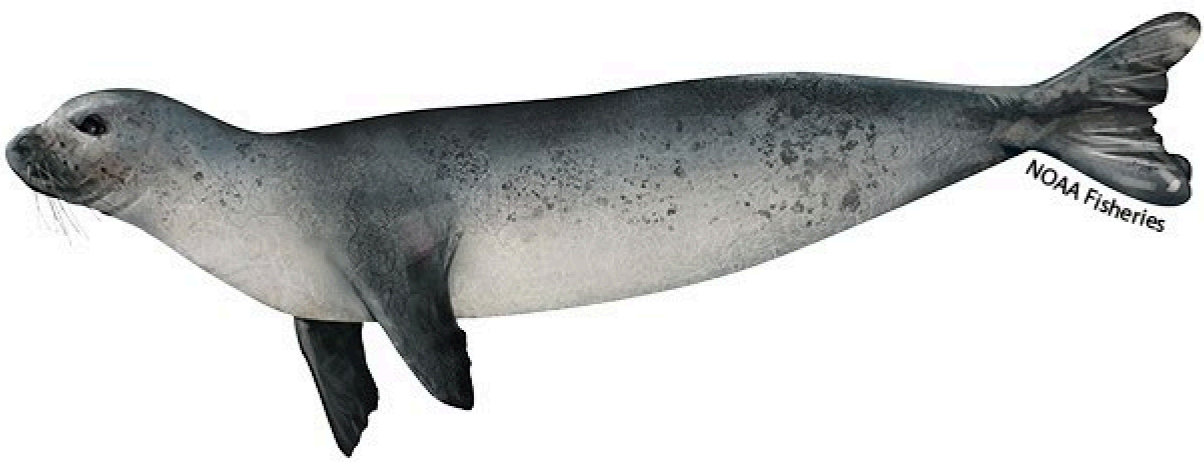
Mediterranean monk seal
(*Monachus monachus*)

5-Year Review:
Summary and Evaluation



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National Marine Fisheries Service
Office of Protected Resources
Silver Spring, MD
2024

5-YEAR REVIEW
Mediterranean Monk Seal
(*Monachus monachus*)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

5-YEAR REVIEW
Mediterranean monk seal (*Monachus monachus*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional or Headquarters Office:

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Office of Protected Resources, 1315 East-West Highway, 13th Floor. Silver Spring Maryland 20910.

1.2 Methodology used to complete review

A 5-year review is a periodic analysis of a species' status conducted to ensure that the listing classification of a species currently listed as threatened or endangered on the List of Endangered and Threatened Wildlife and Plants (List) (50 CFR 17.11 – 17.12) is accurate. The 5-year review is required by section 4(c)(2) of the Endangered Species Act of 1973, as amended (ESA) and was prepared pursuant to the joint National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service's 5-year Review Guidance and Template (NMFS and USFWS 2018). The NMFS Office of Protected Resources (OPR) conducted the 5-year review. Information was updated from the status review report (Doss and Nedwell 2017) based on peer-reviewed publications, government and technical reports, conference papers, workshop reports, dissertations, theses, and personal communications. Information was gathered from July 2024. The information on the biology and habitat, threats, and conservation efforts related to Mediterranean monk seals were summarized and analyzed in light of the ESA section 4(a)(1) factors (see **Section 2.3.2** and **Section 2.4**) to determine whether a reclassification or delisting may be warranted (see **Section 3.0**).

NMFS initiated a 5-year review of the Mediterranean monk seal, and solicited information from the public, on August 7, 2024 (89 FR 64413). No public comments were received.

1.3 Background

1.3.1 FRN citation announcing initiation of this review

89 FR 64413, August 7, 2024

1.3.2 Listing history

<u>Original listing</u>

Federal Register notice: 35 FR 8491

Date listed: June 2, 1970

Entity listed: Species

Classification: Endangered

1.3.3 Associated rulemakings

None

1.3.4 Review history

This is the second 5-Year Review for the Mediterranean monk seal. The first 5-year review was conducted by Doss and Nedwell (2017).

1.3.5 Species' recovery priority number at start of 5-year review

No recovery priority number has been issued for Mediterranean monk seals

1.3.6 Recovery plan or outline

A recovery plan was not prepared for Mediterranean monk seals as the species exists solely in foreign waters and, therefore, the threats to this species occur under foreign jurisdiction.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy[1]

2.1.1 Is the species under review a vertebrate?

_X_ Yes

____No

2.1.2 Is the species under review listed as a DPS?

____Yes

_X_ No

2.1.3 Is there relevant new information for this species regarding the application of the DPS policy?

_X_ Yes

____ No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

___Yes

_X_ No

Not applicable. A recovery plan was not prepared for Mediterranean monk seals as the species exists solely in foreign waters and, therefore, the threats to this species occur under foreign jurisdiction.

[1] To be considered for listing under the ESA, a group of organisms must constitute a "species," which is defined in section 3 of the ESA to include "any subspecies of fish or wildlife or plants, and any distinct population segment [DPS] of any species of vertebrate fish or wildlife which interbreeds when mature". NMFS and USFWS jointly published a policy regarding the recognition of DPSs of vertebrate species under the Endangered Species Act (61 FR 4722, February 7, 1996). "DPS" is not a scientifically defined term; it is a term used in the context of ESA law and policy. Furthermore, when passing the provisions of the ESA that give us authority to list DPSs, Congress indicated that this provision should be used sparingly. We have discretion with regard to listing DPSs and, in order to be consistent with the directive of the Congressional report that followed the introduction of the DPS language in the ESA to identify DPSs sparingly. We will generally not, on our own accord, evaluate listings below the taxonomic species.

2.3 Updated information and current species status of the Mediterranean monk seal (*Monachus monachus*)

2.3.1 Biology and habitat of the Mediterranean monk seal

2.3.1.1 New information on the species' biology and life history

In this section, new information and research that has been conducted or published since the previous 5-year status review of the Mediterranean monk seal (Doss and Nedwell 2017) is presented.

Mediterranean monk seals (*Monachus monachus*) are one of the most endangered marine mammal species, and the most endangered pinniped species. Its global population currently consists of three geographically and genetically isolated subpopulations (**Fig. 1**). The largest subpopulation is in the eastern Mediterranean Sea, and the two remaining populations are in the Madeira archipelago and off the coasts of the Cabo Blanco peninsula, on the border of Mauritania and Western Sahara (Karamanlidis *et al.* 2016). Historically, the species was present throughout the Mediterranean and Black seas and in North Atlantic waters from the coast of Northwestern Africa to Spain, including the Canary Islands and the Azores (Karamanlidis 2024a).

