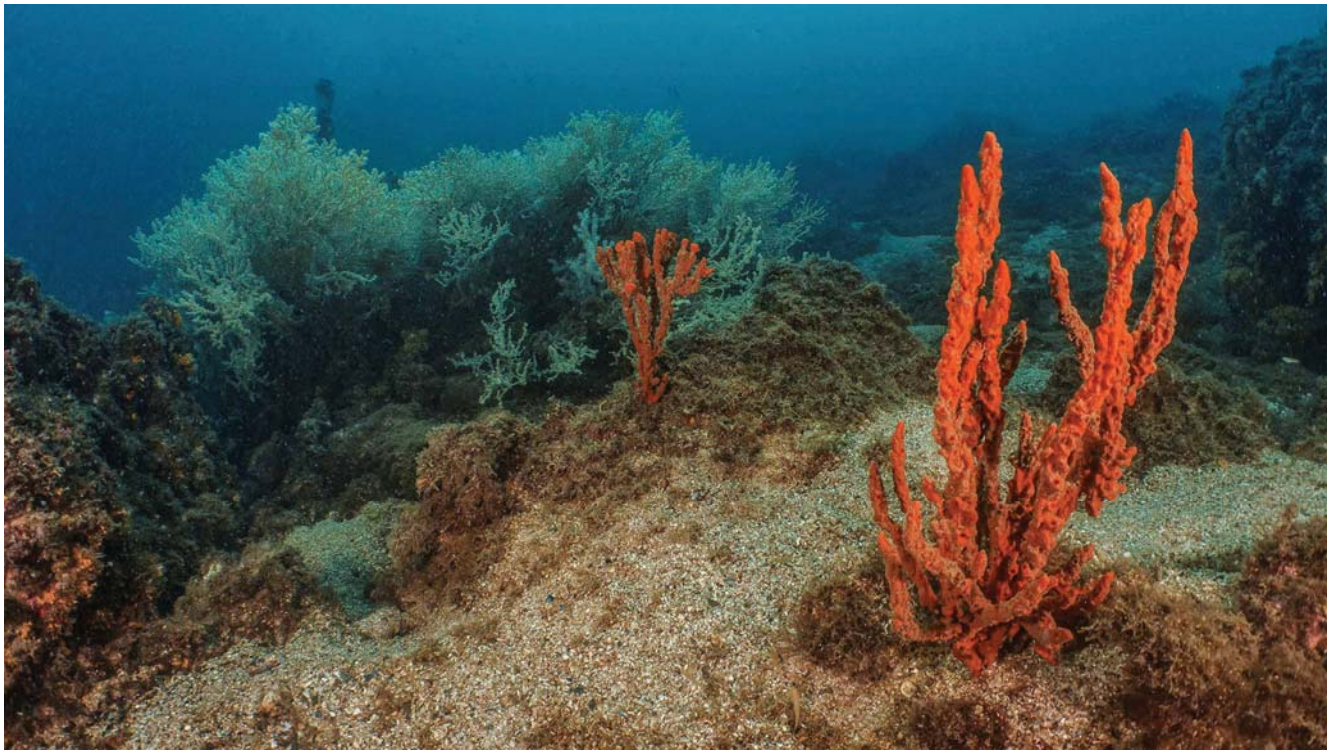


Photo 6. *Acanthella cannabina* in the central area

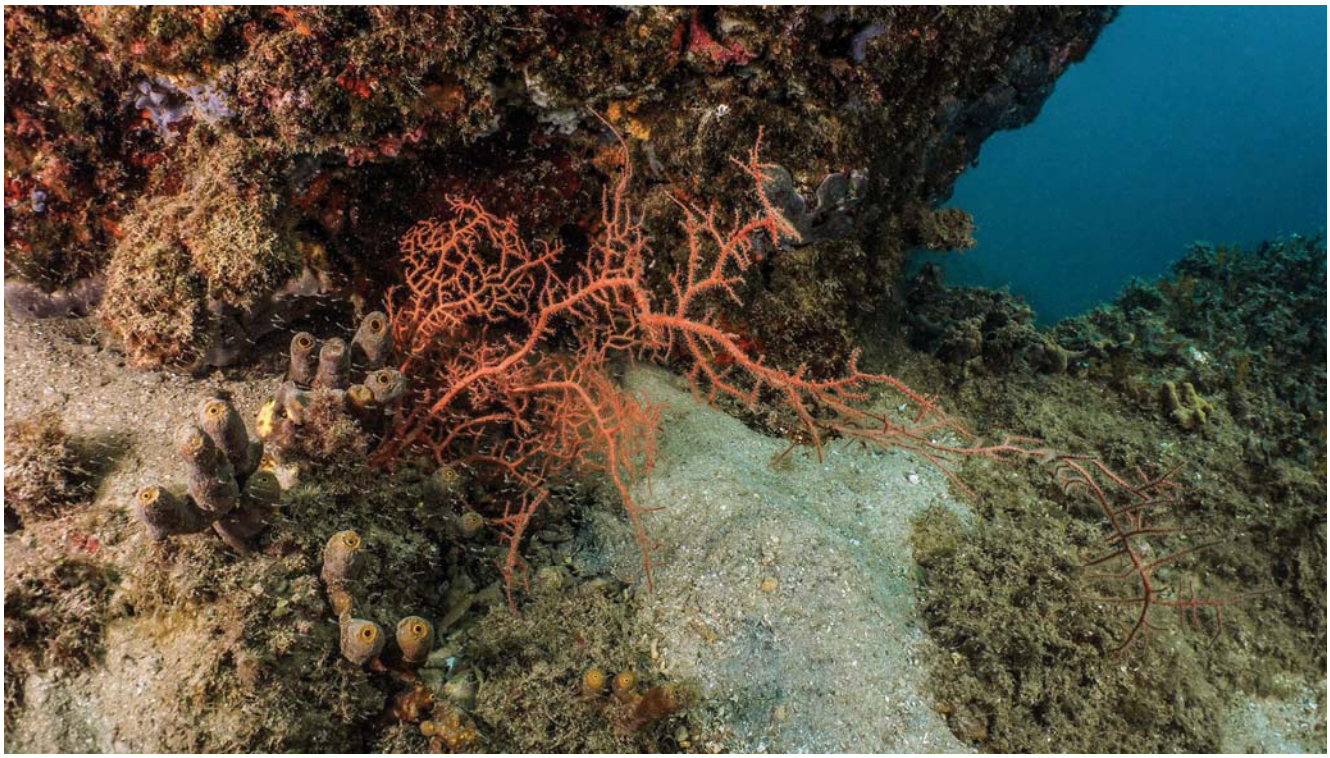


Photo 7. *Leptogorgia sarmentosa* and *Aplysina aerophoba/cavernicola*

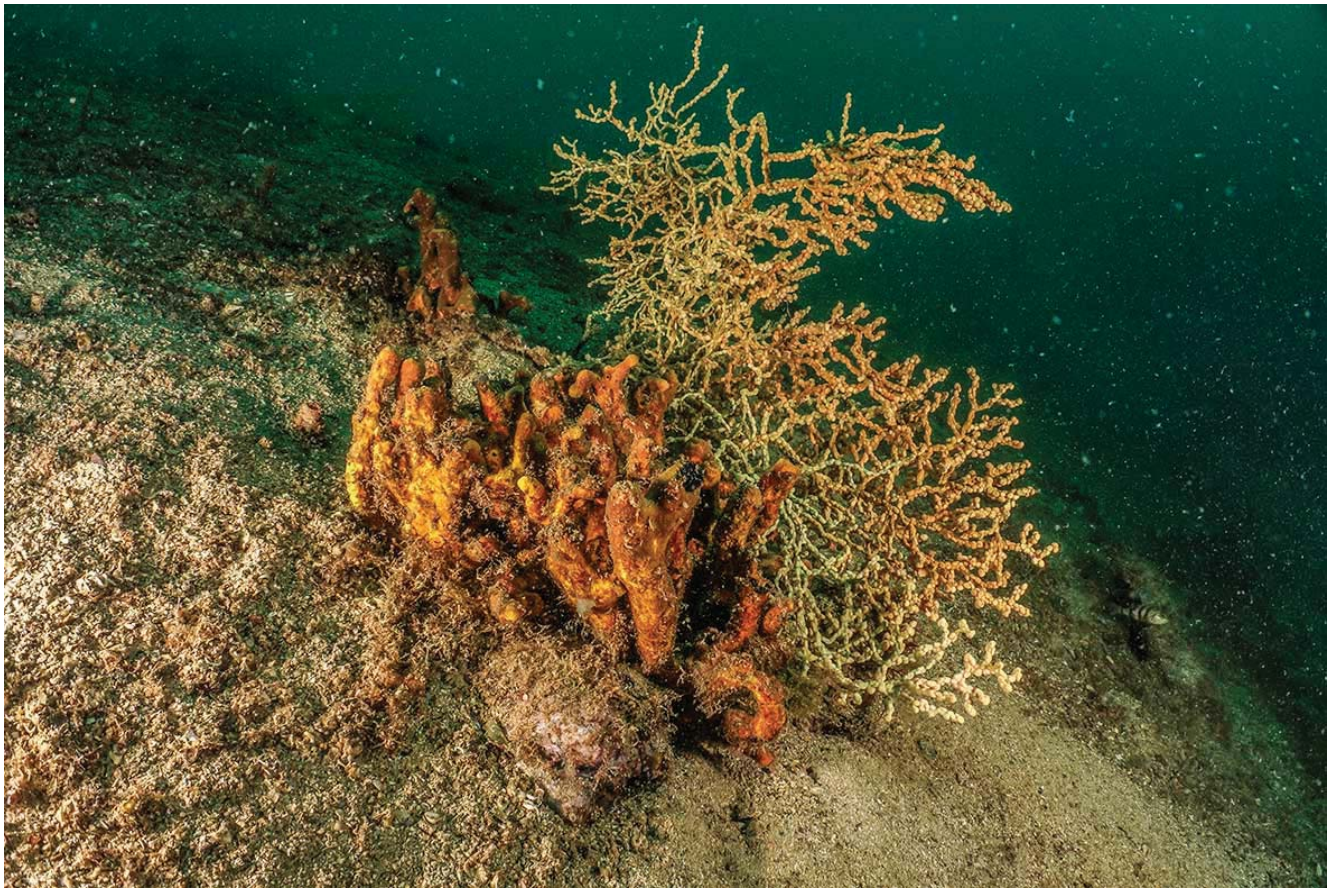


Photo 8. *Aplysina aerophoba/cavernicola* and *Savalia savaglia*: at the base a plastic can

Photo 9. *Parazoanthus axinellae* on a coral herm of *Polycyathus muellerae*; on the left, branches of *Savalia savaglia*

Photo 10. A coral herm of *Polycyathus muellerae*: at the center colonies of *Phyllangia americana mouchezi*

Photo 11. A typical assemblage of the site: top left *Polycyathus muellerae*, bottom left to top center branches of *Savalia savaglia*, bottom center *Parazoanthus axinellae*, left center the *Stolonifer Sarcodictyon catenatum*

Photo 12. *Cladocora caespitosa* with *Halimeda tuna* at low depth

Photo 13. Coral blocks on the western side of the site

Photo 14. Huge amount of debris, mostly plastic bottles

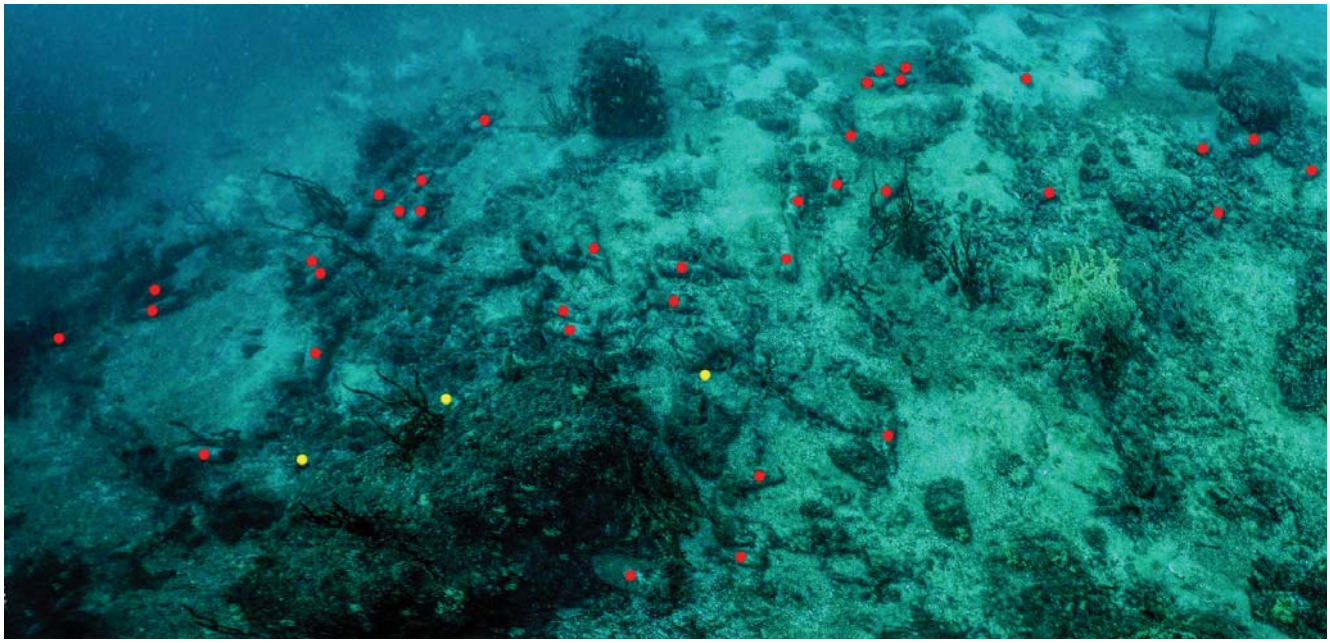


Photo 15. Huge amount of debris, mostly plastic bottles – enlarged: plastic bottles (red dots) and a line (yellow dots) are pointed out

Photo 16. Debris (plastic bottles) at the base of an assemblage of *S.savaglia*

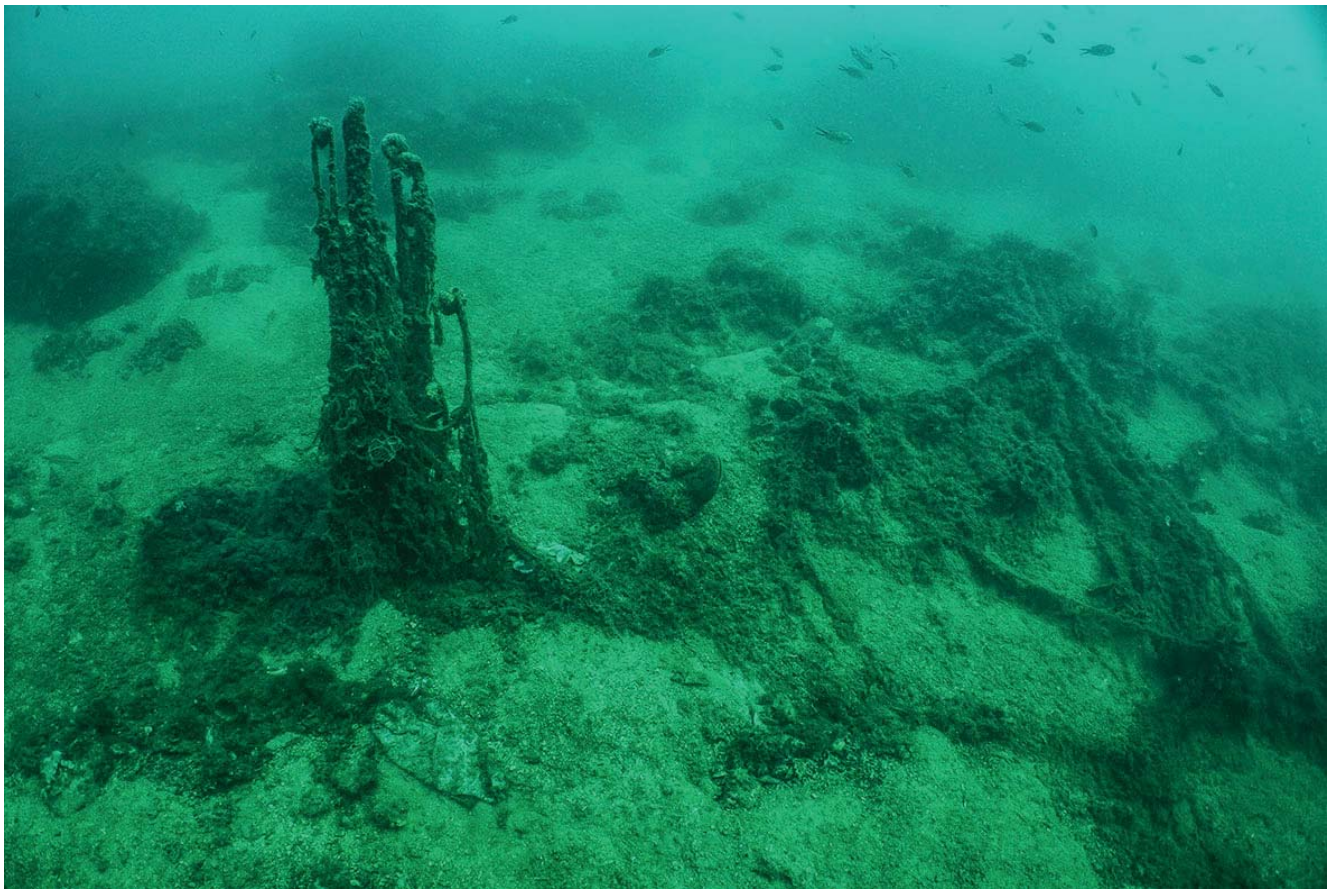


Photo 17. Abandoned net and other debris; in the center a dead *Pinna nobilis*

4.1.3 Biodiversity

Both from photo transect and from gauged images, 50 Operative Taxonomic Units (OTU) have been detected. Erect species that define the biocenosis have been counted: their number x m^2 and their average height have been calculated. Necrosis and/or epibiosis of the distal parts of the erect species was considered but was not found in any. The presence in the site of colonies of *Savalia savaglia* with the basal parts dead and/or colonized by epibionts as before examined, is a different phenomenon that will be discussed in the conclusions.

The algal component is mainly formed by a turf of brown algae that cover the surface of rocky and coral blocks. The calcareous encrusting algae are rare and contribute insignificantly to the external shape of bioconstructions. The most common alga is the emisciaphilic *Halimeda tuna*, while in the shallows *Padina pavonia* is widespread.

Within the invertebrates, Porifera are present with 18 OTU: the most common is *Acanthella cannabina* with about 1 individual each 10 m^2 and an average height of 36 cm (n = 12, maximum 66 cm). *Aplysina aerophoba/ cavernicola* is present with less than 1 individual x 10 m^2 (0.6) and average height of 13.6 cm (n = 5, maximum 26 cm). The *Aplysina aerophoba/ cavernicola* question will be deepened in the conclusions, being the two species distinguishable only on the basis of DNA analysis: in the cases examined here, the usual identification based on ecology is not reliable. Of the encrusting sponges just few were determined to species level (*Haliclona mucosa, Hexadella racovitzai* and *Phorbas tenacior*).

