Priority marine habitats and benthic species around the coast of Salina Island (Southern Tyrrhenian Sea, Italy)

Report
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1. INTRODUCTION

The Aeolian Archipelago is located in the Southern Tyrrhenian Sea and is composed by seven inhabited islands (Lipari, Vulcano, Salina, Panarea, Stromboli, Filicudi, Alicudi) occupying a total area of 115.2 km^2 (Calvo et al. 2005a, fig. 1). The islands arise from the seabed along a submarine arc that stretches from the border of a wide Tyrrhenian depression at 1000-2000 metres depth. Since their volcanic origin, the Aeolian Islands shores are very steep and high rocky cliffs cover a wide part of the coastal promontories (G. Bernardi, 2018 PhD thesis, not published).

Local water circulation of the Aeolians are characterized by a strong water masses coming from the Strait of Messina, as this tiny channel is well known for its local strong currents caused by the encountering between the low and the high Tyrrhenian-Ionian Seas. This phenomenon is responsible to the great amount of water exchanges in the archipelago, which confers unique conditions in their chemistry and oceanography (Faranda & Povero 1996; Italiano & Nuccio 1991), with consequent marked gradients during the four seasons and direct effects on phytoplankton communities (Calvo et al. 2005b).

Fig. 1: A general map showing Aeolian island located up to the Northern side of Sicily, with a yellow mark in Salina island. Font: Google Earth, 38°34’55’’N 14°47’25’’ E.

Salina Island covers 26.8 km^2 and it is the second greatest island after Lipari (fig. 2). On 1984 the two green mountains have been recognized as a natural terrestrial reserve, called "Le Montagne delle Felci e dei Porri" (Italian Law Decree, March 14th, 1984) and as a Natura 2000 site (SIC code. ITA 030028), together with "Sea bottoms of Salina" (SIC code. ITA030041) and "the Lake of Lingua" (SIC / SPA cod. ITA030029). Finally, in 2000 UNESCO declared the Aeolian Islands as a Natural Heritage site.

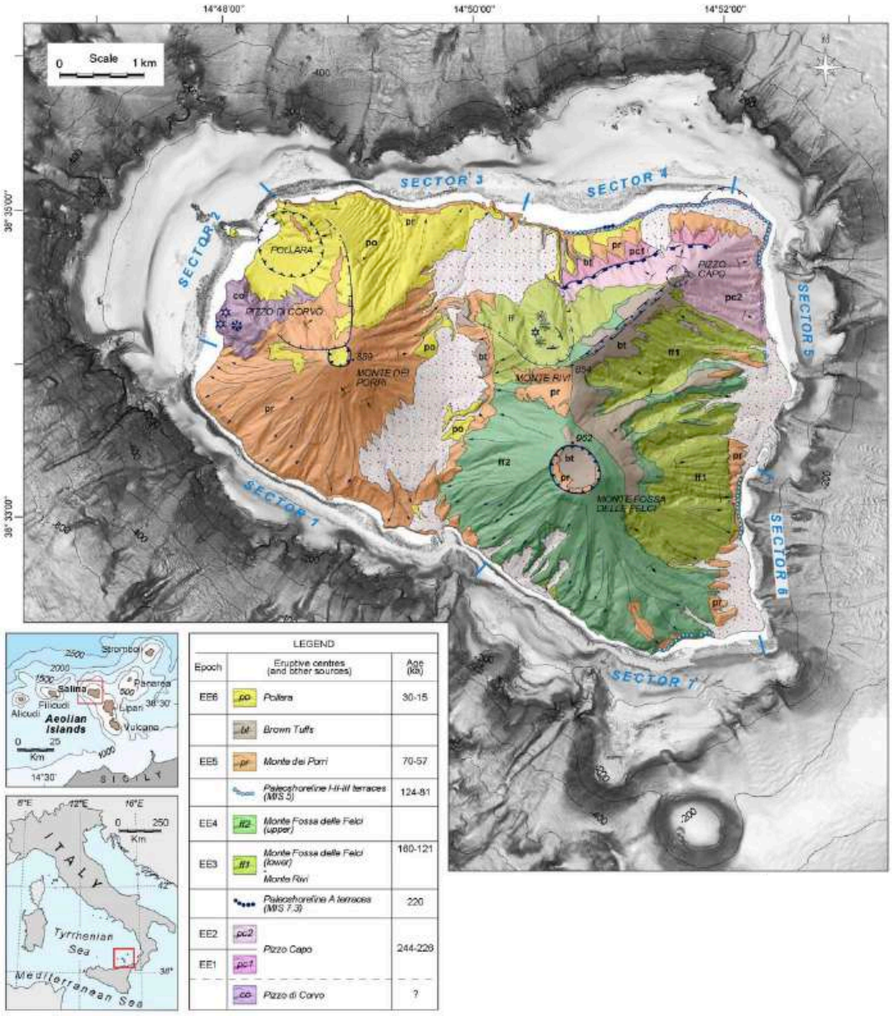


Fig. 2: A map of Salina island represented by a simplified geomorphological feature showing its morpho-structural feature (Source: Romagnoli et al., 2018).

Besides the dominance of natural environments in almost all the islands, the archipelago is inevitably affected by human-induced activities, which can be primarily identified in: 1) local fishing pressure either from artisanal or recreational fishing activities (Bernardi G. 2018, PhD thesis not published), massive tourism during the summer season (pers. Obs.) and marine litter (Fastelli et al. 2017).

To build up an updated baseline regarding marine biodiversity in Salina Island, underwater visual surveys have been conducted focusing the attention to benthic species of peculiar conservation interest. On this regard, the Bern Convention and the Habitats Directive (92/43/EEC) are the current EU Directives called for species protection in European environmental action, giving guidelines to member states towards successful management policies also in the Mediterranean Sea. In particular, the Habitat Directive has implemented the Bern Convention in the EU marine framework, by applying to the preservation of 'natural habitat types of Community interest', which: i) are in danger of disappearing in their natural realms; or ii) have a small natural distribution range; or iii) present outstanding examples of typical characteristics of biogeographical regions.

1.1. Coastal Monitoring

An effective monitoring program can be developed when a detailed and long-term scientific baseline is available. At the best of our knowledge, detailed information is lacking of current status (presence, abundance and distribution dynamics) of peculiar species in Salina. To this end, the present report describes a first quick assessment of marine protected habitats and species present around the coasts of Salina Island.

Surveys have been performed in the main dive spots, providing the first baseline information for a deeper understanding and effective preservation plans needed in the area. The methodology adopted here was designed to be easily repeatable in future assessments, even with the help of trained volunteers.

a) Reef Check Mediterranean

Reef Check Italia Onlus is partner of the worldwide coral reef monitoring program, known as Reef Check Foundation, recognized by United Nations. In Italy, it has been founded in 2008 with the goal of being dedicated to "*the study, protection and recovery of the Mediterranean seabeds and coral reefs*", executed by volunteers (Reef check Med, 2019). The program is based on a specific methodology that allows volunteers recently trained to be part of underwater monitoring and increase the number of scientific data uploaded on the open GIS webpage (https://www.reefcheckmed.org/italiano/reef-check-med/webgis/)

b) A case of study of Centrostephanus longispinus (Philippi, 1845), a protected sea urchin species

The sea urchin *Centrostephanus longispinus* (Philippi, 1845, Echinodermata: Echinoidea), is a protected species inserted in the Annex IV of the Habitat Directive (HD code 1008) and in the Barcelona Convention. The species has a nocturnal behaviour, as it uses to hide itself in ravines during the day and to come out for foraging during the night (Cerrano et al., 2014). This is why its monitoring is difficult and it may probably be more abundant than expected. In the present study, we assessed its distribution and abundance in the main diving hotpots around Salina island.

1.2. Objectives of the study

Main objectives of this study are:

a) to record the presence and abundance of protected/vulnerable/invasive species, following the *visual census* protocol of Reef Check Mediterranean Sea, considering the habitats related;

b) to assess the distribution and to estimate the abundance of the sea urchin *Centrostephanus longispinus* by depth transects.

2. METHODOLOGY

2.1. Sampling stations

A total of five dive sites were selected, named Faraglione di Pollara, Le Tre Pietre, Secca del Capo II and II, Scoglio Cacato and Grotta dei Gamberi (table 1).

Table 1. Scuba diving spots, its geographic coordinates (Datum WGS84), date, maximum depth and dive time.

Site	Latitude	Longitude	Data	Depth max (m)	Dive time (min)
Faraglione di Pollara	38,57897° N	14,799008° E	18-22/9/19	40	60
Grotta dei Gamberi	38°37,275' N	14°49,823' E	20/9/19	40	60
Le Tre Pietre	38,53599° N	14,84951° E	18-22/9/19	40	60
Scoglio Cacato	38°35,025' N	14°54,596' E	20/9/19	40	60
Secca del Capo I and II	38°37,275' N	14°54,596' E	19-21/9/19	40	60

All sites were chosen based on their habitat characteristics, summarised in Table 2. Habitats censused were *P. oceanica* on Rocks, Coastal Rock, Offshore Rock and Rocky Cliff, following the description in the Manual of Reef Check Mediterranean – Italy.

Table 2. Priority Habitat (left column); habitat description by Reef check Mediterranean Guide (central column); related site where the habitat has been observed (right column).

Habitat	**Description - Reef check Mediterranean Guide**	**Site**
Posidonia on rocks	"discontinuous meadows of *Posidonia oceanica* on rocky bottom mixed with gravels and sand"	Le Tre Pietre, Scoglio Cacato
Offshore Rock	"off shore discontinuous rocky bottoms"	Secca del Capo
Coastal rocks	"discontinuous rocky bottoms close to the coast"	Faraglione di Pollara
Rocky cliff	"vertical or sub-vertical continuous rocky bottom"	Grotta dei Gamberi

2.2. Underwater visual census and sampling methods

The Underwater visual census (UVC) methodology has been used for species recording (presence/absence and abundance, Table 3) and for habitats description, following Reef check Mediterranean book reference.

The UVC is today considered one of the most suitable, effective and standardized methods for gathering information *in situ* with limited environmental impacts on marine ecosystems, such as monitoring inside MPAs censusing of particular species (e.g. species with IUCN protection status, Tessier et al. 2013), studying marine areas with sensitive biotopes (Bohnsack & Bannerot 1986; Harmelin-Vivien et al., 1985) and collecting preliminary data in those marine areas oriented to become protected (Claudet et al. 2006; Harmelin-Vivien et al, 1995). Even though the UVC sampling has some limitations, (i.e. accuracy of cryptic fish species (Francour, 1997), this recording system has also many advantages, as it is repeatable and low-cost effective for obtaining a relatively quick evaluation on coastal assemblages (Thompson & Mapstone 1997; Watson et al., 1995).

The tools used for underwater activities included:

- A Reef Check ID underwater slate with a pencil
- A plastic ruler of 15 cm
- A wet note
- An underwater camera with flash
- A mesh bag for underwater tools transport

The diving team was composed by four people trained for guidelines of the underwater Reef check monitoring protocol, by adopting the ID Reef Check Italy as a baseline for species identification and abundance estimation records (fig. 3), together with site name, geographic coordinates, date, time, minimum and maximum depth, visibility and the predominant habitat. In each dive site two dives were conducted, with a total of 10 hours of observation during the five days of field work. Following the Reef check Mediterranean book guide, it has also been described marine habitats that include habitat-forming species (i.e. gorgonians), or potential indicators of thermal anomalies (i.e. cold or warm affinity species) that could disappear or spread and become invasive, as well as fragile species depleted by human impact (i.e. *Pinna nobilis*). To this end, a list of the main benthic groups (table 4) observed and estimation of abundance (occasional, frequent, abundant) between 4 and 40 metres have been reported. Each site showed a specific assemblage, according to the type of the habitat and depth fully described in the Results. Finally, underwater photos of some specimens of *C. longispinus* have been taken for qualitative surveys, with the help of a ruler close to their bodies as a dimension scale of single individuals.