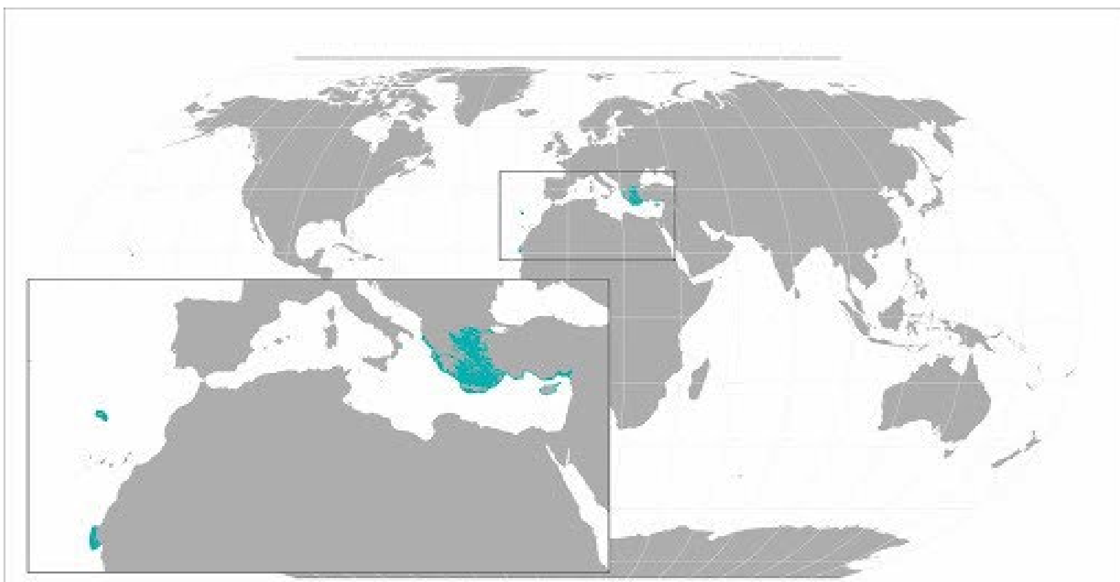

Figure 1. Current distribution of the Mediterranean monk seal (source: NOAA).

The main threats to the species are: (1) terrestrial and marine habitat loss and degradation; (2) bycatch in fishing gear; (3) deliberate killing of seals by fishers due to perceived conflicts over fish (3) pollution; (4) disease; and (5) unpredictable threats such as cave collapses (Karamanlidis 2024a).

2.3.1.1.1 Life history

No substantive new information on Mediterranean monk seal life history has been published since the previous 5 year status review (Doss and Nedwell 2017).

2.3.1.1.2 Survival

Muñoz-Cañas *et al.* (2017) noted that due to the fact that researchers can identify individual animals after the age of 2 years, animals can be followed through time in the Cabo Blanco Peninsula in Western Sahara/Mauritania. However, younger animals are harder to identify. To estimate mortality rates they summed the number of pups born from 2003 to 2012, together with the estimated subadults (over 2 years) and the estimated adult population in 2005. They then subtracted all of the deaths and disappearances of animals from known age categories. This gave a potential, theoretical population size of 337 animals, assuming that there was zero mortality up to 2 years of age. As the size of the population at the time was 222 animals, this meant that 115 individuals must have died before reaching the age of 2 years. This gives a survival rate of 0.6151 between 2 months and 2 years of age, or a 38.85% mortality rate during the study period. This suggested a relatively high mortality rate for young seals (<2 years), compared to other pinniped species.

Fernandez de Larrinoa *et al.* (2021) further described the age-specific rates of Mediterranean monk seals at the Cabo Blanco. From birth to two months of age, survival rates averaged 0.59 (*i.e*., 59% survived; range: 0.41-0.74). From birth to one year of age the media survival rate was 0.46 and from one to two years it was 0.75. After two years of age survival estimates varied by sex, with a male survival rate of 0.94 and female rate of 0.97. Fernandez de Larrinoa *et al.* (2021) also noted that the initial survival rate of monk seals was very low compared to other species of seals, but there is a relatively low mortality rate for animals if they survive to adulthood.

Similarly, for the smaller population of monk seals in the Madeira Archipelago, Pires *et al*. (2023) estimated the survival rate of pups from birth to 2 months of age as 0.57, and to 1 year of age as 0.47 (range: 0.31-0.64). The survival rate from 1 to 2 years was 0.85 and beyond two years rates it was 0.90 for males and 0.98 for females. The survival rates were strikingly similar to those of the Cabo Blanco population, which Pires *et al*. (2023) noted was quite surprising as the Madeira Peninsula is not as productive as the waters of Cabo Blanco and one would expect a lower survival rate.

Karamanlidis (2024a) stated that annual pup survival until weaning in Greece was suspected to be higher than in Cabo Blanco or Madeira and gave a value of 0.7. However, this appears to be an arbitrary estimate and is not based on an analysis of field data.

Mellen (2021) reported that in the prior two years, 19 Mediterranean monk seals had been found dead in Greece, which if the current population estimates were correct (**Section 2.3.1.2**; **Table 2**; Karamanlidis *et al.* 2023), this would comprise 4.2-5.6% of the Greek seal population. Considering the often remote areas that monk seals inhabit, and the likelihood of all seal carcasses being sighted or recovered being very low, the actual mortality rate is likely to be much higher.

2.3.1.1.3 Reproduction and growth

Fernandez de Larrinoa *et al.* (2021) reported upon the reproductive rates of Mediterranean monk seals on the Cabo Blanco Peninsula, Mauritania. From 2005 to 2016, the average gross reproductive rate was estimated at 0.71. The age at first birth was three years of age, with females potentially giving birth every year thereafter.

Between the ages of 6 and 17, the reproductive rate exceeded 0.80. The estimated intrinsic rate of growth[2] was 1.058, *i.e.*, a 5.8% per annum increase in the number of animals in the population. Despite high seal pup mortality rates (**Section 2.3.1.1.2**), the high reproductive rate of monk seal females results in positive rate of growth. However, this rate is much lower than other seal species, for example, the harbor seal has an intrinsic rate of growth of 12% (Härkönen *et al.* 2002).

This rate of growth helped the Cabo Blanco population of Mediterranean monk seals recover after a mass mortality event in 1997 (Martínez-Jauregui *et al.* 2012), during which approximately two thirds of the population died (Forcada *et al.* 1999) - possibly due to a disease outbreak or a toxic algal bloom (Reyero *et al*. 1999).