Anthozoa are the second group in number with 10 species. Among them, *Savalia savaglia* is undoubtedly the species that characterizes the site. Less scenic but no less important is *Polycyathus muellerae*: it effectively structures the habitat, building articulated or compact blocks that provide a fundamental substrate for the installation of other organisms. Isolated coral herms, formed by *Polycyathus muellerae* and secondarily by *Phyllangia americana muochezi,* may reach heights that exceed 1 m (1.16 m) and volumes that exceed 1 m^3 (1.24 m^3). The Gorgonidae *Leptogorgia sarmentosa* is scattered in the site with few colonies (17.2 each 100 m^2), but probably it has played an important role in the diffusion of *Savalia savaglia,* offering with its ramifications suitable substrates for the settlement of zoanthid's larvae. The finding of colonies of the stolonifer *Sarcodictyon catenatum* requires specific insights.

Other invertebrates such as Bryozoa, and Ascidiacea do not seem to play an important role in shaping the evironment, but most probably Polychaeta contribute to consolidating the carbonate formations of the blocks formed by Scleractinia.

In the following Table 3 the 50 OTU characterizing the site are listed: for erect structuring species, the number of individuals or colonies and their density x m^2 are indicated.

Table 3. Site DV01 – Summary of the species (50) that characterize the site with an indication of the abundance of structuring species

Phylum	Class	Species	Presence	Abundance	N° x m^2	Epibiosis	Entrapment
Rhodophyta	Florideophyceae	*Asparagopsis taxiformis*	x				
Chlorophyta	Ulvophyceae	*Codium bursa*	x				
Chlorophyta	Ulvophyceae	*Codium coralloides*	x				
Rhodophyta	Florideophyceae	*Corallinales encrusting*	x				
Rhodophyta	Florideophyceae	*Corallinales (maerl)*	x				
Ochrophyta	Phaeophyceae	*Dictyota dichotoma*	x				
Ochrophyta		Ochrophyta turf	x				
Chlorophyta	Ulvophyceae	*Flabellia petiolata*	x				
Chlorophyta	Ulvophyceae	*Halimeda tuna*	x				
Ochrophyta	Phaeophyceae	*Padina pavonia*	x				
Rhodophyta	Florideophyceae	*Peyssonnelia spp.*	x				

Phylum	Class	Species	Presence	Abundance	N° x m²	Epibiosis	Entrapment
Rhodophyta	Florideophyceae	*Peyssonnelia squamaria*	x				
Chlorophyta	Ulvophyceae	*Pseudochlorodesmis furcellata*	x				
Rhodophyta	Florideophyceae	*Tricleocarpa fragilis*	x				
Porifera	Demospongiae	*Acanthella cannabina*	x	77	0.096		
Porifera	Demospongiae	*Agelas oroides*	x				
Porifera	Demospongiae	*Aplysina aerophoba/cavernicola*	x	48	0.06		
Porifera	Demospongiae	*Cymbaxinella verrucosa*	x	1	0.001		
Porifera	Demospongiae	*Cymbaxinella damicornis*	x				
Porifera	Demospongiae	*Chondrosia reniformis*	x				
Porifera	Demospongiae	*Cliona rhodensis*	x				
Porifera	Demospongiae	*Dysidea avara*	x				
Porifera	Demospongiae	*Haliclona fulva*	x				
Porifera	Demospongiae	*Haliclona mucosa*	x				
Porifera	Demospongiae	*Hexadella racovitzai*	x				
Porifera	Demospongiae	*Ircinia variabilis*	x				
Porifera	Demospongiae	*Petrosia ficiformis*	x				
Porifera	Demospongiae	*Phorbas tenacior*	x				
Porifera	Demospongiae	*Pleraplysilla spinifera*	x				
Porifera	Demospongiae	*Sarcotragus foetidus*	x				
Porifera	Demospongiae	*Encrusting sponges*	x				
Cnidaria	Anthozoa	*Alcyonium coralloides*	x				
Cnidaria	Anthozoa	*Caryophyllia inornata*	x				
Cnidaria	Anthozoa	*Cladocora caespitosa*	x				
Cnidaria	Anthozoa	*Leptogorgia sarmentosa*	x	17	0.021		
Cnidaria	Anthozoa	*Madracis pharensis*	x				
Cnidaria	Anthozoa	*Parazoanthus axinellae*	x				
Cnidaria	Anthozoa	*Phyllangia americana mouchezi*	x				
Cnidaria	Anthozoa	*Polycyathus muellerae*	x				
Cnidaria	Anthozoa	*Sarcodictyon catenatum*	x				
Cnidaria	Anthozoa	*Savalia savaglia*	x	509	0.64		1
Cnidaria	Hydrozoa	Hydrozoa n.i	x				
Bryozoa	Gymnolaemata	*Reteporella grimaldii*	x				
Bryozoa	Gymnolaemata	*Schizomavella cf. mamillata*	x				
Bryozoa		Bryozoa n.i.	x				
Anellida	Polychaeta	*Protula tubularia*	x				
Anellida	Polychaeta	*Serpula vermicularis*	x				
Chordata	Ascidiacea	*Clavelina lepadiformis*	x				
Chordata	Ascidiacea	*Halocynthia papillosa*	x				
Chordata	Ascidiacea	*Microcosmus sabatieri*	x				

4.1.4 Debris

In the area of the transect 147 objects have been counted of anthopogenic origin, as described in the following Table 4.

Table 4. Debris abundance and distribution

Debtype	Abundance m²	N°
Net	0.0025	2
Lines	0.00875	7
Plastic bottles, cans	0.1725	138
General	0.18375	147

The high presence of waste materials of human origin is probably due to the proximity of the coastal road. Bottles and cans not only are foreign bodies in the habitat and reduce its high aesthetic value, but they play an important role in the deterioration of the facies formed by the high number of *Savalia savaglia* colonies. As before highlighted, bottles and cans are easily transported by currents generated by undewater and aerial streams giving more strenght to the abrasive action of the sediments at the base of the colonies. They also act as a dam for the accumulation of sediments at the base of the colonies, creating favorable conditions for the covering of the colonies and their consequent suffocation by sediments.

4.1.5 MAES index

Applying the collected data to the scheme for the calculation of MAES index (see page 6), the scores resulting for the site Drazin Vrt are shown in the following Table 5.

The scores relative to density of erect species, Average height, % of colonies with epibiosis/necrosis are referred to *Savalia savaglia*. In this case, the total score of the index is obviously conditioned by the high presence of waste in the transect area.

Table 5. MAES score for DV01

Site	Nº megabenthic taxa	% biotic cover basal layer	Density erect species	Average height dominant erect species	% colonies epibiosis / necrosis	Litter density	Total score	Ecological status
DV01	50	50	0.63	54	0	0.18	14	Moderate
Score	3	2	3	2	3	1		

4.2 Sopot

This site has not been the subject of previous monitoring investigations. A speleologic survey, among others, reported these informations: "*During diving exploration of submarines springs, a unique ecosystem has been found, which deserves further study. As a matter of fact, low temperature fresh waters exit, strong mixing of waters, turbidity and poor brightness typical of these sites favours growth in shallow waters (around 15-20 m) of a true "forest" of* Gerardia savaglia*, with* Aplysina aerophoba, Parazoanthus axinellae, Cerianthus membranaceus, Flabellina affinis, *and* Cratena peregrina" (Eusebio *et al.*, 2007).

4.2.1 Geographical and operational framework

The site is located at 18.679589°E and 42.509819° N (central point) and the monitored area is about 35 m from the coast line (anchor at 25 m from the coast). Morphological and environmental aerial conditions are quite similar to those reported for Drazin Vrt. A few meters high slope, vegetated by shrubs, ends on the coastal road of the Bay. East of the site there is a huge water inlet that drains at sea level. In winter and spring it forms a waterfall with important flows. At the time of this monitoring the release of fresh water was not active. The karstic system of Sopot has been thoroughly explored and described by Eusebio *et al.*, 2007. It consists of a large main aerial cavity and an important submerged spring at a depth of about 30 m. The system is typically intermittent with maximum flow rates in winter and spring, while in late summer and early autumn it is almost always dry.

On the shoreline, blocks and pebbles are the resultant materials of the construction of the road and also occupy the first meters of the submerged area. Materials of anthropic origin are observed on the slope and in the shoreline area.

The submerged area degrades rapidly and just a few meters from the shoreline the bottom reaches a depth of 7 m, where the first colonies of *Savalia savaglia* are encountered, to degrade with greater steepness up to 16-18 m. In the first few meters the bottom is characterized by a sand and scattered blocks, covered with photophilic algae (mainly *Cystoseira corniculata* and *Padina pavonia*), ending at around 7-8 m of depth on a mixed bottom of coarse sediments and bioconcretions, with few scattered rocky blocks.

Photo 18. The shoreline at Sopot

The coral blocks, mixed with huge assemblages and sparse colonies of *Savalia savaglia*, end at 18 m on a bottom covered with thin sediments. In the sedimentary areas there are clear signs of important sediment transports that interfere with the development of colonies of erect species.

As before reported the area is characterized by submerged springs that were not active at the moment of this monitorig. When active, the one located west of the monitoring site at 30 m depth, has an estimated flow of 15-20 m^3 per second in the month of April (Eusebio *et al.*, 2007). Compared with the conditions observed at Drazin Vrt, the turbidity of the water on Sopot site was considerably higher.

The non rectilinear transect SO01 was performed within the beginning and the end of the presence of *Savalia savaglia* colonies, corresponding to these coordinates:

- Starting point: 18.680859° E, 42.510763° N;
- End point: 18.679617° E, 42.50898° N.

The distance between these two strongholds is 200 m and the transect covered an area of 800 m^2 (200 x 4 m).

Along the transect were performed three dives with different purposes as outlined in the next Table 6. In the 3 dives, a total area of about 1,600 m^2 has been surveyed.

Table 6. Dive roster – Sopot

Site	Date	Depth	Time	Activities
Sopot dive 1	13 09 2019	17.9	82	Photographic transect in the whole area. Videos for specific assemblages. Collection of samples
Sopot dive 2	13 09 2019	18.8	68	Photographic transect to obtain metric areas. Collection of samples
Sopot dive 3	17 09 2019	16.4	57	Photographic transect for deepening analysis and for communication material

Photo 19. *Cystoseira corniculata* at low depth

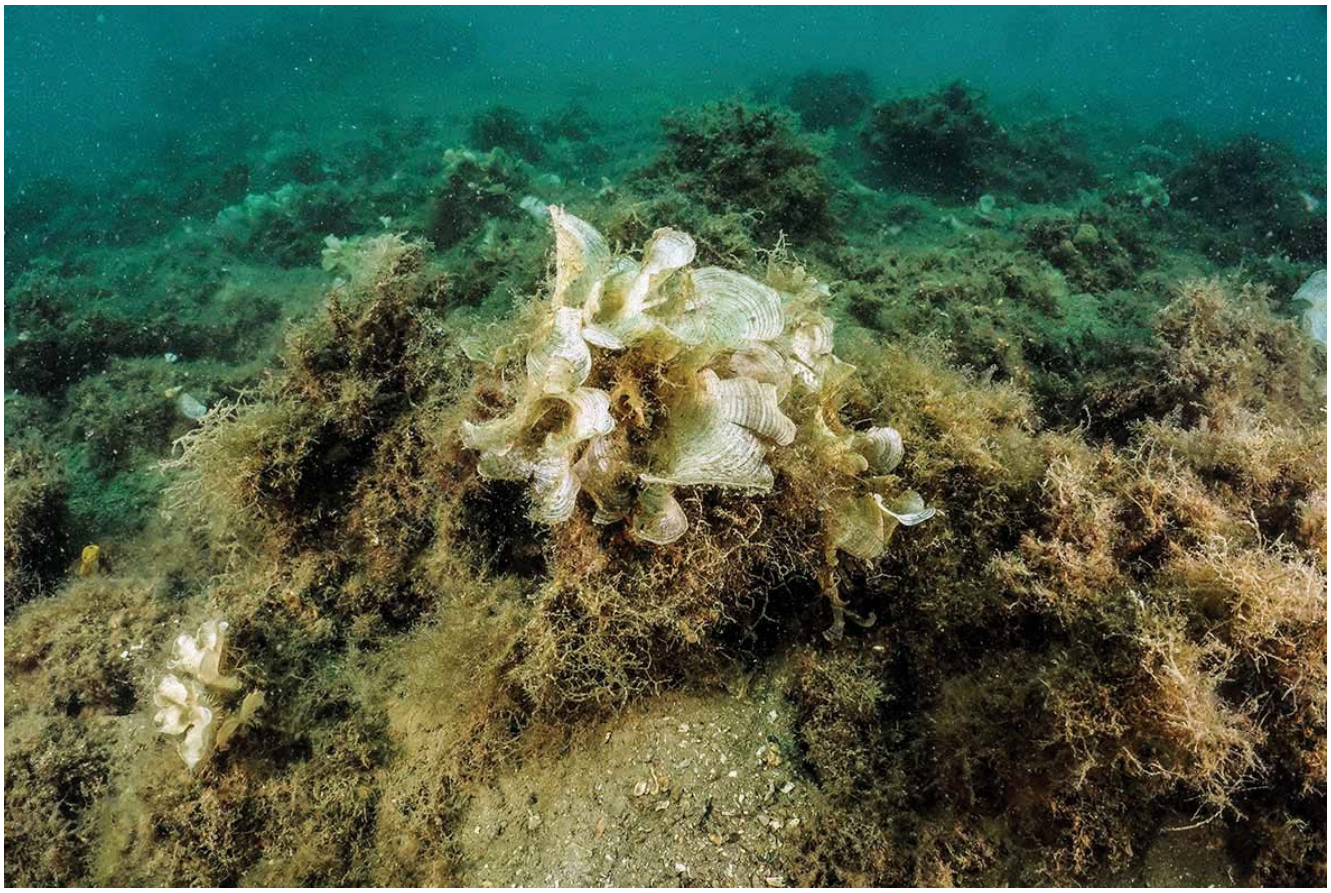


Photo 20. *Padina pavonia* at low depth

4.2.2 Megabenthic assemblages

The transect SO01 was conducted in similar environmental conditions at DV01, except for worse visibility conditions. It is characterized by the alternance of sedimentary areas, scattered or grouped colonies of the Zoantharia *Savalia savaglia*, scattered coral blocks mainly formed by the Scleractinia, *Polycyathus muellerae*, scattered stony blocks. The biocenosis is also characterized by large sponges growing both on coral and stony blocks (*Acanthella cannabina, Axinella polypoides, Cymbaxinella verrucosa, Cymbaxinella damicornis* and *Aplysina aerophoba/cavernicola*), colonies of *Leptogorgia sarmentosa* and *Parazoanthus axinellae*. The encrusting calcareous algae component is irrelevant being present with very small and very sparse formations.

Savalia savaglia, the most common species, is distributed in a range of 8-17 m depth, both in sedimentary areas and to a lesser extent on bioconcretions and even less on stony blocks. It is distributed in metric assemblages and with sparse colonies in a number counted/estimated near to 500 colonies (483). As in DV01, counts are quite difficult for the species because, in the large assemblages, it is difficult to distinguish different colonies and anastomosis processes are largerly diffused. The average height of the colonies is 45 cm with a maximum of about 60 cm. The largest assemblage occupies an area of about 7 m^2. The assemblages show a moderate presence of epibiosis or necrosis in the distal branches, while, as at DV01, the lower part of the colonies in contact with the bottom shows the evident consequences of the high sediment transport that characterizes the area (due mainly to aerial and submerged springs), which is amplified by the accumulation of debris (mainly plastic bottles) at the base of the colonies. Patches of dead colonies of *Savalia savaglia* as described in DV01 were not found. Few colonies with large central stems were detected.

In the western side of the transect there is a facies constituted mainly by *Axinella polypoides* and scattered *Acanthella cannabina*. In the whole site, complex coral formations are sparse: the main component is the scleractinia *Polycyathus muellerae* and the presence of patches of *Phyllangia americana mouchezi* is moderate. Coral herms are diffusely covered by *Parazoanthus axinellae* and host colonies of *Savalia savaglia* and *Leptogorgia sarmentosa,* and conspicous individuals of *Acanthella cannabina and Aplysina aerophoba/cavernicola,* the latter being diffused also at low depths. *Parazoanthus axinellae is also hosted by Cymbaxinella verrucosa and C.damicornis.*

Alive *Cladocora caespitosa* is present with small cushion-like colonies in association with emisciaphilic algae (*Halimeda tuna*).

