

Martina CANESSA, MONTEFALCONE M., CANOVAS MOLINA A., COPPO S., DIVIACCO G., BAVESTRELLO G., MORRIC., BIANCHI C.N.

DiSTAV, Dipartimento di Scienze della Terra, dell'Ambiente e della Vita, Università di Genova, Corso Europa 26, 16132 Genova, Italy

E-mail: montefalcone@dipteris.unige.it

SUBMERGED MARINE CAVES OF LIGURIA: UPDATING THE KNOWLEDGE

Abstract

Marine caves are priority coastal habitats according to the EU Habitat Directive, but they have received a comparatively lower attention with respect to other Mediterranean key coastal habitats, such as seagrass meadows and coralligenous reefs. This paper reviews and updates the existing knowledge on the underwater marine caves of Liguria, an administrative region in NW Italy. The available bibliographic information, retrieved from regional archives, grey literature and scientific publications, has been implemented with records by divers to build a database on the distribution and typology (both geological and biological) of marine underwater caves of Liguria. The database has been implemented on a GIS platform. Out of the 76 marine caves recorded along the coast, only 20 are submerged, reaching a maximum depth of 40 m. 21 caves are distributed in the Western Ligurian Riviera and 56 in the Eastern Riviera. Major caves are located in karst areas. Geological and morphological information is available for virtually all caves, whereas biological data are limited to 13 caves, and are rarely accompanied by historical series. This first attempt provides useful indications to focus future investigations, and could become a potential management tool for local administrations to protect these habitats.

Key-words: Marine caves, bibliographic information, GIS, Liguria, Mediterranean Sea.

Introduction

Submerged marine caves are today considered priority habitats according to current EU standards, including the Marine Strategy Framework Directive and the Barcelona Convention (Giakoumi *et al.*, 2013). The scientific interest that these delicate habitats received in the last 50 years, however, is not yet supported by complete and updated information for all the cavities that, being unique, require specific management measures. At national and regional level, there are few examples of detailed knowledge on the topography and the biological communities characterizing an underwater cave (e.g. Parravicini *et al.*, 2010; Gerovasileiou *et al.*, 2013), because caving and speleological tradition has always been more developed on land than at sea, due to the practical limits of the exploration of the latter (Bixio, 1987; Bianchi *et al.*, 1996).

Liguria, an administrative region in NW Italy, has a record of excellence in the state of knowledge and protection of *Posidonia oceanica* seagrass meadows (Bianchi & Peirano, 1995; Diviacco & Coppo, 2006), but today it is necessary to extend this knowledge to other priority habitats: actions are being undertaken for coralligenous reefs, whereas underwater marine caves have received to date a comparatively lower attention with respect to other Mediterranean key coastal habitats.

Materials and methods

Available information on positioning, type of survey, geology, topography and biology of each cave of Liguria, with the relevant bibliography, has been collected from regional

archives, grey literature, scientific publications, and records by divers. The database has been implemented on a GIS platform.

Getting inspiration from the method developed by Leriche *et al.* (2004), we constructed a Reliability Index (RI) to assess the quality of the information existing on each cave. Each available source of data was classified based on five items: i) positioning, ii) survey, iii) geology, iv) biology, and, v) for the latter category, data acquisition period.

For each item, a score 0 to 3 was assigned. RI, ranging from 0 to 15, was computed as the sum of all scores for each cave.

Positioning

Approximate localisation = 0

Coordinates reconstructed = 1

Coordinates provided = 2

Coordinates provided and verified = 3

Survey

No data = 0

Size and depth only = 1

Rapid survey = 2

Instrumental survey = 3

Geology

No data = 0

Indirect information = 1

General description = 2

Information on geology and genesis = 3

Biology

No data = 0

General description = 1

Quali-quantitative information = 2

Quali-quantitative information with historical series = 3

Age of biological data

No data = 0

Data more than 20 years old = 1

Data between 10 and 20 years old = 2

Data less than 10 years old = 3

Results

The database of the Ligurian marine caves was mainly built using information provided by the Land Registry of caves and karst areas of Liguria Region, containing well articulated data about the geological, morphological, and topographical aspects, updated to 2008. There are, however, gaps of knowledge about biology for almost all cavities. The book “*Sea caves: fifty years of research in Italy*” by Cicogna *et al.* (2003) provided additional cadastral information. A total of 84 sources of data, divided as shown in Fig. 1, have been collected.