In contrast, for the Madeira population the age of first reproduction was estimated at 6 to 7 years of age, *i.e*., at least three years later than females at Cabo Blanco (Pires *et al*. 2023). The oldest reproductive female observed was 19 years of age, although a pregnant female died at 21 years of age. Pires *et al.* (2019) also noted a skewed sex ratio in Madeiran monk seals with 3.3 times as many females as males - which they attribute to a higher rate of male mortality.

Females in the eastern Mediterranean and Madeira subpopulations give birth in October and November, but the Cabo Blanco females can give birth throughout the year (Karamanlidis *et al.* 2023; Pires *et al.* 2023).

The realized growth rate of the Madeira population (from 2012 to 2021) was 1.032 (95% confidence interval: 1.02−1.05), *i.e*., a 3.2% increase in population size. However, the intrinsic growth rate calculated from survival and reproductive rates was 0.998, *i.e*., a 0.2% decrease in population per annum.

The mean gross reproductive rate of seals in Madeira was just 0.31; less than half the value (0.71) reported for Cabo Blanco (Pires *et al.* 2023). Pires *et al*. (2023) suggest that, although the survival rate of Madeira monk seals is similar to those at Cabo Blanco, the later age of first reproduction and, hence, the lower rate of growth, may be due to the waters around Madeira being less productive than the Cabo Blanco peninsula, with the resulting lack of nutrition delaying female reproduction.

2.3.1.1.4 Feeding and diet

Previous studies have noted that Mediterranean monk seals are opportunistic predators consuming fish and cephalopods (mainly the common octopus *Octopus vulgaris*), with over 530 prey species reported in stomachs of deceased seals in Greece (Salman *et al.* 2001; Pierce *et al.* 2011; Karamanlidis *et al.* 2016). Since the previous 5-year status review there have been several studies that have noted the feeding behavior of monk seals.

Bundone *et al.* (2022) identified three possible fish species consumed by monk seals in Albania via an analysis of their scat: a sparid, most probably a gilt-head sea bream (*Sparus aurata*); a sea bass (*Dicentrarchus labrax*); and a garfish (*Belone belone*). Pieces of seagrass (*Posidonia oceanica*) and a small pearl were also present in the scat.

[2] The intrinisic rate of population growth is the number of net proportion of new individuals in a population, calculated by the number of births minus the number of deaths per generation time.

Tonay *et al.* (2016) analyzed the stomach contents of an adult monk seal found stranded near Antaly, Turkey. In the study, 69 individual food items, belonging to nine taxa, were counted. Fish from the Sparidae family were the most common species consumed (seabreams and porgies), including the Morocco dentex (*Dentex marrocanus*) and the common pandora (*Pagellus erythrinus*), as well as the common octopus (*Octopus vulgaris*). The band toothed conger (*Ariosoma balearicum*) and the meagre (*Argyrosomus regius*) were reported for the first time as monk seal prey items. In addition, remains of at least three green sea turtles (*Chelonia mydas*) were found in the seal's stomach – the first time that this species had been reported being consumed by Mediterranean monk seals. Subsequently, Kıraç and Türkozan (2023) reported additional instances of green sea turtle predation along the Turkish coast.

Quintano and Chatzipavlis (2023) and Snape *et al*. (2022) also noted loggerhead turtle (*Caretta caretta*) carcasses that they suggested that been attacked and partially consumed by a monk seal off of Lesbos [Lesvos Island], Greece and Boğaz [Bogazi] Beach, Iskele [Trikomo] in Cyprus.

Ríos *et al*. (2017) reported that monk seals interacted with fishing gear, taking some of the catch on 19% of fishing trips around Lipsi Island, Greece. The majority of the species being caught included: the common octopus (*Octopus vulgaris*); the common cuttlefish (*Sepia officinalis*); the Mediterranean parrotfish (*Sparisoma cretense*); the dusky spinefoot (*Siganus luridus*); the red scorpionfish (*Scorpaena scrofa*); garfish (*Belone belone*); and several sparid fish: the common dentex (*Dentex dentex*); the saddled seabream (*Oblada melanura*); and the common pandora. Catch levels were significantly lower when cuttlefish, parrotfish, seabream and pandora were being caught, suggesting a preference for these species.

Kıraç and Ok (2019) also examined the stomach contents of a 5 month old seal found off the coast of Foça, Turkey. The young animal's stomach was half full and it had eaten a bandtooth conger eel and five common octopuses. This study suggest that Mediterranean monk seals can forage for themselves as young as five months old.

Antichi *et al.* (2019) observed monk seal behavior via land-based surveys off the island of Samos, Greece. The seals spent 22.7% of their time feeding and the fish observed in the area were primarily sparids: the white seabream (*Diplodus sargus*; 14.7%) and the annular seabream (*Diplodus annularis;* 14.4%).

Finally, Hernandez-Milian *et al.* (2018) analyzed the stomach contents from 35 seals from the Cabo Blanco Peninsula. In total, 312 individual prey items from at least 25 species were identified. Two-thirds of the prey items were fish with half of these being sciaenids (drums and croakers). However, in terms of biomass, consumed cephalopods were the most important prey (69% of the prey by weight). The latter were primarily octopuses (98% by weight). Some species consumed overlapped with local fisheries, notably monkfish (*Lophius* spp.; 18% of the fish consumed) and hake (*Merluccius* spp.; 4% of the fish consumed). Juvenile monk seals seemed to have a statistically significant preference for monkfish (Hernandez-Milian *et al.* 2018).

2.3.1.1.5 Social structure and behavior

Antichi *et al.* (2019) noted the behavior of monk seals via land-based surveys off the island of Samos, Greece. During these land surveys, 5 sightings were recorded and the two main behaviors observed were "surface swimming" (24.8%) and feeding (22.7%).

Charrier *et al.* (2017, 2023) published new information on the vocal behavior of Mediterranean monk seals. In Charrier *et al.* (2017), vocal behavior on-land during the pupping season was recorded. Five call types were identified: "bark"; "chirp"; "grunt"; "short scream"; and "scream". Of these, "bark" and "scream" were the two main call types. In contrast, Charrier *et al.* (2023) described underwater calls of monk seals. They defined 18 call types divided into three main categories: "harmonic"; "noisy"; and "pulsative" calls (ranging from 100-1000Hz). They noted that this information could be used to develop automated acoustic detection systems for monk seals.

True seals can hold their breath while sleeping and have been observed sleeping while floating motionless at the surface (called "bottling"), or on the seabed. Karamanlidis *et al.* (2017) noted six instances when Mediterranean monk seals have been found sleeping at the surface or underwater. The data suggested that outside of the breeding season when sea caves are utilized, these seals may rest at sea. Thus, important "resting" areas and habitat may not be limited to sea caves.