Photo 21. The main assemblage of *Savalia savaglia* and, front right, individuals of *Aplysia cavernicola/aeropohoba*; top right, *Acanthella cannabina*

Photo 22. Colonies of *Savalia savaglia* on sedimentary bottom

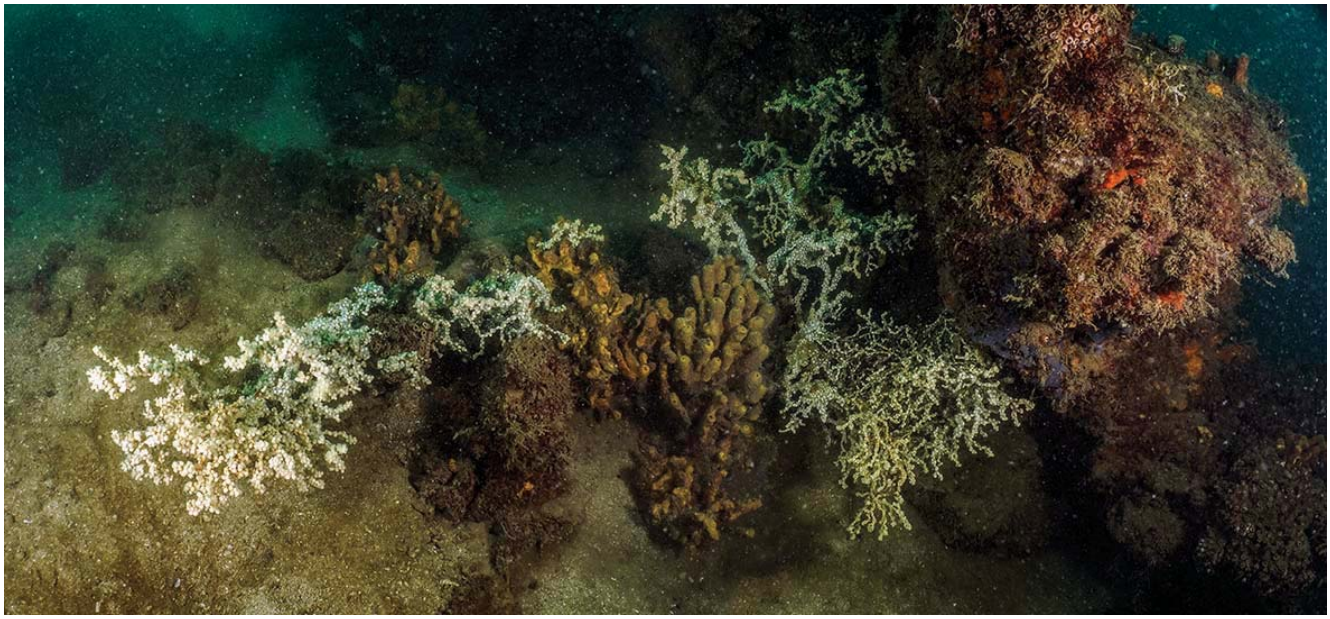


Photo 23. Colonies of *Savalia savaglia* on coral herms and individuals of *Aplysina aerophoba/cavernicola*

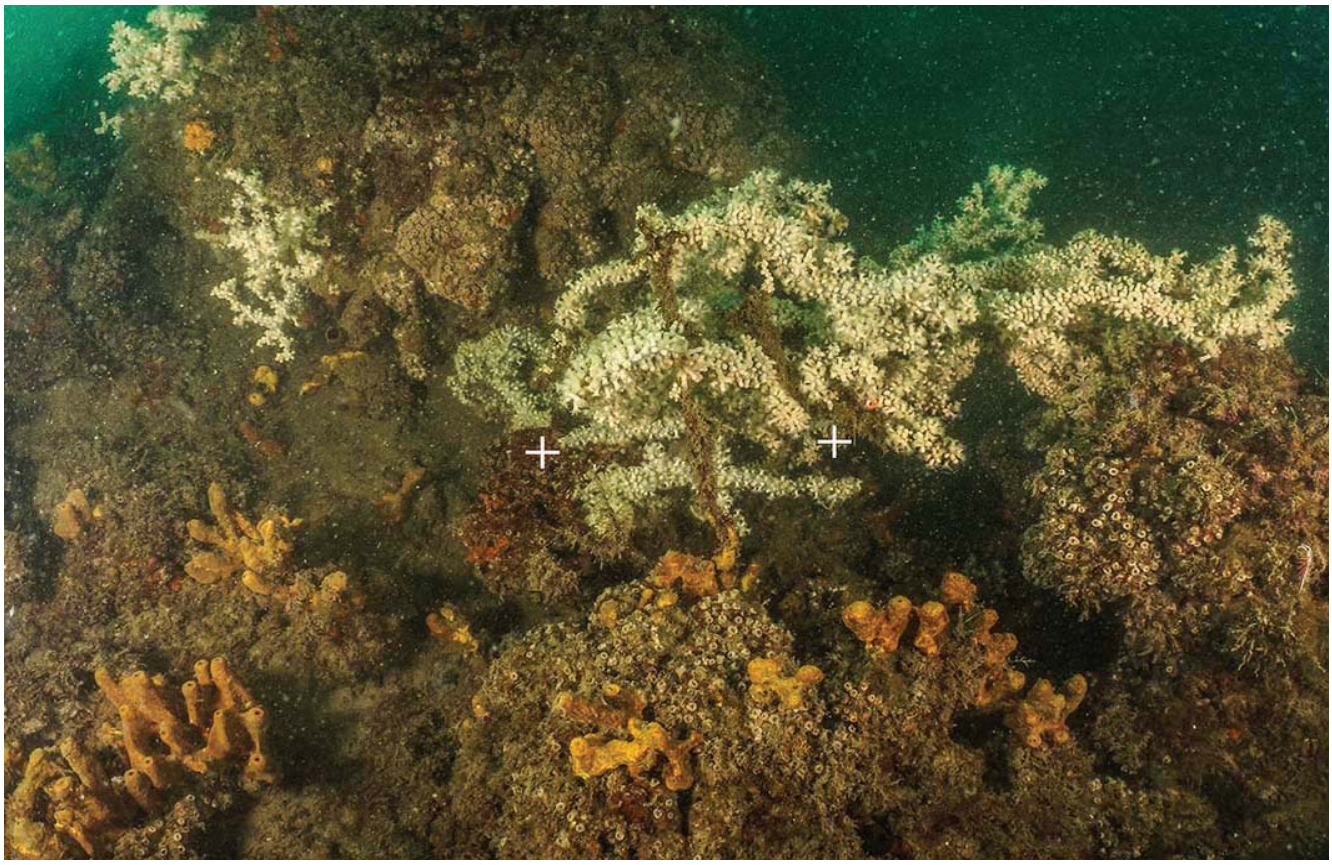


Photo 24. Colonies of *Savalia savaglia* on coral herms formed by *Polycyathus muellerae* and individuals of *Aplysina aerophoba/cavernicola*

Photo 25. Colonies of *Parazoanthus axinellae* on coral herms formed by *Polycyathus muellerae*, *Aplysina aerophoba/cavernicola* and a colony of *Leptogorgia sarmentosa*

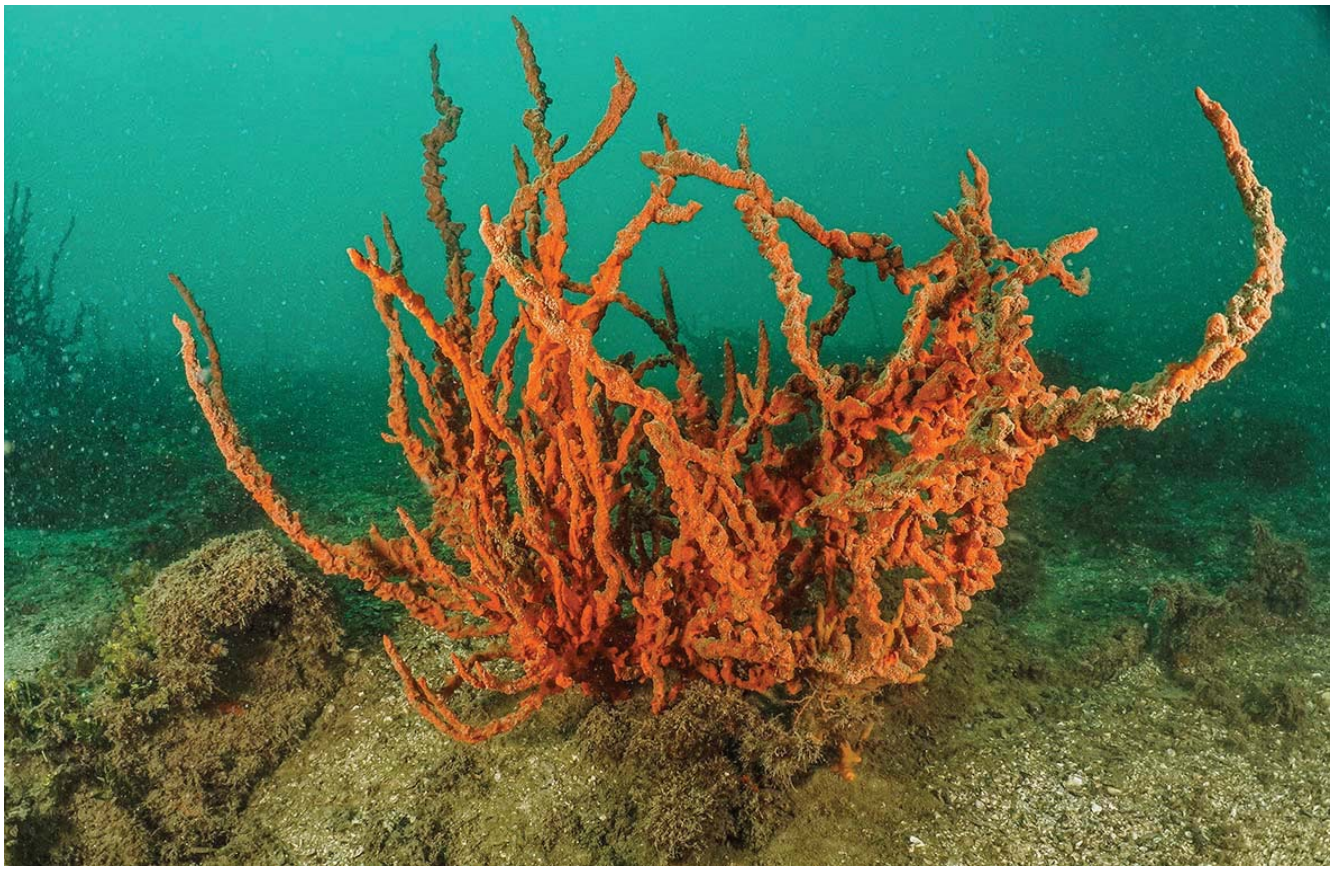


Photo 26. A huge *Acanthella cannabina*

Photo 27. Sympatry of *Axinella polypoides*, *Acanthella cannabina* and *Aplysina aerophoba/cavernicola*

Photo 28. Facies of *Axinella polypoides*, *Cymbaxinella verrucosa* covered by *Parazoanthus axinellae* and a lost line

Photo 29. The colonies of *Leptogorgia sarmentosa* in open habitats show a "disheveled" habitus, typycal in Boka Kotorska

Photo 30. A panoramic view of coral blocks and sedimentary patches

4.2.3 Biodiversity

Both from photo transect and from gauged images, 46 Operative Taxonomic Units (OTU) were detected. Erect species that define the biocenosis were counted: their number x m^2 and thier average height was calculated. Necrosis and/or epibiosis of the distal parts of the erect species has been considered but was not found in any. As for DV01, the presence in the site of colonies of *Savalia savaglia* with the basal parts dead and or colonized by epibionts as before examined, is a different phenomenon that will be discussed in the conclusions.

The algal component is mainly formed by a turf of brown algae that cover the suface of rocky and coral blocks. The calcareous encrusting algae are rare and contribute insignificantly to the external shape of bioconstructions. The most common alga is the emisciaphilic *Halimeda tuna*, while in the shallows *Padina pavonia* and *Cystoseira corniculata* are diffused.

Within the invertebrates, Porifera are present with 22 OTU: the most common is *Aplysina aerophoba/ cavernicola* with about 1.2 individualsl each 10 m^2 and an average height of 14 cm (n = 5, maximum 21 cm). The species shows a high rate of necrosis regardin 11.1% of the individuals in the transect. *Axinella polypoides* is present about 1.2 individuals each 10 m^2 and an average height of 39 cm (n = 6, maximum 54.5 cm). *Acanthella cannabina* is present with about 1.1 individuals each 10 m^2 and an average height of 53.5 cm (n = 7, maximum 68 cm). *Cymbaxinella verrucosa* (always in symbiosys with *Parazoanthus axinellae*) is present with about 0.017 individuals each m^2 and lower is the presence of *Cymbaxinella damicornis*. Of the encrusting sponges only *Phorbas tenacior* was determined to species level. Diffused is the presence of *Chondrilla nucula.* An individual of sponge of the genus *Tethya* (diameter 7.4 cm), fits the external morfological description and large dimensions of *Tethya meloni* Corriero, Gadaleta e Bavestrello, 2015, a new species described from specimens from the Tyrrenian, Jonian and Adriatic sea (Venice, Porto Badisco, Bar and Albania). For a correct identification the collection of samples is needed.

Anthozoa are the second group in number with 7 species. Among them, *Savalia savaglia* is undoubtedly the species that characterizes the site: 2% of the colonies are affected by epibiosis in the distal portion of the branches. Like at DV01, *Polycyathus muellerae* is quite important to effectively structure the habitat, building articulated or compact blocks that provide a fundamental substrate for the installation of other organisms. Isolated coral herms, formed by *Polycyathus muellerae* and secondarily by *Phyllangia*

americana muochezi, rarely reach heights that exceed 1 m. The Gorgonidae *Leptogorgia sarmentosa* is scattered in the site with few colonies (22, 2.7 each 100 m^2) affected at a high rate by epibiosis (13%).

As in DV01, other invertebrates such as **Bryozoa**, and **Ascidiacea** do not seem to play an important role in shaping the evironment, but most probably **Polychaeta** contribute to consolidating the carbonate formations of the blocks formed by Scleractinia.

In the following **Table 3** the 44 OTU characterizing the site are listed: for erect structuring species, the number of individuals or colonies, their density x m^2, the % of epibiosi/necrosis and the individuals or colonies entrapped by debris are indicated.

Table 7. Site SO01 – Summary of the species (46) that characterize the site with an indication of the abundance of structuring species

Phylum	Class	Species	Presence	Abundance	N°x m^2	Epibiosis	Entrapment
Chlorophyta	Ulvophyceae	*Codium coralloides*	x				
Rhodophyta	Florideophyceae	*Corallinales encrusting*	x				
Ochrophyta	Phaeophyceae	*Cystoseira corniculata*	x				
Ochrophyta	Phaeophyceae	*Dictyota dichotoma*	x				
Ochrophyta		*Feltro di alghe brune*	x				
Chlorophyta	Ulvophyceae	*Halimeda tuna*	x				
Ochrophyta	Phaeophyceae	*Padina pavonia*	x				
Rhodophyta	Florideophyceae	*Peyssonnelia spp.*	x				
Chlorophyta	Ulvophyceae	*Pseudochlorodesmis furcellata*	x				
Porifera	Demospongiae	*Acanthella cannabina*	x	89	0.11	3.40%	
Porifera	Demospongiae	*Aplysina aerophoba/cavernicola*	x	99	0.12	11.1% necrosis	
Porifera	Demospongiae	*Axinella polypoides*	x	99	0.12		1
Porifera	Demospongiae	*Cymbaxinella verrucosa*	x	14	0.017		
Porifera	Demospongiae	*Cymbaxinella damicornis*	x	7	0.008		
Porifera	Demospongiae	*Chondrilla nucula*	x				
Porifera	Demospongiae	*Chondrosia reniformis*	x				
Porifera	Demospongiae	*Dysidea avara*	x				
Porifera	Demospongiae	*Dysidea fragilis*	x				
Porifera	Demospongiae	*Haliclona fulva*	x				
Porifera	Demospongiae	*Haliclona mediterranea*	x				
Porifera	Demospongiae	*Ircinia oros*	x				
Porifera	Demospongiae	*Ircinia variabilis*	x				
Porifera	Demospongiae	*Petrosia ficiformis*	x				
Porifera	Demospongiae	*Phorbas tenacior*	x				
Porifera	Demospongiae	*Pleraplysilla spinifera*	x				
Porifera	Demospongiae	*Sarcotragus cf.spinosulus*	x				
Porifera	Demospongiae	*Spugne incrostanti*	x				
Porifera	Demospongiae	*Tethya cf. meloni*	x				
Cnidaria	Anthozoa	*Alicia mirabilis*	X				
Cnidaria	Anthozoa	*Cladocora caespitosa*	x				
Cnidaria	Anthozoa	*Epizoanthus sp.*	x				
Cnidaria	Anthozoa	*Leptogorgia sarmentosa*	x	22	0.02	13.00%	1
Cnidaria	Anthozoa	*Parazoanthus axinellae*	x				
Cnidaria	Anthozoa	*Phyllangia americana mouchezi*	x				
Cnidaria	Anthozoa	*Polycyathus muellerae*	x				
Cnidaria	Anthozoa	*Savalia savaglia*	x	483	0.60	2%	7
Cnidaria	Hydrozoa	Hydrozoa n.i	x				

Phylum	Class	Species	Presence	Abundance	N°x m²	Epibiosis	Entrapment
Bryozoa	Stenolaemata	*Frondipora verrucosa*	x				
Bryozoa	Gymnolaemata	*Schizomavella cf. mamillata*	x				
Bryozoa		Bryozoa n.i.	x				
Anellida	Polychaeta	*Protula tubularia*	x				
Anellida	Polychaeta	*Serpula vermicularis*	x				
Chordata	Ascidiacea	*Halocynthia papillosa*	x				
Chordata	Ascidiacea	*Microcosmus sabatieri*	x				

4.2.4 Debris

In the area of the transect 115 objects of anthopogenic origin were counted as described in the following Table 8.

Table 8. Debris abundance and distribution

Debtype	Abundance m²	N°
Pot	0.00125	1
Lines	0.026	21
Tires	0.00875	7
Glass bottles	0.016	13
Plastic bottles, cans	0.05	40
Plastic	0.03	24
Net	0.00125	1
Cask, large metallic debris	0.01	8
General	**0.14**	**115**

The range of waste materials of human origin found on the site is much wider than DV01. As for DV01, the high presence of waste materials of human origin is probably due to the proximity of the coastal road. The considerations developed for DV01 on the negative role of human waste also apply to this site. The presence of tires and other large debris shows that it is not a matter of fortuitous entry into the sea, but of the result of deliberate actions aimed at getting rid of bulky waste.

