Öztürk B. (Ed.) 2019. Marine Caves of the Eastern Mediterranean Sea.
Biodiversity, Threats and Conservation. Turkish Marine Research Foundation (TUDAV)
Publication no: 53, Istanbul, Turkey.

Habitat mapping of underwater Bilge Taş Cave (Wisdom Stone Cave) in the Northeastern Mediterranean Sea: Structure and biodiversity

Cemal TURAN[1,2*], Necdet UYGUR[2,3], Mahmut İĞDE[1,2], Servet A. DOĞDU[1,2]

[1] Molecular Ecology and Fisheries Genetics Laboratory, Marine Science Department, Faculty of Marine Science and Technology, İskenderun Technical University, 31220 İskenderun, Hatay, TURKEY
[2] Nature and Science Society, Modern Evler, 303 Sok. No: 9, D: 1, İskenderun, Hatay, TURKEY
[3] Maritime Vocational School, İskenderun Technical University, İskenderun, Hatay, TURKEY

***Corresponding author:** cemal.turan@iste.edu.tr

Introduction

Marine caves constitute an ordinary highlight of the Mediterranean rough coastline. Up to date, 738 marine underwater caves were reported within the eastern Mediterranean, representing one fourth of the known Mediterranean marine underwater caves (Giakoumi *et al.* 2013). Despite that, data with respect to their biodiversity and community structure is restricted in comparison to their north-western and central Mediterranean regions (Gerovasileiou *et al.* 2016).

Mediterranean marine caves play important roles as reservoirs for the restocking of important species and have a critical environmental value in connection to function (Cicogna *et al.* 2003; Chevaldonne and Lejeusne 2003). Besides, the marine caves are considered to be a connection between closed habitats. (Rastorgueff *et al.* 2015; Bussotti *et al.* 2015). The caves also play an economically important role for a local diving center due to the high frequency of requests from divers to explore them. Management action will need to be evaluated in order to reduce and prevent the impact of recreational divers on the benthic community (Di Franco *et al*. 2009; Di Franco *et al.* 2010).

The primary logical information about the biodiversity of the eastern Mediterranean marine caves were obtained during the Calypso undertaking within the 1950s to Kastelorizo, in the Levantine Basin (Laborel 1961). Afterward, Riedl (1966) gave extra biodiversity information for Aegean caves, centering mainly on the description of uncommon and recent species (Bailey 1969; Hayward 1974; Pulitzer-Finali 1983; Voultsiadou and Vafidis 2004).

There are restricted studies about marine cave biodiversity in the Levantine Basin (Tsurnamal 1969; Tsurnamal 1975; Ben-Eliahu and Ten Hove 1992),

which gives information from the coasts of Lebanon, where a number of new species were reported (Pérez *et al.* 2004; Vacelet *et al.* 2007; Harmelin *et al.* 2009).

The objective of the current study was to describe, for the first time, the geomorphology and biodiversity of a marine cave named Bilge Taş (Wisdom Stone) in the Antakya Bay, Northeastern Mediterranean Sea, including the assessment of ecology, biodiversity and structure for the environmental management of critical habitats in the Mediterranean coast of Turkey.

Material and method

The study was carried out in 2018 in the underwater Bilge Taş Cave in the Antakya Bay, northeastern Mediterranean Sea, Turkey (Figure 1). The coordinates of the cave are (35°57'17.2"N 35°55'19.8"E).

