

MONITORING THE MEDITERRANEAN MONK SEAL IN THE CENTRAL MEDITERRANEAN SEA

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Abstract: The Mediterranean monk seal *Monachus monachus* was once a common inhabitant of the Mediterranean Sea. Over time, its distribution has experienced a sharp reduction, primarily attributed to various factors stemming from human activities. Known reproductive sub-populations of the species are nowadays concentrated along the coasts of Greece and Turkey. However, occasional but recurrent sightings or movements of individuals are being recorded along most of the coasts in the species' former distribution range within the Mediterranean Sea. The Marine Strategy Framework Directive require the establishment of monitoring programmes to obtain indicators for the Good Environmental Status of European waters. Here we present the monitoring programmes we carried out on the Endangered Mediterranean monk seal in the central Mediterranean Sea. The output of the work carried out in the central Mediterranean Sea for such a long period of time indicates the relevance of continuous monitoring systems for the monk seal as a top predator in the area. The species may be useful as a key species within the Marine Strategy Framework Directive for Descriptors D1 (Marine Biodiversity), D4 (Food Webs) and D10 (Marine Litter).

Keywords: Marine ecosystems, Biodiversity. Threatened species, Monitoring of coastal ecosystems

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Referee List (DOI 10.36253/fup_referee_list)

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Luigi Bundone, Aliko Panou, Gema Hernandez-Milian, Giulio Pojana, *Monitoring the mediterranean monk seal in the Central Meditorean Sea*, pp. 92-100, © 2024 Author(s), CC BY-NC-SA 4.0, DOI: 10.36253/979-12-215-0556-6.07

Introduction

The Mediterranean monk seal (*Monachus monachus*, Hermann 1779; hereafter MMS) is the only pinniped species among the marine mammals inhabiting the Mediterranean Basin.

The species was once a common inhabitant of the Mediterranean Sea. However, its distribution and abundance has experienced a sharp reduction over the past millennia, primarily due to various factors stemming from human activities.

With an estimated population of about 400-500 individuals in the Mediterranean Sea, mainly concentrated in its northeastern coasts, namely Greece and Turkey [1], the MMS is actually an endangered species. Recent studies, however, highlight the MMS' recovery trend and the possible spread of individuals throughout the Mediterranean Sea [2-4]. It has therefore been very recently categorized as Vulnerable by the IUCN [3].

The Marine Strategy Framework Directive (hereafter MSFD) has been in force since 2008 [5].

Its main objective is to achieve healthy and resilient European marine waters as also their sustainable use using various so-called Descriptors to assess its Good Environmental Status (GES). To accomplish this goal, member states should establish monitoring programmes (MoPs) to gather data on specific criteria and indicators set by the MSFD, covering biological diversity, species populations, habitats, ecosystem functions, as well as human activities and their impacts [6].

Addressing every species in European seas would be unachievable; hence, emphasis has been placed on establishing indicators and criteria focusing on representative ecosystems, species or ecotypes [7]. Furthermore, priority was given to MoPs for endangered species and those relating to Marine Reserves or Marine Protected Areas.

Marine mammals, both cetaceans and pinnipeds, have been used as reference ecotypes within the MSFD in European countries since top predators may act as sentinels of ecosystems or at least provide a reference for understanding impacts on the environments [e.g. 8, 9].

The NGO "Archipelagos - environment and development" has been monitoring the MMS for over 35 years within the central Ionian Sea, Greece. Additionally, and in parallel with its Italian branch, "Archipelagos - ambiente e sviluppo, Italia" it has conducted studies on the species' distribution and ecology in the Adriatic Sea in collaboration with national institutions and NGOs based in this region.

Here we list the MMS monitoring programmes carried out by the two "Archipelagos" sister organizations in the Adriatic-Ionian Region over the last 35 years. As the species is a top predator, such data may be useful for three Descriptors of the MSFD.

Materials and Methods

We examined in detail the monitoring programmes on the MMS we carried out in the Ionian-Adriatic region, namely Greece, Italy, Albania, Montenegro and Croatia, with various levels of effort through time.

Our monitoring programmes embrace: (A) recording and evaluation of seal sightings, (B) Monitoring habitat availability and the use of terrestrial habitats by the species, (C) Individual identification carried out through systematic photo-identification programmes and opportunistic collection of photographic material. Cases of strandings and by-caught individuals were also recorded over long periods of time.