Karamanlidis *et al.* (2021a) used an infrared video system to monitor the behavior of monk seals within a breeding cave in Greece. Two females and their pups (one male and one female) were recorded and it was found that, after birth, the time spent in attendance with pups decreased gradually. Following birth, one seal stayed with her pup continuously for 113 hours, while the other remained with hers for 44 hours, was absent for 3.5 hours and then returned for a further 64 hours. After the first 10 days the females started to be absent for periods of 0.5-13.8 hours, presumably to forage for food. On returning to the caves the mothers were observed vocalizing and calling their pups to them.

The female pup and her mother were once absent from the cave for about three days (the pup was not observed for 63 hours and the mother was absent for 93 hours). The male pup and his mother were absent for periods of 20 hours or more (up to 101 hours) on at least four occasions. Unlike Hawaiian monk seals the mothers in this study appeared to take foraging breaks, whereas Hawaiian monk seals stay with their pups continuously and fast.

The pups went into the water and started to swim at 3 and 6 days of age. The females eventually abandoned the caves when their pups were 96 and 112 days old. For the former, her pup (female) stayed in the cave until they were 125 days old, whereas the latter (male pup) left on the same day as their mother. Males were occasionally seen entering the caves, but they just rested briefly before leaving.

2.3.1.1.6 Movement

Fernandez De Larrinoa *et al.* (2019) and Pires *et al*. (2020) attached depth recording tags to monk seals found on the Madeira archipelago. Tags remained on animals for 30-378 days. The study found that the majority (80%) of the dives were between 0m and 49m and 99.6% of the dives of were to a depth less than 200m. The maximum dive depths recorded were 393m for an adult male and 429m for a breeding female.

The researchers noted four different dive types: traveling; shallow foraging; deep bottom foraging; and bottom resting. Shallow foraging dives were to an average depth of 26m and deep bottom foraging dives were to an average of 102m.

Mediterranean monk seal have been reported moving considerably, travelling up to 300 km in "straight line" distances (Roditi-Elasar *et al.* 2021; Kurt and Gücü 2021). In the eastern Mediterranean, female monk seals appear to move greater distances (16.3-245 km) than male monk seals (37.5-101 km) (Kurt and Gücü 2021).

Fernández de Larrinoa *et al.* (2016) found that tagged adult seals in Cabo Blanco (whose breeding/resting sea cave area was within 1km) travelled up to 80km to the north and south of their breeding caves and offshore out to 12 nautical miles. However, juvenile seals travelled up to 25 nautical miles offshore. This indicates that the species travels much further offshore than previously thought, which has implications for management.

2.3.1.1.7 Other information on the biology of the species

Graic *et al.* (2024) examined the brain of a stranded monk seal[3] - the first time such an examination has been conducted. They found the seal's brain to body mass ratio was slightly higher than expected.[4] The brain's olfactory bulbs, albeit somewhat reduced in size compared to other carnivores, suggested that the monk seal's sense of smell was important, but perhaps not quite as much as in terrestrial carnivores. The development of the rostral colliculi (which is involved in vision and coordinating head movement) also suggested that the seal's visual system was important. It had well developed temporal lobes, additionally suggesting that sound was an important sense. The trigeminal nerve also was well developed, which indicates that the seal's whiskers, or vibrissae, are important in the species' sensory suite.

The surface of the seal's brain displayed much more folding compared to terrestrial carnivores of a similar brain size. Often, the more cortical folding observed in a species indicates more complex cognitive functioning. In summary, Graic *et al.* (2024) noted some similarities to terrestrial carnivores, but also some seemingly convergent similarities with cetacean brains, perhaps being related to adaptations to the complexities of the aquatic environment. However, the study provided some information on the potential cognitive and sensory abilities of monk seals that may have some relevance to conservation - *i.e.*, they have well-developed acoustic sensory systems and, therefore, may be sensitive to underwater noise.

[3] A young seal pup weighing 22.5 kg, with a total length of 118 cm.

[4] The encephalization quotient (ratio of brain to body mass) was 3.46. In comparison a dog's value is 1.2, a Rhesus monkey is 2.1, a chimpanzee is 2.2-2.5, a bottlenose dolphin's is 5.3 and a human's is 7.4-7.8 (Roth and Dicke 2005). This perhaps suggests a higher level of intelligence than a carnivore of equivalent mass. Although it should be noted that this was a young animal and the encephalization quotient can change as an animal ages.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate), or demographic trends

In 1988, the Madeira monk seal population was almost extirpated, with an estimated 6-8 animals (Marchessaux 1989). By 2013 it had increased to 19, and by 2021, the estimate was 27 animals (Pires *et al*. 2023). Annual pup production is currently estimated as an average of 3.5 pups (Pires *et al.* 2023).

The monk seal subpopulation in Cabo Blanco is estimated to be approximately 350 individuals (Fernández de Larrinoa *et al.* 2021, Cedenilla *et al.* 2022) of which 184 are mature individuals. An estimated 70 pups are born annually in this population (Karamanlidis *et al.* 2023) but, as noted above (**Section 2.3.1.1.2**), the mortality rate for seal pups in this population is high, with more than half dying before they are 1 year of age.

The eastern Mediterranean population is primarily found in the coastal areas of Greece and Turkey. However, obtaining an estimate of numbers in this region is difficult due to the large area of coastline and thousands of islands and islets in the region (Kurt and Gücü 2021; Pietroluongo *et al.* 2022a). Therefore, the actual number of seals in this region is largely unknown (Panou *et al*. 2023).

There are, however, estimates of numbers of animals from unpublished reports from the two main breeding islands Astakida and Gyaros from 2008 and 2012 (**Table 1**). Panou *et al.* (2022) installed infrared cameras in 16 sea caves on Greek islands in the Ionian Sea[5] and reported six monk seal births in 2018, two in 2019, 11 in 2020 and another 11 in 2021. Panou *et al.* (2022) considered that this might indicate some recovery in the Ionian Sea population.

In Turkey, Dede *et al.* (2019) reported five individuals (an adult male and female, two young animals and one pup) from Gökçeada Island off of the northeastern coast Moreover, Saydam and Güçlüsoy (2023) reported 18 individual monk seals in Gökova Bay, southwestern Turkey. There is also a small breeding population in Cyprus (Nicolaou *et al.* 2019, 2021, Beton *et al.* 2021, Papageorgiou *et al.* 2023).

Table 1. Estimated number of pup, mature adult and total animals in the two main Greek Mediterranean monk seal breeding islands (source: Karamanlidis 2024b).