Photo 31. Debris at the base of a colony of *Savalia savaglia*

Photo 32. *Axinella polypoides* eradicated from a net, then abandoned

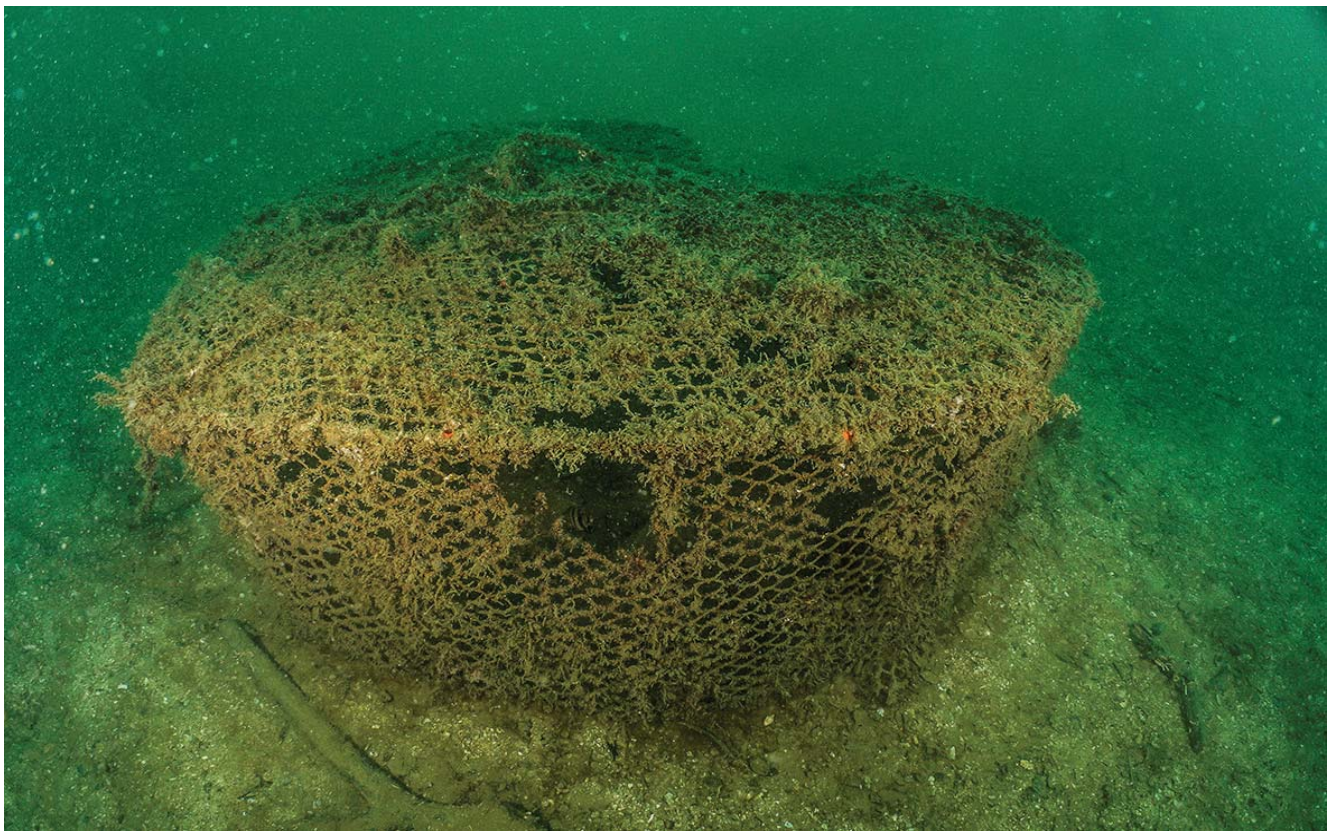


Photo 33. An abandoned pot

Photo 34. A tire with glass bottles accumulated by bottom currents

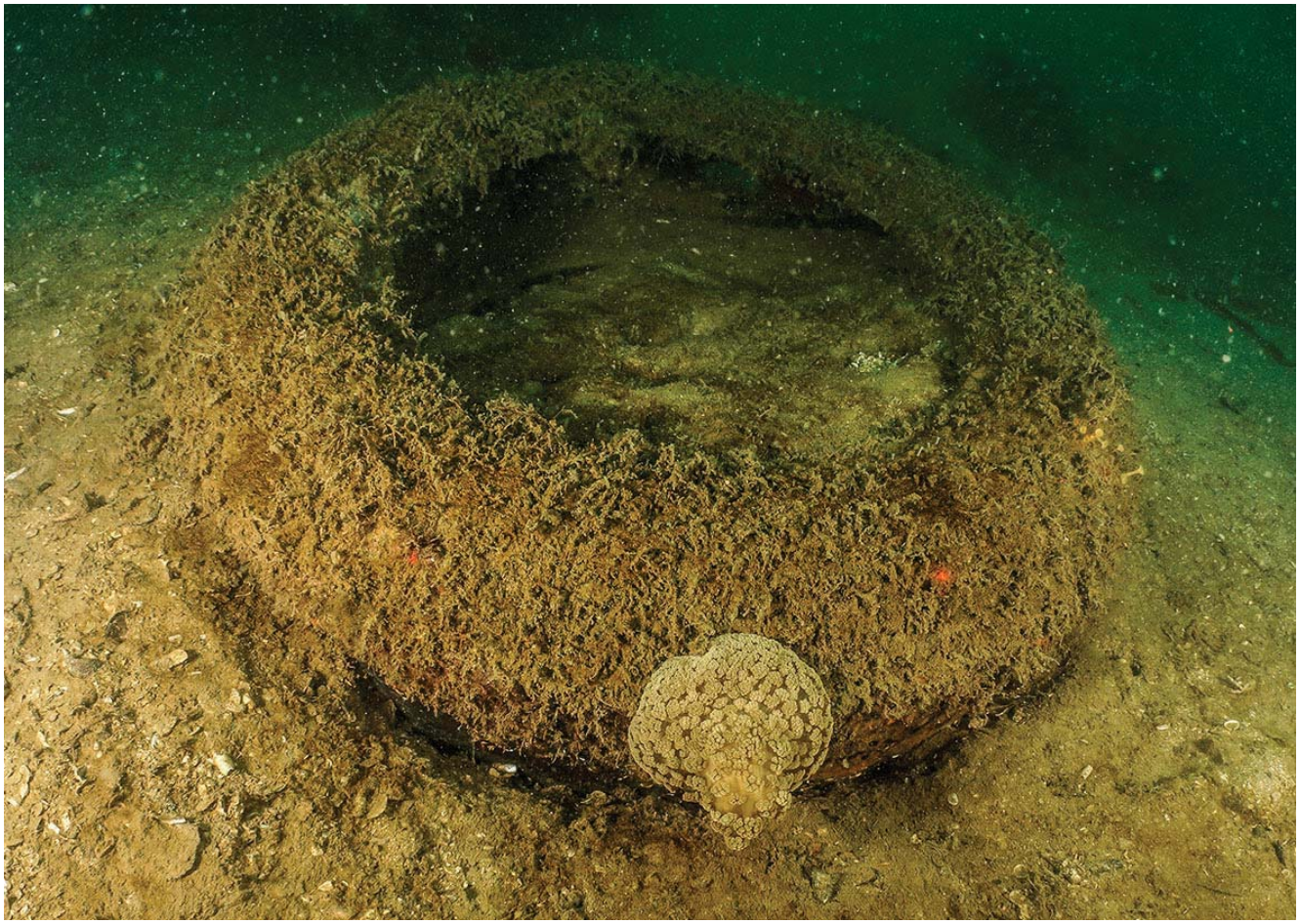


Photo 35. *Alicia mirabilis*, a nocturnal anthozoan, is settled on an abandoned tire

Photo 36. A cask and other metallic debris

Photo 37. A large plastic container

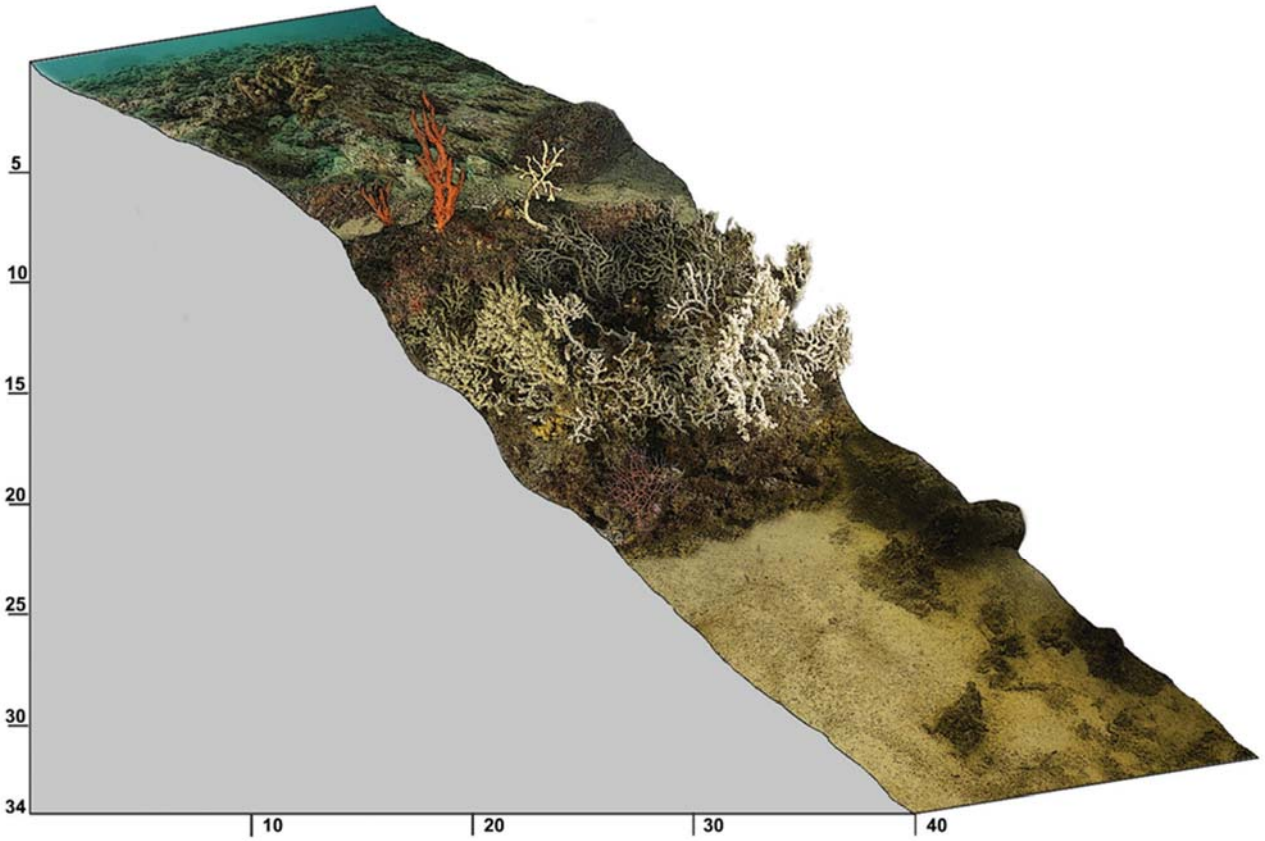
4.2.5 MAES index

Applying the collected data to the scheme for the calculation of MAES index (see page 6), the scores resulting for the site Sopot are shown in the following Table 9.

The scores relative to density of erect species, average height, % of colonies with epibiosis/necrosis are referred to *Savalia savaglia*. In this case, as for DV01, the total score of the index is obviously conditioned by the high presence of waste in the transect area.

Table 9. MAES score for SO01

Site	Nº megabenthic taxa	% biotic cover basal layer	Density erect species	Average height dominant erect species	% colonies epibiosis / necrosis	Litter density	Total score	Ecological status
SO01	45	50		0.60	45	2	14	Moderate
Score	3	2		3	2	3		



Schematic rendering of the habitats with *Savalia savaglia* facies, described in the report: x axis = distance in meters from the shoreline; y axis = depth

4.3 Turski rt

This site has not been the subject of previous monitoring investigations. It was included in monitoring program mainly to investigate a population of Alcyonacea observed by IBM researchers in previous dives and to verify its relevance.

4.3.1 Geographical and operational framework

The site is located in 18.686263° E and 42.477892° N (central point) at the corner in the northwest end of Verige Strait and the monitored area is about 30 m from the coast line. Morphological and environmental aerial and underwater conditions are quite different from those reported for the two other sites. The coastal road is just a few meters above the shore with a steep, almost vegetation-free escarpment: at the mouth of the strait, where the coastal road curves to north-west, a parking lot serves a tourist facility directly overlooking the coast. At sea level there is a small pier. Once overtaken the pier, the rocky coast continues high in a more natural environment.

Anthropogenic materials occupy the first meters of the submerged area. In correspondence with the facility a large submerged area is occupied by huge and various objects and the marine environment is severely degraded. The site is located at the narrowest point of the Verige strait, approximately 280 m wide: each day a great number of small vessels and up to 3 cruise ships navigate through the strait.

Photo 38. The monitoring site of Turski rt in a zenithal image from Google Earth

Photo 39. The monitoring site of Turski rt: the starting point of the site survey

Photo 40. The monitoring site of Turski rt at the right, in the center a cruise ship in the Verige Strait

The rectilinear transect TR01 of 100 m x 0.5 was performed in correspondence with the presence of the colonies of *Spinimuricea klavereni*. The beginning and the end of the survey correspond to these coordinates:

- Starting point: 18.686263° E, 42.477892° N;
- End point: 18.686398° E, 42.479354° N.

A total area of about 6,000 m^2 was surveyed in 2 dives with different purposes as outlined in the Table 10.

Table 10. Dive roster – Turski rt

Site	Date	Depth	Time	Activities
Turski rt dive 1	16 09 2019	33.8	55	Photographic transect. Videos for specific assemblages. Collection of samples
Turski rt dive 2	17 09 2019	33.6	55	Photographic survey to obtain gauged areas. Video transect

Photo 41. The monitoring site of Turski rt: the tourist facility and the end part of the survey

4.3.2 Megabethic assemblages

The submerged area degrades rapidly with a constant slope in the terminal part of the strait and before the turn in correspondence with the building on the shore. In the first few meters the bottom is characterized by a coarse sediment, scattered pebbles often covered by a layer of encrusting red algae, and colonized by the sponge *Dysidea avara*. Colonies of *Leptogorgia sarmentosa* are scattered as the depth increases. Visibility is poor and often becomes null. At 28 m the bottom is silty and the first colonies of *Spinimuricea klavereni* are observed in the turbidity. They are sparse until the depth of 32 m. Gaining lesser depth and going on in the direction of the corner, first the bottom is covered by sparse and small colonies of *Cladocora caespitosa,* some with evident bleaching. Around, many colonies are damaged and surrounded by fragmented corallites and other debris. In correspondence to the turn of the coast, all kinds of anthropogenic materials appear: a minivan, a cage, the chassis of a car, cables, metallic objects, glass and plastic bottles, two cars, a rubbish container. Some biogenic blocks are sparse until the bottom becomes uniformly covered by building waste. Then at low depth, past the corner, coarse sediment alternates with rocks covered by photophilic algae and *Aplysina aerophoba*. A total area surveyed in the 2 dives covers about 6,000 m^2.

Photo 42. *Dysidea avara* at low dewpth

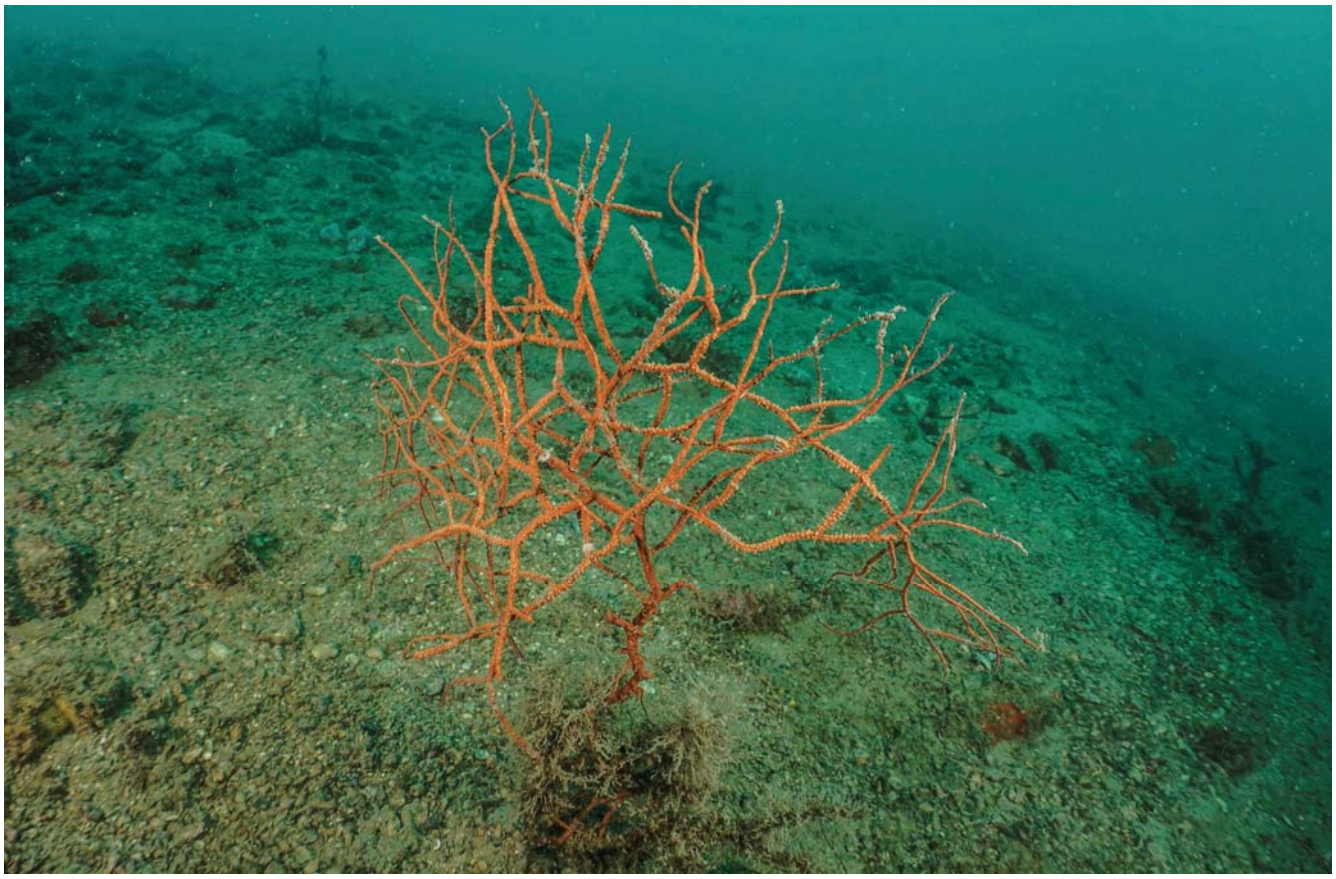


Photo 43. *Leptogorgia sarmentosa* with the nudibranch *Tritonia nilsodhneri* and its eggs

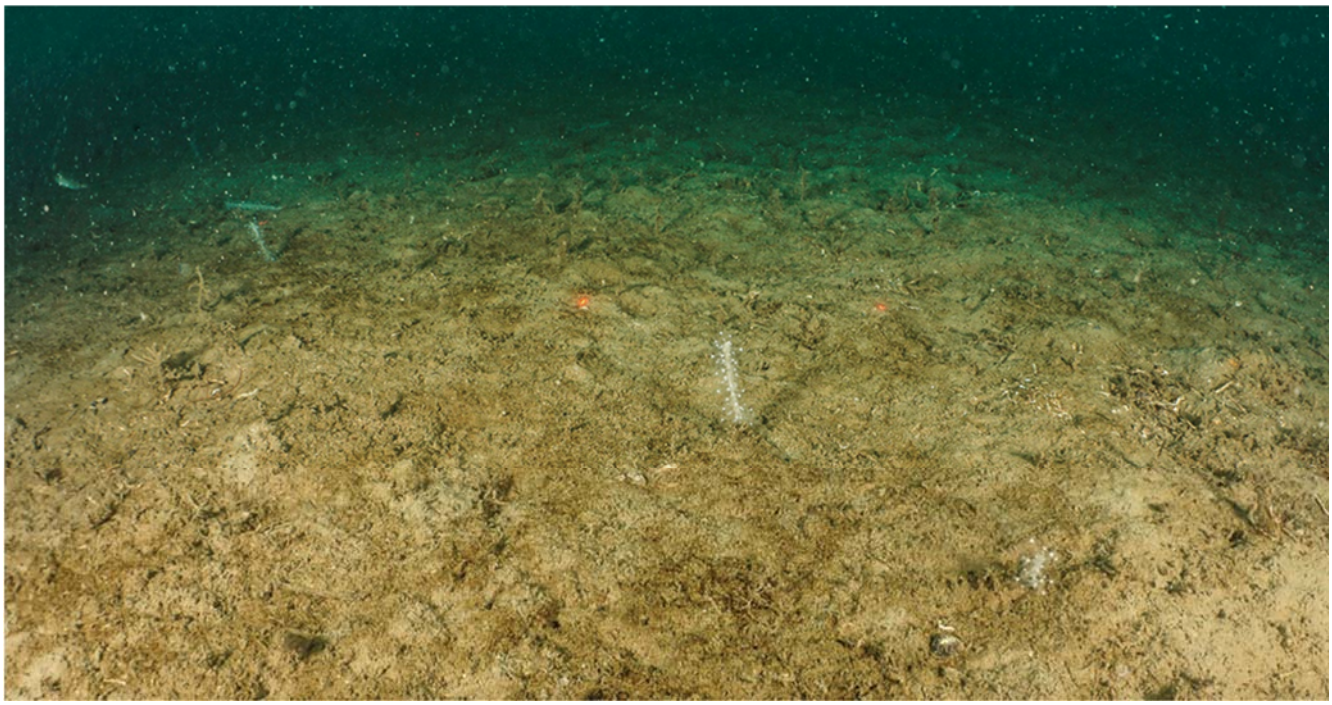


Photo 44. Four small colonies of *Spinimuricea klavereni* on the muddy bottom at 32 m depth

