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THE SEA CAVES OF THE MARINE PROTECTED AREA OF PORTOFINO (LIGURIAN SEA): LACK OF KNOWLEDGE AND MANAGEMENT

Abstract

*Sea caves are priority habitats in need of protection according to the Habitat Directive of the European Union and to the Mediterranean Action Plan of the United Nations Environment Programme, and most Mediterranean Marine Protected Areas (MPAs) include sea caves. The rocky cliffs of the Portofino MPA (Ligurian Sea) host a number of sea caves, which are habitual destinations for recreational scuba divers. This notwithstanding, these caves have never been the subject of dedicated studies, and no specific management plans exist. The aims of this paper are to take stock of present knowledge, to report on the results of expeditious topographic surveys of some cavities, and to provide a first inventory of the most conspicuous species that inhabit them. The sea caves of Portofino MPA are essentially rockfall and/or marine erosion cavities, with few or no speleothems due to the geological nature of the rock (conglomerate). Some of Portofino sea caves reach the surface and include an emerged part; most of them, however, are completely submerged, and open at depths that can be grouped in three levels: 7-10 m, 20-25 m, and 33-38 m. All are rather small, their lengths being mostly comprised between 10 m and 20 m. Among the conspicuous species inhabiting the caves, *Corallium rubrum*, *Homarus gammarus*, *Palinurus elephas*, and *Sciaena umbra* are of conservation interest. Dearth of knowledge, divers' safety and need of protection for habitats and species combine to claim for developing management plans for the sea caves of Portofino MPA.*

Key-words: Expeditious survey, *Corallium rubrum*, *Homarus gammarus*, *Palinurus elephas*, *Sciaena umbra*

Introduction

Mediterranean sea caves are ecosystems of great scientific interest (Bianchi *et al.*, 1996) and represent major biodiversity hot spots (Gerovasileiou & Voultziadou, 2014); yet, they are vulnerable to many anthropogenic threats (Rastorgueff *et al.*, 2015; Montefalcone *et al.*, 2018), and are therefore classified as in need of protection by the Habitat Directive of the European Union and the Mediterranean Action Plan of the United Nations Environment Programme (Giakoumi *et al.*, 2013; Gerovasileiou & Bianchi, 2021). Most Mediterranean Marine Protected Areas (MPAs) include sea caves (Abdulla *et al.*, 2008). The rocky cliffs of the Portofino MPA (Ligurian Sea) host a number of sea caves (Bavestrello *et al.*, 2022), which are well known to recreational scuba divers but have never been the subject of topographic surveys and/or detailed biospeleological studies (Canessa *et al.*, 2014). Consequently, no management plan (monitoring, access regulations, etc.) for Portofino sea caves is available.

This paper aims at: i) taking stock of present knowledge on Portofino sea caves; ii) reporting on the results of expeditious topographic surveys of some of the cavities; and

iii) providing a first inventory of the most conspicuous species that inhabit them, with special attention to those of conservation interest according to European Directives and other international agreements (Relini, 1999).

Materials and methods

Information on the sea caves of the Portofino MPA has been collated from the literature and direct field observations by scuba diving. Expeditious topographic surveys have been carried out in some of the caves, and schematic plans and sections are provided, in which depths are measured instrumentally (dive computer) while lengths and width have been estimated by eye, fin-strokes and/or arms stretch. The inventory of the most conspicuous species has been undertaken visually.

Results and Discussion

Some of the sea caves of Portofino reach the surface and include an emerged part; almost all of them are mentioned in the volume of Bixio (1987) and listed, without a cadastral number, in the census of Ferrari (2003). Most of the sea caves of the Promontory, however, are completely submerged or include a major submerged part, and are frequently visited by recreational divers. From west to east, they include (Tab. 1): the Shrimps Cave (Grotta dei Gamberi); the Dragon Tunnel (Tunnel del Dragone); the Tortonese Cave (Grotta Tortonese); the Armatum Cave (Grotta dell'Armato); the Marcante Cave (Grotta Marcante); the Ravioli Rock Caves (Grotte dello Scoglio del Raviolo) I and II; the Halocline Cavern (Caverna dell'Aloclino); the Saint George Church Cave (Grotta della Chiesa di San Giorgio); the Paraggi Castle Cave (Grotta del Castello di Paraggi); and the Paraggi Crib Grotto (Grottina del Presepe di Paraggi). Other smaller cavities, however, are widespread throughout the Promontory.