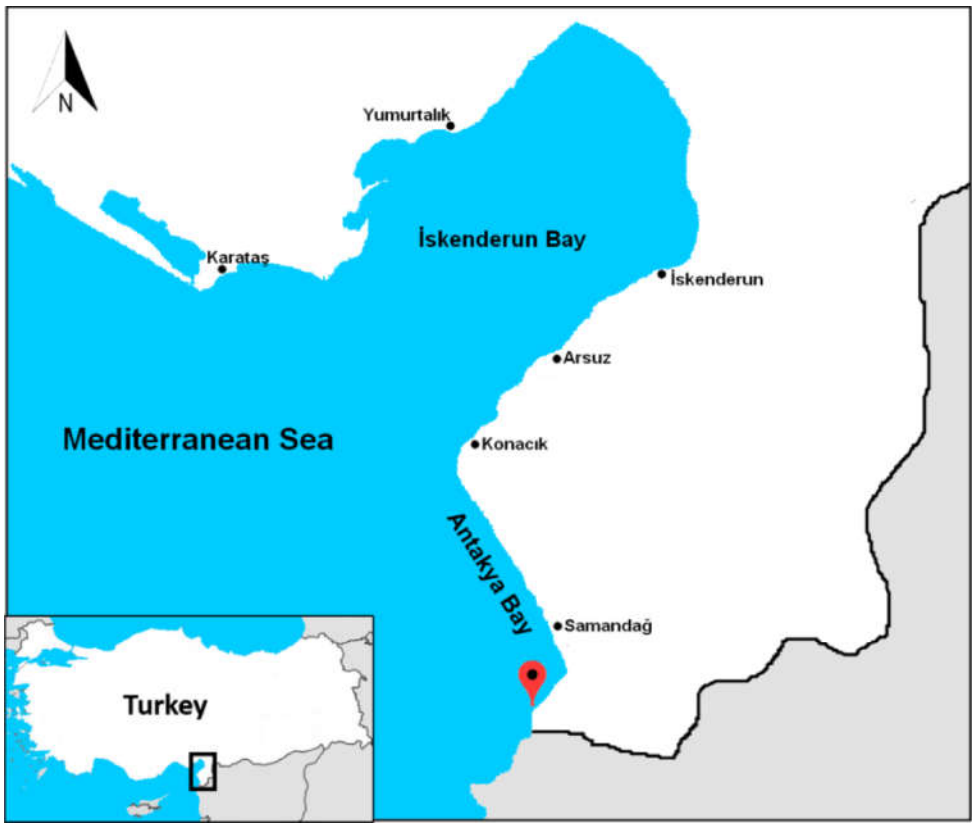

Figure 1. Location of the Bilge Taş Cave.

Nearly 30 dives have been performed since 2018, and average dive time was 45 minutes. Species sampling along the cave was carried out by visual identification, photographing and videos using three underwater cameras. During visual identification and taking videos, three 5000 lumens video lights and 2000 lumens spot lights were used for diving. The species were cross-

checked and listed with taken notes, photographs and videos by each diver after each dive. A yellow colored cord was lined along the cave at the beginning of the study in case of any loss or accident. The biggest challenge during the dives was temperature differences between the Galleries in the cave. In Gallery 3, there is a freshwater spring which is 21-22℃ along the year that negatively affects diving comfort. During summer, the water temperature is 28℃ in the entrance of the cave. In winter, it is reversed, the water temperature in the entrance of the cave is about 16℃, and 21℃ in the Gallery 3. Therefore, divers should be ready for temperature shock during dives in the cave.

Geomorphological depictions of the Bilge Taş Cave were carried out with classic topographical and hydrobiological techniques comprising dimensional mapping (Ereskovsky *et al.* 2013; Ereskovsky *et al*. 2016). The coordinates of the Bilge Taş Cave passages were described with a dive watch. The cave depths were instantly measured with a diving gauge. Two divers used underwater meters in cooperation to measure the dimensions of tunnels, domes and other parts. Underwater topographic mapping was carried out with length measured between the entrance and the end of the cave, then navigation survey was followed with an underwater compass. Distribution of species mapping along the cave was carried out using R studio.

Result

Bilge Taş Cave is structured as entrance and 3 galleries. The entrance of the cave is surrounded with sandy ground but the interior of the cave ground was rocky. Width and depth of the cave were measured as 38 m and 27 m for entrance, 33 m - 25 m for gallery_1,33 m and 27 m for gallery_2 and 32 m and 12 m for gallery_3, respectively (Figure 2, 3).