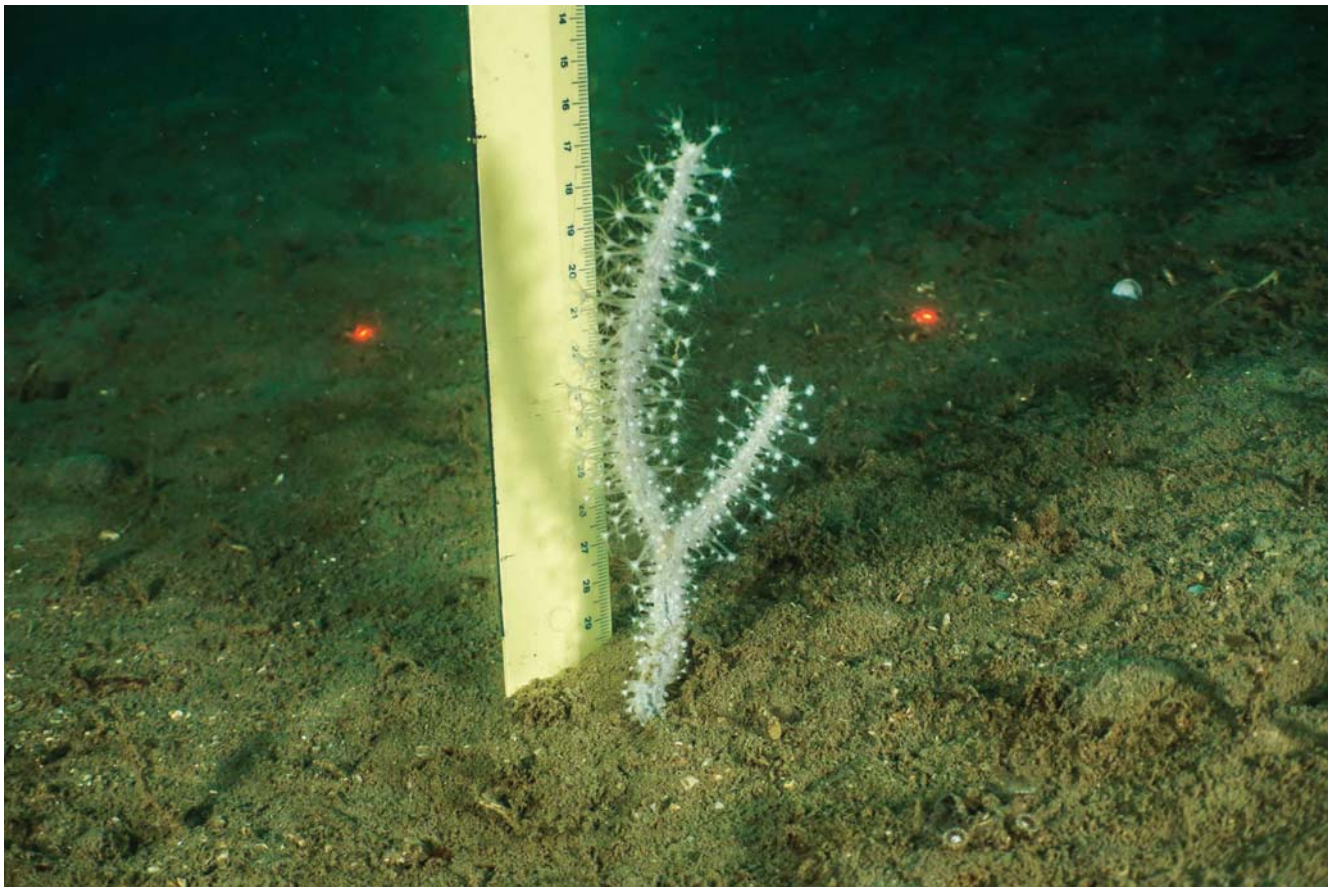


Photo 45. A branched colony of *Spinimuricea klavereni* is gauged

Photo 46. *Cladocora caespitosa* surrounded by corallites rubble

Photo 47. Barren with building waste

Photo 48. Huge metallic waste

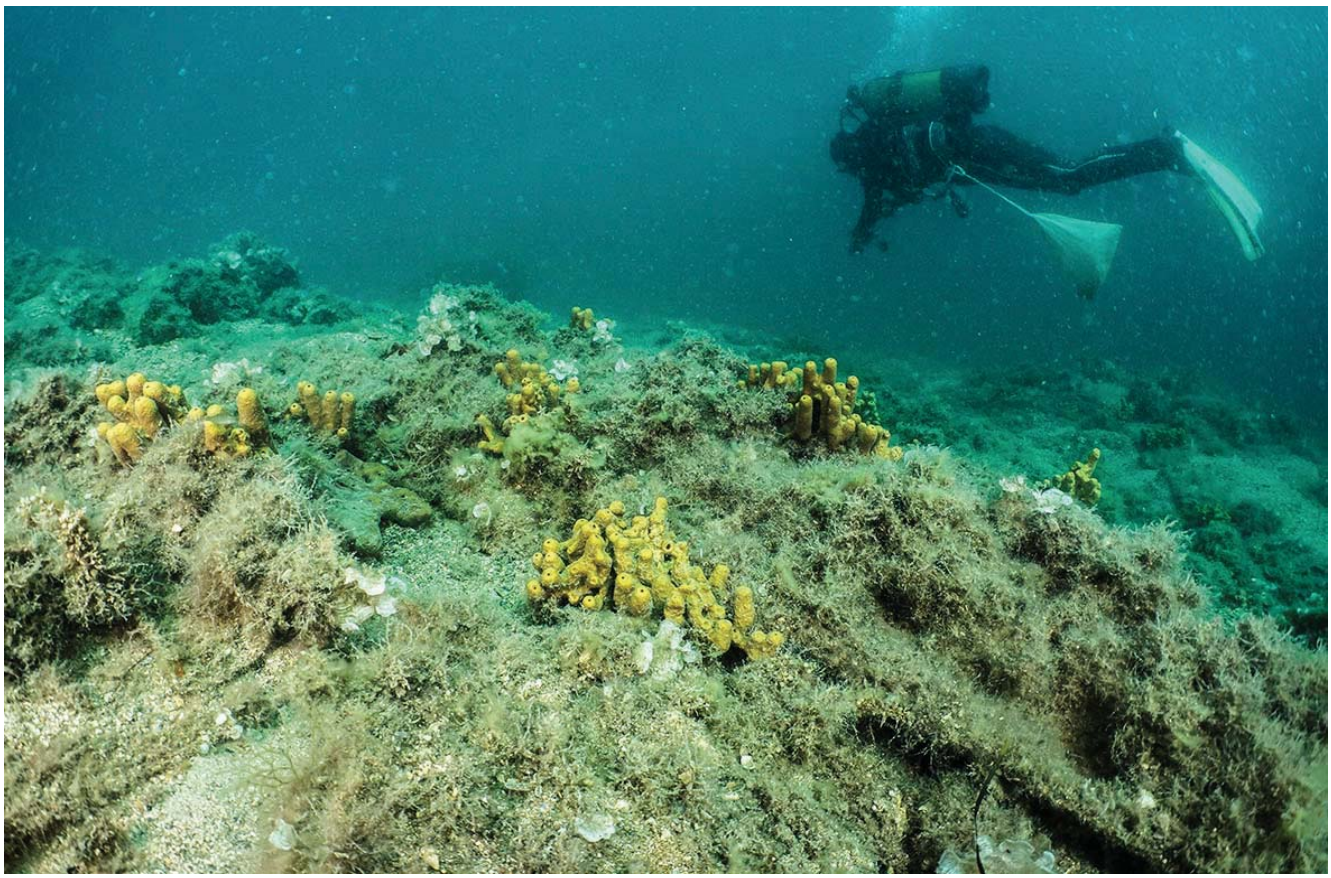


Photo 49. *Aplysina aerophoba-cavernicola* in low depth

4.3.3 Biodiversity

Both from photo transect and from gauged images, 40 Operative Taxonomic Units (OTU) were detected. Erect species that define the biocenosis have been counted: their number x m^2 and thier average height were calculated. Necrosis and/or epibiosis of the distal parts of the erect species has been considered.

The **algal component** is mainly formed by a turf of brown algae that cover the suface of rocky and coral blocks. The calcareous encrusting algae are found on pebbles and on rubble, but do not build bioconstructions. In the shallows a turf of brow algae covers the rocks, *Padina pavonia* is diffused. The finding of *Sargassum acinarium* is relevant.

Within the invertebrates, **Porifera** are present with 11 OTU: at low depths, *Aplysina aerophoba/cavernicola* shows necrosis in some individuals. The most common species is *Dysidea avara* that forms a facies in the south part of the site.

Anthozoa are the second group in number with 10 species. The plexaurid *Spinimuricea klavereni* is the most common species distributed on muddy bottom within 28 an 33 m of depth: *Spinimuricea klavereni* is a typical mesophotic species that until now had been found in the infralittoral zone only in Marmara sea (Topçu & Öztürk, 2015). The facies here described is the first report for the Adriatic sea and confirms the peculiar environmental conditions of Boka Kotorska, where mesophotic species can be found at very moderate depths. The abundance is 0.72 colonies per m^2 and the average height in the transect is < 10 cm, but 4 colonies, measured outside of the transect, had an average height of 13 cm. One colony at 28 m was 25 cm high. None of the colonies was affected by epibiosis nor necrosis. To confirm the mesophotic affinity of the site, small colonies of *Alcyonium palmatum* were found in association with *Spinimuricea klavereni*. The Gorgonidae *Leptogorgia sarmentosa* is scattered in the site: 13 colonies were counted and 50% was affected by epibiosis. The limited diffusion of bioconstruction appears to be ascribed to *Cladocora caespitosa*. Many small colonies were found surrounded by rubble of broken corallites; bleaching was reported on many colonies. The presence of *Polycyathus muellerae* is sporadic.

As the other monitoring sites, **Bryozoa** do not seem to play an important role in shaping the evironment.

In the following **Table 11** the 40 OTU characterizing the site are listed: for erect structuring species, the number of individuals or colonies, their density x m^2 (in the transect), the % of epibiosi/necrosis and the individuals or colonies entrapped by debris are indicated.

Table 11. Site TR01 – Summary of the species (40) that characterize the site with an indication of the abundance of structuring species

Phylum	Class	Species	Presence	Abundance	N°x m2	Epibiosis	Entrapment
Chlorophyta	Ulvophyceae	*Codium coralloides*	x				
Rhodophyta	Florideophyceae	*Corallinales encrusting*	x				
Rhodophyta	Florideophyceae	*Corallinales (maerl)*	x				
Rhodophyta	Rhodimeniaceae	*Chrysymenia ventricosa*	x				
Ochrophyta	Sargassaceae	*Cystoseira corniculata*	x				
Ochrophyta	Phaeophyceae	*Dictyota dichotoma*	x				
Ochrophyta		*Feltro di alghe brune*	x				
Ochrophyta	Phaeophyceae	*Padina pavonia*	x				
Rhodophyta	Florideophyceae	*Peyssonnelia spp.*	x				
Rhodophyta	Florideophyceae	*Peyssonnelia squamaria*	x				
Chlorophyta	Ulvophyceae	*Pseudochlorodesmis furcellata*	x				
Ochrophyta	Sargassaceae	*Sargassum cf. acinarium*	x				
Porifera	Demospongiae	*Agelas oroides*	x				
Porifera	Demospongiae	*Aplysina aerophoba/cavernicola*	x				
Porifera	Demospongiae	*Cymbaxinella verrucosa*	x				

Phylum	Class	Species	Presence	Abundance	N°x m2	Epibiosis	Entrapment
Porifera	Demospongiae	*Chondrilla nucula*	x				
Porifera	Demospongiae	*Dysidea avara*	x				
Porifera	Demospongiae	*Haliclona fulva*	x				
Porifera	Demospongiae	*Petrosia ficiformis*	x				
Porifera	Demospongiae	*Phorbas tenacior*	x				
Porifera	Demospongiae	*Sarcotragus foetidus*	x				
Porifera	Demospongiae	*Sarcotragus cf.spinosulus*	x				
Porifera	Demospongiae	*Spugne incrostanti*	x				
Cnidaria	Anthozoa	*Aiptasia mutabilis*	x				
Cnidaria	Anthozoa	*Alcyonium palmatum*	x				
Cnidaria	Anthozoa	*Caryophyllia smithii*	x				
Cnidaria	Anthozoa	*Cerianthus cf. membranaceus*	x				
Cnidaria	Anthozoa	*Cladocora caespitosa*	x				
Cnidaria	Anthozoa	*Epizoanthus paxii*	x				
Cnidaria	Anthozoa	*Leptogorgia sarmentosa*	x	13		50.00%	0
Cnidaria	Anthozoa	*Parazoanthus axinellae*	x				
Cnidaria	Anthozoa	*Polycyathus muellerae*	x				
Cnidaria	Anthozoa	*Spinimuricea klavereni*	x	36	72%	0	0
Cnidaria	Hydrozoa	Hydrozoa n.i	x				
Bryozoa	Gymnolaemata	*Reteporella grimaldii*	x				
Bryozoa	Gymnolaemata	*Schizomavella cf. mamillata*	x				
Bryozoa	Bryozoa	Bryozoa n.i.	x				
Anellida	Polychaeta	*Serpula vermicularis*	x				
Chordata	Ascidiacea	*Halocynthia papillosa*	x				
Chordata	Ascidiacea	*Phallusia mamillata*	x				

4.3.4 Debris

In the transect and in the whole area objects of anthopogenic origin were found, whose count was impossible ouside of the transect, as described in the following Table 12.

Table 12. Debris abundance and distribution

Debtype	Abundance m²	N°
Plastic	0.04	4
Other (cars, rubbish container, bus, building waste, etc.)	Very high	Hundreds
General	Very high	Hundreds

The range of waste materials of human origin found on the site is much wider than the other two sites. The high presence of waste materials of human origin is due to the proximity of the coastal road (one of the most favourable places on the whole coast to get rid of bulky and expensive to eliminate artifacts) and to the construction and use of the building located in the corner.

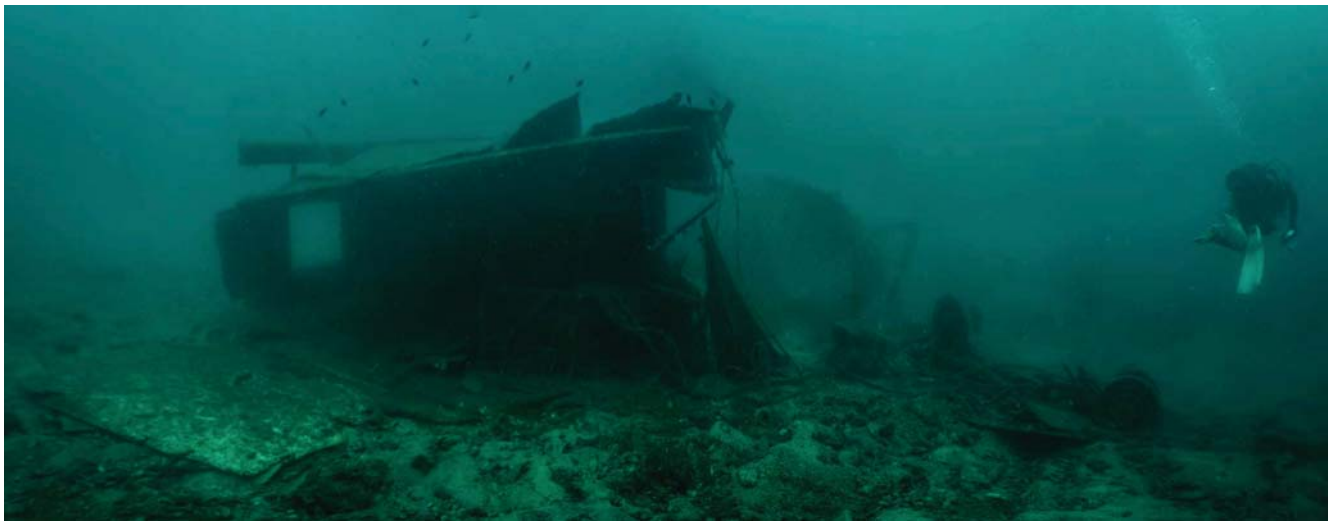


Photo 50. The presence of the diver gives a reference for the dimensions of what probably was a minivan

Photo 51. The chassis of a car, cables, a cage

Photo 52. A car

Photo 53. Another car

Photo 54. Plastic abd glass bottles, a wheel cover, and other debris

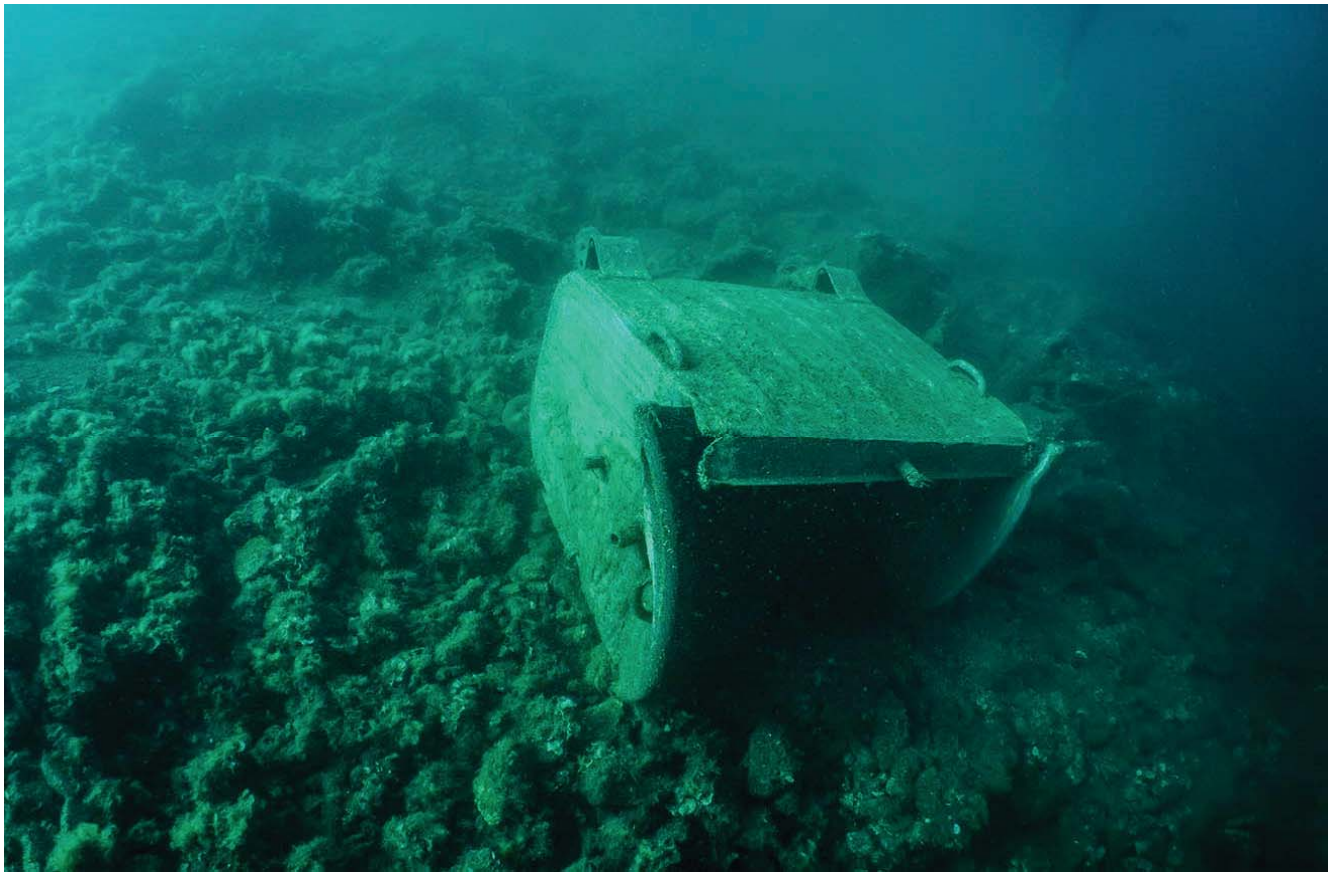


Photo 55. A street garbage container

4.3.5 MAES Index

Applying the collected data to the scheme for the calculation of the MAES index (see page 6), the scores resulting for the site Turski rt are shown in the following Table 13.