Tab. 1: Topographic features of the main submerged cavities of the Portofino Marine Protected Area, listed from west to east. Length and width measurements are approximate.

Name of the cavity	Depth (m)	Length (m)	Width (m)
Shrimps Cave	38-32	15	3
Dragon Tunnel	25-10	15	2
Tortonese Cave	10-0	20	3
Armatum Cave	24-20	10	1
Marcante Cave	36-31	10	5
Ravioli Rock Cave I	28	10	1.5
Ravioli Rock Cave II	35	10	2.5
Halocline Cavern	7-5	4	5
Saint George Church Cave	10	15	5
Paraggi Castle Cave	7-15	24	2
Paraggi Crib Grotto	20	2	2

The Shrimps Cave takes its name from the huge numbers of the unicorn striped shrimp *Plesionika narval* that find shelter in the dark part of this blind-ended cave (Fig. 1). The semi-dark portion of the cave is home to several individuals of the forkbeard *Phycis phycis*. The sponge *Axinella verrucosa* colonizes the rocky portions of the otherwise sandy pavement, while encrusting sponges (*Petrosia ficiformis* and others) and serpulid tubeworms are the main space occupiers of the walls. Schools of the cardinal fish *Apogon*

imberbis occur through the cave. The cave also harbours juveniles of the European lobster *Homarus gammarus* and of the spiny lobster *Palinurus elephas*.

P. narval is also found in the two caves of Paraggi, located at the opposite end of the Promontory. The Paraggi Castle Cave is a blind-end cavity (Fig. 1), whose walls are colonized by massive sponges, ascidians and hydrozoans in a first zone after the entrance and then by encrusting sponges, while most of the cave has almost bare walls, with serpulids only. In addition to the shrimp, the motile fauna is represented by the common prawn *Palaemon serratus*, the brown meagre *Sciaena umbra* and the cardinal fish *A. imberbis* (Bianchi & Morri, 1994). Not far from this cavity is the small Paraggi Crib Grotto, with a pavement of fine sediment and the walls covered by massive sponges. The motile fauna includes, besides *P. narval*, the golden coral shrimp *Stenopus spinosus* and the leopard-spotted goby *Thorogobius ephippiatus*. The squid *Loligo vulgaris* visits the grotto, as evidenced by the presence of the typical ootheca hanging from the ceiling (Bianchi & Morri, 1994).