	Number of animals	Mature adults	Annual pup production	Reference
Gyaros	-	18	8	Karamanlidis and Dendrinos 2012 in Karamanlidis (2024b)
Astakida	18	12	6	MOm 2008 in Karamanlidis (2024b)

As adult seals are frequently at sea and are difficult to count and because pups hauled out on breeding beaches are easier to count than adults, Karamanlidis (2024b) used a method known as a "pup multiplier" to estimate how many Mediterranean monk seals there are in the eastern Mediterranean. The estimate involves counting the number of pups and then multiplying by a chosen number to estimate the number of mature

[5] Including Kefalonia and Ithaca and the smaller islands of of Atokos, Formicula, Kalamos, Kastos and Meganisi.

adults, and a second number to estimate the total population size.[6] Karamanlidis (2024b) estimated a mature adult multiplier value of 2.5-3.5 and a total population multiplier of 4.5-6.0.[7] Therefore, to estimate the total population size the annual pup production would be multiplied by 4.5 to get a minimum estimate and by 6.0 to get a maximum estimate of population size (see values in **Table 2**).

Table 2. Estimated number of pup, mature adult and total animals in the two main Greek Mediterranean monk seal breeding islands (from Karamanlidis 2024b). Numbers marked with an asterisk were calculated using a "pup multiplier" of 2.5–3.5 for estimating the number of mature individuals, and 4.5–6.0 for estimating the total number of individual (Karamanlidis *et al.* 2023; Karamanlidis 2024b). Number marked with § used a pup multiplier of 3.71 for mature adults and 7.71 for the total population, rounded to the nearest full number (Pires *et al.* 2023).

	Number of animals	Mature adults	Annual pup production	Reference
Madeira	27	13§	3.5	Pires *et al*. 2023
Capo Blanco	350	184	70	Fernández de Larrinoa *et al.* 2021, Cedenilla *et al.* 2022
Greece	337-450*	187-262*	75	Unpublished data in Karamanlidis *et al.* 2023
Turkey	76-103*	42-59*	17	Unpublished data in Karamanlidis *et al.* 2023
Cyprus	13-18*	7-10*	3	Unpublished data in Karamanlidis *et al.* 2023
Other eastern Mediterranean	10-10*	12-12*	2	Unpublished data in Karamanlidis *et al.* 2023

From an unpublished estimate of pup production, and using a multiplier value, Karamanlidis (2024b) estimated a population size of 246-341 Mediterranean monk seals in the eastern Mediterranean. This value was used in the most recent status evaluation of the Mediterranean monk seal by the IUCN (Karamanlidis *et al.* 2023). As this estimate is slightly higher than the previous estimation of 187-240 animals (Karamanlidis *et al.* 2019), the population was deemed to be increasing, and it was a major rationale for downlisting the Mediterranean monk seal's IUCN categorization from "endangered" to "vulnerable"in 2023 (Karamanlidis *et al.* 2023).

However, pup multipliers are typically used in combination with regular surveys and detailed information on demographic parameters (e.g., Russell *et al.* 2019). However, as Karamanlidis (2024b) notes "such information is not available yet for the Mediterranean monk seal in the eastern Mediterranean Sea" (p. 266).

Moreover, age-related fecundity and mortality is also a major factor in population structure and abundance but, as Karamanlidis (2024b) also states, there is "too little information is available on the age distribution in order to evaluate if and how the proposed pup multipliers might be affected" (p. 266).

[6] The number is typically calculated from survey data on pup and adult numbers gathered from a specific (easier to study) area.

[7] Karamanlidis (2024b) states: "multipliers were arbitrarily proposed for each demographic parameter: 1 multiplier following a conservative approach that should be considered the minimum estimate, and 1 multiplier following a more optimistic approach that should be considered the maximum estimate" (p. 263).

Gülce *et al.* (2014) conducted a study using camera traps in monk seal caves in Turkey, and noted a skewed sex ratio and high female mortality rates – this could, for example, greatly affect population structure and estimates. Gülce *et al.* (2014) for example, noted that this demographic issue was a major factor that increased the extinction risk for the subpopulation.

Using the pup multiplier method to estimate abundance, the final population estimate is very much influenced by: (a) the accuracy of the initial count of the number of pups; and (b) the multiplier value used. As the data upon which the pup production values in Karamanlidis *et al.* (2023) and Karamanlidis (2024) are based are from unpublished sources or from personal communications to the author(s), their accuracy cannot be evaluated. Secondly, the pup production multiplier in Karamanlidis (2024b) is essentially a "best guess" based on pup multipliers calculated for other species, rather than one derived from empirical data.

To show the influence of using a different pup multiplier value, if one was to take data from the major breeding location on Astakida (**Table 1**) and use that to calculate a pup multiplier value (*i.e.*, 3.0) it would give a total population estimate of 225 animals in Greece and 66 animals in the other eastern Mediterranean locations – considerably less that the estimated values in Karamanlidis (2024a, 2024b) and Karamanlidis *et al*. (2023).

Therefore, western Mediterranean population estimates in Karamanlidis (2024a, 2024b) and Karamanlidis *et al*. (2023) should be used with some caution when it comes to management decisions. To produce an abundance estimate comparable to stock assessments conducted under the auspices of the U.S. Marine Mammal Protection Act, for example, a series of regular surveys would need to be conducted in the western Mediterranean - using population assessment methodologies and analytical methods that have been rigorously tested statistically and validated with empirical data.

Mediterranean monk seals typically rest and breed in secluded, remote, seacaves (Bareham and Furreddu 1975). Camera traps have recently been used in these breeding caves in Greece (Bundone and Panou 2022), Turkey (Gülce *et al.* 2014; Dede *et al*. 2019) and Cyprus (Nicolaou *et al*. 2019; Beton *et al.* 2021). These camera traps have had some success in photo-identifying individual animals. For example in Cyprus, a combination of camera trap data and sightings reported by the general public has led to the identification of 14 individual seals, including five pups (one born in 2011, two in 2015 and one each in 2017 and 2018; Nicolaou *et al.* 2019). Beton *et al*. (2021) also reported identifying four adult and three pups in three of eight caves monitored with camera traps. One site on the north-west of Cyprus supported at least three adult seals and pupping occurred there over 3 consecutive years (Beton *et al.* 2021).

Studies such as these, combined with a network to share images with other monk seal researchers, could allow capture-recapture analyses to be conducted to not only estimate abundance in this difficult to assess species, but also to monitor the movement and behavior of individual seals in the region.