The scores relative to density of erect species, average height, % of colonies with epibiosis/necrosis are referred to *Spinimuricea klavereni*. In this case, as for DV01 and SO01, the total score of the index is obviously conditioned by the high presence of waste in the transect area.

Table 13. MAES score for TR01

Site	Nº megabenthic taxa	% biotic cover basal layer	Density erect species	Average height dominant erect species	% colonies epibiosis / necrosis	Litter density	Total score	Ecological status
TR01	40	30	0.72	< 10	0	Very high	13	Moderate
Score	3	1	3	1	3	1		

5 Laboratory Work Results

The aim of the laboratory analyses was to focus on Anthozoa and mainly to:

- verify morphological differences between the colonial Scleractinia *Cladocora caespitosa, Polycyathus muellerae* and *Phyllangia americana mouchezi* to define the origin of bioconstructions spread on monitoring sites and to estimate the percentage contribution of each species to bioconstructions;
- verify a correct taxonomical identification of the pleuxaurid *Spinimuricea klavereni* on the basis of the analyses of the sclerites;
- verify other taxonomical identifications

All collected samples are stored at IBM, Kotor.

5.1 Scleractinia

In the collected samples of colonial Scleractinia the soft tissues were dissolved obtaining cleared corallites to make the characters of the calyx clearly visible. *Cladocora caespitosa* was photographed in situ focusing on bleached corallites, present in living colonies. All obtained high resolution photographs were optimized with the software Photoshop CS6 on MAC OS platform.

The analysis of the photos of the samples and those collected in the field returned three well distinguished morphological categories, actually referable to three different species: *Polycyathus muellerae*, the most numerous, *Phyllangia americana mouchezi*, occasional, and *Cladocora caespitosa*, in small globular formations, but not in large assemblages with the previous two species.

In the following tables the three morphologies are highlighted and assigned to the three species: Table 14 shows living colony in situ and the morphological characteristics of the calices of *Polycyathus muellerae*.

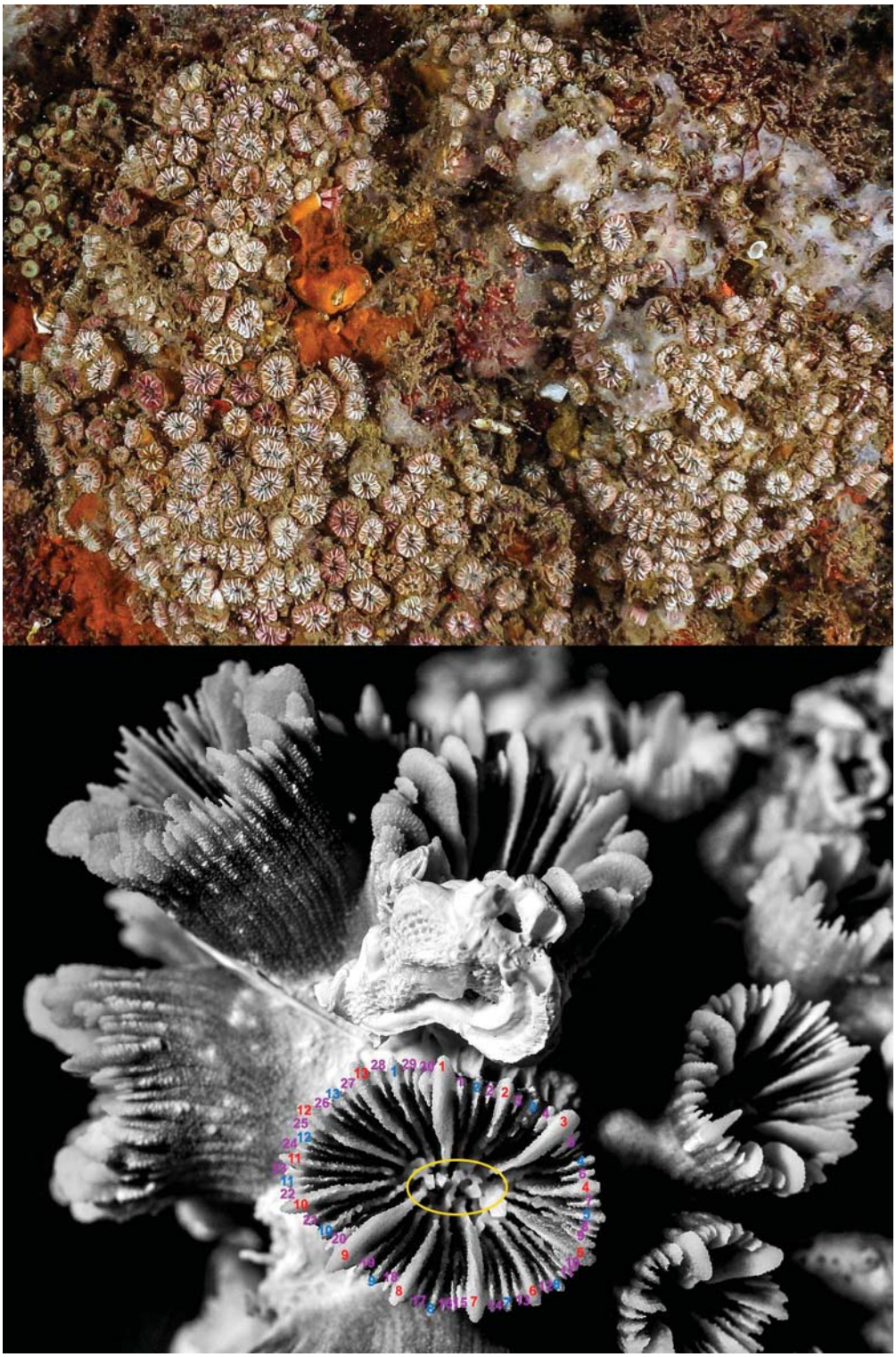
Table 15 shows living colony in situ and the morphological characteristics of the calices of *Phyllangia americana mouchezi*.

Table 16 shows living and bleached colony in situ and the morphological characteristics of the calices of *Cladocora caespitosa*.

Table 14. *Polycyathus muellerae*

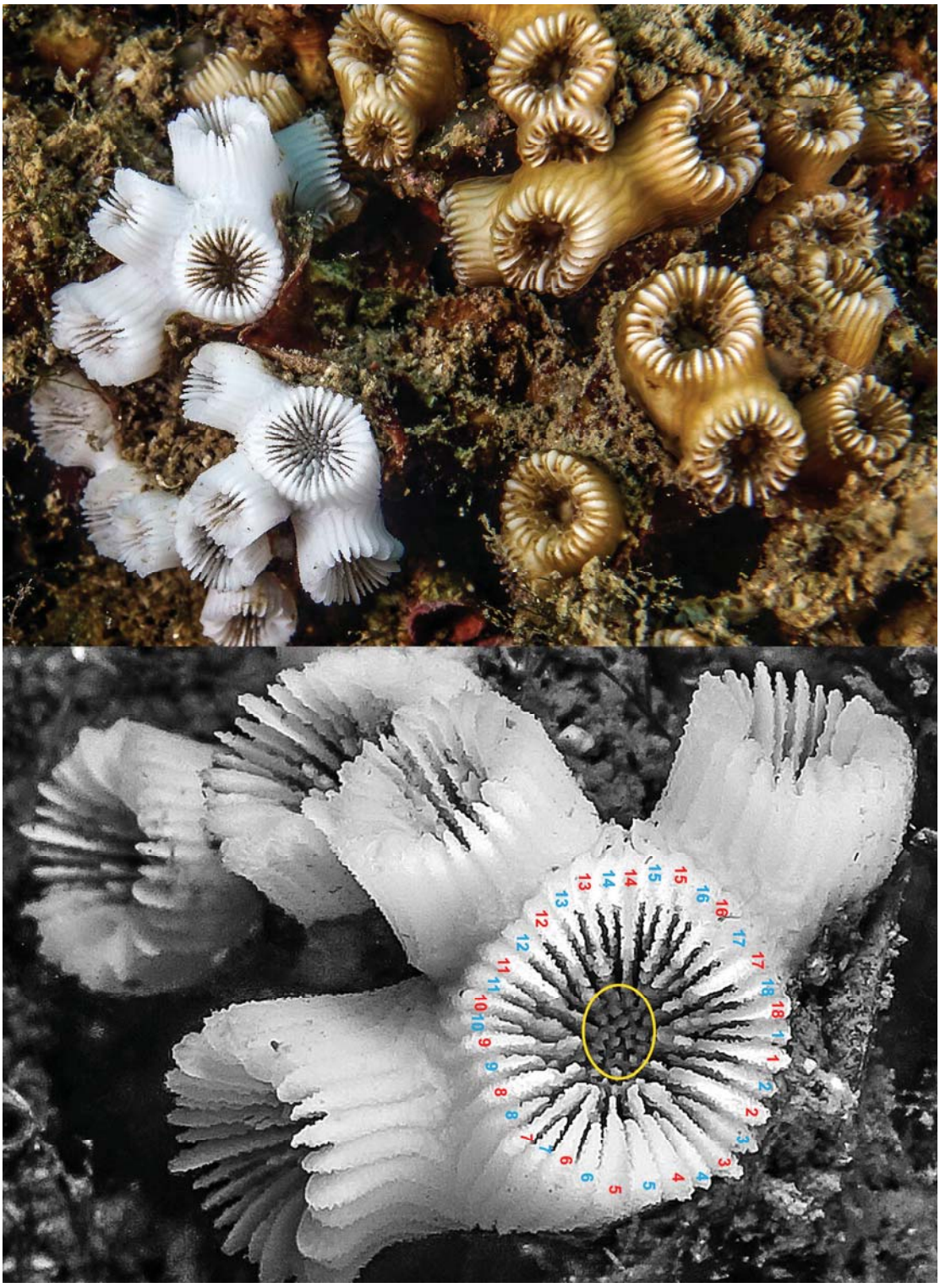
Morphological analysis: 48 septa in 3 orders (12 red, 12 blue and 24 violet), pali present (green P), a fusion of pali forms the columella (yellow ellipse). Average diameter of calices 4.62 mm (n=49).

Table 15. *Phyllangia americana* mouchezi



Morphological analysis: 56 septa in 3/4 orders (13 red, 13 blue and 30 violet), pali absent, tubercular (spongy) columella (yellow ellipse). Average diameter of calices 8.3 mm (n=49).

Table 16. *Cladocora caespitosa*



Morphological analysis: 36 septa in 2 orders (18 red, 18 blue), pali absent, papillate columella (yellow ellipse).

5.2 *Spinimuricea klavereni*

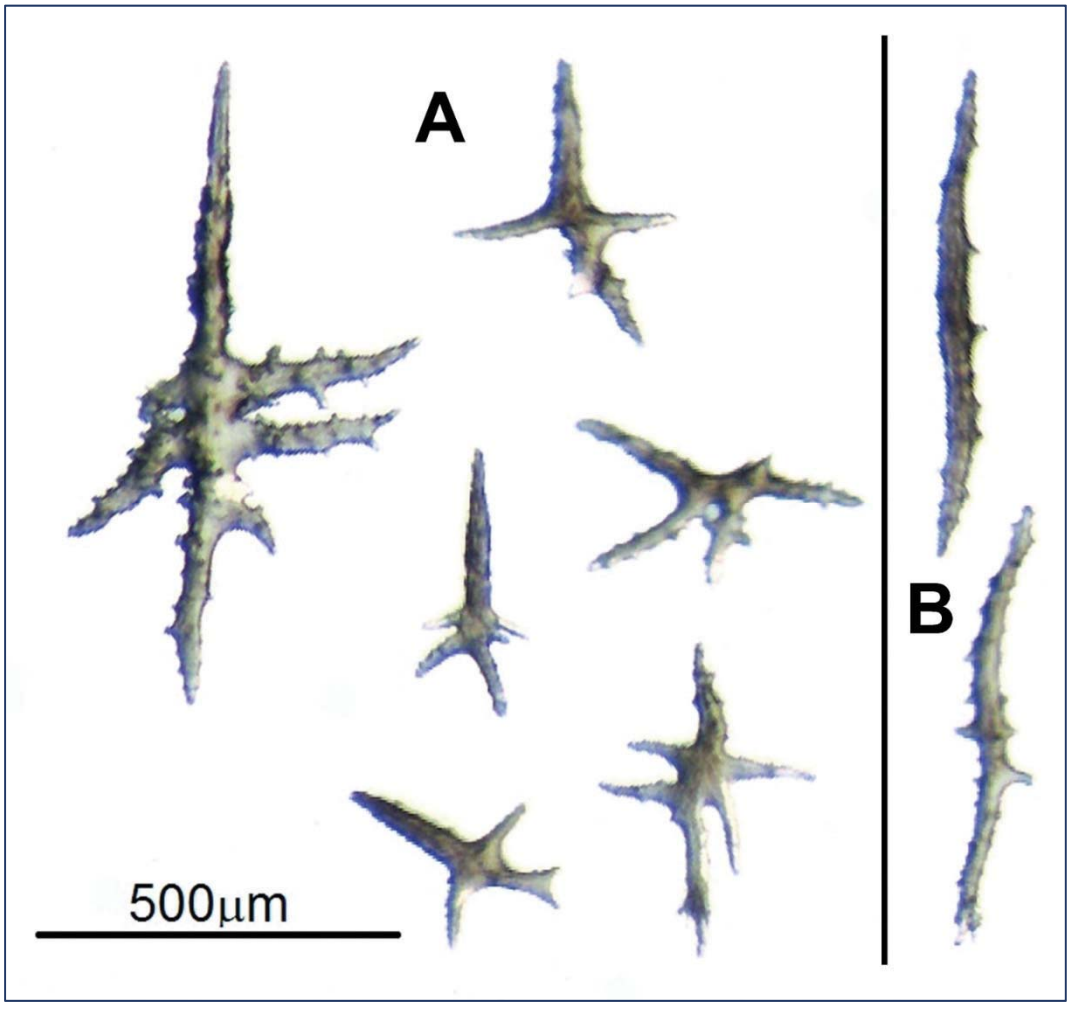
One collected sample of this small plexaurid alcyonacean was treated with 30% hydrogen peroxide to estract the sclerites: the shape of the sclerites is the only morphological character that distinguishes this species from the congeneric *Spinimuricea atlantica*, whose distribution is mainly Atlantic with records from the western Mediterranean.

The photographs obtained under the microscope were compared with the images of the sclerites of *Spinimuricea atlantica* (Ocana *et al.*, 2017) and those of the sclerites of *Spinimuricea klavereni* from other mediterranean sites (Carpine e Grashoff, 1975, Santin & Gori, 2018)

In the following image the sclerites estracted from the collected sample are shown. A indicates thornscales from the calyx and B spindles or needles from the coenenchime.

In the next page, the images of the sclerites from Carpine & Grasshoff, 1975 (where the species is described as *Echinomuricea klavereni*) and from Santin & Gori, 2018 are shown.

The comparison with the images present in the literature corroborates the identification of *Spinimuricea klavereni* as well as on the basis of the external morphology also for the structure of the sclerites. Therefore, this is the first report of the species for the Adriatic sea.