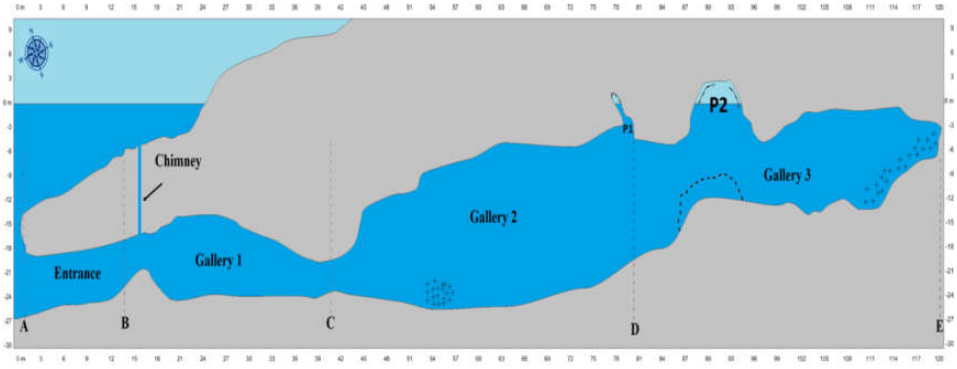

Figure 2. Side profile of the Bilge Taş Cave in the Antakya Bay, Northeastern Mediterranean Sea. P1 and P2, Air pocket; +, small rocks.

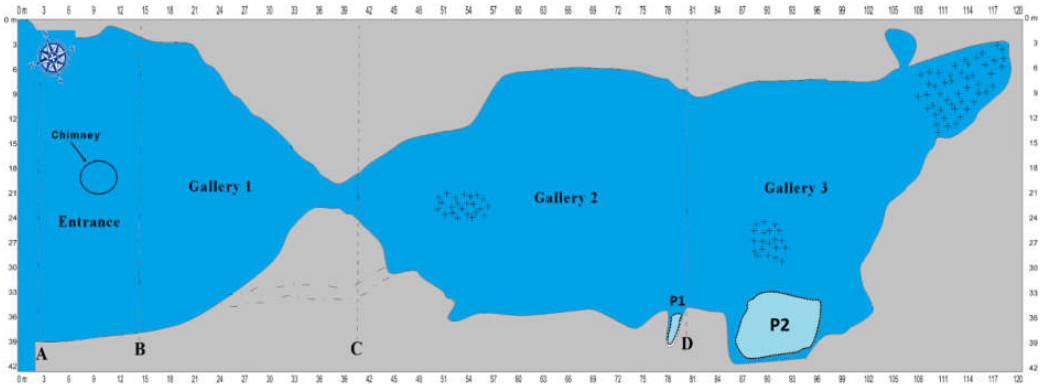

Figure 3. Top view of the Bilge Taş Cave in the Antakya Bay, Northeastern Mediterranean Sea. P1 and P2, Air pocket; +, small rocks.

The length of the cave was measured as 120 m. Moreover, there is 1 chimney in the entrance of the cave which is very narrow and has sun lights. There are also 2 air pockets (P1 and P2, Figure 2,3) in gallery_2 and gallery_3. A total of 27 species were identified in the studied cave, specifically 13 fish, 2 sponges, 4 crustaceans, 4 cnidarians and 4 echinoderms (Table 1).

Side profile and top view of the Bilge Taş Cave in the Antakya Bay, Northeastern Mediterranean Sea are presented in Figure 2 and Figure 3 respectively. The cave can be divided in four sections: entrance, gallery_1, gallery_2 and gallery_3. Moreover, the cave includes two internal air pockets as well as one chimney in the entrance (Figure 3). In the entrance of the cave, 23 species were observed, while the number of species decreased towards to interior of the cave.

For the taxonomic diversity, Pisces were the highest observed with 48%, Porifera species were lowest with 7% (Table 2).