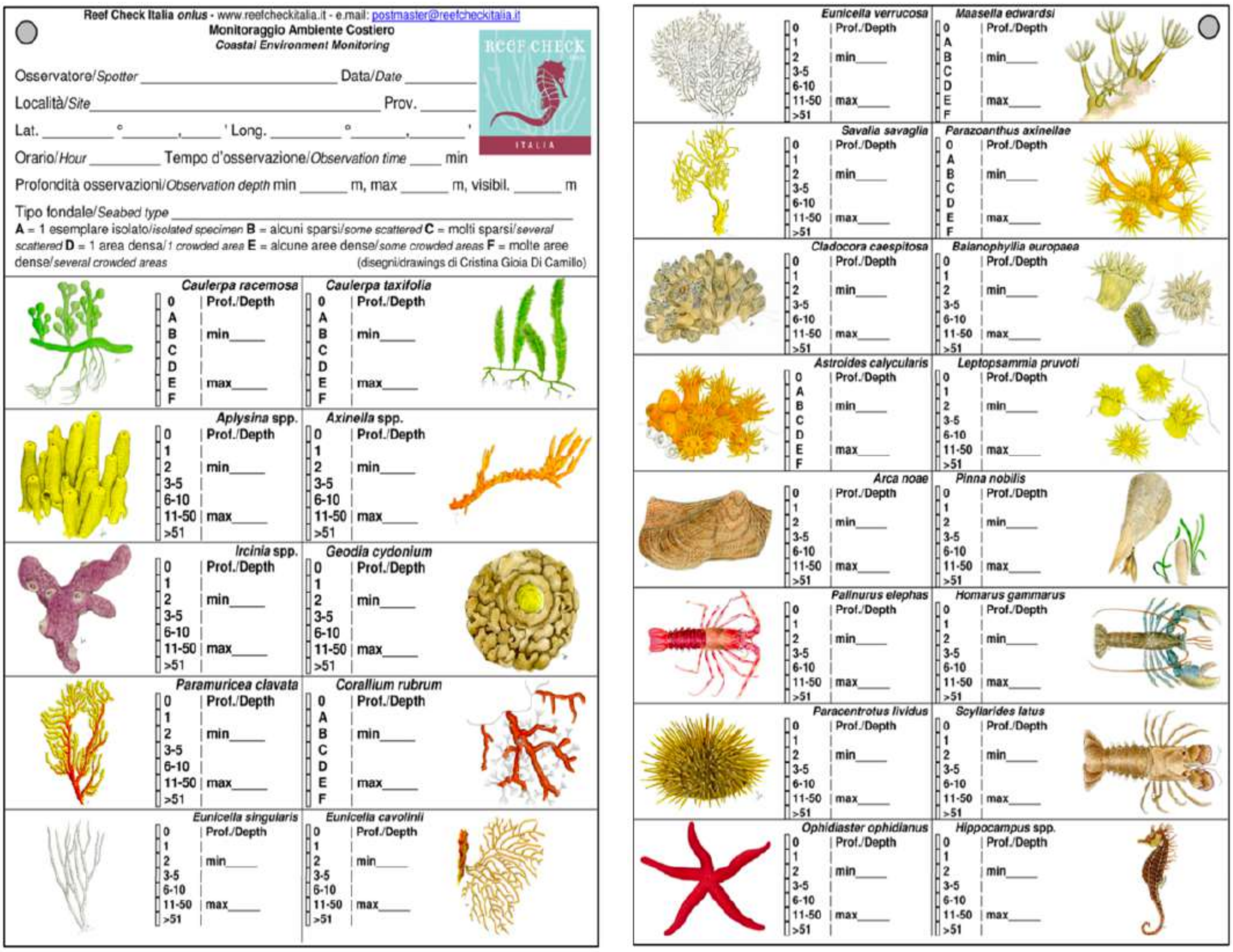


Fig. 3: ID underwater slate of Reef check Mediterranean - Italy *Onlus*.

Table 3. List of Reef check species for the Mediterranean sea - Italy *Onlus*.

Source: www.reefcheckmed.org/english/underwater-monitoring-protocol/wanted-species/

Algae	**Echinodermata - sea urchin**
Caulerpa cylindracea (= *C. racemosa*)	*Paracentrotus lividus*
Caulerpa taxifolia	*Centrostephanus longispinus*
Sponges	**Molluscs**
Ircinia spp.	*Pinna nobilis*
Axinella spp.	*Arca noae*
Aplysina spp.	*Chlamys* spp.
Geodia cydonium	*Pecten jacobaeus*
Tethya spp.	*Patella ferruginea*
Corals	*Rapana venosa*
Corallium rubrum	**Crustaceans**
Eunicella singularis	*Palinurus elephas*
Eunicella cavolinii	*Homarus gammarus*
Eunicella verrucosa	*Scyllarides latus*
Paramuricea clavata	**Ascidiacea**
Maasella edwardsi	*Microcosmus* spp.
Cornularia cornucopiae	*Aplidium conicum*
Epizoanthus arenaceus	*Aplidium tabarquensis*
Parazoanthus axinellae	*Polycitor adriaticus*
Savalia savaglia	**Fishes**
Cladocora caespitosa	*Sciaena umbra*
Astroides calicularis	*Diplodus spp.*
Balanophyllia europaea	*Conger conger*
Leptopsammia pruvoti	*Chromis chromis*
Echinodermata - sea star	*Trisopterus minutus*
Ophidiaster ophidianus	*Hippocampus* spp.

A different method has been adopted for *C. longispinus* observation. Horizontal transect 10 m long were performed for each diver interposed by 5 meters without observation, in every 5 meters depth, starting from 35 metres up to 15 meters.

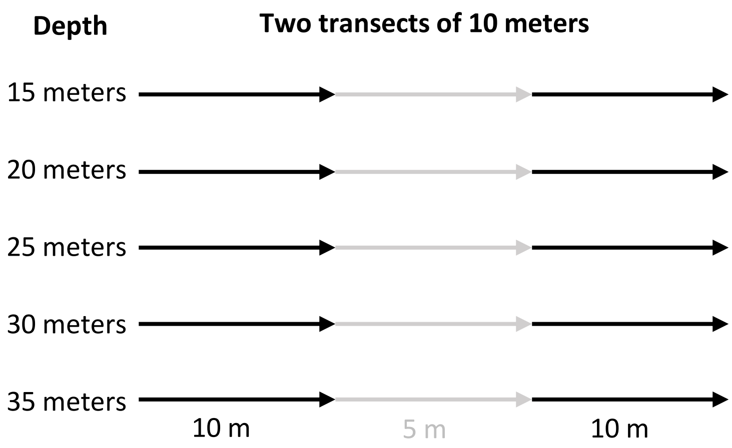


Fig. 4: Scheme of the dive method for *Centrostephanus longispinus*.

For these records, two transects per depth were applied. All specimens inside the transects were counted and measured at 35, 30, 25, 20 and 15 metres (fig. 4).

To take such measurements, sea urchins were photographed, when possible, with a ruler placed close to the subject, in order to set the reference scale with the software ImageJ. For each sea urchin, the smallest diameter (length of exoskeleton) and the largest diameter (diameter of the circumference formed by the spines) were measured, both laterally (fig. 5a) and frontally (fig. 5b). When sea urchins were inside holes and their outlines were not clearly visible, a photo editing software was used to lighten the photo.

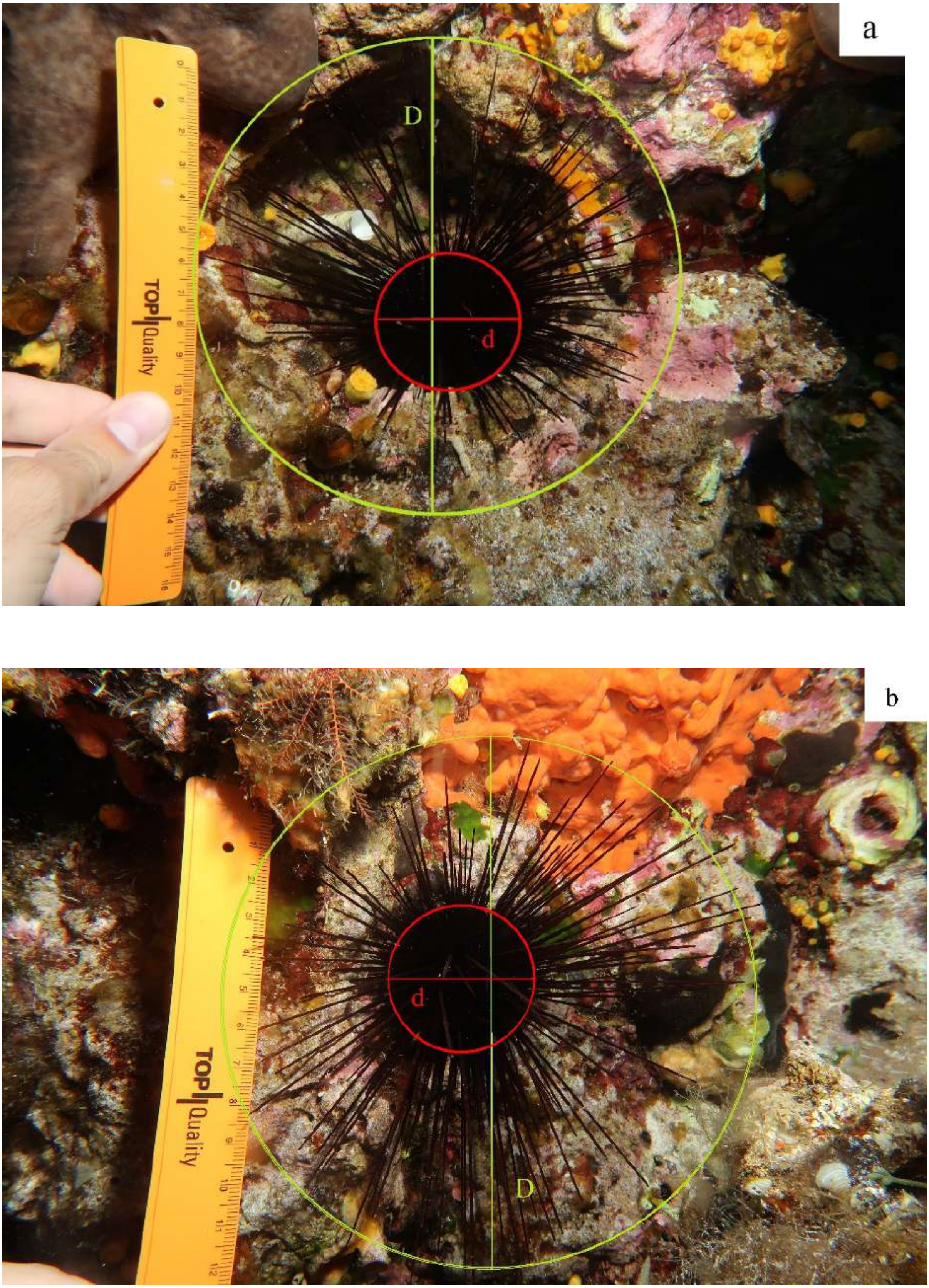


Fig. 5: Illustration of largest diameter (green line) and smallest diameter (red line) of *C. longispinus*. Lateral position (a), frontal position (b).

3. RESULTS

Table 4. List of marine organisms identified in the field work in Salina Island in September 2019.

Marine organisms
Cystoseira spp.
Coralline algae
Seagrasses
Encrusting sponges
Massive sponges
Erect sponges
Hexacorals
Octocorals
Prosobranchs' Gastropods
Opisthobranches' Gastropods
Decapods
Tube worms
Starfishes
Sea Urchins
Bryozoan
Colonial ascidians
Solitary ascidians

3.1. Station 1: Le Tre Pietre

This dive spot is located in the South side of the island coast (fig. 6).