The small size of the Mediterranean monk seal populations, and their restricted breeding distribution, makes the species vulnerable to the ecological phenomenon known as the "Allee effect" (Stephens *et al.* 1999). When population sizes in certain species drop below a certain level, there can be negative effects for these small populations. For example, it may be more difficult for animals to find mates and their ability to defend against predators may be reduced. The small size of the populations are also likely to be reducing their reproductive success due to inbreeding depression (Charlesworth and Willis 2009), *i.e.*, a lack of genetic diversity in a breeding population can lead to more frequent expression of deleterious genes that can reduce the fitness of offspring.

Soulé (1980) suggested that, theoretically, a minimum population size of 50 is necessary to combat inbreeding and a minimum population size of 500 is needed to reduce genetic drift,[8] although Frankham *et al.* (2014) suggested that more than 100 breeding animals are required to prevent inbreeding depression. The highly fragmented distribution and small populations of Mediterranean monk seals makes inbreeding depression and the Allee effect major factors threatening their survival.

2.3.1.3. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding)

Salmona *et al.* (2022) analyzed nuclear DNA in samples from historical (locally extinct) and living populations of Mediterranean monk seals to investigate their population structure. The study found that after analyzing genomic DNA, genetic samples were clustered into four populations: Cabo Blanco (Western Sahara/Mauritania); Madeira; the western Mediterranean; and the eastern Mediterranean. Three of these populations were previously known, but the historical western Mediterranean population is a new finding. This population has been extirpated throughout most of its historical range - one 1993 sample from northern Morocco aligned with this western population, so some remnant animals may still exist. As there have been sightings of seals in the western Mediterranean in recent years, some of these animals could be the last surviving members of this fourth population.

All of the populations show high levels of inbreeding and low levels of genetic diversity. This diversity has been declining since antiquity – modelling conducted during the study suggested that all sampled populations underwent at least one (or more), major declines. Each of these declines involved at least a tenfold decrease in numbers.

These major declines occurred in antiquity: during the rise of the Roman Empire (~ 500-0 BCE); at the beginning of the high mediaeval period (~1000 CE); and at the beginning of the Renaissance (~1500 CE). This appears to be supported by historical information. For example, monk seals were heavily hunted in the Roman era but by the 4th Century monk seals skins had become so rare in Italy, yet highly sought after, a single seal skin would be equivalent to two months of a laborer's wages (Johnson and Lavigne 1999). Later, there reports of thousands of seals laying on sandy beaches in Madeira and Western Sahara, and that these were decimated in hunts by the Portuguese in the 15th century (Johnson and Lavigne 1999). By the 16th century, seals had become so rare in parts of the Mediterranean that when they were encountered they were considered to be curiosities or fantastical creatures (Johnson 2004).

[8] The random genetic skewing of small populations, with normally rare genes becoming unusually common (Masel 2011; Star and Spencer 2013).

Karamanlidis *et al.* (2021b) investigated nuclear DNA microsatellites to investigate the genetic structure of monk seal sub-populations in Greece. They found three genetic clusters: subpopulations in the Ionian Sea, the northern Aegean, and the southern Aegean Sea. They also found that individuals in the northern Aegean were less inbred than the individuals sampled in the southern Aegean Sea.

Karamanlidis *et al.* (2016b) had found that individuals from the Ionian Sea had a distinct mitochondrial DNA haplotype that has not been detected in the Aegean, and Karamanlidis *et al.* (2021b) found that all but one Ionian animals had one or two microsatellite alleles only found in the Ionian Sea. The Ionian Sea subpopulation appears to carry genetic material that is not found in the Aegean Sea and Karamanlidis *et al.* (2021b) opined that this subpopulation should be considered an important unit for conservation.

Via this genetic analysis Karamanlidis *et al.* (2021b) estimated the effective population size[9] for the Aegean populations: for the entire region it was an estimated 50 animals (95% confidence: 40–66); for the North Aegean it was 28.5 (19–47); and for the South Aegean 67 (44–121).

Dayon *et al.* (2020) specifically looked at microsatellites in Mediterranean monk seals from the two North Atlantic subpopulations. Even before the Cabo Blanco mass mortality event in 1997 (see **Section 2.3.2.3.1)**, the seals' genetic profile indicated that the population was small and inbred. The population's genetic diversity decreased slightly after the mass mortality event. Moreover, it appears that some varieties of genes were completely absent in the population after the mortality event. The Madeiran population had an even lower genetic diversity.[10] The results suggested that although the Madeira subpopulation was genetically distinct from Cabo Blanco animals, it was historically derived from the Cabo Blanco population. Dayon *et al.* (2020) suggesting that translocating seals from Cabo Blanco to Madeira may help to increase the latter subpopulations' genetic diversity and, therefore, the health of the population, in Madeira.

Karamanlidis *et al.* (2016b) had previously noted extremely low diversity in monk seal mitochondrial DNA. Gaubert *et al*. (2019) expanded on this mitochondrial DNA research in recent (1989-2014) and historical (1833-1975) samples from Mediterranean monk seals. The "recent" samples came from: Greece; Turkey; Croatia; Cabo Blanco; and Morocco. The historical samples came from: Algeria; Bulgaria (Black Sea); Croatia; France; Greece (Crete); Italy (including Sardinia, Elbe Island and Capraia Island); Madeira and Cabo Blanco. Two new, rare haplotypes were discovered, but in general the genetic diversity of the samples was extremely low. The authors suggested that there was a low probability for further, as yet unreported, haplotypes existing in the population (Gaubert *et al*. 2019). Moreover, haplotypes that had been previously considered diagnostic of either North Atlantic or eastern Mediterranean populations were found in both of these populations in both historical and recent samples (and therefore were not unique to these populations). Gaubert *et*

[9] The number of individuals in a hypothetical population that would experience the same rate of genetic drift, inbreeding, and loss of genetic diversity as an actual population**.**

[10] They were fully homozygous, *i.e*., having two identical varieties of each particular gene.

al. (2019) concluded that Mediterranean monk seals have had a low genetic diversity extending back into the mid-1800s. Moreover, the 1997 mass mortality event (see **Section 2.3.2.3.1**) in Cabo Blanco likely caused local haplotype extinctions. Gaubert *et al*. (2019) also opined that the current genetic profile of the Mediterranean monk seal likely derives from the combined effects of historical extinctions, persistently low levels of genetic diversity and genetic drift[11] in small breeding groups.

Rey-Iglesia *et al*. (2021) also examined mitochondrial DNA in monk seals and like Gaubert *et al*. (2019) they noted a decrease in genetic diversity in the last 200 years with recent samples showing almost a quarter of the genetic diversity of historical specimens. They noted that historically there had been some genetic mixing of North Atlantic and eastern Mediterranean populations with North Atlantic haplotypes being reported in seals from Elba Island. Like Salmona *et al.* (2022), they noted at least one extinct genetic lineage in the mid-Mediterranean. They also noted that there is a distinct separation between the populations in Madeira and Cabo Blanco with those populations clustering separately in the Bayesian analysis that they had conducted.

