A novel approach for Mediterranean monk seal conservation: an artificial ledge in a marine cave

EZGI SAYDAM, HARUN GÜÇLÜSOY and ZAFER ALI KIZILKAYA

Abstract The Mediterranean monk seal *Monachus monachus*, categorized as Endangered on the IUCN Red List, comprises 600–700 individuals in the eastern Mediterranean Sea and eastern Atlantic Ocean. Habitat degradation is a severe threat to the species. In 2016 and 2017, coastline surveys were conducted in Gökova Bay, south-west Turkey, to identify suitable monk seal habitat. A significant factor hindering recovery of the monk seal population of this Turkish coast and the nearby Greek islands is the limited number of marine caves suitable for resting and/or pupping. We identified four caves as possible monk seal resting and pupping caves. An additional cave with all essential features for seal usage except a ledge was also identified. An artificial ledge was built in this cave in July 2019 and seal usage was monitored by camera trap until September 2020. A total of 405 camera-trap events were analysed to examine presence of any monk seals on the ledge, and to understand the purpose (resting and/or pupping), frequency of use, sex and age group of any individuals using the cave. One juvenile used the cave four times for resting (420 minutes in total), predominantly nocturnally. This is the first construction of a dry ledge in a cave of this kind for monk seals. The camera recordings suggest this approach could provide habitat for this species in areas where there is insufficient dry protected area on land.

Keywords Camera trap, Endangered species, Gökova Bay, marine cave, Mediterranean monk seal, *Monachus monachus*, monitoring, Turkey

The Mediterranean monk seal *Monachus monachus* is categorized as Endangered on the IUCN Red List, with a total of 600–700 individuals in three known subpopulations distributed across the eastern Atlantic and the eastern Mediterranean coasts (Karamanlidis & Dendrinos, 2015). The largest subpopulation in the eastern Mediterranean comprises 350–450 individuals (Karamanlidis et al., 2019). Approximately 100 of these are in the coastal waters of Turkey (Güçlüsoy et al., 2004), 14 in north-west and southern Cyprus (Nicolaou et al., 2019) and seven in northern Cyprus (Beton et al., 2021). The species is subject to multiple anthropogenic threats, including deliberate killings and the entanglement of subadults in fishing nets. However, the most significant threats to monk seals in the eastern Mediterranean are habitat deterioration, destruction and fragmentation (Karamanlidis et al., 2019).

Suitable marine cave habitats are essential for monk seals to haul out and rest or raise pups. Here we investigate the provision of artificial habitat for monk seals. There have been trials of a similar approach for other species: e.g. nest-boxes for the European roller *Coracias garrulus* (Monti et al., 2019), nesting platforms for the white stork *Ciconia ciconia* (Döndüren, 2015) and man-made snowdrifts for Saimaa ringed seals *Phoca hispida saimensis* (Auttila, 2015).

Gökova Bay in the eastern Aegean Sea, on the south-west Mediterranean coast of Turkey (Fig. 1) has a marine area of 1,851 km², with diverse marine habitats important for multiple species (Ünal et al., 2015). It comprises both Gökova and Datça-Bozburun Special Environmental Protection Areas (Güçlüsoy, 2015). Datça-Bozburun consists of two peninsulas, Reşadiye (Datça) Peninsula and Bozburun Peninsula, and with a total marine area of 737 km² it is the largest Special Environmental Protection Area in the Turkish Mediterranean Sea (Güçlüsoy, 2015). Prior to this study, there had been no camera-trap monitoring of Mediterranean monk seals in Gökova Bay.

During 2016–2017 we surveyed Mediterranean monk seal habitat along most of Gökova Bay's 322 km coastline (Saydam & Güçlüsoy, 2019), and interviewed local fishers and sailors to identify the locations of any marine caves potentially suitable for Mediterranean monk seals to breed and rest. We examined potential caves by snorkelling (Karamanlidis et al., 2004; Dendrinos et al., 2007), and we installed camera traps in the four suitable caves located.

In October 2017, we discovered one marine cave without a dry ledge that was otherwise suitable for seals and could potentially provide protection from inclement weather. An area within the cave suitable for the construction of an artificial ledge, at the end of the cave (Fig. 2, Plate 1a), did not have any marine habitat formations that would require the cave to be otherwise protected (Öztürk, 2019). We constructed the artificial ledge during 22–24 June and 20 July 2019. The final level of the ledge was designed to be 10 cm above sea level during high tide, to keep the ledge dry in rough weather.