Fig. 6: Station 1. The red flag shows the dive point named 'Le Tre Pietre'.

This site is characterized by small patches of *Posidonia oceanica* mixed to rocks, with the presence of *Cystoseira* spp. in shallower bottoms up to 20 m depth. Within this depth range is has been found big specimens of massive sponges such as *Petrosia ficiformis* (fig. 8b) and *Chondrosia reniformis,* as well as other species protected by Barcelona Convention, like the hard-bodied corals *Cladocora caespitosa* (fig. 8a)*, Astroides calycularis* and *Ophidiaster ophidianus.*

At a depth of 15 metres a large *P. oceanica* meadow starts stretching down up to around 30 metres depth, where a sandy bottom starts to extends and where few scattered colonies of the white gorgonian *Eunicella singularis* were recorded.

The geomorphological peculiarity of this site is the presence of a huge rocky pinnacle from 23 to 32 metres depth. Its cliffs are characterized by sessile fauna mainly represented by the zoanthid *Parazoanthus axinellae,* several encrusting sponges, the bryozoan *Miriapora truncata* and the tunicate *Halocynthia papillosa*; within its splits there are several individuals of *Centrostephanus longispinus* (fig. 8c). In more sheltered zones, the bivalve *Arca noae* is occasionally present and juvenile individuals of the dusky grouper (*Epinephelus marginatus)* have been observed.

Underwater observations evidenced a clear impact affected by artisanal fishery, mainly represented by trammel nets found underwater during the survey (fig. 8d). This is probably due to the evolution of artisanal fishery in the Aeolian Islands in the last decades: after the 'spadara' driftnet ban (EU reg. n.1239/98), local fishing boats must centre their activity to coastal fishery, so as fishing pressure today represents the main local human-induced stressor exerted around the islands. The presence and abundance for each marine *taxon* is reported in figure 7, following the Reef check Italy *Onlus* protocol.

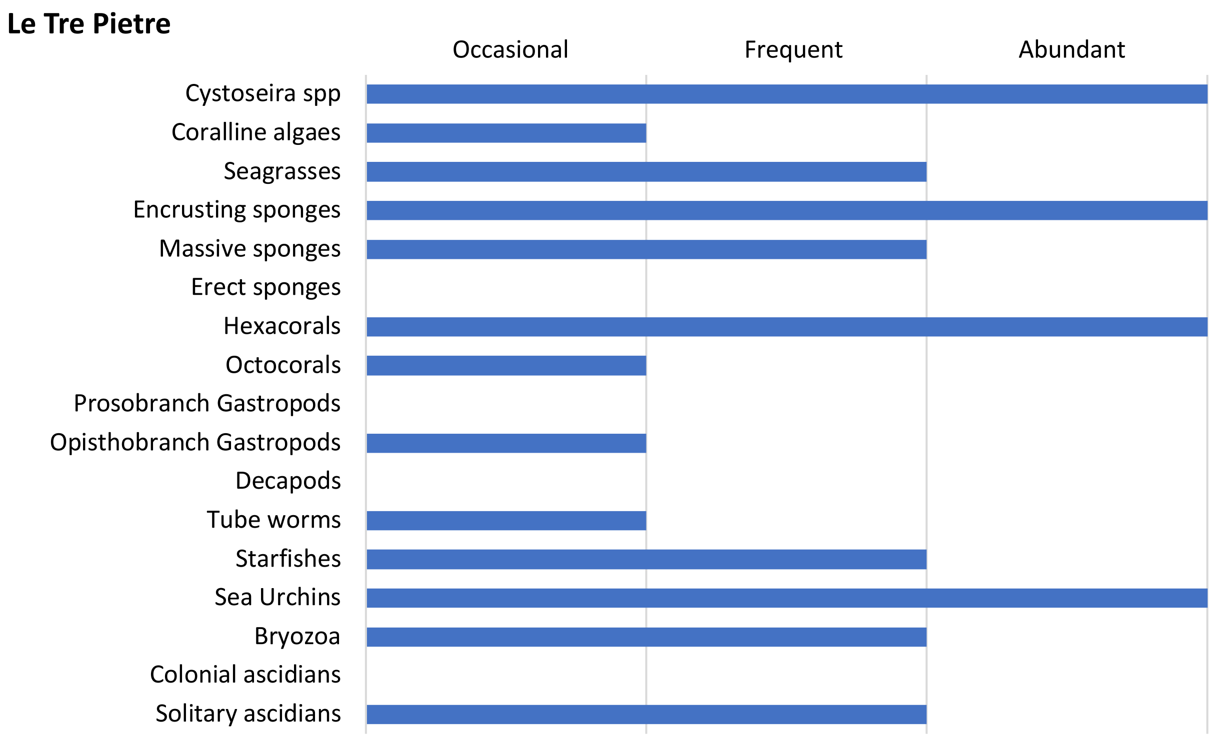


Fig. 7. Abundance of marine life recorded in Le Tre Pietre. No bars: 0; Occasional: 1; Frequent: 2; Abundant: 3.

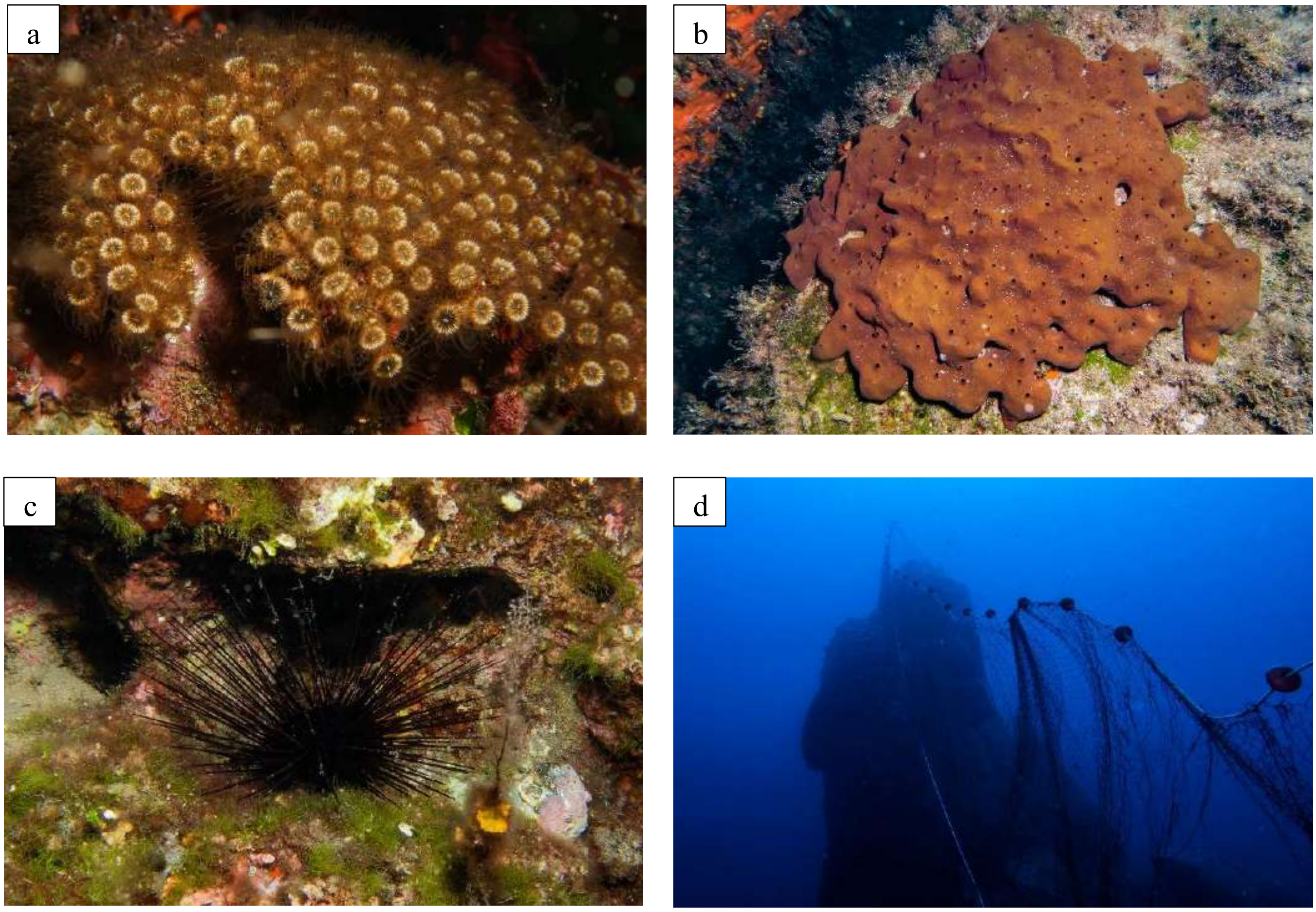


Fig. 8: The zooxanthellate hard-bodied coral *Cladocora caespitosa* (a); The massive sponge *Petrosia* (b); a specimen of the echinoid *Centrostephanus longispinus* (c); trammel net (d).

3.2. Station 2: Faraglione di Pollara

This dive spot is located in the North Western side of the island coast (fig.9).

Fig. 9: Station2: the red flag shows the dive point named 'Faraglione di Pollara'.

Pollara Bay is an ancient crater coming from an explosive eruption dates back about 100.000 years ago, whose diameter is 1km wide. In the middle of the crater there is a sea stuck, called 'Il Faraglione', which represents the volcanic neck formed by the solidification of magma formed during the last eruption of the crater, from which this station takes its name (fig. 9). In the external part of the neck a wide submerged rocky platform is extended, dominated by *Cystoseira* spp. and *Paracentrotus lividus facies* from about 3 metres to 15 metres. This macroalgal forest create a shaded shallow habitat that facilitate the growth of sciaphilous species, such as the bryozoan *Myriapora truncata,* the coral *Astroides calycularis* (fig. 11a), the bivalve *Arca noae* and the starfish *Ophidiaster ophidianus*. The solitary zooxanthellate coral *Balanophyllia europaea* is frequent on rocks were the algal coverage is scarce or absent. The cliff of the platform ends in around 30 meters depth; several colonies of *Eunicella cavolini* (fig. 11c) grow perpendicular on its wall in around 25 metres and some crowded areas of the invasive species *Caulerpa cylindracea* cover the rocks. At all depths is very frequent the presence of the fire-worm *Hermodice carunculata*, here documented feeding *Astroides calycularis* (fig. 11b). The protected species *Centrostephanus longispinus* is only occasionally present in this site. Unlike the internal part of the neck, this side is not affected by anchoring, but some fishing lines were found twisted on the erect bryozoan *Myriapora truncata*, evidencing the presence of anthropic pressure represented by recreational fishing (fig. 11d). The presence and abundance for each marine group can be visualized in figure 10.