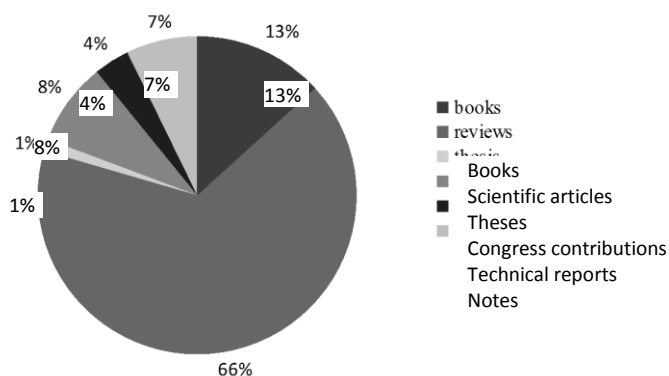


Fig. 1: Bibliographic sources used for the implementation of the database on Ligurian marine caves.

A total of 77 marine cavities are known along the coast of Liguria (Fig. 2): 21 caves are located in the Western Riviera and 56 in the Eastern Riviera; considering their distribution by administrative district, Imperia (IM) hosts 3 caves, Savona (SV) 18 caves, Genova (GE) 30 caves, and La Spezia (SP) 26 caves. Major caves are located in karst areas, and originated by marine ingression into pre-existing terrestrial cavities. Only 20 marine caves exhibit a significant submerged portion, some reaching a maximum depth of 40 m; 51 caves are semi-submerged, while 6 are undefined due to lack of information. Here we will focus on the submerged cavities only.

Geological, morphological and topographical information was found for virtually all cavities, but the biological information is available for 13 cavities only (Grotta Grande di Marina de' La Rocca, Grotta Piccola di Marina de' La Rocca, Grotta delle Sirene, Grotta Marina di Bergeggi, Grotta I di Punta Falco, Grotta dei Gamberi, Grotta I della Colombara or Grotta Tortonese, Grotta II della Colombara or Grotta dell'Armato, Grotta III della Colombara or Grotta Marcante, Grotta del Presepe di Paraggi, Grotta del Castello di Paraggi, Grotta Perora, and Fossa del Tinetto) and is rarely accompanied by historical data series.

In conclusion, the most well-studied Ligurian cavities are the two caves of Ventimiglia, i.e., the Grotta Grande and the Grotta Piccola di Marina de' La Rocca (Montefalcone, unpublished data), the Marine cave of Bergeggi, which counts the higher numbers of bibliographic references (Bianchi *et al.*, 1988; Morri *et al.*, 1994; Parravicini *et al.*, 2010; Sgorbini *et al.*, 1988; to mention scientific publications only), and the Fossa del Tinetto together with other caves of the islands of La Spezia (Chelli *et al.*, 2008; Ugolini *et al.*, 2003; and references therein). A few little-known Ligurian submarine caves have been shortly described, in terms of topography and biology, by Bianchi & Morri (1994).

Historical series of data exist only for Bergeggi, since 1974 (Bianchi *et al.*, 1988), and Ventimiglia, since 2010 (Montefalcone, unpublished data). The former allowed evaluating change due to seawater warming (Parravicini *et al.*, 2010), the latter the impact caused by the construction of a marina (Montefalcone, unpublished data).

The cavities that achieved the highest RIs are the Grotta Marina of Bergeggi, the two caves of Marina de' La Rocca, and the Fossa del Tinetto (Fig. 3).