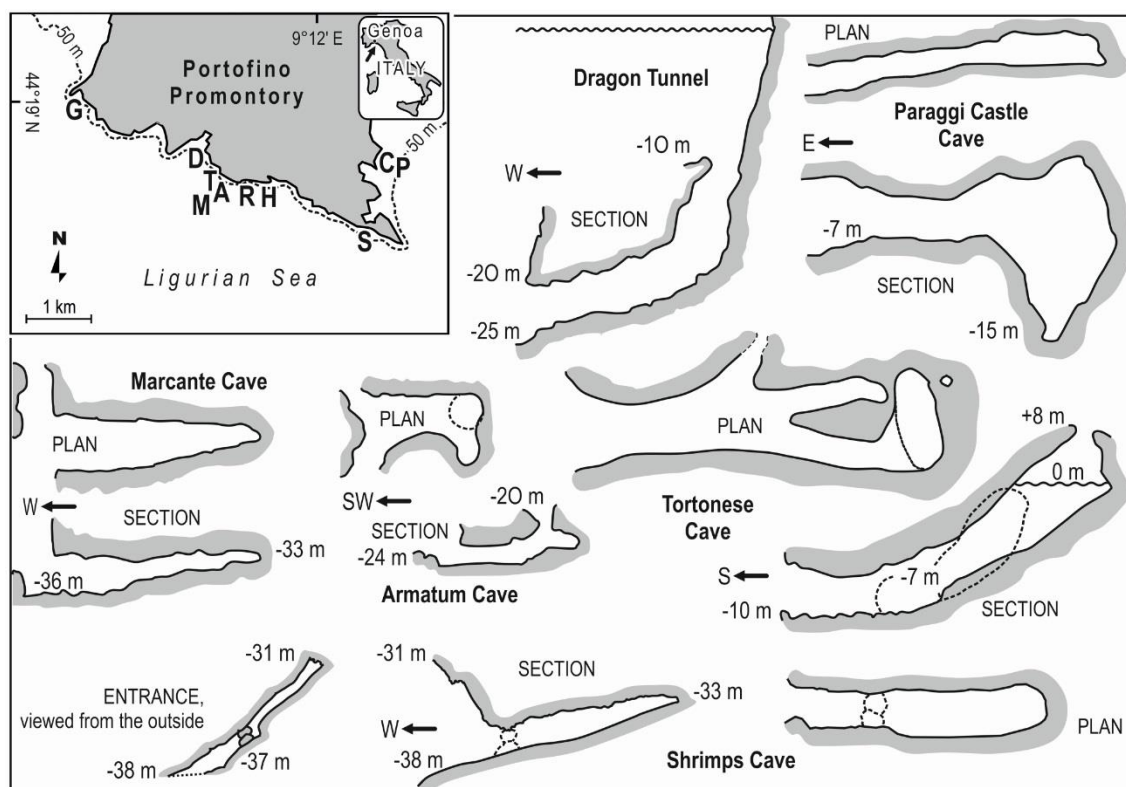


Fig. 1: Location of the main sea caves of the Portofino Promontory, and expeditious survey schemes of some of them (horizontal scale approximate). A) Armatum Cave; C) Paraggi Castle Cave; D) Dragon Tunnel; G) Shrimps Cave; H) Halocline Cavern; M) Marcante Cave; P) Paraggi Crib Grotto; R) Ravioli Rock Caves (I and II); S) Saint George Church Cave; T) Tortonese Cave.

A major system of cavities is represented by the three Dovecot Caves (Grotte delle Colombara), located at different depths on the same rock spur. The shallowest is the Tortonese Cave (Fig. 1), named in honour of Enrico Tortonese (1911-1987), who first cited it in a study on the benthos of the region (Tortonese, 1961). The yellow cluster anemone *Parazoanthus axinellae* and the calcareous sponge *Ascandra contorta* abound

at the entrance, while the ceiling is colonized by the sunset cup coral *Leptopsammia pruvoti*. In the inner part, the rock is almost bare, apart from scattered encrusting sponges. *H. gammarus*, *S. spinosus* and *A. imberbis* are the commonest motile species. The eastern branch of the cave surfaces to an inner 'lake'. The emerged walls of the lake show some modest speleothems due to the percolation of meteoric water and the vault has a window through which the sky and the terrestrial vegetation can be seen. The submerged walls are colonized only by serpulids, while the midlittoral rock of the lake is encrusted by the barnacle *Microeuraphia depressa*; *P. serratus* swims in the water. The Armatum Cave occurs deeper: is a tunnel-shaped passage between boulders (Fig. 1). The entrance arch is characterized by the abundance of the hydrozoan *Eudendrium armatum*, from which the cave takes its name. The moray eel *Muraena helena*, attended by the cleaner shrimp *Lysmata seticaudata*, may be encountered. *L. pruvoti* colonizes the ceiling, while the walls are populated by *Agelas oroides*, *P. ficiformis* and other massive or encrusting sponges; a small chamber on the eastern side of the tunnel has bare rock with scattered serpulids. The deep Marcante Cave was first mentioned by Tortonese (1958), which illustrated its location thanks to the indications of the diver Duilio Marcante (1914-1985). It is a wedge-shaped cavity (Fig. 1), which houses a rich population of the red coral *Corallium rubrum* on the ceiling (Cattaneo-Vietti *et al.*, 1993; Bavestrello *et al.*, 1994), together with *L. pruvoti* and *P. ficiformis*; the terminal portion of the cave has almost completely bare rock, with few serpulids.

C. rubrum also occurs on the ceiling of the Dragon Tunnel (Fig. 1), which is however mostly characterized by the scleractinians *L. pruvoti*, *Madracis pharensis* and *Polycyathus muelleriae*; the sponge *P. ficiformis* is also abundant. *P. phycis* takes refuge inside the tunnel.