Moreover, Stoffel *et al.* (2018) reviewed the genetic diversity of multiple pinniped species and concluded that Mediterranean monk seals had gone through a population "bottleneck" where the effective population size had likely been reduced to fifty animals or fewer.

The low level of genetic diversity in Mediterranean monk seals has been highlighted as a potential threat to the species (Pastor *et al.* 2004, 2007). Low genetic diversity is likely to be reducing the population's reproductive success due to inbreeding depression (Charlesworth and Willis 2009), *i.e*., a lack of genetic diversity in a breeding population can lead to more frequent expression of deleterious genes that can reduce the fitness of offspring. Congenital defects and stillborn pups have been reported in several monk seal populations (Bareham and Furreddu 1975; Pastor *et al*. 2004). For example, female monk seals have been found displaying polythelia (supernumerary teats) with possible polymastia (additional mammary glands) and it has been suggested that this congenital condition might arise from monk seals' lack of genetic diversity (Cedenilla *et al.* 2022). Low genetic diversity is, therefore, a significant issue that likely impacts the health of Mediterranean monk seals.

2.3.1.3.1 eDNA studies and Mediterranean monk seals

As Mediterranean monk seals primarily haul out in remote sea caves and are hard to see in the ocean, it is extremely difficult to get accurate information on the distribution of this species. To try to determine if monk seals are present in areas, scientists have been using eDNA methods.[12] Valsecchi *et al*. (2022) used a ferry as a platform of opportunity to sample water off the east coast of Corsica in the Tyrrhenian Sea (2018–2019) and monk seal DNA was detected in 47% of the samples. Samples were also taken in 2020 from the Pelagie Islands (between Tunisia and Sicily) and monk seal

[11] The random genetic skewing of small populations, with normally rare genes becoming unusually common (Masel 2011; Star and Spencer 2013).

[12] This term refers to the method of collecting DNA from the environment (e.g. seawater, substrates) and using it for research purposes, such as was determining thepresence of species by identifying the sampled DNA to species level.

DNA was detected in 67% of these latter samples.

A second study utilized water samples collected via a citizen science project, with samples from 120 locations over an area of 1500 km by 1000 km (Valsecchi *et al*. 2022). Positive detections of monk seal eDNA occurred throughout the study area, in particular six "hotspot" areas where monk seals had occurred historically: northern Sicily; Majorca; Elba; Sardinia; the northern Adriatic (Croatia and Italy); and southeastern Italy. The latter is particularly interesting as it coincides with recent sightings by fishers in this region (Bundone *et al*. 2023). These studies show that this technique could possibly be used to monitor monk seal occurrence despite the difficulty in observing and visually monitoring this species.

2.3.1.4. Taxonomic classification or changes in nomenclature

No changes in Mediterranean monk seal taxonomic classification or nomenclature have occurred since the previous 5 year status review (Doss and Nedwell 2017).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.)

Historically, the Mediterranean monk seal was present throughout the Mediterranean and Black seas and in North Atlantic waters from the coast of Northwestern Africa to Spain, including the Canary Islands and the Azores (Panou *et al.* 2019; Karamanlidis 2024a; **Fig. 2**). However, as noted above, the species is currently fragmented into three subpopulations: the Madeira peninsula; the Cabo Blanco peninsula in Mauritania/Western Sahara; and more than 4000km away, the third population in the eastern Mediterranean. Historically there was a fourth population **(Section 2.3.1.3**; Rey-Iglesia *et al*. 2021; Salmona *et al*., 2022) in the mid- and western Mediterranean, which is now likely to be extinct.

Photo-identification and tagging studies suggest that there is no movement between these populations (Fernández de Larrinoa *et al*. 2021; Pires *et al.* 2023), with genetic data suggesting that the eastern Mediterranean population has been isolated from the remaining two populations for some time now, *i.e*., several hundred years at least (Rey-Iglesia *et al*. 2021).

The population in Cabo Blanco is restricted to just three breeding caves along a 1.5km stretch of coast and the adjacent marine environment extending approximately 80km to the north and south of the caves and 12 nm offshore (Fernández de Larrinoa *et al*. 2021).

On the Madeira archipelago, there are 12 potential breeding caves on the main island, of which 2 are currently used by monk seals. On the adjacent Desertas Island there are 13 marine caves, of which 9 are used by seals (Pires *et al.* 2020). The marine habitat of the seals is confined to the shelf around Madeira and the Desertas Islands, which is an area less than 750 km^2 (Fernández de Larrinoa *et al.* 2019).