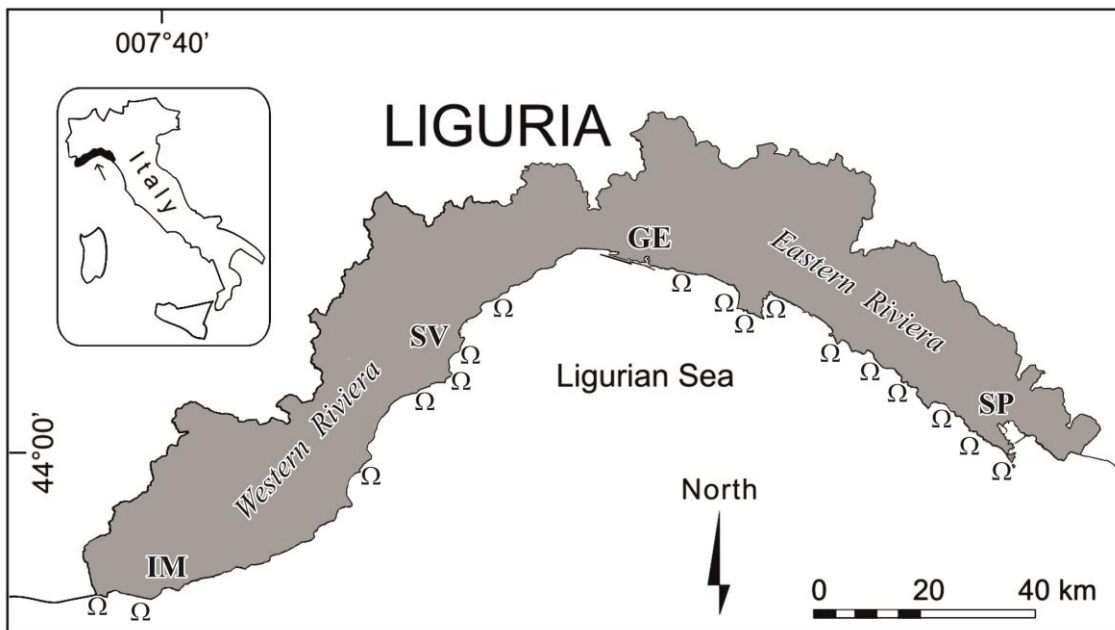


Fig. 2: Distribution of marine caves along the coasts of Liguria. Each symbol (Ω) may represent more than one cavity. IM = Imperia, SV = Savona, GE = Genova, SP = La Spezia.

