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Unveiling the state of some underexplored deep coralligenous banks in the Gulf of Naples (Mediterranean Sea, Italy)

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HIGHLIGHTS

- ROV-videos allow to characterize the deep coralligenous habitats.
- Morphological Groups, easy to identify, detect changes in diversity and abundance.
- Increase of sediment led to a decrease of MGs abundance and coralligenous cover.
- The MGs and sediment cover are useful proxies to evaluate the coralligenous state.

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ABSTRACT

Deep coralligenous banks are remote and not yet sufficiently explored habitats, harboring several benthic species living in generally stable conditions. These high biodiversity spots, represent also refugia for numerous demersal organisms from adverse environmental conditions and provide several ecosystem functions.

Recently, the wide employ of Remotely Operated Vehicles (ROVs) as standard tools for monitoring programs has shed light on the effects of the increasing human activities and global changes on these sensitive habitats. As a consequence, the impacts of different stress conditions on the slow-growing species of coralligenous communities have become more and more evident.

In order to evaluate the status of deep coralligenous banks of Mediterranean Sea, a monitoring project was implemented to improve their knowledge, and to investigate on the principal issues characterizing these communities. In particular, ROV-video analysis revealed, among the main stressors, the increase of sediment resuspension and deposition probably due to trawl fishing, causing a decrease of coralligenous cover. The impact of this pressure leads to an overall loss of diversity and abundance, with changes in community structure and dynamics. Monitoring activities on large spatio-temporal scales are therefore very useful and needed to assess change patterns and to suggest appropriate management and conservation tools.

1. Introduction

Coralligenous habitats, made of calcareous algae and other macro and megabenthic species growth on hard bottoms of either biogenic (rhodoliths) or geologic (debris or rock) origin Ballesteros (2006), show high levels of diversity, harboring approximately 20% of Mediterranean species (Kipson et al., 2011) and exhibit great structural complexity (Garrabou et al., 2002; Ballesteros, 2006). They are among the habitats exposed to major threats in the Mediterranean Sea, being characterized by the presence of species highly sensitive to human disturbance (Bo et al., 2013, 2014). For these reasons, coralligenous bioconstructions are considered among the endangered habitats according to international agreements (Habitat Directive 92/43/CEE; SPA/BIO Protocol; Barcelona Convention; Berna Convention).

The habitat-forming species most characteristic of these zones are sponges and anthozoans, although other phyla and classes, such as mollusks, polychaete tube-worms, bryozoans, cirriped crustaceans, etc., may also have a predominant role in some cases or be a fundamental part of mixed habitats, through the formation of complex bioconstructions or large communities that provide three-dimensional structures (Aguilar et al., 2017). At great depths,

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benthic communities growth is facilitated by the influx of nutrient-rich deep waters (White et al., 2005); nevertheless the accumulation of sediment, occurring with higher rates, often prevents the growth of sessile organisms (Berelson, 2002; Balata et al., 2007a, b). Generally, deep and offshore banks are characterized by relatively stable environmental conditions and limited anthropogenic stressors (Riegl and Piller, 2003; Johnston et al., 2016), representing a local recruitment source for the shallow communities (Lesser et al., 2009). They may also harbor species from adverse conditions and may play an important role in the recovery of impacted areas (Ridgway and Hoegh-Guldberg, 2000; Bongaerts et al., 2010).

In recent years, the importance of the deep sea for biomass hotspots, habitat complexity, ecological interactions and chemosynthetic production (De Leo et al., 2010; Danovaro et al., 2014) has been proved and the conservation of this ecosystem has become of relevant interest (Rengstorf et al., 2013; Wedding et al., 2013). At the same time, these systems are becoming threatened by a combination of anthropogenic impacts, such as fishing, pollution, introductions of alien species and climate change, leading to structural and functional changes that can be evaluated only with knowledge of the present state of deep marine biodiversity (Jackson et al., 2001; Walther et al., 2002; Halpern et al., 2008).

Despite the high ecological, aesthetic and economic value of coralligenous deep banks (Tribot et al., 2016), very few studies deal with the whole animal and plant communities, including the main taxonomic groups and the most important environmental variables (Casellato and Stefanon, 2008). This gap of information is especially due to the complexity involved in studying these highly diverse systems with slow dynamics, coupled with general logistical constraints related to deep rocky habitats sampling (Kipson et al., 2011). In particular, deep sea habitats are among the less studied environments on Earth, due to their remoteness and to difficulties in observing and sampling organisms (Gage and Tyler, 1992).

Since knowledge of deep reef communities are mostly focused in the Pacific and Atlantic Oceans (Kahng and Kelley, 2007; Kahng et al., 2010; Bridge et al., 2011; Bongaerts et al., 2015), the aim of this work is the characterization of some deep coralligenous bioconstructions of the Mediterranean Sea, for a better understanding of composition and structure of deep coralligenous communities. Recent technological advances in multibeam sonar and Remotely Operated Vehicles (ROVs) have markedly improved mapping and monitoring of deep bioconstructions at a large scale, with standardized methods based on video and photo analysis. This method is used to obtain important qualitative and quantitative data on community structure and density of the deep benthic communities (Bo et al., 2009; Long and Baco, 2014; Du Preez et al., 2016; Ferrigno et al., 2017, 2018), allowing to provide guidelines for the application of a rapid, nondestructive protocol for biodiversity assessment and status (Ferrigno et al., 2017).