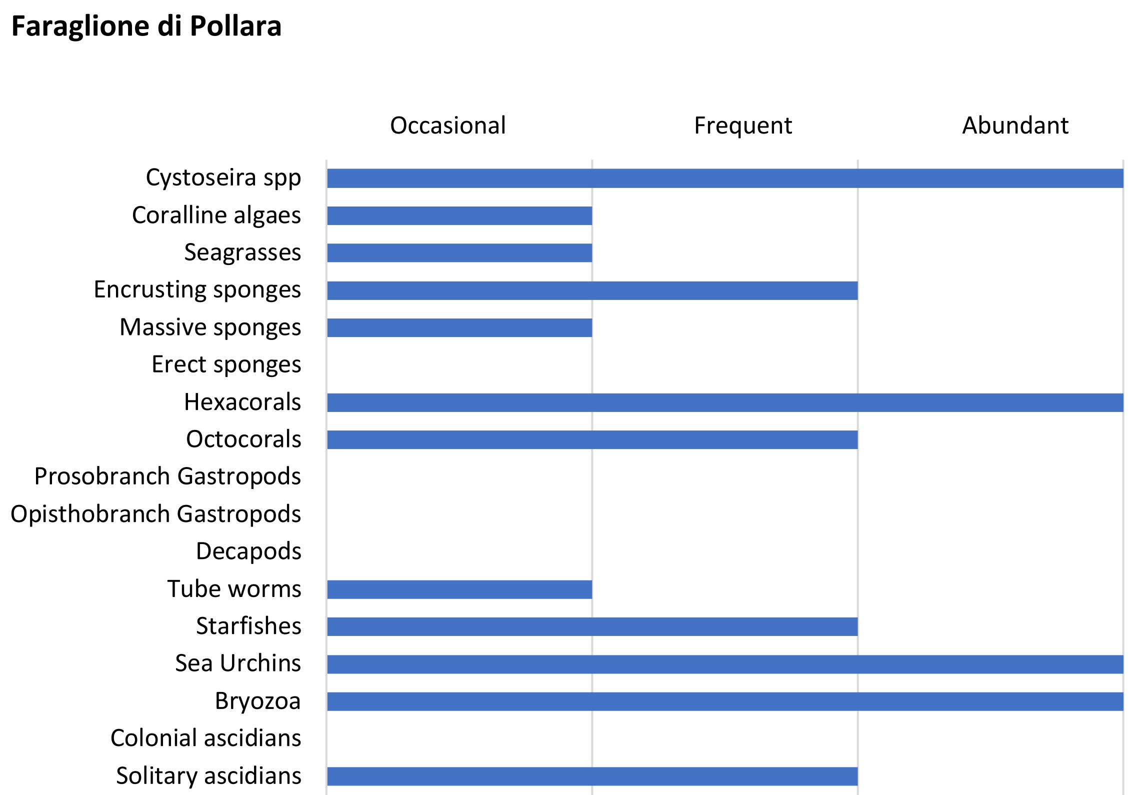


Fig. 10: Abundance of marine life recorded in Faraglione di Pollara. No bars: 0; Occasional: 1; Frequent: 2; Abundant: 3.

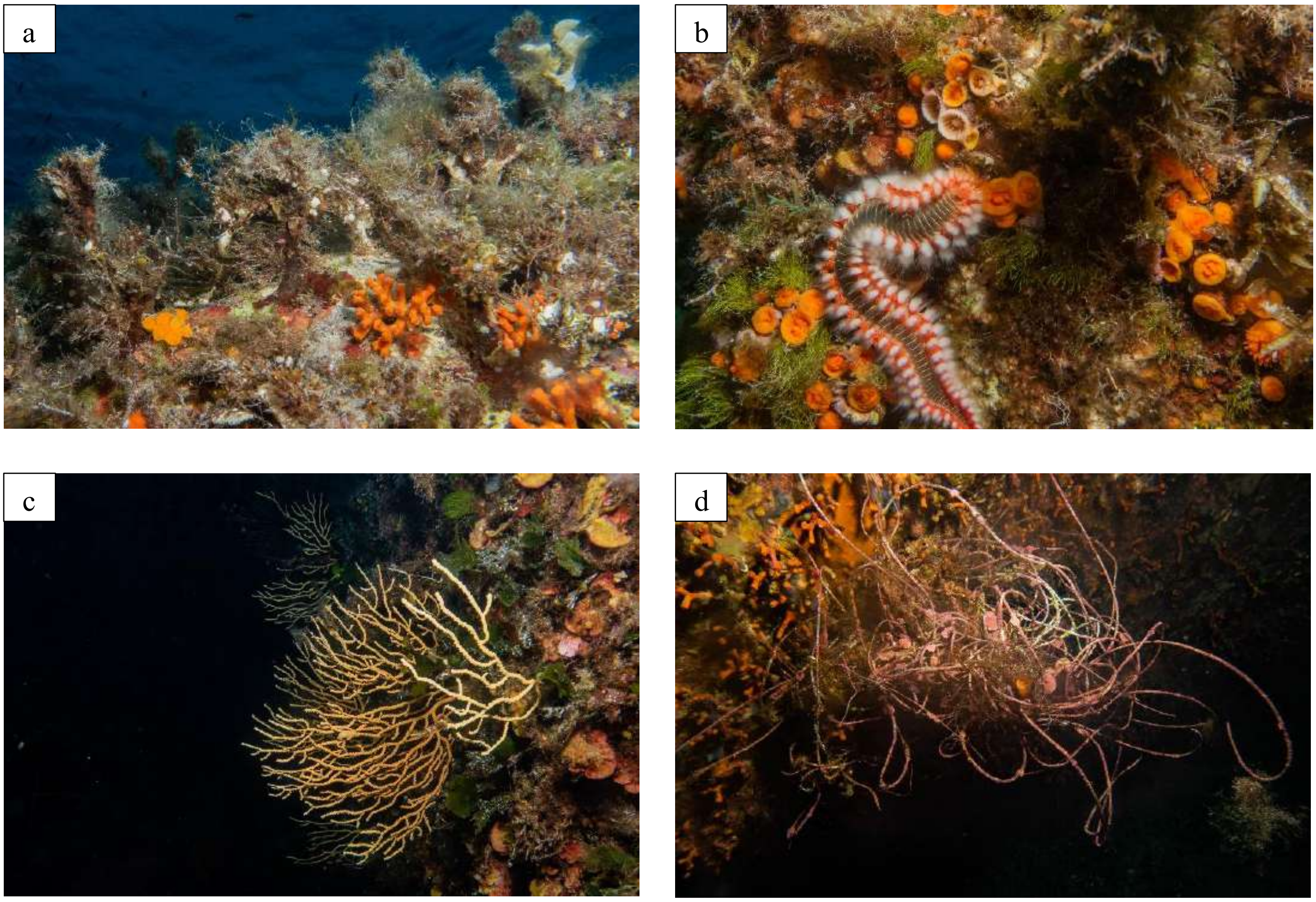


Fig. 11: *Myriapora truncata* and *Astroides calycularis* under *Cystoseira* fronds (a); *Hermodice carunculata* feeding on *Astroides calycularis* (b); *Eunicella cavolini* (c); fishing lines on *Myriapora truncata* (d).

3.3. Station 3: Secca del Capo

This dive spot is located in the South side of the island coast (fig. 12).

Fig. 12: Station 3: the red flag shows the dive point named Secca del Capo.

This rocky sea bank (fig. 12) is formed by two submerged pinnacles, where the shallower starts at 8 metres and goes down up to 40 metres depth, while the second has the top at 25m and ends over 45 metres depth. The sea bank is affected by diverse human disturbances, such as anchoring from leisure boating, due to the absence of mooring buoys, as well as professional/recreational fishing. The presence and abundance for each marine group can be visualized in figure 13.

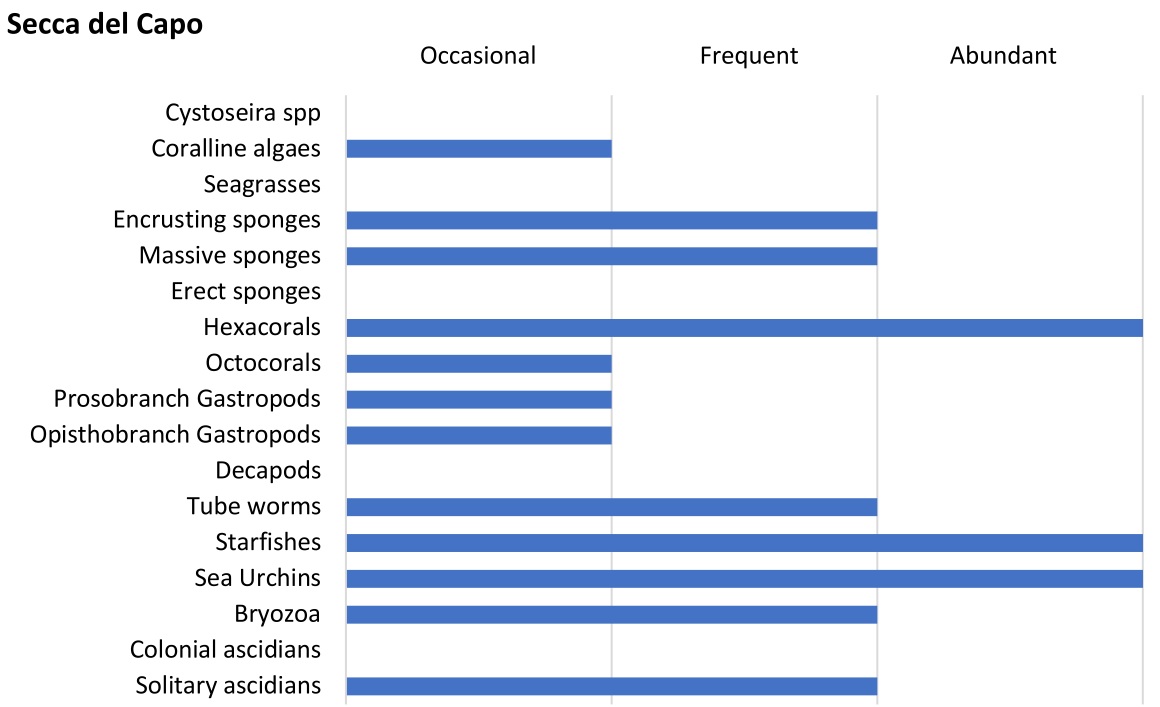


Fig. 13: Abundance of marine life recorded in Secca del Capo. No bars: 0; Occasional: 1; Frequent: 2; Abundant: 3.

The shallow zones, until 12-15 metres, are characterised by evident anchoring pressure and barrens from the *grazing* action of sea urchins *Paracentrotus lividus* and *Arbacia lixula* (fig. 14a). Down the tips of the sea bank, those sides with no a direct exposition to light are characterized by the presence of the hard corals *Astroides calycularis* and *Leptopsammia pruvoti* facies, while the soft coral *Corynactis viridis* (fig. 14b) is present in some spots. Massive sponges such as *Ircinia* spp. and *Chondrosia reniformis* are frequent in this dive station and some big massive specimens of *Cliona viridis* (fig. 14c) have been observed in both pinnacles. The hard substratum is covered by several crowded areas of *Caulerpa cylindracea* (fig. 14d) and by the numerous small-sized crinoid *Antedon mediterranea* (fig. 14e). At all depths the fire-worm *Hermodice carunculata* is frequent, as well as the starfish *Ophidiaster ophidianus*. Other common starfishes are *Hacelia attenuata, Echinaster sepositus* and *Marthasterias glacialis*. Electric rays *Torpedo marmorata* were found in proximity to holes and rocky crevices. Small colonies of *Eunicella cavolini* seem to be present only in a small area directly exposed to direct currents (fig. 14e). An interesting aspect is the unusual abundance of

Centrostephanus longispinus (fig. 14f), very common in rocky holes starting from the depth of 20 until 35 metres.