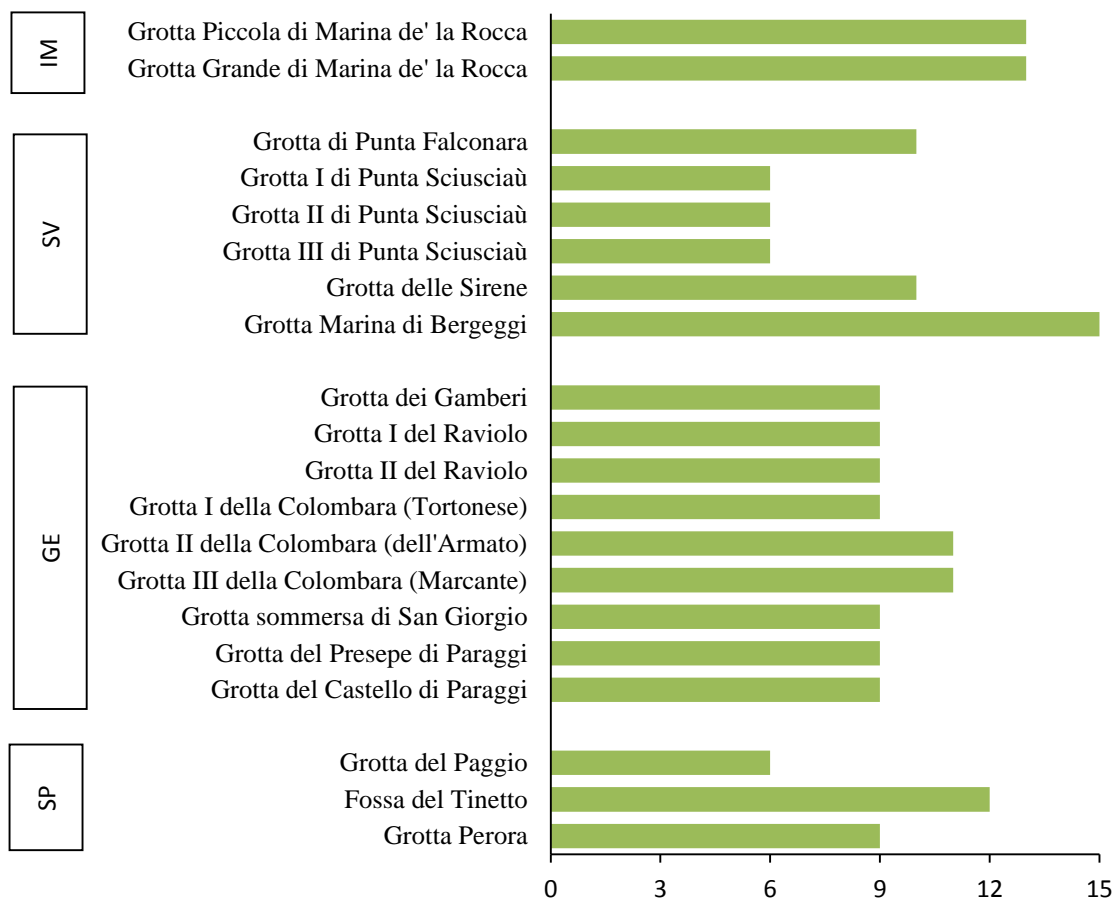


Fig. 3: Values of the Reliability Index (RI) for the Ligurian submerged caves, divided by district. IM = Imperia, SV = Savona, GE = Genova, SP = La Spezia.

Conclusions

This first attempt to assess the state of knowledge on the submarine caves of Liguria evidenced that the most important gap that should be filled in the near future concerns the biology and ecology of cave-dwelling communities. Reconnaissance surveys should be planned in those caves where no data are available, and regular monitoring activities should be carried out in caves where historical information is available, in order to obtain continuous data series that will supply useful indications on the health status of the cave communities and to highlight change in the cave ecosystem following global and local impacts.

A detailed and updated knowledge on the submarine caves of Liguria would provide the basic information for enforce protection measures, especially for those caves that today are still outside the boundaries of marine protected areas and of sites of community interest.

Bibliography

- BIANCHI C.N., CATTANEO-VIETTI R., CINELLI F., MORRI C., PANSINI M. (1996) - Lo studio biologico delle grotte sottomarine: conoscenze attuali e prospettive. *Boll. Mus. Ist. Biol. Univ. Genova*, 60-61 (1994-1995): 41-69.
- BIANCHI C.N., CEVASCO M.G., DIVIACCO G., MORRI C. (1988) - Primi risultati di una ricerca ecologica sulla grotta marina di Bergeggi (Savona). *Boll. Mus. Ist. Biol. Univ. Genova*, 52 suppl. (1986): 267-293.
- BIANCHI C.N., MORRI C. (1994) - Studio bionomico comparativo di alcune grotte marine sommerse: definizione di una scala di confinamento. *Mem. Ist. Ital. Speleol.*, 6 (2) : 107-123.
- BIANCHI C.N., PEIRANO A. (1995) - *Atlante delle fanerogame marine della Liguria: Posidonia oceanica e Cymodocea nodosa*. ENEA, Centro Ricerche Ambiente Marino, La Spezia: 146 pp.
- BIXIO R. (1987) - *Le nostre grotte. Guida speleologica ligure*. Sagep, Genova: 176 pp.
- CHELLI A., PAPPALARDO M., CALLEGARI F. (2008) - Rapporti fra livelli di carsificazione e paleo-linee di riva nelle isole del Golfo della Spezia (Liguria Orientale). *Atti Soc. Tosc. Sci. Nat., Mem.*, serie A, 113 : 25-37.
- CICOGNA F., BIANCHI C.N., FERRARI G., FORTI P., eds (2003) - Grotte marine: cinquant'anni di ricerca in Italia. *Ministero dell'Ambiente e della Tutela del Territorio*, Roma: 505 pp.
- DIVIACCO G., COPPO S. (2006) - Atlante degli habitat marini della Liguria: descrizione e cartografia delle praterie di *Posidonia oceanica* e dei principali popolamenti marini costieri. *Regione Liguria*, Genova: 205 pp.
- GEROVASILEIOU V., TRYGONIS V., SINI M., KOUTSOUBAS D., VOULTSIADOU E. (2013) - Three-dimensional mapping of marine caves using a handheld echosounder. *Mar. Ecol. Progr. Ser.*, 486 : 13-22.
- GIAKOUMI S., SINI M., GEROVASILEIOU V., MAZOR T., BEHER J., POSSINGHAM H.P., ABDULLA A., ÇINAR M.E., DENDRINOS P., GUCU A.C., KARAMANLIDIS A.A., RODIC P., PANAYOTIDIS P., TASKIN E., JAKLIN A., VOULTSIADOU E., WEBSTER C., ZENETOS A., KATSANEVAKIS S. (2013) - Ecoregion-based conservation planning in the Mediterranean: dealing with large-scale heterogeneity. *PLoS ONE*, 8(10): e76449.
- LERICHE A., BOUDOURESQUE C.F, BERNARD G., BONHOMME P., DENIS J. (2004) - A one-century suite of seagrass bed maps: can we trust ancient maps? *Estuar. Coast. Shelf Sci.*, 59 (2): 353-362.
- MORRI C., BIANCHI C.N., DEGL'INNOCENTI F., DIVIACCO G., FORTI S., MACCARONE M., NICCOLAI I., SGORBINI I., TUCCI S. (1994) - Gradienti fisico-chimici e ricoprimento biologico nella Grotta Marina di Bergeggi (Mar Ligure). *Mem. Ist. Ital. Speleol.*, 6 (2): 85-94.