Finally, the collection and analysis of MMS faeces allowed to carry out trophic and contaminant studies.

Results

Biogeographical reviews of available data on the presence of the MMS were preliminarily carried out, with the exception of Croatia, for the countries surveyed [10-15].

Our monitoring programmes can be structure in three main key points:

A Seal sightings

Seal sightings were recorded in the entire Ionian Sea in Greece (1985-2023) [15-18], in Southern Apulia in Italy (2011-2023) [2, 12], in Albania (2018-2022) [10, 11], in Montenegro (2013-2017) [14, 15, 19] and in Croatia (2011-2013) [2, 20].

Seal sightings were recorded using the interview protocols of the two NGOs, in order to evaluate the reliability of the data. Whenever available, photos and videos documenting these encounters were also collected from all countries.

In June 2017, the very first video documentation of an MMS encounter in Southern Apulia was recorded [21].

MMS sightings in Montenegro continued to be recorded from our local collaborator. In August 2023, the very first video documentation of an MMS encounter in the country was recorded (Dušan Varda, *pers. comm.*).

B Terrestrial habitat

The terrestrial habitat (marine caves with beach/es inside) was monitored along numerous coastlines to establish habitat availability and abundance in each region (Fig.1). The marine caves suitable for the MMS where then regularly surveyed to verify their effective use by the seals through visits either for detecting seal tracks or presence or through camera traps for obtaining pictures of seals.

Greece

- Central Ionian Sea: years 1985-2002, 2018 - present [13, 16, 18, 22].
- Zakynthos, southern Ionian Sea: years 1989-1992, 1997-1999 [23-25].
- NW Corfu: years 2021 - present [26]. The use of one cave was confirmed.

Italy, Southern Apulia: years 2011-2015 [12, 27]. No cave use was confirmed.

Albania: Karaburun-Sazan: year 2019 [10, 11].

In August 2019, it was recorded the very first documented use of cave in the country by the recovering of a monk seal scat. Cave use was confirmed afterward by infrared cameras installed in caves (2020-2021) [11].

Montenegro, entire coastline: years 2013-2015 [28]. No cave use was confirmed.

Croatia: Istria/NW Croatia: years 2011-2013 [20].