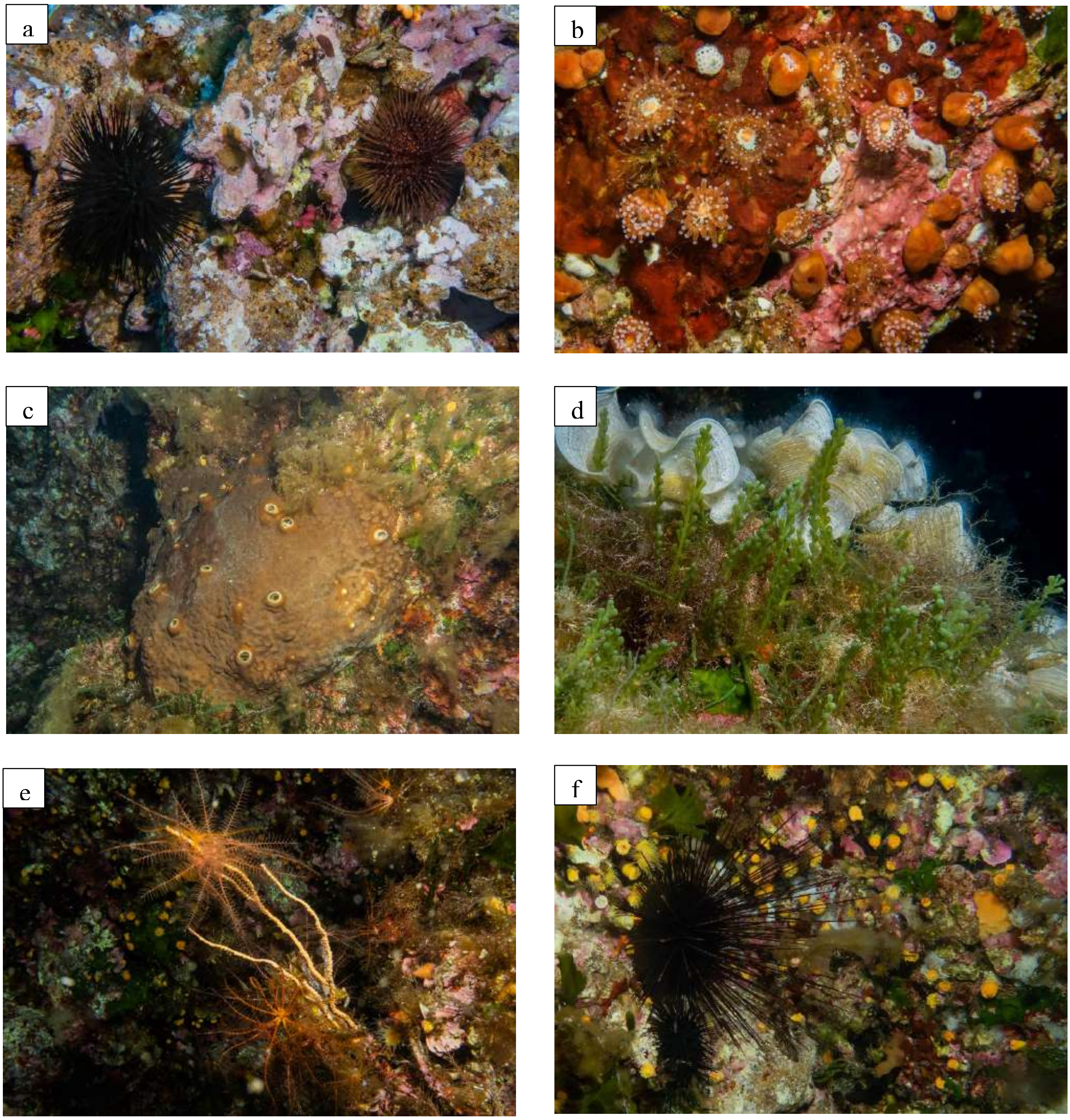


Fig. 14: *Paracentrotus lividus* and *Arbacia lixula* (a); *Corynactis viridis* (b); *Cliona viridis* (c); *Caulerpa cylindracea* (d); *Eunicella cavolini* and *Antedon mediterranea* (e); *Centrostephanus longispinus* and *Leptopsammia pruvoti* (f).

3.4. Station 4: Scoglio Cacato

This dive spot is located in the Eastern side of island coast (fig. 15).

Fig. 15. Station 4: the red flag shows the dive point named Scoglio Cacato.

In the North-East side of the Island coastline (fig. 15) it has been censused a multispecies seagrass meadow composed by *Cyomodocea nodosa*, *Halophila stipulacea* and *Posidonia oceanica* (fig. 17a). The meadow starts from about 8-10 metres up to 25-28 meters depth and its density increases moving away from the coast. In the shallow area of the meadow, there are just few isolated *C. nodosa* shoots, probably due to the anchoring pressure of touristic boats. Where meadow ends, big rocks appear on the sandy bottom and some *Epinephelus marginatus* hide around them (fig. 17b). On these rocks live important sessile species, such as massive sponges (*Sarcotragus foetidus*, *Petrosia ficiformis*), *Astroides calycularis* and the bivalve *Arca noae* (fig. 17c). The peculiarity of this station is a large stone wall, between 30-

32 meters depth, that create a well-defined step on the bottom and numerous microhabitats for the sessile and vagile fauna. The starfishes *Ophidiaster ophidianus* and *Peltaster placenta* (fig. 17d) are frequent, while other echinoderms such as *Cidaris cidaris* and *Centrostephanus longispinus* are occasional, as well as the lobster *Palinurus elephas*. The presence and abundance for each marine group can be visualized in the figure 16.

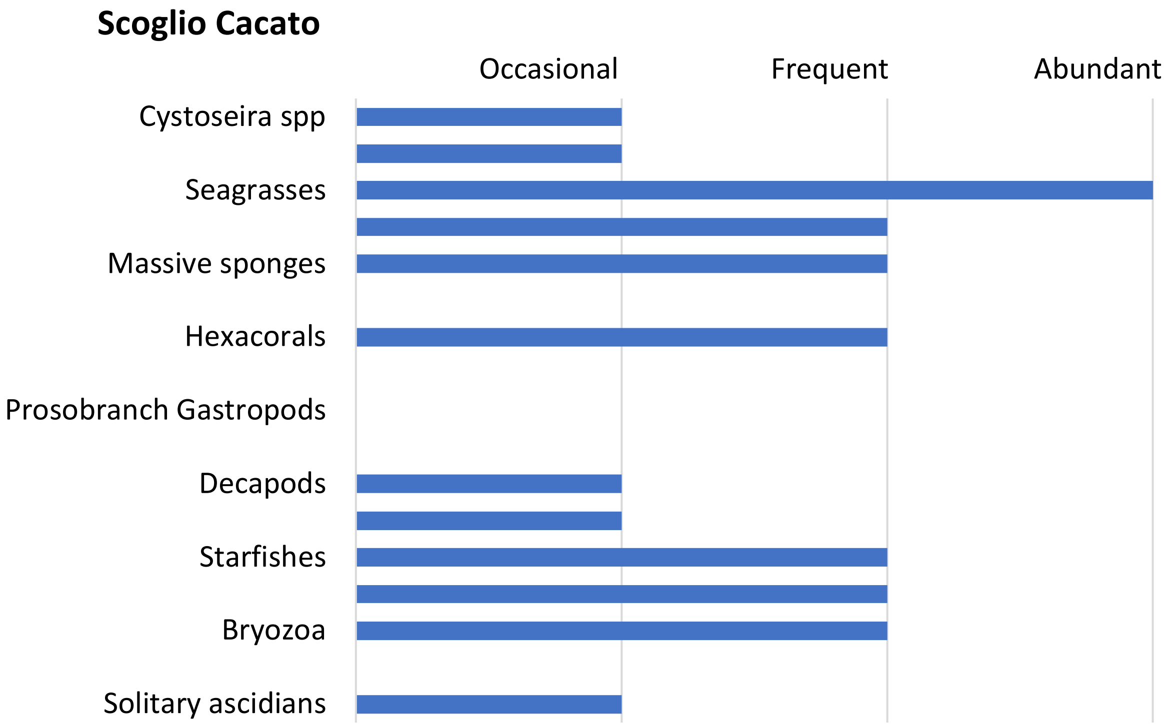


Fig. 16: Abundance of marine life recorded in Scoglio Cacato. No bars: 0; Occasional: 1; Frequent: 2; Abundant: 3.

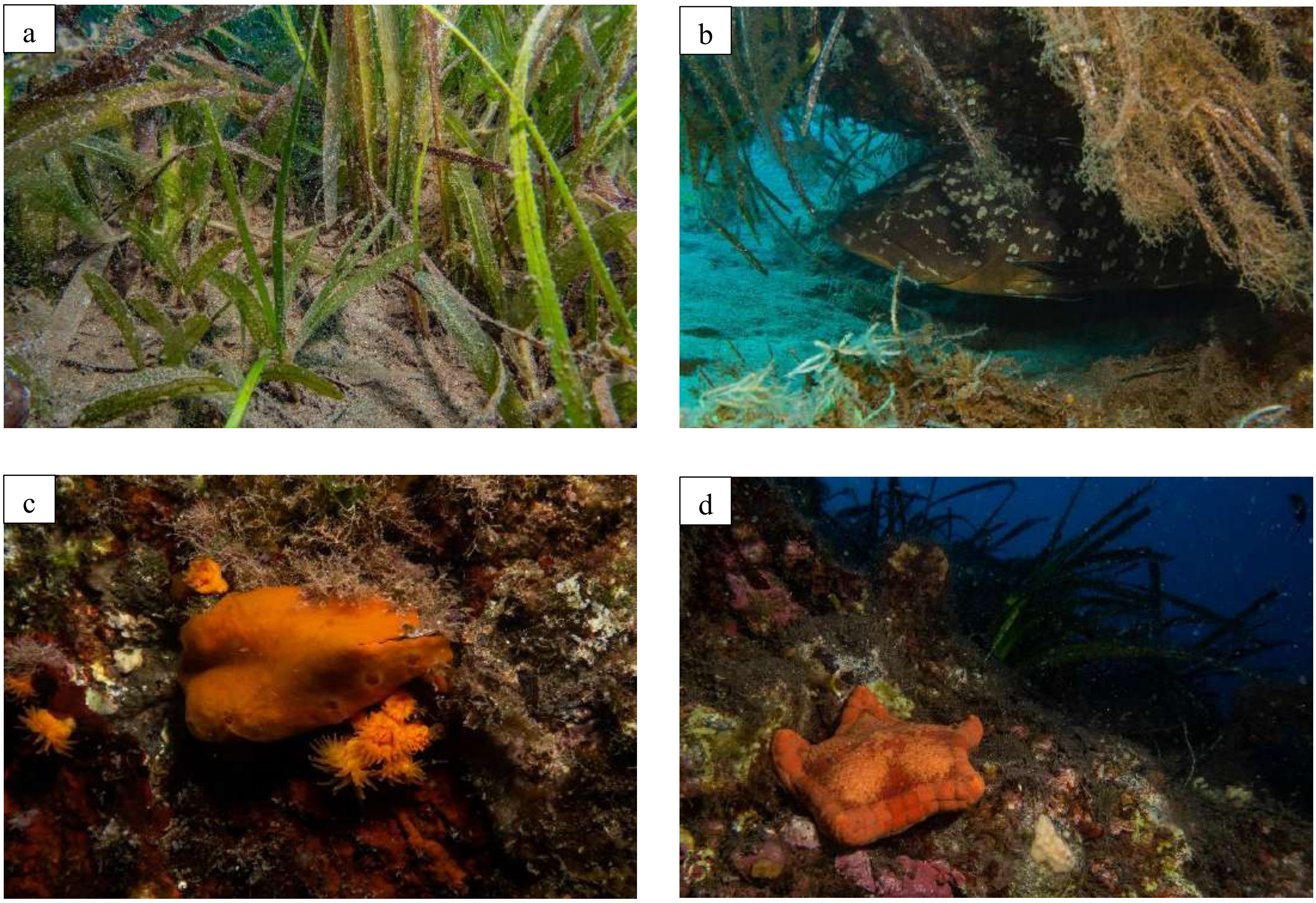


Fig. 17: *Halophila stipulacea, Cyomodocea nodosa* and *Posidonia oceanica* (a); *Epinephelus marginatus* (b); *Arca noae* (c); *Peltaster placenta* (d).

3.5. Station 5: Grotta dei Gamberi

This dive spot is located in the South side of the island coast (fig. 18).