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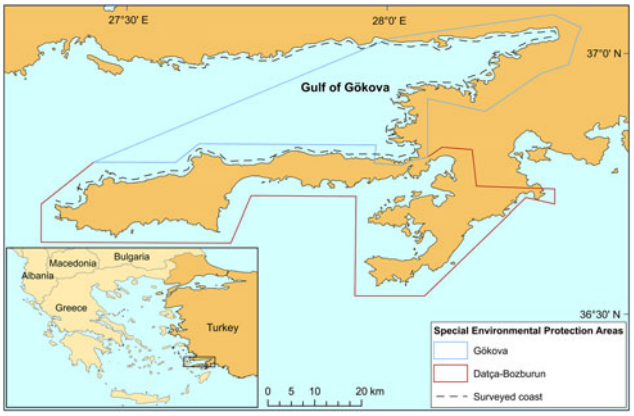
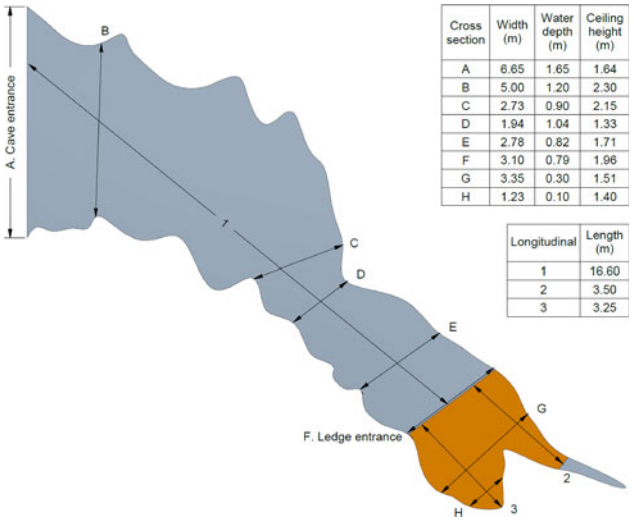


FIG. 1 The location of the Gökova and Datça-Bozburun Special Environmental Protection Areas in the eastern Mediterranean, and the 322 km length of coastal area Gökova Bay surveyed. The exact locations of the caves mentioned in this article are not provided, for the security of the species.



Cross section	Width (m)	Water depth (m)	Ceiling height (m)
A	6.65	1.65	1.64
B	5.00	1.20	2.30
C	2.73	0.90	2.15
D	1.94	1.04	1.33
E	2.78	0.82	1.71
F	3.10	0.79	1.96
G	3.35	0.30	1.51
H	1.23	0.10	1.40

Longitudinal	Length (m)
1	16.60
2	3.50
3	3.25

FIG. 2 The dimensions of the marine cave in which the ledge was constructed (Plate 1).