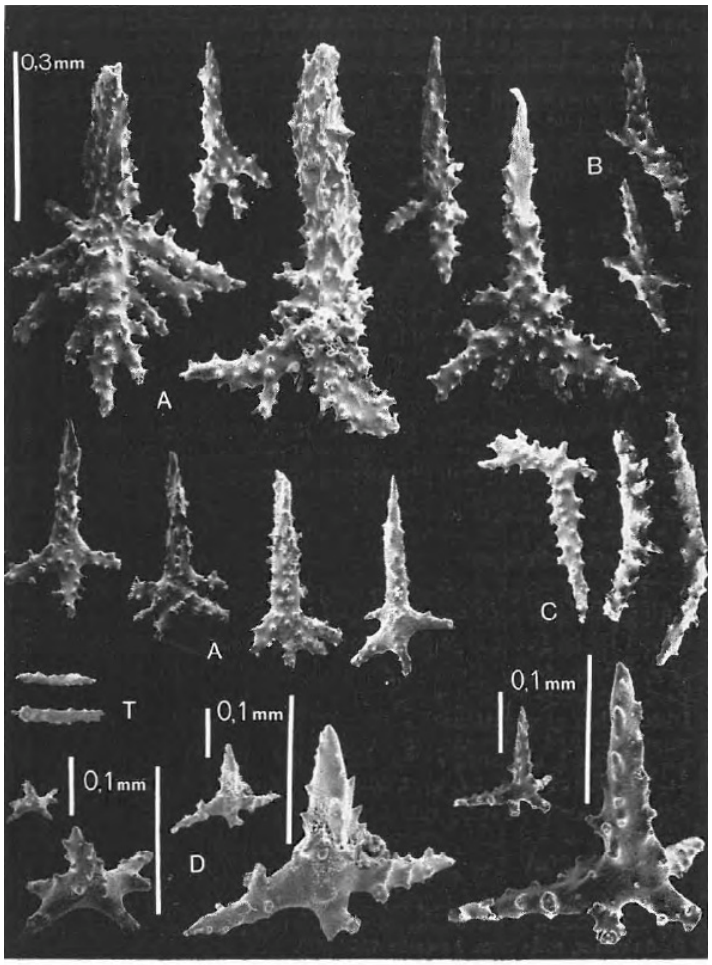
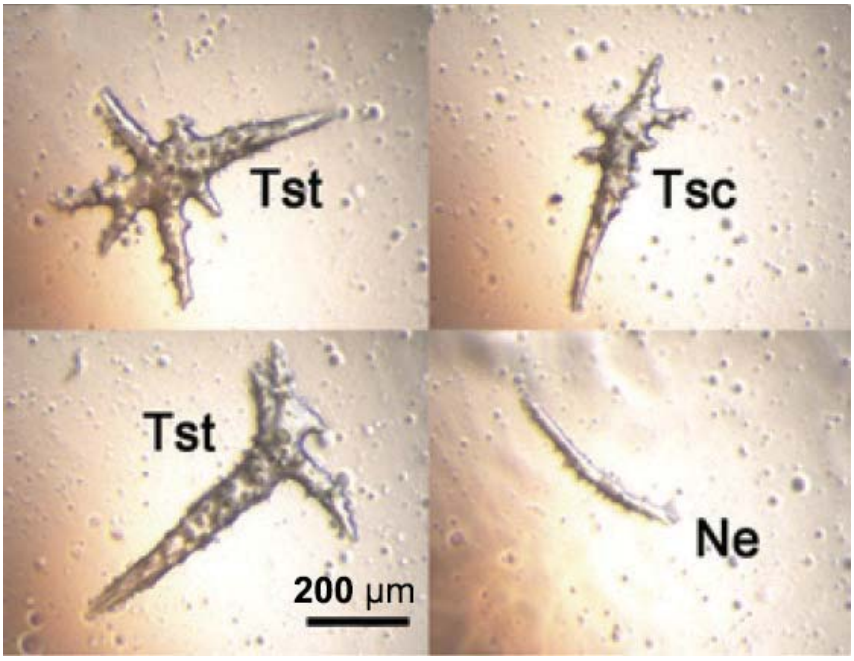
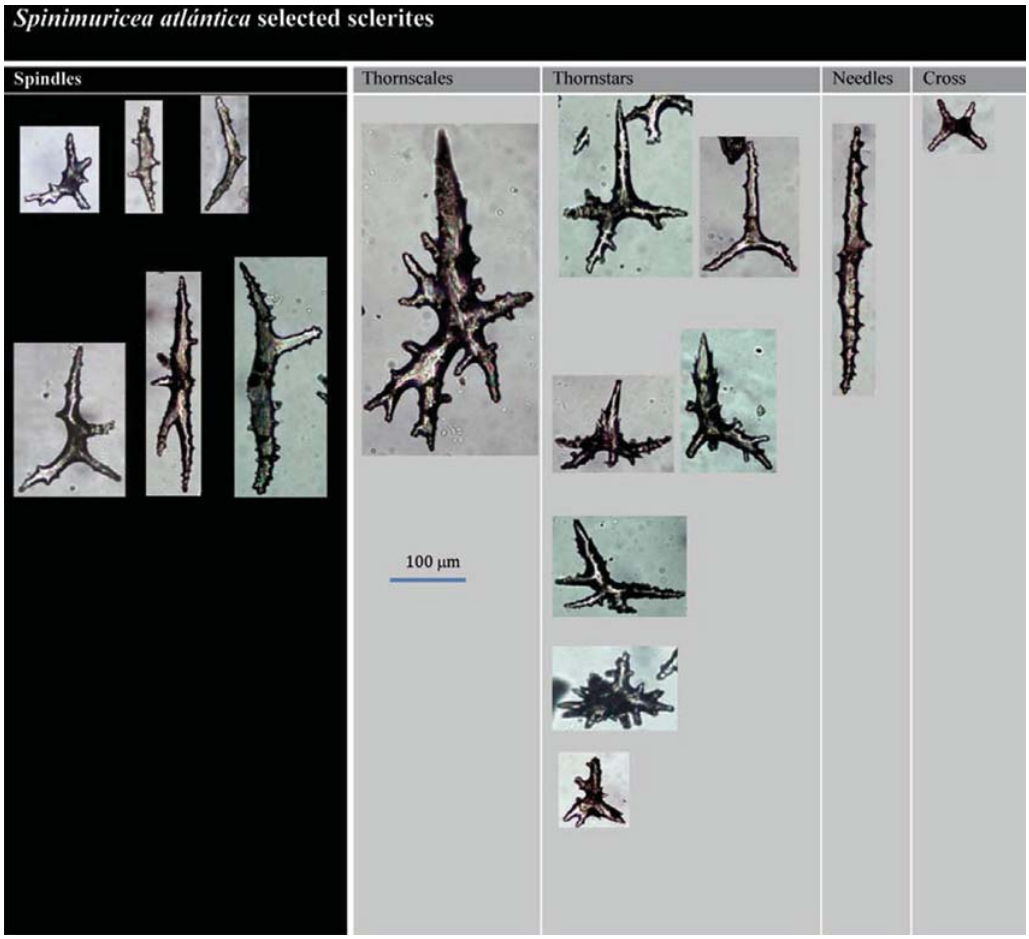


FIG. 14. — ***Echinomuricea klavereni*** : sclérites
A = grandes plaques à aiguillon du calice; *big thornscales from the calyx.*
B = petites plaques à aiguillon du calice, situées entre les grandes; *small thornscales from the calyx, located between the big ones.*
C = fuseaux du cœnenchyme; *spindles from the coenenchym.*
D = étoiles à aiguillon du cœnenchyme; *thornstars from the coenenchym.*
T = bâtonnets des tentacules; *rods from the tentacles.*
(Photo. M. Grasshoff)

Spinimuricea klavereni: above, the sclerites from Carpine & Grasshoff 1975; below, from Santin & Gori, 2018



The morphology of the sclerites of *Spinimuricea atlantica* (Ocana *et al.*, 2017) shows pronounced protuberances an evident distinctive character: they are missing in the images of the sample of *Spinimuricea klavereni* collected to further confirm the correct identification of the species.



Spinimuricea atlantica: scheme of the sclerites from Ocana *et al.*, 2017.

Photo 56. *Spinimuricea klavereni*: close up of the polyps from Turski rt

5.3 *Alcyonium palmatum*

In the transect TR01 a sample af a small alcyonacean was photographed contracted in situ, collected and photographed alive in laboratory and then preserved in ethanol 96%.

High resolution photographs were aimed at the observation of two morphological features that can distinguish *Alcyonium palmatum* from the other mediterranean species, *Alcyonium acaule*: the number of pinnulae on the polyp tentacles and the distribution and number of the crown spiculae.

As shown in the following photographs the pinnulae are 14 and exceed the number of those expected for *Alcyonium acaule*. The crown spiculae are concentrated and are distributed in 22-24 rows as expected for *Alcyonium palmatum*. Therefore the specimen was identified as *Alcyonium palmatum* which is consistent with the ecological conditions of the finding in the muddy area where the transect was held and with the sterile basal part of the stalk.

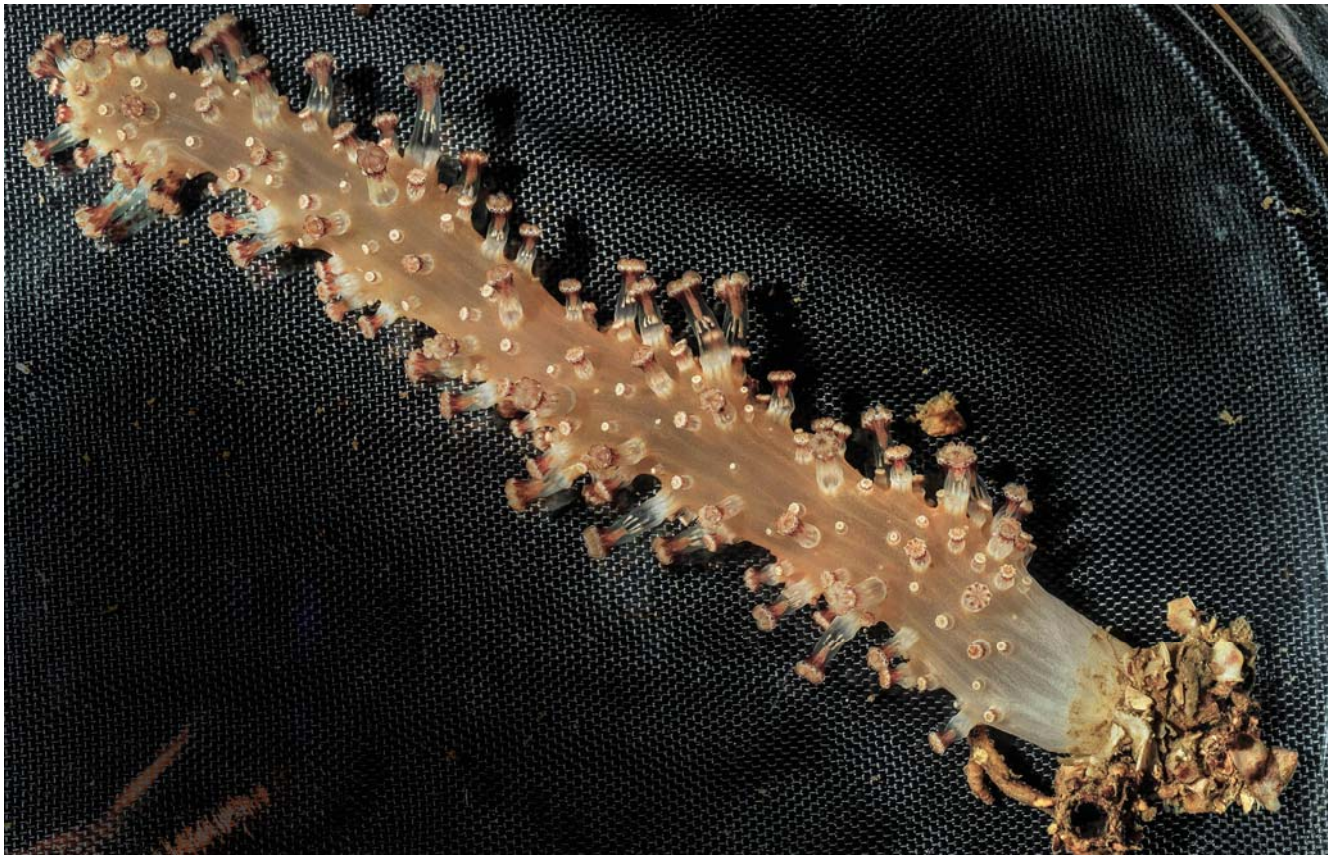


Photo 57. *Alcyonium palmatum*: the collected pecimen with body and polyps expanded

Photo 58. *Alcyonium palmatum*: polyp clearly shows the crown spiculae concentrated in the upper part of the stalk

Photo 59. *Alcyonium* palmatum: the pinnulae along the tentacles are a distinctive feature: in this case they are 14 on each side of the tentacle

6 Training Activities

On-the-job training of local researchers was performend concerning:

- Photography on gauged areas using different laser gauges and different photographic gears;
- Video/photographic transects with laser gauges and different video/photo gears;
- Macro photography of samples with different gears;
- Use of macro photography for the identification of morphological characters suitable for the taxonomic classification of the samples.

Particular attention was paid to identifying the differences between the various devices available for the collection of video images and photos, in relation to the particular conditions of the monitored sites that offer, as previously described, poor visibility (sometimes less than 1 m) and high content of particulate matter in suspension.

Local researchers use Olympus TG5 compact digital cameras in underwater housings (capable of getting both photos and video) and GoPro video camera. The lack of a wide-angle wet add-on for the photo cameras severely limits their use, which on the other hand is sufficiently suitable for the collection of macro images both underwater and in the laboratory. Olympus TG5 has a very useful function (Microscope) suitable for the reproduction of small subjects that can be very useful for recognizing underwater organisms and allowing the collection of images on laboratory samples with wide field depth and richness of details.

Video transects were made with the available equipments. The difference in the results obtained is remarkable, highlighting that a greater sophistication of the recording medium is amplified in the analysis of the results. The least usable results were obtained with Olympus TG 5, those made with GoPro are more useful, those made with the Sony a6000 mirrorless camera (see paragraph 3.2) are far superior. The main difference between the video obtained with Olympus TG5 and with GoPro is in the angle of view, much wider in the last. The main difference between Go Pro and mirrorless camera is on quality of images depending on the dimension of the sensor.

A training video and photo session with the use of laser gauges was conducted in a site outside of the bay, where visibility is much better than inside the bay.

The following images, estracted from video frames, show the result otained with the three devices:

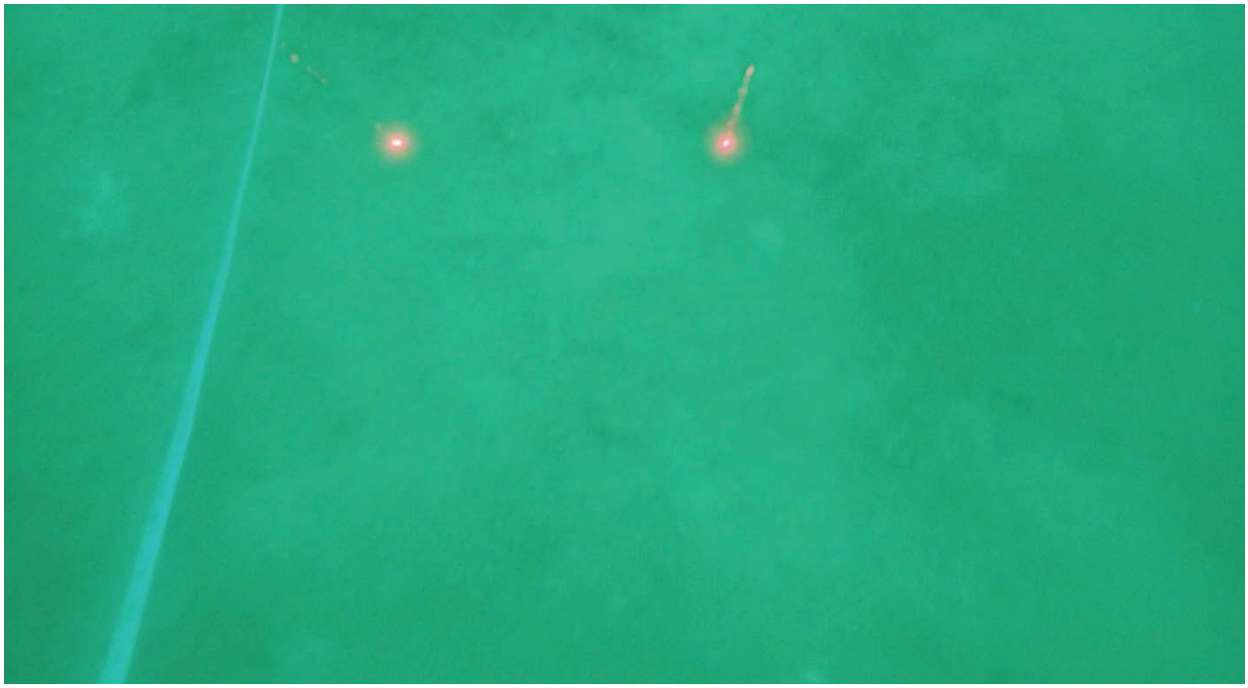


Photo 60. Olympus TG5 + laser gauge 10 cm

Photo 61. GoPro + laser gauge 10 cm

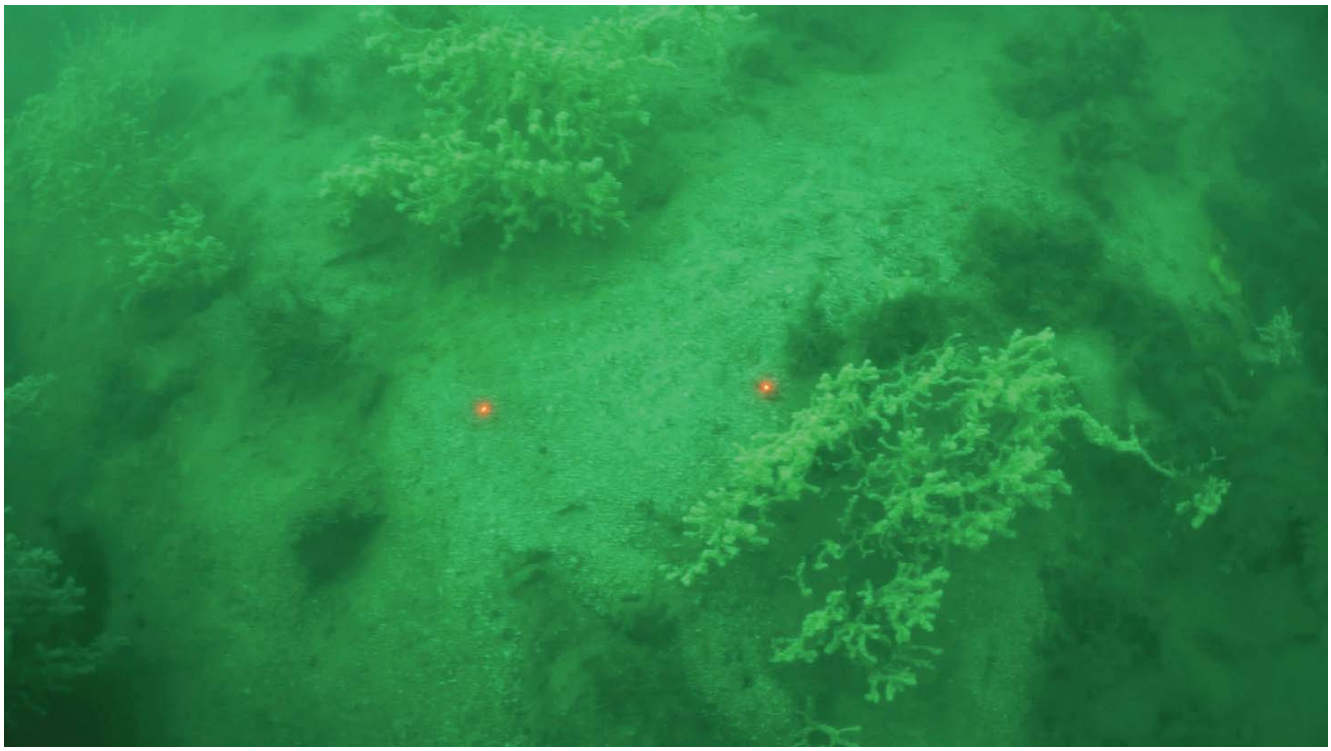


Photo 62. Sony a6000 + laser gauge 20 cm

7 Conclusions

7.1 General considerations

The undertaken activities improved the knowledge concerning the 3 monitored sites both under quantitative and qualitative perspectives, providing key informations for the conservation of key habitats and species and for future monitoring activities.