Fig. 18. Station 5: the red flag shows the dive point named Grotta dei Gamberi.

This dive spot (fig. 18) takes its name from a small cave carved in a vertical wall at the depth of 32 metres. The peculiarity of the cave is the presence of a numerous colony of shrimps *Plesionika narval*, and some spiny lobsters (*Palinurus elephas*, fig. 20a). The external vertical wall is covered by sessile fauna, such as encrusting sponges and erect sponges (*Axinella verrucosa*) (fig. 20b), as well as stony corals (*Astroides calycularis*) and bryozoans (*Myriapora truncata*). Small colonies of *Eunicella cavolini* (fig. 20c) grow perpendicular to the wall, where some of these are covered by algal epibionts. During the dive it has been observed the fire-worm *Hermodice carunculata*, and the sea urchin *Centrostephanus longispinus* has been detected occasionally inside holes. In the shallow part of the wall there is a rocky platform covered by *Cystoseira* forest (fig. 20d), which creates many microhabitats for invertebrates (*Ophidiaster ophidianus, M. truncata, A. calicularis,* hermit crabs) and fishes (*Salpa salpa, Thalassoma pavo*). The presence and abundance for each marine group can be visualized in figure 19.

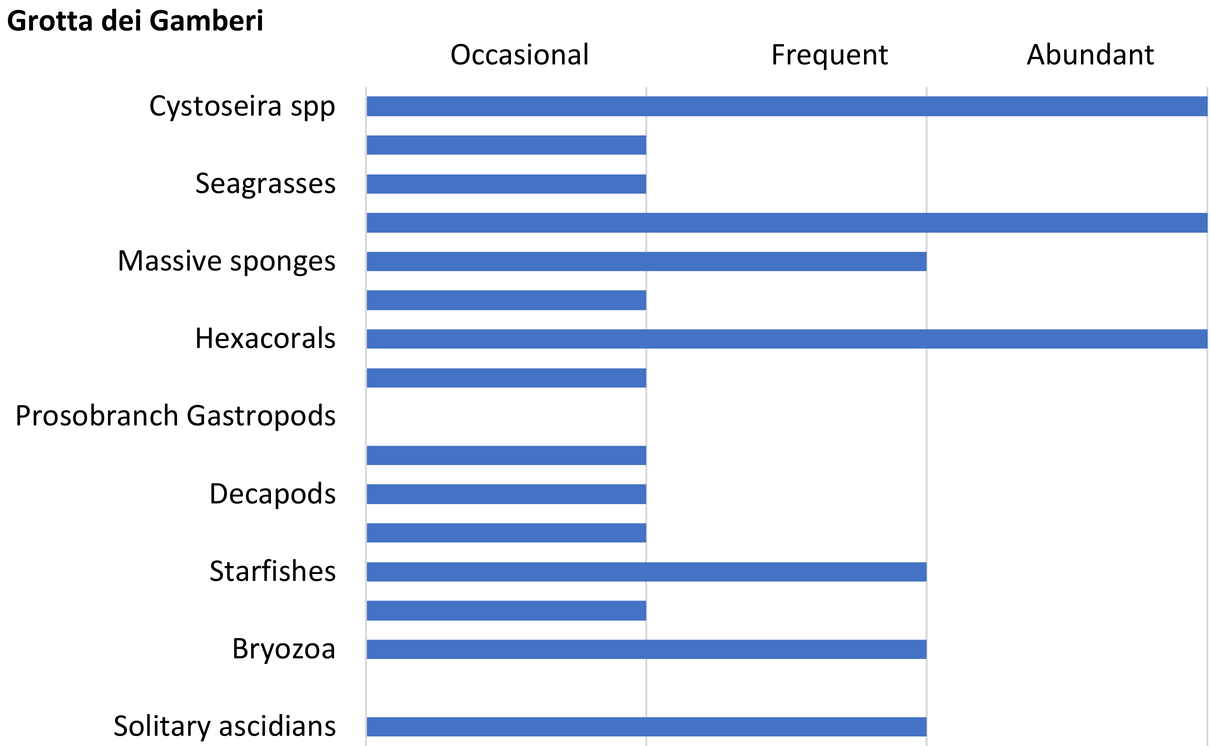


Fig. 19: Abundance of marine life recorded in Grotta dei Gamberi. No bars: 0; Occasional: 1; Frequent: 2; Abundant: 3.

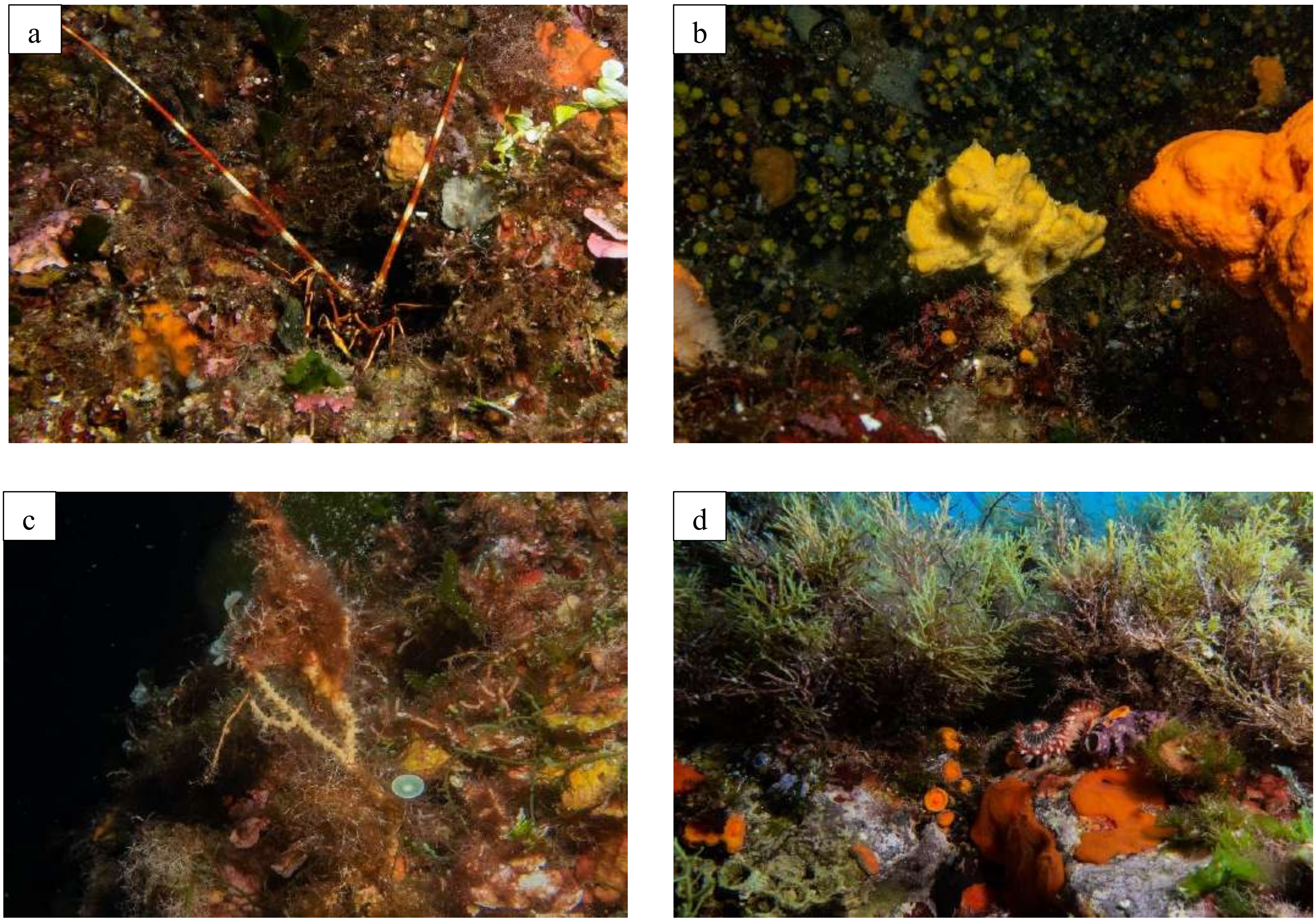


Fig. 20: *Palinurus elephas* (a); *Axinella verrucosa* (b); *Eunicella cavolinii* (c); *Astroides calycularis* and *Hermodice carunculata* under *Cystoseira* thalli (d).

3.6. Distribution of the main species

To have a general view on the different abundances of taxa considered here, Tab. 5 compares the abundances of the main taxa among the different sites, in relation to following range of abundance:

/: not observed;

+: 1-5 individuals / some scattered;

++: 5-20 individuals / several scattered;

+++: 20-40 individuals / some crowded areas;

++++: >40 individual / several crowded areas.

Table 5. The abundance for each taxon of interest for conservation measures related to the scuba diving spots. (1: included in habitat Directive Annexes; 2: included in Barcelona Convention Annex; 3 included in the list of Alien and/or invasive species).

Species	Le Tre Pietre	Faraglione di Pollara	Secca del Capo	Scoglio Cacato	Grotta dei Gamberi
Caulerpa cylindracea (3)	+	+	+++	/	/
Cystoseira spp. (2)	++++	++++	/	+	++++
Posidonia oceanica (1, 2)	++++	++	/	+++	+
Cymodocea nodosa	/	/	/	++++	/
Halophila stipulacea (3)	/	/	/	++++	/
Axinella spp. (2)	/	/	/	/	+
Petrosia ficiformis	++	/	+	+	+
Eunicella cavolini	/	++	++	/	+
Eunicella singularis	+	/	/	/	/
Astroydes calycularis (2)	+++	++++	++++	+++	++++
Cladocora caespitosa (2)	+	+	/	/	/
Corynactis viridis	/	/	+	/	/
Arca noae	+	+	/	+	/
Pinna nobilis (1, 2)	/	/	/	/	/
Pinna rudis (2)	/	/	+	/	/
Hermodice carunculata	+++	+++	+++	++	+++

Ophidiaster ophidianus (2)	++	++	++	++	++
Centrostephanus longispinus (1, 2)	++	+	+++	+	+
Paracentrotus lividus (2)	+++	+++	+++	+	+
Antedon mediterranea	/	/	++++	/	/
Cidaris cidaris	/	/	+	+	/
Peltaster placenta	/	/	/	+	+
Palinurus elephas (2)	/	/	/	+	+
Epinephelus marginatus (2)	+	/	/	+	/

3.7. Main information about the protected species Centrostephanus longispinus

Kingdom	Animalia
Phylum	Echinodermata
Class	Echinoidea
Order	Diadematoida
Family	Diadematidae
Genus	*Centrostephanus*
Species	*longispinus*

Scientific name: *Centrostephanus longispinus (*Philippi*,* 1845*)*

- v. *Diadema longispinna,* Philippi, 1845
- v. *D. europeum,* A. Agassiz & Desor, 1846
- v. *D. europaeum,* Dujardin & Hupé, 1862

Common name: hatpin urchin (EN)

a) Morphology

C. longispinus is the only species of the order Diadematoida present in the Mediterranean Sea. The body has a depressed shape, which does not exceed 6 cm in diameter, with long spines that can reach 10 cm of length. The genus *Centrostephanus* have a hard exoskeleton, with dorsal plates and long hollow spines. In particular, *C. longispinus* has primary and secondary dorsal spines: the first are long at least as the body diameter (max 6 cm), while latter are thinner and no longer than 30 mm. Around the mouth there are ten big primary plates, with numerous small black spines and tube feet. *C. longispinus* has two possible colour morphs, one with black spines, and another with yellowish and purple striped spines (Guallart & Templado, 2012).

b) Distribution and ecology

Centrostephanus longispinus is almost continuously distributed in the Atlantic Ocean and in the Mediterranean Sea, limited to its ecological habitat. Single specimens can be found in distinct habitats, for instance Posidonia meadows, but also detrital bottoms, even though it seems they preferred rocky circalittoral bottom with strong currents.