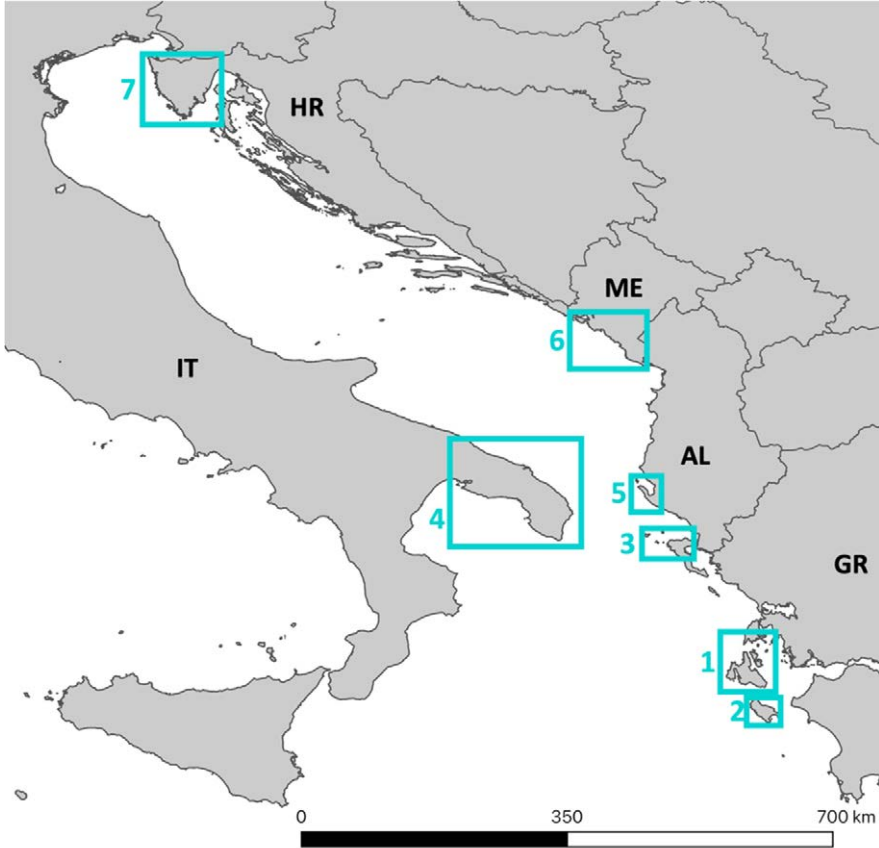


Figure 1 – Research areas: Greece, central Ionian Sea (1), Zakythos (2) and Northern Corfu (3); Italy, Southern Apulia (4); Albania, Karaburun-Sazan (5); Montenegro (6); Croatia, Iстрия (7).

C Photo-identification

Systematic photo-identification was carried out using camera traps in Greece (2018 - present) and in Albania (2019). Additional data was collected through opportunistic surveys (own data and citizen science). In the central Ionian Sea, Greece (2018-2023), 25 sub-adult and adult animals (Fig. 2) were identified and the use of one cave in NW Corfu by 2 seals was documented.

In Albania (2022), two individuals were documented [11].

In Croatia, Iстрия, own data collected through opportunistic surveys and data obtained through citizen science, allowed the identification of an adult female frequenting mainly the northern coast of the country [20].

Additionally, bycatch of MMSs in coastal fishing gear has been monitored within the framework of several early projects in the eastern Ionian Sea [13, 29, 30].



Figure 2 – Adult male captured by infrared cameras and subsequently identified in the central Ionian, Greece.

More recent monitoring work includes the analysis of the MMS' diet from faeces collected in marine caves (Fig.3) in the countries mentioned above (1998 – present), except for Montenegro [11, 31].

Finally, an innovative study on microplastics (Fig.3) and their additives in monk seal faeces from Zakynthos Island, eastern Ionian Sea, has been carried out [32].



Figure 2 – Monk seal faeces (left), diet remains (center) and a fiber (right) found in faeces.

Discussion

The overall output of the above monitoring programmes indicates the relevance of continuous monitoring systems for the MMS as a top predator and is described in detail in the relevant bibliography. But the species might also become a useful key species within the MSFD for three Descriptors: D1, D4 and D10, as several on-going MMS monitoring programmes of various NGOs will obviously be continued, and new programmes may be launched. Here, price vs. value of the various MSFD MoPs should also be considered, of course and existing monitoring

programmes may be useful at the same time for the overall evaluation of the GES in each Member State.

Furthermore, data obtained through the NGOs' monitoring programmes might also be valuable for the use of innovative modelling tools within the implementation of the MSFD as described in Lynam et al. 2016 [33].

The studies focusing on the MMS' biogeography, sightings, terrestrial habitat availability and use, photo-identification, by-catch and strandings provide insights into potential indicators of the species' abundance and distribution (Biological Descriptor -D1).

The trophic ecology of the various species in the marine ecosystem is addressed by the Food Web Descriptor (D4), using stomach content analysis. Incorporating information about top predators into this Descriptor presents challenges due to the difficulty of obtaining samples from carcasses. However, the use of seal faeces can serve as a valuable alternative tool for acquiring pertinent information for this Descriptor [e.g. 9]. Concerning the MMS, such samples can easily be collected in caves during the monitoring activities, either within dedicated programmes for assessing the use of caves by the MMS or during occasional monitoring of caves.

Marine litter impacts are considered in the Descriptor (D10). Again here, during MMS monitoring programmes, samples can be collected to analyse the incidence of microplastics, and even macroplastics, in faeces of the MMS as a marine top predator (Criterion 3, amount of litter and micro-litter ingested by marine animals). Here, the recommendations of Gago et al. (2016) [34] should be taken into consideration as well.

The difficulties in obtaining information on this species stem from two factors: (1) challenges in studying it due to their distribution, abundance, habitat use and ecology in general, and (2) the lack or limitation of financial resources for many NGOs already conducting these studies, and despite their significant expertise and specialization.

Collaborative efforts with national institutions (e.g. ministries, research institutions, universities, etc.) and the provision of funding resources might be the most effective strategy for meeting the requirements outlined by the EU within the MSFD, particularly regarding assessments of top predators such as the MMS.

Acknowledgments

We would like to thank the many dozens of volunteers who helped all these years in our monitoring programmes.

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