- PARRAVICINI V., GUIDETTI P., MORRI C., MONTEFALCONE M., DONATO M., BIANCHI C.N. (2010) - Consequences of sea water temperature anomalies on a Mediterranean submarine cave ecosystem. *Estuar. Coast. Shelf Sci.*, 86 (2) : 276-282.
- SGORBINI S., BIANCHI C.N., DEGL'INNOCENTI F., DIVIACCO G., FORTI S., MORRI C., NICCOLAI I. (1988) Méthodologie d'une étude hydrobiologique dans la grotte marine de Bergeggi (mer Ligure). *Rapp. Comm. Int. Mer Médit.*, 31 (2) : 119.
- UGOLINI U., FERDEGHINI F., SARA G., MORRI C., BIANCHI C.N. (2003) - Indagine ecologica sulla grotta sottomarina dell'isola del Tinetto (Golfo di La Spezia, Mar Ligure orientale): dati preliminari. *Biol. Mar. Medit.*, 10 (2): 48-57.

The finding interpretation and the presentation of the material, expressed in this publication are entirely those of authors and should not be attributed to UNEP.

Les informations et la présentation des données, qui figurant dans cette publication sont celles des auteurs et ne peuvent être attribuées au PNUE.

Copyright :

© 2014 United Nations Environment Programme, Mediterranean Action Plan, Regional Activity Center for Specially Protected Areas (RAC/SPA)

© 2014 Programme des Nations Unies pour l'Environnement, Plan d'Action pour la Méditerranée, Centre d'Activités Régionales pour les Aires Spécialement Protégées (CAR/ASP)

This publication may be reproduced in whole or in part, and in any form for educational or non-profit purposes, without special permission from the copyright holder, provided acknowledgement of the source is made. No use of this publication may be made, for resale or for any other commercial purpose whatsoever, without permission in writing from UNEP.

La présente publication peut être reproduite en totalité ou en partie, et sous n'importe quelle forme, dans un objectif d'éducation et à titre gracieux, sans qu'il soit nécessaire de demander une autorisation spéciale au détenteur du copyright, à condition de faire mention de la source. La présente publication ne peut être utilisée, pour la revente ou à toutes fins commerciales, sans un accord écrit préalable du PNUE.

Citation :

UNEP/MAP – RAC/SPA, 2014. Proceedings of the 1st Mediterranean Symposium on the conservation of Dark Habitats (Portorož, Slovenia, 31 October 2014). LANGAR H., BOUAFIF C., OUERGHI A., edits., RAC/SPA publ., Tunis: 84 p.

PNUE/PAM – CAR/ASP, 2014. Actes du 1er Symposium méditerranéen sur la conservation des Habitats Obscurs (Portorož, Slovénie, 31 octobre 2014). LANGAR H., BOUAFIF C., OUERGHI A., édits., CAR/ASP publ., Tunis : 84 p