It is a stenotherm and thermophilic species and previous works suggest that the increasing in population density could be related to the increasing of global water temperature.

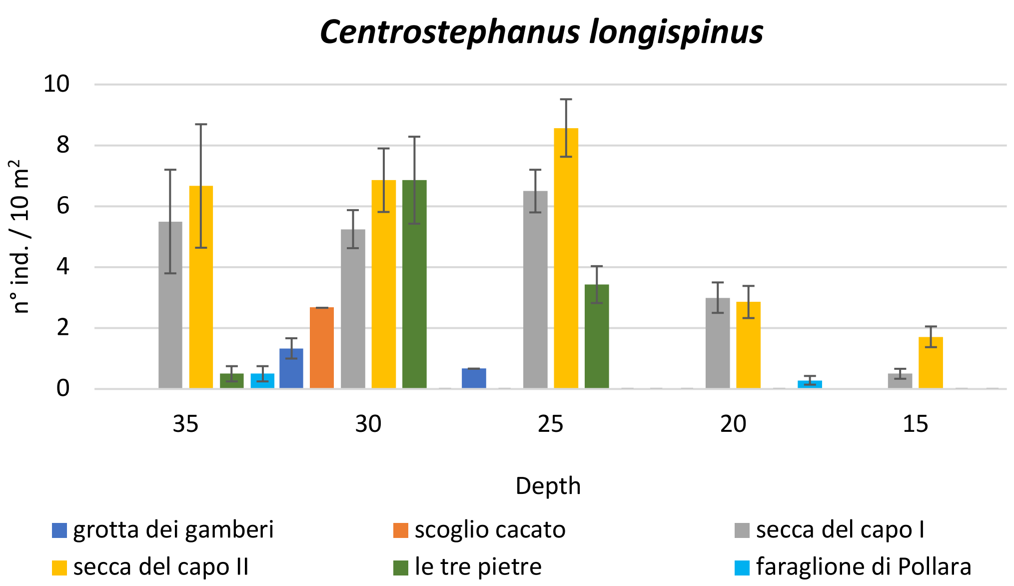
It can move quickly although usually stay still in holes and darkness zones during the day; during the night it moves for grazing purposes (detritus and calcareous algae). It reproduces with external fecundation and its larval development is unknown, but it is probably planktonic to balance its low dispersion capacity as others diadematids.

c) Conservation status and vulnerability

The rarity of this species may be due to the inaccessibility of its habitat, as its distribution range is between 3 and 250 metres, even though it seems it prefers bathymetries beyond 60 metres. Due to the difficulty in detecting its distribution, studies carried out to far doesn't allow to make any accurate map of its presence and abundance (Guallart & Templado, 2012), compromising any effective strategy for any conservation measures by the International Union for Conservation of Nature (IUCN). However, it has been supposed that this species may be threatened by illegal harvesting due to its aesthetic value (Relini and Tunesi, 2009). In the last decades many benthic termophilous species, such as the sea urchins *Arbacia lixula* and *Centrostephanus longispinus*, became very abundant and frequent in North Western Mediterranean (UNEP-MAP RAC/SPA 2010). Taking in account this trend we can hypothesize that its life cycle would be affected by global warming.

3.8. Distribution and abundance of *Centrostephanus longispinus*

A specific monitoring for *Centrostephanus longispinus* distribution and abundance has been carried out within all stations taken into account in this study. Results about its estimation of



abundance are reported in figure 21, as the average of individuals on 10 m^2 for each depth transect. In this graphic, the dive spot 'Secca del Capo' was divided into two different survey sites: Secca del Capo I, which is related to the shallowest pinnacle of the sea bank, and Secca del Capo II, which is related to the second deepest one.

C. longispinus was thus present in all stations, but with a different bathymetric distribution. Only at the Secca del Capo I and Secca del Capo II the sea urchin was observed at all depths, although with different abundances. At Scoglio Cacato it was observed just at 30 m depth while at Grotta dei Gamberi and Faraglione di Pollara at 30 and 25 metres and 30 and 20 metres respectively. The highest number of specimens has been observed at Secca del Capo II at 25 metres (8,6 average individuals on 10 m^2) while the depth of 30 m is the only one common to all stations.

A total of 56 individuals, photographed at 30, 25 and 20 metres inside and outside the transects, were measured using ImageJ software. For the smaller diameter recorded, the minimum and the maximum values are 2.25 and 7.59 cm, measured respectively at Secca del Capo I (£0 metres) and Secca del Capo II (20 metres). For the larger diameter recorded, the minimum and the maximum values are 7.44 and 23.72 respectively at Secca del Capo II (20 metres) and Le Tre Pietre (30 metres). The average size in the studied locations at the three depths (when present) are reported in Fig. 22.

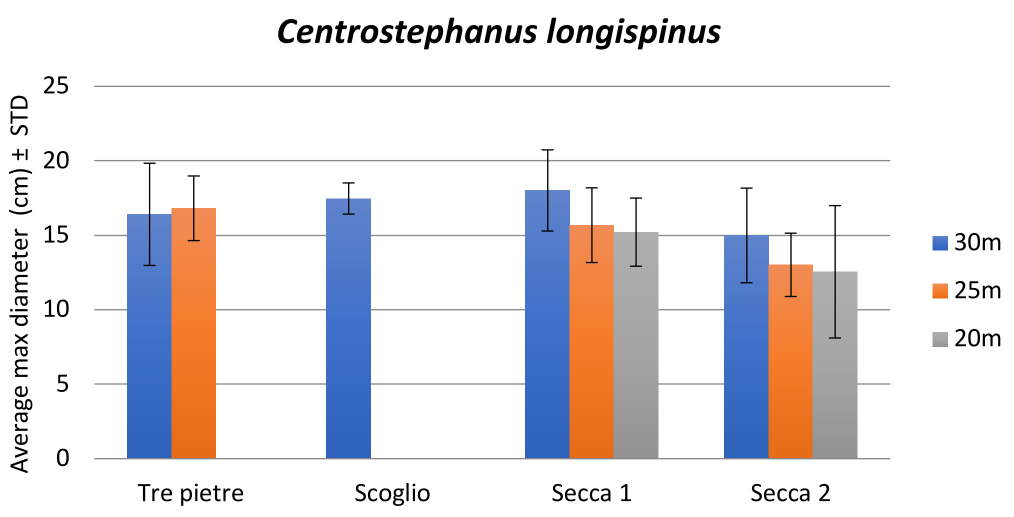


Fig. 22. Average values of diameters of *Centrostephanus longispinus* for each dive point and its depths, bars represent standard deviation.

For each depth was calculated the average values of D/d ratio (fig. 23). The lowest average value is at 20 metres (3.05 ± 0.33), the maximum at 25 metres (3.83 ± 0.73) and the intermediate value at 30 metres (3.58 ± 0.54).

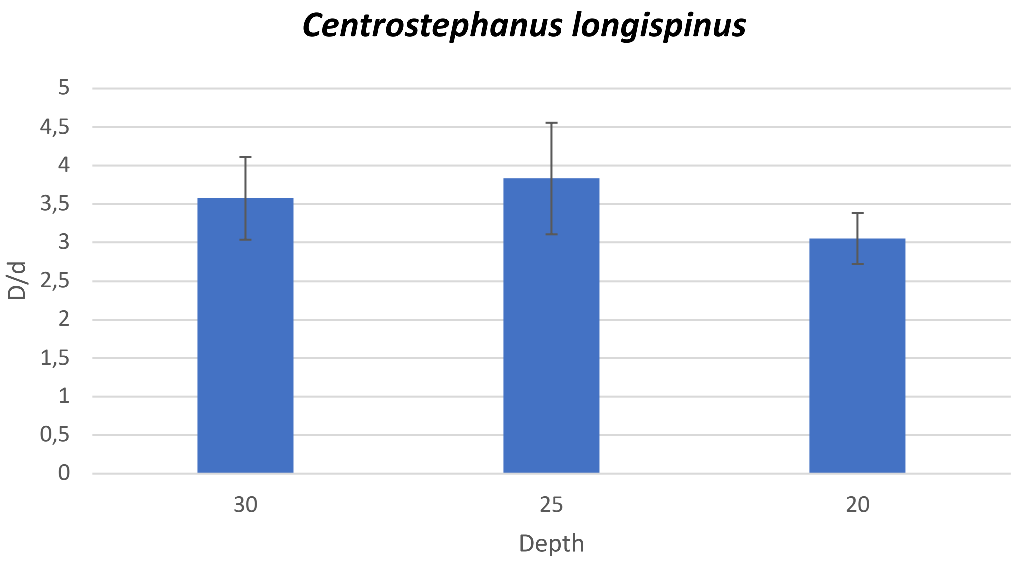


Fig. 23. Average values of D/d ratio, bars represent standard deviation.

4. DISCUSSIONS AND CONCLUSIONS

The field work was carried out at 5 dive spots along the coasts of Salina Island and each station shows some biological and geomorphological peculiarities. The lighted hard bottoms, from the surface to 35 metres depth, are generally dominated by algal canopies and seagrass meadows, such as *Cystoseira* spp. and *P. oceanica*. Their presence increases the spatial complexity of seabeds, providing numerous microhabitats for sessile and vagile organisms for mating, refuge and feeding purposes (Cheminée et a., 2016; Serrano et al., 2017). Among these marine forests, the sea urchin of commercial value *Paracentrotus lividus* was observed in all diving spots dominated by *Cystoseira* canopies, living in sympatry with *Arbacia lixula* and occasionally with *Sphaerechinus granularis*. The absence of barrens suggests that the grazing activity is in equilibrium with the growth rate of the algal canopy, even if the fishing pressure is not regulated by any national measures (i.e. marine protected areas) that should encourage natural habitat recovery. An exception is represented in the offshore site 'Secca del Capo', where the upper portion of the sea bank presents wide barren areas. Anyway, in this site local currents are generally very strong all year round, so we can suppose that propagules and frequent anchoring of tourism boats could affect the algal coverage, especially if this phenomenon is coupled with sea-urchins grazing.

Soft bottoms around Salina island hosts generally dense meadows of *Posidonia oceanica*. In one site (Scoglio Cacato) the meadow is not homogeneous, as it shows low density areas where pioneer species (i.e. *Cymodocea nodosa*) and the alien species *Halophila stipulacea* are present, in particular close to the coastal area, likely due to the mechanical stress of anchoring that open corridors inside the *P. oceanica* meadows.

In dim light conditions, pre-coralligenous and coralligenous biocenosis are present in all the areas surveyed, but they generally occur in low densities and in small sizes. This condition unveils habitats where external disturbance can affect the integrity of the epibenthic layer (Valisano et al., 2019), but the mineralogical peculiarities of the island can also play an important role in shaping local communities (Bavestrello et al. 2000). Indeed, the volcanic origin of the rocks may limit the growth of coralline algae, which use to facilitate the colonization by sessile fauna and trigger the formation of bioconstructions. Nevertheless, the biocenosis observed during the study showed the presence of numerous species listed in the annexes of the Barcelona Convention because endangered or regulated for commercial exploitation. Some of these, for instance *Sarcotragus foetidus, Astroides calycularis, Ophidiaster ophidianus, Pinna rudis, Paracentrotus lividus* and *Palinurus elephas,* which are present and/or frequent in several stations, gave to the island a unique naturalistic value, which can be considered a crucial point for the institution of a Marine Protected Area in Salina island.

Regarding the standing sessile fauna (i.e. sponges, gorgonians) the current study evidenced very low values along vertical cliff of the diving sites surveyed. The lack of a baseline dataset does not discriminate whether it is caused by anthropogenic impact or by ecological characteristics of the environment. However, fishing lines, ghost nets and trammel nets were observed at various locations, supporting the first hypothesis rather than the second.