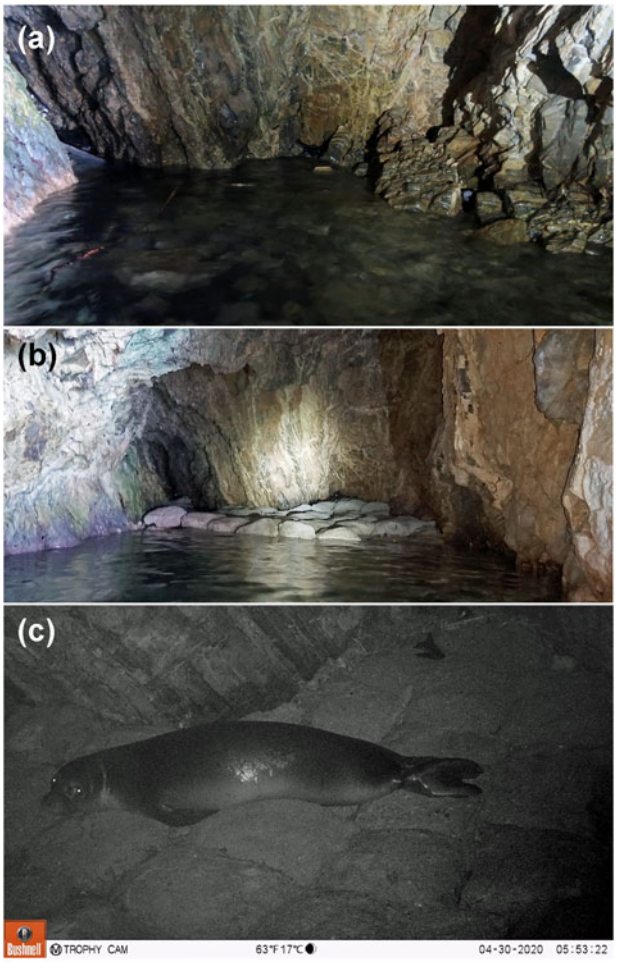


PLATE 1 (a) The cave (Fig. 2) prior to construction of the dry ledge, (b) following construction of the ledge, and (c) a juvenile monk seal *Monachus monachus* using the ledge.

Jute sacks, with a volume of c. 27 l, filled with a sand and cement mixture at a ratio of c. 350 kg of pozzolanic cement (TS EN 197-1 CEM IV/B (P) 32.5 N) to 1 m^3 gravelly sand, boulders and crushed stone were transferred by truck to a loading point 11 km from the cave. We transported all materials on an 8.5 m fishing boat to the cave entrance. The boulders weighing 10–25 kg each, and crushed stone, were transferred in a rigid inflatable boat to the opening of the narrow chamber of the cave and then moved in large buckets or by hand. The boulders (filling a total area of 4 m^3) were laid as the foundation and 300 kg of crushed stone was used to fill the spaces between them. The jute sacks were then transported from the fishing boat by a canoe to the ledge location, to keep them dry. A total of 120 jute sacks were laid on the foundation, to become wet and thus for the sand and cement mixture to set (Plate 1b).

During 24 June 2019–17 September 2020 we monitored the cave using a camera trap, visiting once every 2 months to download any recordings and replace batteries. The camera was set in hybrid-mode, to take three consecutive photographs and a 15-s video for each trigger. The recordings from the 405 events were analysed to determine any use of the cave by seals, and the purpose (resting and/or pupping), frequency of use, and to identify the sex and age group of any seals (Samaranch & González, 2000).

The recordings revealed that a monk seal first used the artificial ledge 8 months after construction (Table 1, Plate 1c) and on three additional occasions (Table 2), with the longest stay nearly 5 h. Its size, inferred relative to the dimension of the jute sacks, and morphology indicated it was a juvenile. It mostly used the cave nocturnally (Table 1). The proximity of other caves suitable for seals in Gökova Bay (c. 20 km and 84 km away) may have contributed to the discoverability of the ledge by monk seals.

Table 1 Details of the camera-trap recordings from the cave (Figs 1 & 2, Plate 1) in which we constructed a ledge for the monk seal *Monachus monachus*. Each event comprises three images (taken at 1-s intervals) and one 15-s video.

	Nocturnal triggers	Diurnal triggers
Total number of triggered events	252	153
Number of seal-triggered events	45	14
Total recordings (s)	4,536	2,754
Seal recordings (s)	810	252

Table 2 Details of the use of the marine cave by a juvenile monk seal.

Date	Entry time	Exit time	Duration of cave use
24 March 2020	04.09.40	09.05.53	4 h 56 min 13 s
30 April 2020	05.53.20	06.45.44	52 min 24 s
10 May 2020	02.14.40	02.48.49	34 min 9 s
13 May 2020	05.19.39	05.57.16	37 min 37 s

This intervention was the first construction of an artificial dry ledge in a marine cave for Mediterranean monk seals, and the first to provide evidence that such a ledge can be discovered and used by a seal. As habitat loss and degradation are the most significant threats to this species, increasing the number of potential cave habitats for resting and/or pupping by improving cave structure could potentially be an important method for the conservation and protection of this species. However, consideration of impacts on existing habitats (e.g. those of sessile invertebrates inside caves), alongside discussions with monk seal experts, responsible governmental agencies and any local stakeholders, is essential. The use of this artificial ledge by an Endangered Mediterranean monk seal contributes potentially important information to support future conservation of the species. Future monitoring should determine the suitability of this artificial habitat for pupping, which is key to supporting monk seal populations. We continue to monitor this cave by camera trap.

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Author contributions Ledge design: ES, ZAK; monitoring design: all authors; fieldwork: ES, ZAK; data analysis, writing: ES, HG.

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards. The permit for ledge construction and monitoring was provided by the Turkish Ministry of Environment and Urbanization (24 May 2019, 70879856-250-E.117731).

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