For the origin of the species observed in the cave, Atlantic and Mediterranean originated species were highest (58%), however, non-indigenous species of Indo-Pacific origin was recorded 31% of the species in comparison to the indigenous species. Some observed species belonging to different Phylums in the Bilge Taş Cave are given at Figure 4. Two Porifera species (*Haliclona* sp. and *Axinella* sp.) were unspecified at the species level.

Table 1. List of taxa recorded in the Bilge Taş Cave. Cave zones are given at Figure. 1. U: origin Unidentifed; A, Atlantic Ocean; IP, Indo-Pacific; C, Cosmopolitan; *, Threatened (IUCN)

Species	Entrance	Gallery_1	Gallery_2	Gallery_3	Origin
Kingdom Animalia					
Subphylum Vertebrata					
Superclass Pisces					
Sargocentron rubrum (Forsskal, 1775)	x	x			IP
Pagrus caeruleostictus (Valeneiennes, 1830)		x	x	x	A
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	x	x	x		A
**Sciaena umbra* Linnaeus, 1758	x	x	x	x	A
Mycteroperca rubra (Bloch, 1793)	x	x			A
Pempheris rhomboidea (Kossmann & Räuber, 1877)	x	x	x		IP
Apogon imberbis (Linnaeus, 1758)	x	x	x		A
**Dasyatis pastinaca* (Linnaeus, 1758)		x			A
Epinephelus costae (Steindachner, 1878)	x	x			A
Parupeneus forsskali (Fourmanoir & Guézé, 1976)	x	x			IP
Cheilodipterus novemstriatus (Rüppell, 1838)	x				IP
Torquigener flavimaculosus Hardy & Randall, 1983	x	x			IP
**Umbrina cirrosa* (Linnaeus, 1758)		x			A
Phylum Porifera					
Axinella sp.	x	x			U
Haliclona sp.	x	x	x		U

Table 1. Continued

Phylum Arthropoda					
Subphylum Crustacea					
Scyllarides latus (Latreille, 1802)	x	x	x		A
Plesionika narval (Fabricius, 1787)		x	x	x	C
Diogenes pugilator (Roux, 1829)	x	x			A
Saron marmoratus (Olivier, 1811)	x				IP
Phylum Cnidaria					
Cerianthus membranaceus (Gmelin, 1791)	x				A
Aglaophenia octodonta Heller, 1868	x				A
Actinia equina (Linnaeus, 1758)	x	x			C
Anemonia sulcata (Pennant, 1777)	x				A
Phylum Echinodermata					
Arbacia lixula (Linnaeus, 1758)	x				A
Sphaerechinus granularis (Lamarck, 1816)	x				A
Echinaster sepositus Retzius, 1783	x				A
Diadema setosum Leske, 1778	x				IP

Table 2. Taxonomic diversity and origin of species observed in the Bilge Taş Cave.

Taxonomic Diversity		Origin			
Taxonomic Group	**Total**	**Atlantic Species**	**Indo-Pacific Species**	**Cosmopolitan Species**	**Unidentifed at Species level**
Pisces	13	8	5	-	-
Porifera	2	-	-	-	2
Crustacea	3	2	1	-	-
Echinodermata	4	3	1	-	-
Cnidaria	4	3	-	1	-
Total	**27**	**16**	**8**	**1**	**2**