2. Materials and methods

2.1. Study area

This study was carried out within the marine and coastal area off Capri Island, extending to the north of Marina Grande port (Capri) towards the Sorrento peninsula, in N–E direction (Fig. 1).

Both Sorrento Peninsula and Capri Island have a carbonate-sedimentary origin and the sea bottom consisting mostly of a large muddy plain, which, off the peninsula southern coasts, fall down into the abyssal plain to about 900 m depth, through a steep continental slope (Russo, 1992, 2000). Their coasts are characterized by steep cliffs, allowing the presence and distribution of coralligenous biocoenoses, even at shallower depths (Russo, 1992, 2000).

The overall study area presents a strong economic interest due to touristic vessel traffic, more intensified in the summer season, and to small fishing activities. In particular, the area selected for the investigation shows a very high maritime traffic, due to its proximity to the port. From the biological point of view, the presence of several banks of coralligenous platform in deeper waters, is long known by local fishermen. Other information, useful for the choice of this study area, derived from some bibliographic data of the area (Russo, 1992, 2000) and from recent video-surveys aimed at assessing the presence and the status of several red coral colonies in the Gulf of Naples (Bavestrello et al., 2014).

Table 1
Position and depth of sampled sites.

Site	LON	LAT	Depth
TR 2	40°33′47.074″ N	14°14′42.666″ E	75 m
TR 3	40°33′54.431″ N	14°14′47.573″ E	79 m
TR 4	40°34′02.331″ N	14°14′48.385″ E	83 m
TR 5	40°34′10.237″ N	14°14′50.096″ E	91 m
TR 6	40°34′17.450″ N	14°14′50.916″ E	96 m
TR 7	40°34′23.678″ N	14°14′58.498″ E	99 m
TR 8	40°34′31.268″ N	14°15′07.433″ E	96 m
TR 10	40°34′40.643″ N	14°15′21.267″ E	100 m
TR 11	40°34′49.567″ N	14°15′21.168″ E	107 m
TR 12	40°34′54.785″ N	14°15′31.915″ E	107 m
TR 13	40°35′01.032″ N	14°15′38.741″ E	111 m
TR 14	40°35′09.831″ N	14°15′41.128″ E	110 m
TR 15	40°35′16.384″ N	14°15′46.008″ E	108 m
TR 17	40°35′23.739″ N	14°16′09.115″ E	100 m
TR 18	40°35′34.045″ N	14°16′10.579″ E	103 m
TR 19	40°35′38.903″ N	14°16′18.856″ E	100 m
TR 20	40°35′49.198″ N	14°16′18.519″ E	105 m
TR 21	40°35′55.238″ N	14°16′23.857″ E	96 m
TR 22	40°36′00.277″ N	14°16′33.823″ E	97 m
TR 23	40°36′03.098″ N	14°16′45.861″ E	91 m
TR 26	40°36′22.258″ N	14°17′00.517″ E	100 m
TR 29	40°36′32.915″ N	14°17′24.048″ E	104 m
TR 30	40°36′45.503″ N	14°17′12.795″ E	115 m
TR 31	40°36′43.107″ N	14°17′41.814″ E	108 m
TR 32	40°36′47.649″ N	14°17′47.960″ E	109 m

2.2. Field activities

Initially, a preliminary ROV survey was carried out in order to define the presence and the location of the coralligenous banks based on previous data and empirical knowledge of the area. Following this exploratory survey, a total of 25 sites, with a distance of 200 m from each other, were chosen along a bathymetric gradient from coastline to offshore, and monitored for a length of 250 m each. The surveys, in the same 25 sites, were conducted in November 2014, April 2015, March 2016, and January 2017, for a total of 100 ROV transects (Table 1).

Monitoring of coralligenous banks located between 75 and 115 m depth were carried out by means of a R.O.V. (Remotely Operated Vehicle). The ROV Perseus of Ageotec was used; it was equipped with HD camera (DVS-3000 high definition), 2 lights and 2 laser pointers at the fixed distance of 14.5 cm for the calculation of the images surface, and a navigation camera with underwater positioning system USBL (Ultra Short Base Line System), interfaced with the on-board navigation system, which allows to determine the real time geographical position and ROV depth. A reconstruction of the underwater routes was performed in order to replicate them in the following phases of monitoring, so to acquire useful data to assess possible future modifications of habitats induced in response to different human activities.

2.3. Data management

The area characterized by the presence of the deep hard bottom habitats was qualitatively investigated. ROV Videos were displayed using the VisualSoft® software, returning HD movies with overlay