Another interesting observation has been carried out in two sites (Le Tre Pietre and Scoglio Cacato), which revealed the presence of some adult individuals of *Epinephelus marginatus*, a vulnerable often used as an bioindicator of the state-of-art of natural marine systems (Prato et al., 2016; Condini et al., 2018), which suggests that greater efforts to protect their habitat could help the establishment of permanent populations. Since in both sites traces of anthropogenic pressure were evident (i.e. trammel nets and anchorage), a marine protected area would play an important nursery role for many protected species censused during the present study.

Among the monitored species, *Centrostephanus longispinus* caught the diving team's attention for both its high abundance and its presence in shallower waters, with a minimum depth range registered at 11 metres, even though more dense aggregations seem to prefer deeper bathymetric ranges. Few individuals were observed at Scoglio Cacato because of the lack of hard substratum. The ecological needs of this species are still unknown, but this study provides weighty information on its distribution and its capacity to form dense populations also in shallower waters.

During the field work it has been noticed anthropic impacts at different scales, which seem to affect coastal bottom areas around all the coast of the Island. In particular, anchoring damages on hard bottoms and on seagrasses emphasize the need of deploying mooring buoys for touristic and diving boats. Also, numerous nets and fishing lines were found entangled on benthic organisms, suggesting the entity of pressure that insist in those natural systems.

Based on the present results, the present study wants to write up the first preliminary considerations about habitat characterization and human interactions occurring in the area, which will call for a special attention to future biodiversity conservation plans and an effective management of fishing activities. All dive spots include from 5 (Secca del Capo) to 8 (Scoglio Cacato, Grotta dei Gamberi) protected species; some of these species are particularly frequent or abundant in all sites, such as *Cystoseira* spp, *Astroydes calicularis, Ophidiaster ophidianus* and *Paracentrotus lividus*. The emblematic species *Epinephelus marginatus* and *Palinurus elephas* were detected in two sites (Le Tre Pietre, Scoglio Cacato and Grotta dei Gamberi, Scoglio Cacato respectively) and few individuals of *Axinella verrucosa* were observed in Grotta dei Gamberi. Among the invasive species, *Caulerpa cylindracea* was censused but it was particularly frequent only at Secca del Capo, where it forms several crowded areas from 20 to 40 metres. These information reveals not only the great biological value of the area but also the vulnerability of habitats and their associated species, which are still not protected by any national conservation policies.

The Aeolian Archipelago cover an undoubtful role as a pit stop area for many target species in the open waters of the Southern Tyrrhenian Sea like the Mediterranean spearfish (*Tetrapturus belone*; Rafinesque, 1810), the albacore tuna (*Thunnus alalonga*; Bonnaterre, 1788), the dolphinfish (*Coryphaena hippurus;* Linnaeus, 1758), the amberjack (*Seriola dumerili*; Risso, 1810) and other big Carangids (i.e. *Caranx crysos;* Mitchill, 1815) (Potoschi et al., 1999), while others like the swordfish (*Xiphias gladius*; Linnaeus, 1758) and the bluefin tuna (*Thunnus thynnus*; Linnaeus, 1758), use the area for reproduction and as nursery ground (De Metrio et al 1995). Finally, the presence of healthy populations of cetaceans, particularly striped dolphins (*Stenella coeruleoalba*; Meyen, 1833), sperm whales (*Physeter macrocephalus*; Linnaeus, 1792) and common dolphins (*Delphinus delphis*; Linnaeus, 1758), suggests that this archipelago is also an important area for marine mammals and chelonians (Blasi & Boitani, 2012).

At the same time, the wide distance from the coast of Sicily might represent a limit for larval dispersal and propagules supply of several species: in case of habitat fragmentation due to anthropogenic impacts, time recovery and ecosystem services restoration could last a very large time span and, vice versa, fragmentation processes can be faster than expected (Haddad et al., 2015).

The responsibility of scientists is to turn this tide, transforming the Aeolian Islands in a crucial hot spot area leading a strategic network with other closer MPAs, represented by Capo Milazzo and Ustica Island, which are respectively 15 and 60 nautical miles far from the archipelago. Therefore, appropriate measures of conservation to preserve the exceptional beauty of the Aeolian Islands must be taken into account with urgency, striving local and national institutions and helping natural systems to come back close to their pristine state in the upcoming future.

5. REFERENCES

1. Bavestrello, G., Bianchi, C. N., Calcinai, B., Cattaneo-Vietti, R., Cerrano, C., Morri, C., ... & Sara, M. (2000). Bio-mineralogy as a structuring factor for marine epibenthic communities. *Marine Ecology Progress Series*, *193*, 241-249.
2. Bernardi, G. (2018). Patterns distributions of fish communities associated with different hard bottom in Salina island: A preliminary study for the future Marine Protected Area in the Aeolian Archipelago (Southern Tyrrhenian Sea, Mediterranean Sea). *Ph.D. thesis. Università degli Studi Di Napoli 'Parthenope'. Napoli.*
3. Blasi, M. F., & Boitani, L. (2012). Modelling fine-scale distribution of the bottlenose dolphin Tursiops truncatus using physiographic features on Filicudi (southern Thyrrenian Sea, Italy). *Endangered Species Research, 17*(3), 269-288.
4. Bohnsack, J. A., & Bannerot, S. P. (1986). A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. *NOAA Tech. Rep. NMFS 41*.
5. Calvo, S., Tomasello, A., Pirrotta, M. & Di Maida, G. (2005a). Alla Predisposizione Dell'attivita "Fase Di Analisi - Classificazione Dello Stato Ecologico e Dello Stato Ambientale Dei Corpi Idrici Superficiali" - COGESID S.p.A.
6. Calvo, S., Tomasello, A., Pirrotta, M. & Di Maida, G. (2005b). Classificazione Dello Stato Ecologico e Dello Stato Ambientale Dei Corpi Idrici Superficiali - Acque Marino Costiere - COGESID S.p.A.
7. Cerrano, C., Ponti, M., & Rossi, G. (2014) Manuale EcoDiver MAC: Guida al Monitoraggio dell'Ambiente Costiero Mediterraneo. Ver. 4.0. Reef Check Italia onlus, Ancona, pp. 102. ISBN 978-88-906783-2-5.
8. Cheminée, A., Merigot, B., Vanderklift, M. A., & Francour, P. (2016). Does habitat complexity influence fish recruitment?. *Mediterranean Marine Science*, *17*(1), 39-46.
9. Claudet, J., Pelletier, D., Jouvenel, J. Y., Bachet, F., & Galzin, R. (2006). Assessing the effects of marine protected area (MPA) on a reef fish assemblage in a northwestern Mediterranean marine reserve: Identifying community-based indicators. *Biological conservation*, *130*(3), 349-369.

10. Condini, M. V., García-Charton, J. A., & Garcia, A. M. (2018). A review of the biology, ecology, behavior and conservation status of the dusky grouper, Epinephelus marginatus (Lowe 1834). *Reviews in Fish Biology and Fisheries*, *28*(2), 301-330.
11. Faranda, F. M. & Povero, P. (1996). Caratterizzazione Ambientale Marina Del Sistema Eolie e Dei Bacini Limitrofi Di Cefalù e Gioia (EOCUMM 95). Data Report.
12. Fastelli, P., Blašković, A., Bernardi, G., Romeo, T., Čižmek, H., Andaloro, F., … & Renzi, M. (2017). Plastic litter in sediments from a marine area likely to become protected (Aeolian Archipelago's islands, Tyrrhenian sea). *Marine Pollution Bulletin, 119*(1), 372-375.
13. Francour, P. (1997). Fish assemblages of Posidonia oceanica beds at Port-Cros (France, NW Mediterranean): assessment of composition and long-term fluctuations by visual census. *Marine Ecology*, *18*(2), 157-173.
14. Guallart, J. & Templado, J. (2012). Centrostephanus longispinus. En: VV.AA., *Bases ecológicas preliminares para la conservación de las especies de interés comunitario en España: Invertebrados*. Ministerio de Agricultura, Alimentación y Medio Ambiente. Madrid. 58 pp.
15. Haddad, N. M., Brudvig, L. A., Clobert, J., Davies, K. F., Gonzalez, A., Holt, R. D., ... & Cook, W. M. (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science advances*, *1*(2), e1500052.
16. Harmelin-Vivien, M. L., Harmelin, J. G., Chauvet, C., Duval, C., Galzin, R., Lejeune, P., ... & Lasserre, G. (1985). Evaluation visuelle des peuplements et populations de poissons méthodes et problèmes. *Revue d'écologie*.40(4):467–539.
17. Italiano, F., & Nuccio, P. M. (1991). Geochemical investigations of submarine volcanic exhalations to the east of Panarea, Aeolian Islands, Italy. *Journal of Volcanology and Geothermal Research*, *46*(1-2), 125-141.
18. Potoschi, A., Cannizzaro, L., Milazzo, A., Scalisi, M., & Bono, G. (1999). Sicilian dolphinfish (Coryphaena hippurus) fishery. *Scientia Marina*, *63*(3-4), 439-445.
19. Prato G, Gascuel D, Francour P (2016) Guidelines for monitoring high trophic level predators and trophic interactions in Mediterranean MPAs. In: MMMPA Supervisory Board (ed) *Monitoring Mediterranean Marine Protected Areas: A set of guidelines to support the development of management plans*. MMMPA European project (FP7-PEOPLE-2011-ITN grant 290056), Reef Check Italia onlus, Ancona, p 73-79 ISBN 978-88-906783-4-9

20. Romagnoli, C., Casalbore, D., Ricchi, A., Lucchi, F., Quartau, R., Bosman, A., ... & Chiocci, F. L. (2018). Morpho-bathymetric and seismo-stratigraphic analysis of the insular shelf of Salina (Aeolian archipelago) to unveil its Late-Quaternary geological evolution. *Marine Geology*, *395*, 133-151.
21. Reef Check Mediterranean Sea. (2019, September). Retrieved from https://www.reefcheckmed.org/
22. Relini G., Tunesi L. (eds) (2009) – Le specie protette del protocollo SPA/BIO (Convenzione di Barcellona) presenti in Italia. Schede descrittive per l'identificazione *Protected species according to the SPA/BIO protocol (Barcelona Convention) present in Italy. Identification sheets Biol. Mar. Mediterr*., 16 (Suppl. 2): 433 pp.
23. Serrano, O., Serrano, E., Inostroza, K., Lavery, P. S., Mateo, M. A., & Ballesteros, E. (2017). Seagrass meadows provide 3D habitat for reef fish. *Frontiers in Marine Science*, *4*, 54.
24. Tessier, A., Pastor, J., Francour, P., Saragoni, G., Crec'hriou, R., & Lenfant, P. (2013). Video transects as a complement to underwater visual census to study reserve effect on fish assemblages. *Aquatic Biology*, *18*(3), 229-241.
25. Thompson, A. A., & Mapstone, B. D. (1997). Observer effects and training in underwater visual surveys of reef fishes. *Marine Ecology Progress Series*, *154*, 53-63.
26. UNEP-MAP RAC/SPA 2010. The Mediterranean Sea Biodiversity: state of the ecosystems, pressures, impacts and future priorities. By Bazairi, H., Ben Haj, S., Boero, F., Cebrian, D., De Juan, S., Limam, A., Lleonart, J., Torchia, G., and Rais, C., Ed. RAC/SPA, Tunis; 100 pages.
27. Valisano, L., Palma, M., Pantaleo, U., Calcinai, B., & Cerrano, C. (2019). Characterization of North–Western Mediterranean coralligenous assemblages by video surveys and evaluation of their structural complexity. *Marine pollution bulletin*, *148*, 134-148.
28. Watson, R. A., Carlos, G. M., & Samoilys, M. A. (1995). Bias introduced by the non-random movement of fish in visual transect surveys. *Ecological Modelling*, *77*(2-3), 205-214.