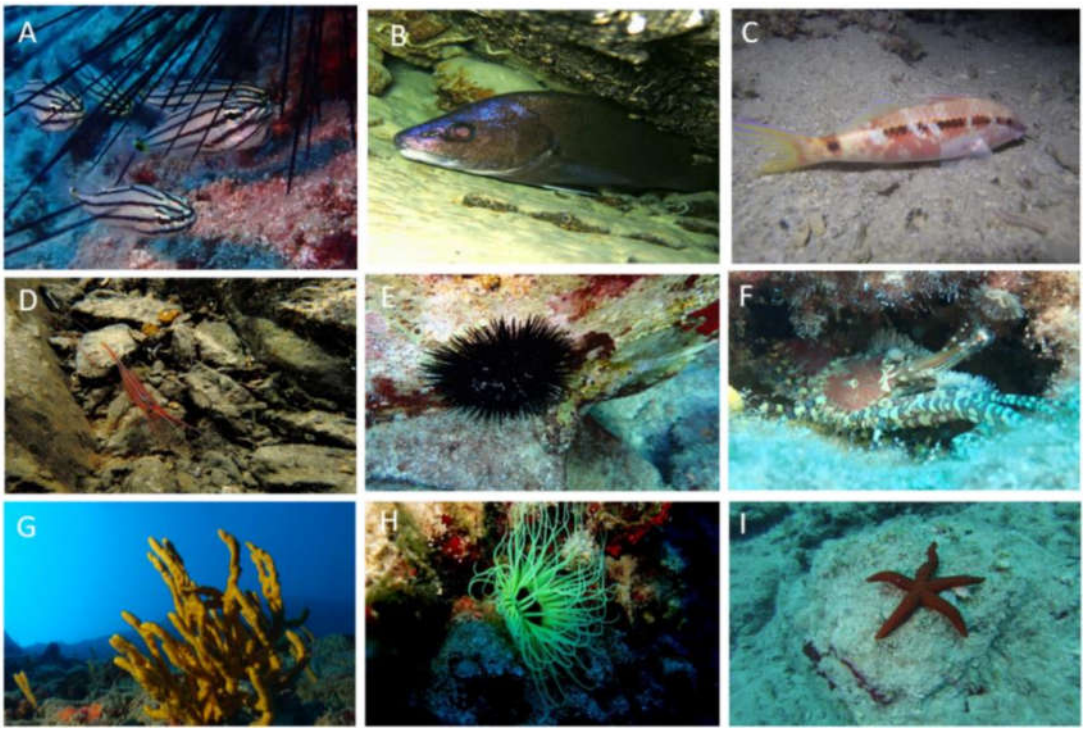

Figure 4. Some observed species from the Bilge Taş Cave. **A:** Cheilodipterus novemstriatus, **B:** *Sciaena umbra*, **C:** *Parupeneus forsskali*, **D:** *Plesionika narval*, **E:** *Arbacia lixula*, **F:** *Saron marmoratus*, **G:** *Axinella* sp., **H:** *Cerianthus membranaceus* and **I:** *Echinaster sepositus*.

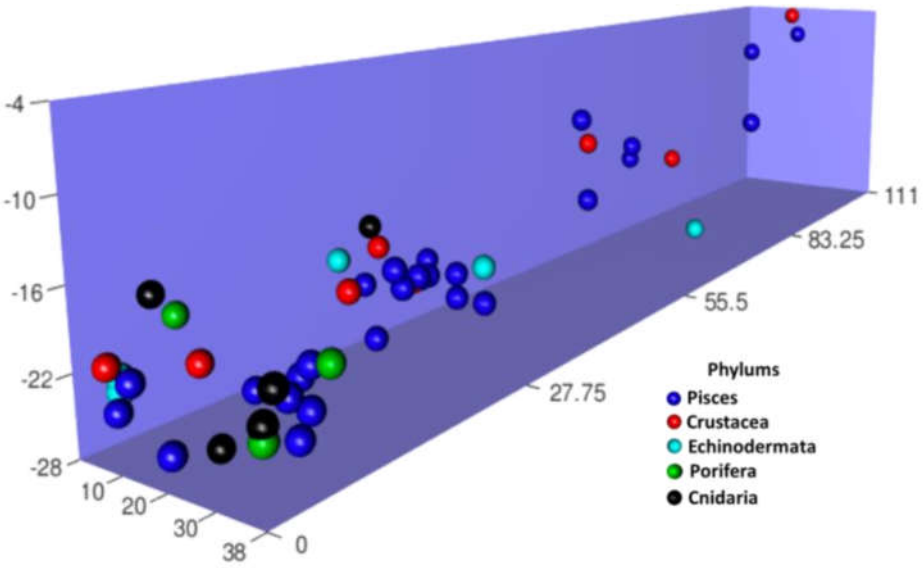

Figure 5. Distribution and location of the Phylums along the underwater Bilge Taş Cave. The dimension of the figure box is given as actual size of the cave as meter.