7.1.1 Biodiversity

On the side of biodiversity, the following Table 17 shows the list of benthic species observed in the 3 sites, as detected from videos and photos:

Table 17. Benthic species observed in the three monitoring sites

Phylum	Class	OTU	DV01	SO01	TR01	Protected
Rhodophyta	Florideophyceae	*Asparagopsis taxiformis*	x			
Chlorophyta	Ulvophyceae	*Codium bursa*	x			
Chlorophyta	Ulvophyceae	*Codium coralloides*	x	x	x	
Rhodophyta	Florideophyceae	*Corallinales encrusting*	x	x	x	
Rhodophyta	Florideophyceae	*Corallinales (maerl)*	x		x	
Rhodophyta	Rhodimeniaceae	*Chrysymenia ventricosa*			x	
Ochrophyta	Sargassaceae	*Cystoseira corniculata*		x	x	ASP 2
Ochrophyta	Phaeophyceae	*Dictyota dichotoma*	x	x	x	
Ochrophyta		*Feltro di alghe brune*	x	x	x	
Chlorophyta	Ulvophyceae	*Flabellia petiolata*	x			
Chlorophyta	Ulvophyceae	*Halimeda tuna*	x	x		
Ochrophyta	Phaeophyceae	*Padina pavonia*	x	x	x	
Rhodophyta	Florideophyceae	*Peyssonnelia spp.*	x	x	x	
Rhodophyta	Florideophyceae	*Peyssonnelia squamaria*	x		x	
Chlorophyta	Ulvophyceae	*Pseudochlorodesmis furcellata*	x	x	x	
Ochrophyta	Sargassaceae	*Sargassum acinarium*			x	ASP 2
Rhodophyta	Florideophyceae	*Tricleocarpa fragilis*	x			
Porifera	Demospongiae	*Acanthella acuta*	x	x		
Porifera	Demospongiae	*Acanthella cannabina*	x	x		ASP 2
Porifera	Demospongiae	*Agelas oroides*	x	x	x	
Porifera	Demospongiae	*Aplysina aerophoba/cavernicola*	x	x	x	ASP 2
Porifera	Demospongiae	*Axinella polypoides*		x		ASP 2
Porifera	Demospongiae	*Cymbaxinella verrucosa*	x	x	x	
Porifera	Demospongiae	*Cymbaxinella damicornis*	x	x		
Porifera	Demospongiae	*Chondrilla nucula*		x	x	
Porifera	Demospongiae	*Chondrosia reniformis*	x	x		
Porifera	Demospongiae	*Cliona rhodensis*	x			
Porifera	Demospongiae	*Dysidea avara*	x	x	x	
Porifera	Demospongiae	*Dysidea fragilis*		x		
Porifera	Demospongiae	*Haliclona fulva*	x	x	x	
Porifera	Demospongiae	*Haliclona mediterranea*		x		
Porifera	Demospongiae	*Haliclona mucosa*				
Porifera	Demospongiae	*Hexadella racovitzai*	x			
Porifera	Demospongiae	*Ircinia oros*		x		
Porifera	Demospongiae	*Ircinia variabilis*	x	x		
Porifera	Demospongiae	*Petrosia ficiformis*	x	x	x	
Porifera	Demospongiae	*Phorbas tenacior*	x	x	x	

Phylum	Class	OTU	DV01	SO01	TR01	Protected
Porifera	Demospongiae	*Pleraplysilla spinifera*	x	x		
Porifera	Demospongiae	*Sarcotragus foetidus*	x		x	ASP 2
Porifera	Demospongiae	*Sarcotragus cf.spinosulus*		x	x	
Porifera	Demospongiae	*Spugne incrostanti*	x	x	x	
Porifera	Demospongiae	*Tethya cf. meloni*		x		ASP 2
Cnidaria	Anthozoa	*Aiptasia mutabilis*			x	
Cnidaria	Anthozoa	*Alicia mirabilis*		x		
Cnidaria	Anthozoa	*Alcyonium coralloides*	x			
Cnidaria	Anthozoa	*Alcyonium palmatum*			x	
Cnidaria	Anthozoa	*Caryophyllia inornata*	x			CITES 2
Cnidaria	Anthozoa	*Caryophyllia smithii*			x	CITES 2
Cnidaria	Anthozoa	*Cerianthus cf. membranaceus*			x	
Cnidaria	Anthozoa	*Cladocora caespitosa*	x	x	x	CITES 2
Cnidaria	Anthozoa	*Epizoanthus paxii*		x	x	
Cnidaria	Anthozoa	*Leptogorgia sarmentosa*	x	x	x	
Cnidaria	Anthozoa	*Madracis pharensis*	x			CITES 2
Cnidaria	Anthozoa	*Parazoanthus axinellae*	x	x	x	
Cnidaria	Anthozoa	*Phyllangia americana mouchezi*	x	x		CITES 2
Cnidaria	Anthozoa	*Polycyathus muellerae*	x	x	x	CITES 2
Cnidaria	Anthozoa	*Sarcodictyon catenatum*	x			
Cnidaria	Anthozoa	*Savalia savaglia*	x	x		ASP 2
Cnidaria	Anthozoa	*Spinimuricea klavereni*			x	
Cnidaria	Hydrozoa	Hydrozoa n.i	x	x	x	
Bryozoa	Stenolaemata	*Frondipora verrucosa*		x		
Bryozoa	Gymnolaemata	*Reteporella grimaldii*	x		x	
Bryozoa	Gymnolaemata	*Schizomavella cf. mamillata*	x	x	x	
Bryozoa	Bryozoa	Bryozoa n.i.	x	x	x	
Anellida	Polychaeta	*Protula tubularia*	x	x		
Anellida	Polychaeta	*Serpula vermicularis*	x	x	x	
Chordata	Ascidiacea	*Clavelina lepadiformis*	x			
Chordata	Ascidiacea	*Halocynthia papillosa*	x	x	x	
Chordata	Ascidiacea	*Microcosmus sabatieri*	x	x		
Chordata	Ascidiacea	*Phallusia mamillata*			x	

ASP 2-3 = Barcelona Convention CITES 2 = CITES Convention

70 benthic OTU have been inventoried representing 46.6% of the benthic species listed in the Golder RAC/SPA report, 2013.

Among the algae there are 2 protected species according to the Barcelona Convention: *Cystoseira corniculata* and *Sargassum acinarium*. Monitoring has confirmed the poor quantitative contribution of encrusting calcareous algae.

Among the invertebrates the phylum with the largest number of species is Porifera with 25 OTU. Five species are protected under the Barcelona Convention: *Acanthella cannabina, Aplysina aerophoba/cavernicola,* ***Axinella polypoides*** (not reported in Golder/RAC/SPA report, 2013, nor in Mačić *et al.*, 2015), *Sarcotragus foetidus* and ***Tethya meloni***. The last one, described as *nova species* in 2015 (Corriero *et al.*) was identified as *Tethya citrina* in *the* Golder/RAC/SPA report, 2013. This is the first report for Boka Kotorska (in montenegrin waters the species is reported for Bar).

Among the Porifera, in this report, an uncertainty has been maintained on the determination of the two species of *Aplysina*, *aerophoba* and *cavernicola*. The two species are indistinguishable on the basis of their internal and external morphology. Normally, they are distinguished based on ecological conditions: *cavernicola* is typical of low light environments and is found in coralligenous asssemblages, whereas *aerophoba* is typical of well illuminated ares in photophilic algae assemblages. The particular conditions documented in the monitoring sites with

low light penetration and with the presence of typically mesophotic species makes the distinction between the two species uncertain. Only the analysis of genetic markers of specimens collected at various depths will clarify whether the two species coexist or only one is present.

The second phylum is **Cnidaria** with 18 OTU, **17 belonging to Anthozoa**. 1 species, *Savalia savaglia*, is protected under the Barcelona Convention. The monitoring shed new light on the importance of the assemblages of this species in Boka Kotorska with respect to the whole mediterranean area and to the global distribution of the species. The number of colonies in the two sites of Drazin Vrt and Sopot is a few units less than a thousand: this means that t**he Montenegrin contingent of the species is not only double compared to all the other colonies known for the Mediterranean, but it is close to the consistency of the species in Atlantic sites** (Giusti *et al.,* 2015).

All the 6 reported Scleractinia are protected under CITES 2 Convention. The monitoring and the laboratory analyses have proven that what was considered to be the contribution of *Cladocora caespitosa* to Boka Kotorska bioconstructions, currently must be charged to *Polycyathus muellerae* and, secondarily, to *Phyllangia americana mouchezi*.

The finding of *Spinimuricea klavereni* is the first report of the species for the Adriatic Sea, in ecological conditions similar to those described for the eastern basin of the Mediterranean.

A new finding for Boka Kotorska is ***Sarcodictyon catenatum***, an atlantic and western mediterranean stolonifer: this is a **new report for the whole Adriatic Sea** (Ocaña *et al.*, 2000).

Though fishes were not a target of the monitoring here reported, the presence of ***Thorogobius macrolepis,*** indicated as probable in Golder/RAC/SPA 2013 report, is now confirmed. Finally, the record of a male and two female individuals of ***Sparisoma cretense*** at Turski rt is a new entry for Boka Kotorska.

The presence of the alien species *Womersleyella setacea (Rhodophyta, Rhodomellaceae)* at Sopot and Drazin Vrt and *Pinctada imbricata radiata* (Mollusca, Pteriidae) at Sopot is confirmed (fide V. Mačić).

Photo 63. *Thorogobius macrolepis*

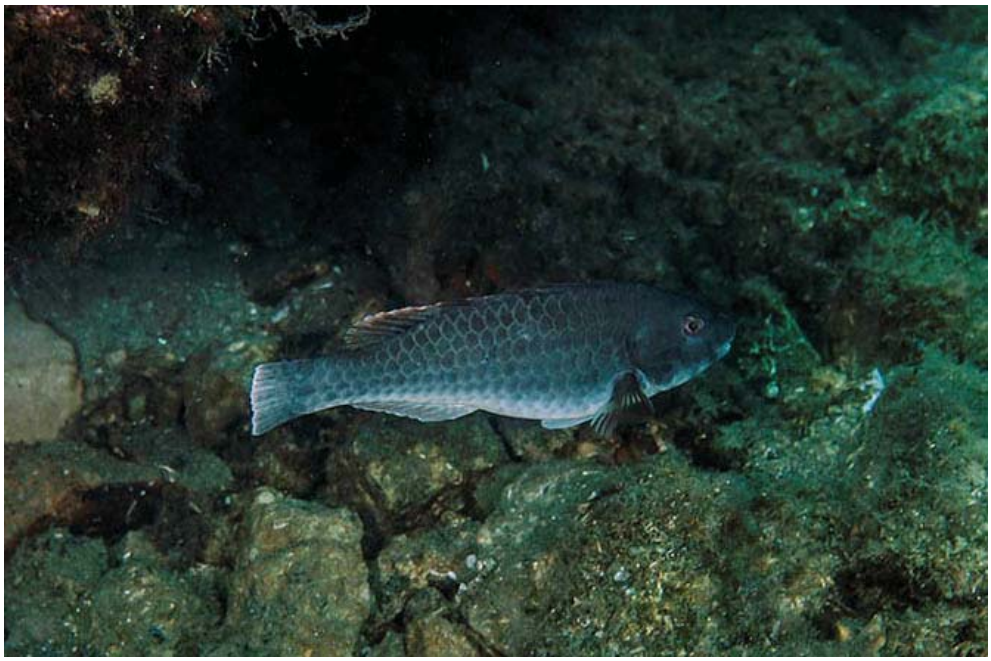


Photo 64. *Sparisoma cretense*, male

7.1.2 Environmental status

Given the particular environmental conditions of Boka Kotorska, the assessment of the environmental status of the monitored sites was assigned to the MAES index for the reasons illustrated in paragraph 3.5. The obtained results indicate a **moderate environmental status** as shown in the **Table 18**:

Given that an index is necessarily a simplification with respect to the complexity of natural environments and the anthropic pressure that invests them, if well calibrated, it can be instrumental to understanding and decision making for suitable measures to achieve the GES (Good Environmental Status).

The striking contradiction between the ecological values (in quantity and quality) found in the monitoring sites and described in this report and the widespread presence of impacts from human activities is well delineated by an analysis of the results of the calculation of the index. In all three sites, it is clear that **what leads from GOOD to MODERATE is the relevance of the litter density, widely documented in the report.**

Table 18. MAES index scores

Site	N° megabenthic taxa	% biotic cover basal layer	Density erect species	Average height dominant erect species	% colonies epibiosis / necrosis	Litter density	Total score	Ecological status
DV01	50	50	0.63	54	0	0.18	14	Moderate
Score	3	2	3	2	3	1		
SO01	45	50	0.60	45	2	0.14	14	Moderate
Score	3	2	3	2	3	1		
TR01	40	30	0.72	< 10	0	Very high	13	Moderate
Score	3	1	3	1	3	1		

7.2 Future insights

Although limited in time, the monitoring here reported provides one step forward in the knowledge of the benthic communities in Boka Kotorska, and at the same time offers indications on which direction future research activities may develop, on what measures can be implemented to reduce the impact of human activities on the sites analyzed and start active conservation management.

7.2.1 Research

In this report, a new hypothesis takes shape:

- the bioconcections spread in Boka Kotorska, previously attributed to *Cladocora caespitosa* and generically indicated as a coralligenous habitat, are instead formed by the joint action of *Polycyathus muellerae* (about 80%) and *Phyllangia americana mouchezi* (about 20%);
- they are not coralligenous sensu stricto;
- the formations of *Cladocora caespitosa* are limited to shallow areas and are of small dimensions (Mačić et al, 2018).

The collection of samples at the monitoring sites confirmed this hypothesis, but further investigations are needed to verify the nature of the large collapsed blocks, devoid of living Scleractinia and with sclerites longer than 30 cm. In support of the formulated hypothesis, the existence of colonies of *Polycyathus muellerae* exceeding 30 cm in height is reported in the literature, while for *Cladocora caespitosa* the largest colonies are indicated with corallites no longer than 10 cm (Zibrowius, 1980). The possibility of dating these remains would lead to further clarification on the dynamics of habitat development.

The identification of some species, new for the bay and in some cases new for the whole Adriatic, took place not on the basis of collected and examined samples, but only on photographic basis. Although the margin of doubt is limited, the collection of samples is desirable in order to confirm the data. They are the sponge *Tethya meloni*, reported also outside the three examined sites in Boka Kotorska, and the stolonifer *Sarcodictyon catenatum* (Photo 11).

Monitoring has allowed a step forward in the knowledge of the sites, the consistency and the quality of the populations. The high dynamism of the natural conditions and the obvious impacts from human activities advise to consider the objective of carrying out a **detailed mapping of the sites** in order to be able to understand their future evolution and any new forms of impact. This measure is essential for undertaking and managing future conservation actions.

Photo 65. A collapsed coral block where long sclerites are visible (length of the block 33-35 cm, laser gauge 22 cm)

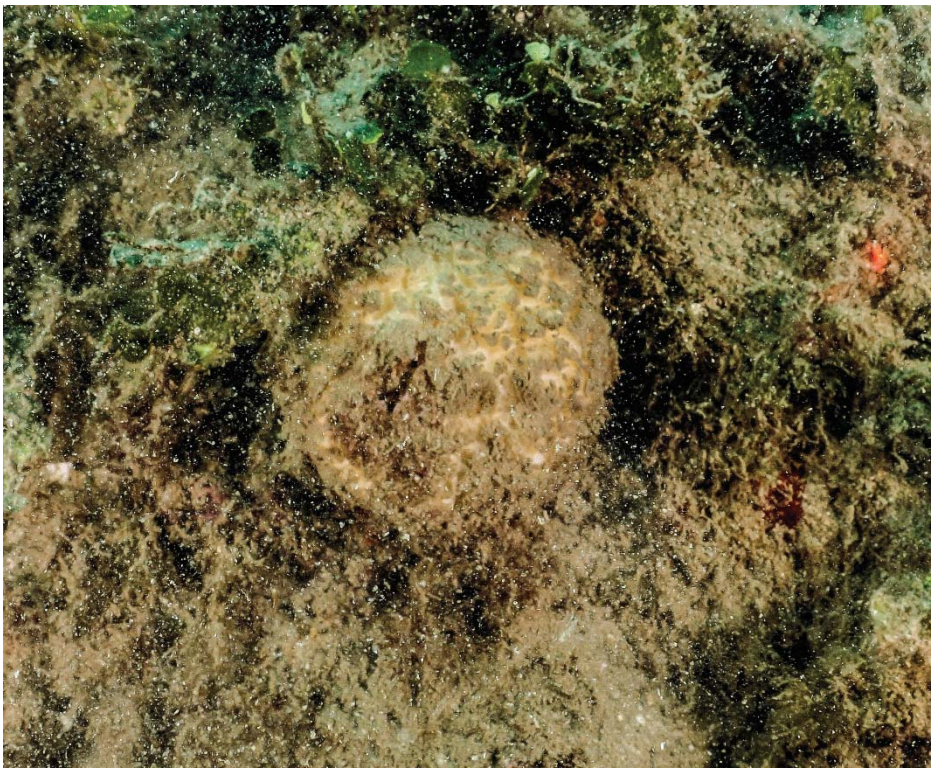


Photo 66. *Tethya cf. meloni* at Sopot (⦰ 7.5 cm)

7.2.2 Impact reduction

The high percentage of litter per m^2 documented here is such that it represents a direct and immediate threat, particularly for the *Savalia Savaglia* facies. Litter amplifies the transport action of the sediments which, although of natural origin, acts as a limiting factor for the colonies of the zoanthid.

The **removal of all waste** from the areas subject to monitoring is an action to be taken into consideration in order to eliminate their influence on natural processes. The colony of *Savalia savaglia* demonstrate a high degree of resilience and the colonization by the zoanthid of some litters has been observed. Therefore the removal should take place with the examination of each individual waste leaving in situ those incorporated by concretions of marine organisms.

The opportunity to remove the large wrecks documented at the Turski rt site should be considered a remote option, both because of the high cost it would have, requiring large lifting equipments, and because the wrecks insist in an area with low biotic coverage.

The removal of litter at the sites Drazin Vrt and Sopot could change the MAES index of the sites from Moderate to Good.

The removal of underwater and coastal litter could be the occasion of **events**, guided and controlled by IBM researchers, that could involve the local population with the aim of raising awareness of the problem and preventing the repetition of deliberate actions of pollution of the marine environment.

7.2.3 Conservation actions

The areas where the monitoring took place are small, and marginal for ship traffic. The biocenoses they host are of global value, both for the rarity of the most representative species, and for their high concentration.

Defining a **no-take, no-entry conservation status** for these areas, in total less than 2.5 ha (0.3% of the total area of Boka Kotorska), would make it possible to eliminate the impact deriving from possible anchoring and fishing gears, thus eliminating main risk factors from human impact.

In order to maintain an indirect control condition, **underwater guided tours** could be promoted by authorized facilities that have undergone special training on the conservation of the site.

Any conservation action should be preceded by a **dissemination action** on the quality of submerged sites and their global value and on the treats from human impact.

The high value of Boka Kotorska lies not only in its history and tradition and its very particular marine and terrestrial landscapes, but also in the richness and rarity of its depths.

7.2.4 Anthozoa

Data collected on Anthozoa, in the monitoring activities here described, open new perspectives on their knowledge and distribution in Boka Kotorska. The discovery of new species for the area and some clarifications on the actual consistency of the presence of species considered constituents of the hard bottoms will be an important contribution to the elaboration of an argumented and updated check list of the Antozoans of Montenegro in the framework of GEF Project.

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Implementation of the ecosystem approach in the Adriatic through marine spatial planning

The GEF-funded project “Implementation of the Ecosystem Approach in the Adriatic Sea through Marine Spatial Planning” (GEF Adriatic) is carried out across the Adriatic-Ionian region with focus on two countries: Albania and Montenegro.

The main objective of the project is to restore the ecological balance of the Adriatic Sea through the use of the ecosystem approach and marine spatial planning. Also, the project aims at accelerating the enforcement of the Integrated Coastal Zone Management Protocol and facilitating the implementation of the Integrated Monitoring and Assessment Program. Eventually, it will contribute to the achievement of the good environmental status of the entire Adriatic. The project is jointly lead by UNEP/MAP, PAP/RAC and SPA/RAC. In Montenegro, the project is being implemented with the coordination of the Ministry of Sustainable Development and Tourism. The project duration is from 2018 to 2021.

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