The Halocline Cavern is a large and low blind-ended opening in the rocky cliff, which has not been surveyed yet. The biota is poor overall: the pavement is colonized by *Chondrosia reniformis* and *P. ficiformis*, the ceiling by *L. pruvoti*, the walls by *Spirastrella cunctatrix* and *Protula tubularia*. In the terminal part, the percolation of meteoric water through the cracks of the rocky cliff creates a freshwater lens floating on seawater, with a permanent halocline easily perceived by divers.

Neither topographical surveys nor faunal inventories are available for the remaining sea caves of the Portofino MPA.

Concluding remarks

Combining literature data and field observations, it has been possible to provide preliminary data on eleven main sea caves of the Portofino MPA; information on the biota inhabiting eight of them has been collated, and expeditious topographic surveys have been provided for six of them.

These caves are essentially landslide and/or marine erosion cavities, with rare or absent speleothems due to the geological nature of the rock (puddinga). The major sea caves in Liguria are located in karst areas, and originate from the marine entry into pre-existing terrestrial cavities (Canessa *et al.*, 2014).

Only a few caves reach the surface and include an emerged part; most are completely submerged, and open at depths that can be grouped into three levels: 7-10 m, 20-25 m, and 33-38 m, which may represent the outcomes of sea-level stands during the Holocene transgression.

All are quite small, mostly between 10 m and 20 m in length and only few meters wide. The small size can represent a problem for diving visitors, who may remain entrapped,

especially in presence of undertow. There have been cases of rescue intervention (three people in Tortonese Cave), and unfortunately fatalities occurred among recreational divers (four people in Saint George Church Cave).

Among the conspicuous species that inhabit the sea caves of Portofino, the red coral *Corallium rubrum*, the European lobster *Homarus gammarus*, the spiny lobster *Palinurus elephas*, and the brown meagre *Sciaena umbra* are of conservation importance, in accordance with EU directives and international agreements (Relini, 1999; Ouerghi *et al.*, 2019). This short list is surely far from complete.

Dearth of knowledge, divers' safety, and need of protection for habitats and species combine to urge the development of management plans for the sea caves of the Portofino MPA. Diving centres should be provided with maps of the caves and diving guides and instructors should be informed about the vulnerability of the cave habitat and species to visitation by divers.

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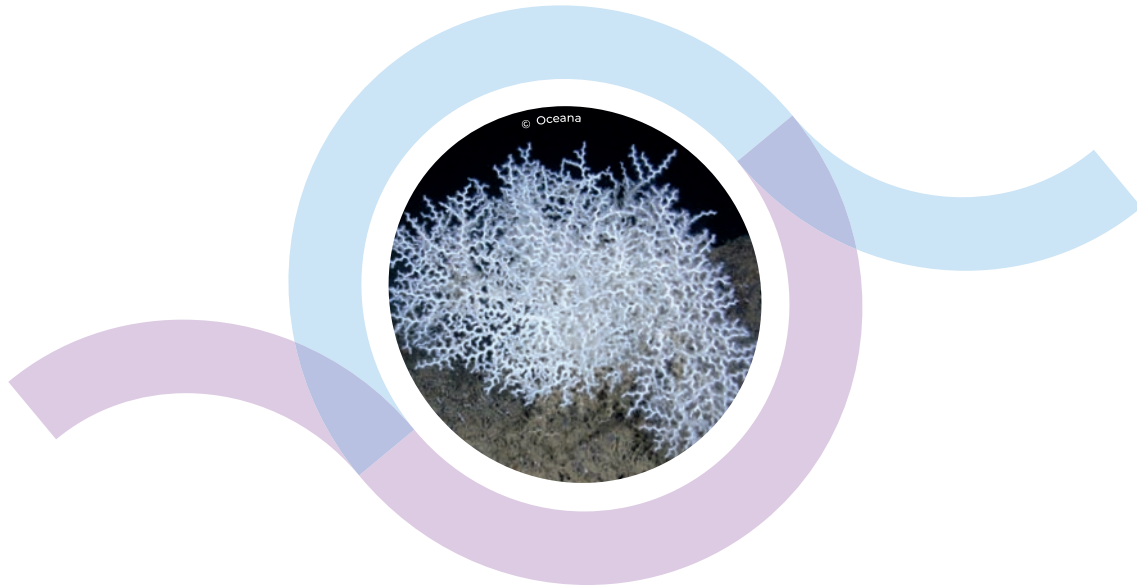


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