Distribution of the Phylums along the cave was given in Figure 5. In the entrance of the cave, relatively many species were observed, while the number of species decreased towards to interior of the cave. Porifera species were only observed at the entrance of the cave but were not observed in other parts of the cave. The species were generally observed at the bottom layer of the cave. Fish and crustacean species were monitored commonly in the most interior part of the cave.

Discussion

Caves are morphologically complex ecosystems with strong environmental gradients (Gerovasileiou and Voultsiadou 2012). The caves are generally administered with restricted studies in the eastern Mediterranean in comparison to the western Mediterranean, just about one study per year for the eastern basin, versus five studies per year for the Mediterranean (Gerovasileiou and Voultsiadou 2012; Gerovasileiou *et al.* 2015).

This study on the Bilge Taş Cave is just a preliminary study that surveys biodiversity and habitat mapping in the Mediterranean coast of Turkey. In total, 27 species were reported from the cave, of which 8 Indo-Pacific non-indigenous species (31%) inhabit the cave. In another cave study, Bussotti (2003) and Bussotti and Guidetti (2009) described a list of 34 fish species from three caves placed within the northwestern Ionian Sea (Bussotti *et al.* 2017). This percentage is higher compared to the Atlantic-Mediterranean species (55%). There is an increasing trend in the number of non-indigenous species in this region (Turan *et al.* 2016; Gerovasileiou *et al.* 2016; Doğdu *et al.* 2016;

Erguden *et al.* 2018 and Turan *et al*. 2018) which indicate that the effects of the climate change and nonindigenous species on the cave habitats in this region should be further investigated.

In similar studies, alien species were observed quite a lot at the entrance and semi dark zones in the Mediterranean caves (Gerovasileiou *et al.* 2016), indicating that dark caves are acceptable as highly selective habitats (Harmelin 1985; Bianchi and Morri 1994; Bussotti and Guidetti 2009; Gerovasileiou *et al*. 2016).

The present study contributes to fill the gap on underwater cave information as a sensitive habitat in the north-eastern Mediterranean. Moreover, one more important finding in the present study concerns the pattern of species diversity and the related possible conservation measures about some fish species such as *Sciana umbra*, *Umbrina cirrosa* and *Dasyatis pastinaca* that were represented on IUCN the Red List (IUCN 2018) and observed in Bilge Taş Cave. Therefore, the cave habitats can be helpful to protect these species and may be considered as marine protected areas (MPAs). Moreover, on account of ecological importance, Bilge Taş Cave in which endangered species live should be recognised as priority habitat for conservation purposes. A monitoring program in this cave should also be conducted in future conservation plans, in order to contribute to the underwater cave biodiversity in the north-eastern Mediterranean.

In conclusion, this study provides first information on marine species diversity and structure in underwater caves in the Mediterranean coast of Turkey, especially, endangered species according to IUCN inhabit caves that indicate conservation of cave biodiversity. Therefore, these important underwater marine caves should be prioritized for considering future MPAs and inclusion oin themarine special management plans for the Mediterranean coasts of Turkey.

Acknowlements

We thank Nature and Science Society (www.dogavebilim.com) for financial support of the project (Mapping of Marine Sensitive Areas in the northeastern Mediterranean).

References

Bailey, J.H. (1969) Spirorbinae (Polychaeta: Serpulidae) from Chios (Aegean Sea). *Zoological Journal of the Linnean Society London* 48: 363-385.

Ben-Eliahu, M.N., Ten Hove, H.A. (1992) Serpulids (Annelida: Polychaeta) along the Mediterranean coast of Israel new population build-ups of Lessepsian migrants. *Israel Journal of Zoology* 38: 35-53.

Bianchi, C.N., Morri, C. (1994) Studio bionomico comparativo di alcune grotte

marine sommerse: definizione di una scala di confinamento. *Mem Istit Ital Speleolog* 6(Suppl 2): 107-123.

Bussotti, S. (2003) Variabilità spazio-temporale di popolamenti bentonici ed ittici di fondo duro in ambienti di grotte marine della Penisola Salentina (Puglia Meridionale), Ph.D. Thesis. Università di Siena, 129 p.

Bussotti, S., Di Franco, A., Francour, P., Guidetti, P. (2015) Fish assemblages of Mediterranean marine caves. *PloS one* 10: e0122632.

Bussotti, S., Di Franco, A., Pey, A., Vieux-Ingrassia, J.V., Planes, S., Guidetti, P. (2017) Distribution patterns of marine cave fishes and the potential role of the cardinal fish Apogon imberbis (Linnaeus, 1758) for cave ecosystem functioning in the western Mediterranean. *Aquatic Living Resources* 30:15.

Bussotti, S., Guidetti, P. (2009) Do Mediterranean fish assemblages associated with marine caves and rocky reefs differ? *Estuarine Coastal and Shelf Science* 81: 65-73.

Chevaldonne, P., Lejeusne, C. (2003) Regional warming-induced species shift in North-West Mediterranean marine caves. *Ecology Letters* 6: 371-379.

Cicogna, F., Bianchi, C.N., Ferrari, G., Forø, P. (Eds) (2003) Grotte Marine: Cinquant'anni Di Ricerca in Italia. Ministero dell'ambiente e della tutela del territorio. Roma, 505 p.

Di Franco, A., Ferruzza, G., Baiata, P., Chemello, R., Milazzo, M. (2010) Can recreational scuba divers alter natural gross sedimentation rate? A case study from a Mediterranean deep cave. *ICES Journal of Marine Science* 67: 871-874.

Di Franco, A., Milazzo, M., Baiata, P., Tomasello, A., Chemello, R. (2009) Scuba diver behaviour and its effects on the biota of a Mediterranean Marine Protected Area. *Environmental Conservation* 36(1): 32-40.

Doğdu, S.A., Uyan, A., Uygur, N., Gürlek, M., Ergüden, D., Turan C. (2016) First record of the Indo-Pacific striped eel catfish, *Plotosus lineatus* (Thunberg, 1787) from Turkish marine waters. *Natural and Engineering Sciences* 1(2): 25-32.

Ereskovsky, A., Kovtun, O.A., Pronin, K.K. (2013) Marine underwater caves of Tarkhankut Peninsula (Black Sea, Ukraine), its biota with emphasis on sponges fauna. In: Commission Internationale pour l'exploration scientifique de la mer Méditerranée (CIESM) 40th Congress.

Ereskovsky, A.V., Kovtun, O.A., Pronin, K.K. (2016) Marine cave biota of the

Tarkhankut Peninsula (Black Sea, Crimea), with emphasis on sponge taxonomic composition, spatial distribution and ecological particularities. *Journal of the Marine Biological Association of the United Kingdom* 96: 391-406.

Erguden, D., Uygar, N., Ayan, O., Gürlek, M., Uyan, A., Karan, S., Doğdu, S.A., Turan, C. (2018) First record marbled shrimp *Saron marmoratus* (Olivier, 1811) from Turkish marine waters. *Natural and Engineering Sciences* 3(2): 141-146.

Gerovasileiou, V., Chintiroglou, C., Vafidis, D., Koutsoubas, D., Sini, M., Dailianis, T., Issaris, Y., Akritopoulou, E., Dimarchopoulou, D., Voutsiadou, E. (2015) Census of biodiversity in marine caves of the eastern Mediterranean Sea. *Mediterranean Marine Science* 16(1): 245-265.

Gerovasileiou, V., Voultsiadou, E. (2012) Marine caves of the Mediterranean Sea: a sponge biodiversity reservoir within a biodiversity hotspot. *PLoS One* 7(7): e39873.

Gerovasileiou, V., Voultsiadou, E., Issaris, Y., Zenetos, A. (2016) Alien biodiversity in Mediterranean marine caves. *Marine Ecology* 37(2): 239-256.

Giakoumi, S., Sini, M., Gerovasileiou, V., Mazor, T., Beher, J. (2013) Ecoregion-based conservation planning in the Mediterranean: Dealing with large-scale heterogeneity. *PLoS ONE* 8: e76449.

Harmelin, J.G. (1985) Les Grottes Sous-Marines Obscures: Un Milieu Extrême Et Un Remarquable Biotope Refuge. *Téthys* 11: 214-229.

Harmelin, J.G., Bitar, G., Zibrowius, H. (2009) Smittinidae (Bryozoa, Cheilostomata) from coastal habitats of Lebanon (Mediterranean Sea), including new and non-indigenous species. *Zoosystema* 31: 163-187.

Hayward, P.J. (1974) Studies on the Cheilostome Bryozoan Fauna of the Aegean Island of Chios. *Journal of Natural History* 8(4): 369-402.

IUCN (2018) The IUCN Red List of Threatened Species. Version 2018-2. http://www.iucnredlist.org (Downloaded on 14 Nov 2018).

Laborel, J. (1961) Le Concrétionnement Algal "Coralligène" Et Son Importance Géomorphologique En Méditerranée. *Recueil des Travaux de la Station Marine d'Endoume* 23(37): 37-60.

Pérez, T., Vacelet, J., Bitar, G., Zibrowius, H. (2004) Two new lithistids (Porifera: Demospongiae) from a shallow eastern Mediterranean Cave (Lebanon). *Journal of the Marine Biological Association of the United Kingdom* 84: 15-24.

Pulitzer-Finali, G. (1983) A collection of Mediterranean demospongiae (Porifera) with, in appendix, a list of the demospongiae hitherto recorded from the Mediterranean Sea. *Annali del Museo civico di storia naturale Giacomo Doria* 84: 445-621.

Rastorgueff, P.A., Bellan-Santini, D., Nike Bianchi, C., Bussotti, S., Chevaldonné, P., Guidetti, P., Harmelin, J.G., Montefalcone, M., Morri, C., Perez, T., Ruitton, S., Vacelet, J., Personnic, S. (2015) An ecosystem-based approach to evaluate the ecological quality of Mediterranean undersea caves. *Ecological Indicators* 54: 137-152.

Riedl, R. (1966) Biologie der Meereshöhlen: Topographie, Faunistik und Ökölogie eines unterseeischen Lebensraumes: eine Monographie: mit 328 Abbildungen im Text und 16 Farbtafeln. Paul Parey.

Turan, C., Erguden, D., Gürlek, M. (2016) Climate change and biodiversity effects in Turkish Seas. *Natural and Engineering Sciences* 1(2): 15-24.

Turan, C., Gürlek, M., Başusta, N., Uyan, A., Doğdu, S., Karan, S. (2018) A checklist of the non-indigenous fishes in Turkish marine waters. *Natural and Engineering Sciences* 3(3): 333-358.

Tsurnamal, M. (1969) Four new species of Mediterranean demospongiae and new data on *Callites lacazii* Schmidt. *Cahiers de Biologie Marine* 10: 343-357.

Tsurnamal, M. (1975) The calcareous sponges of shallow habitats along the Mediterranean Coast of Israel. *Israel Journal of Zoology* 24(3-4): 137-153.

Vacelet, J., Bitar, G., Carteron, S., Zibrowius, H., Pérez, T. (2007) Five new sponge species (Porifera: Demospongiae) of subtropical or tropical affnities from the coast of Lebanon (Eastern Mediterranean). *Journal of the Marine Biological Association of the United Kingdom* 87: 1539-1552.

Voultsiadou, E., Vafdis, D. (2004) Rare sponge (Demospongiae, Porifera) from the Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 84: 593-598.