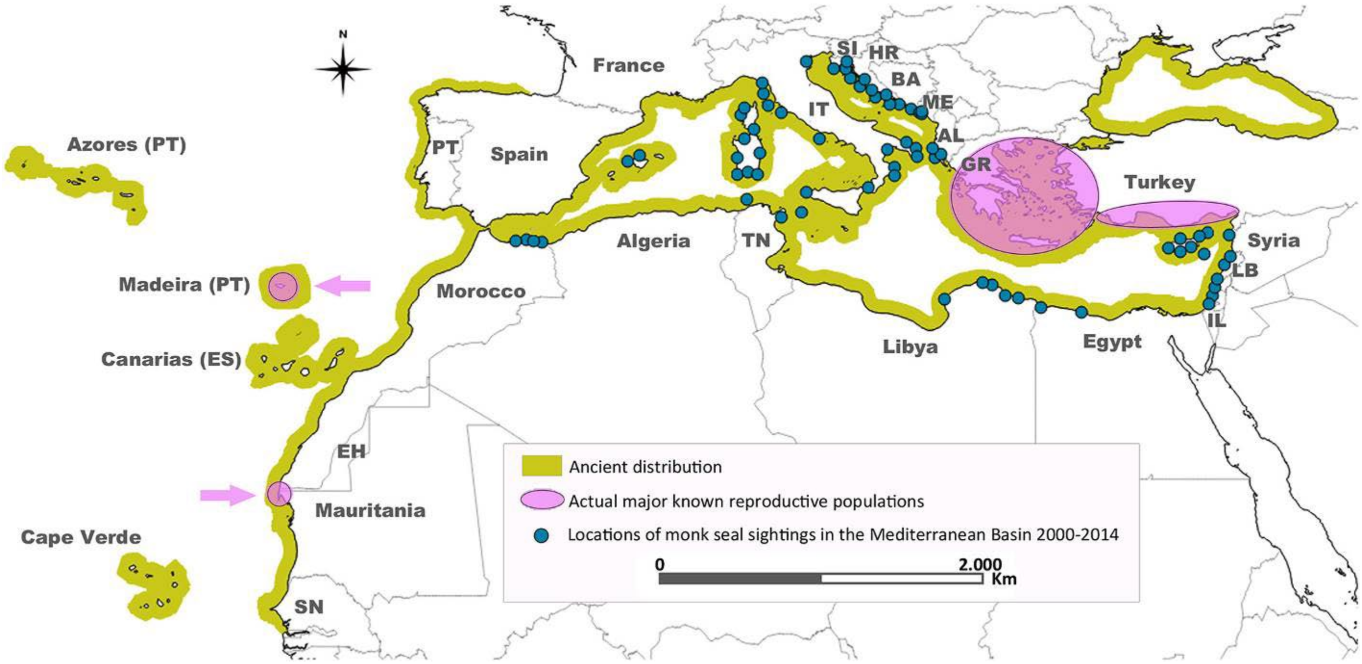

Figure 2. Historic distribution of Mediterranean monk seals and sightings (2000-2014). Areas in pink represent the three known extant populations (source: Panou *et al.* 2019).

The eastern Mediterranean population is primarily found in the coastal areas of Greece and Turkey. Two main monk seal breeding locations in Greece are the remote islands of Astakida and Gyaros (**Fig 3**; Karamanlidis 2024a). In Greece, currently more than 500 caves have been reported to have been used by the species and more than 100 caves that have been used for pupping (Dendrinos *et al.* 2020). However, many possible breeding caves in the region are not used because of human activity nearby (Kıraç and Savaş 2019).

There have also been a small number of seals being reported pupping on open beaches, albeit most of these beaches were in remote locations and/or on uninhabited islands (Dendrinos *et al.* 2022). It has been suggested that use of caves by monk seals is a behavior that has been adopted due to heavy hunting pressure from humans, with the seal seeking out caves for refuge when vulnerable: while pupping and resting (Karamanlidis *et al.* 2016).

Adamantopoulou *et al.* (2023) used twenty years of citizen science data (2000-2020) to monitor the range of monk seals in Greece. The distribution of adult seals increased by 12.5% and pup distribution increased by 185%. The majority of the expanded distribution (67% for all seals and 72% for pups) occurred within the boundaries of marine protected areas. The marine area used by monk seals in Greece is thought to encompass most of the coastline out to a depth of 200m (Adamantopoulou *et al.* 2023).

Panou *et al*. (2023) conducted a literature review on Mediterranean monk seals in the Ionian Sea and highlighted areas where seals have been sighted. This included permanent breeding areas in sea caves on the coast of the Greek islands of Ithaca, Cephalonia [Kefalonia], Zakynthos and Lefkada (**Fig. 4**).

Panou *et al*. (2023) also noted that there have been occasional sightings (~20 over the past decade) off the coast of Albania (Bundone *et al.* 2021), Italy (Fioravanti *et al.*

2020; Zangaro *et al.* 2020; Bundone *et al.* 2023), Israel (Roditi-Elasar *et al.* 2021) and Montenegro (Panou *et al*. 2017) and Gaza, Palestine (Abd Rabou 2023; Abd Rabou *et al*. 2023). More than three hundred sightings have also been reported off the coast of Croatia between the years 2000 and 2014 (Bundone *et al.* 2013, 2019), as well as more recently (Anđelković 2023). However, the sightings off of Croatia are thought to be multiple resightings of just a small number of animals (Bundone *et al*. 2019). In addition to the sightings of seals in the waters of Albania noted above (Bundone *et al.* 2021), Bundone *et al.* (2022) confirmed the presence of at least two monk seals in a breeding cave on the coast of Albania via infrared cameras and findings of seal scat.

The main location for Mediterranean monk seals in Turkish waters is the northeastern Mediterranean coast of Turkey. However, the reproductive rates of seals in this area have recently declined and this, coupled with increased mortality rates, has led to a concern about this population (Kurt *et al.* 2019; Kurt and Gücü 2021). Gökçeada Island, off of the north western coast of Turkey, is one of more important monk seal sites although there are only six caves or haul-out sites that are potential habitat for monk seals. Dede *et al.* (2019) reported five individuals (adult male and female, two young and one pup) using caves on the island.

Güçlüsoy et *al.* (2019) note that Çandarlı Bay, which is situated in the middle of the western coast of Turkey, used to be a monk seal breeding area, and although there are seal sightings they no longer use breeding caves there. This may be due to an increase in development in the area. For example, Kesgin and Nulu (2009) note that within just 15 years the urban area in Çandarlı Bay tripled in size from 580 hectares to over 1,850 hectares (1990 to 2005). Gökova Bay in the southwestern corner of Turkey is also another important monk seal habitat in Turkey. Saydam and Güçlüsoy (2023) reported 18 individual monk seals using five caves in Gökova Bay with two of the caves being used for breeding.

In the Sea of Marmara, between the Aegean Sea and the Black Sea, there have been reports of sightings of monk seals near Karabiga, the Kapıdağ Peninsula and the Marmara Islands (Inanmaz *et al.* 2014; Kıraç and Veryeri 2018; **Fig. 5**). However, the seal is essentially locally extinct in the Black Sea (Kıraç and Savas 1996), although there was a sighting in 1996 on the coast of Silistar, Bulgaria (Boev 2018; **Fig. 6**).

As noted in **Section 2.3.1.2**, despite having been extirpated from Cyprus in the 20th century, there are now increasing numbers of sightings, including reports of pups, around the island, and there now appears to be a small breeding population (Nicolaou *et al.* 2019, 2021; Beton *et al.* 2021; Papageorgiou *et al.* 2023).

Bundone *et al.* (2019) analyzed monk seal sightings[13] in the Mediterranean Basin from 2000 to 2014 and suggested that seals were dispersing, and possibly becoming more stable, in areas where they were previously thought to be extirpated. However, increasing numbers of sightings of monk seals may also be due to a more seal-aware public, and the increased ease by which sightings can be communicated when they are made. Further data/monitoring is necessary to determine whether these areas are

[13] Sightings were collected from a variety of sources, but tourists and those working in tourism areas were a major source. Sighting reports were assessed according to their veracity, ideally due to occompanying photographs, video images or detailed descriptions confirming identity.

being resettled.

A list of countries that were historically occupied by Mediterranean monk seals and where seal sightings, pupping events and regular breeding populations have been observed, are summarized in **Table 3**.

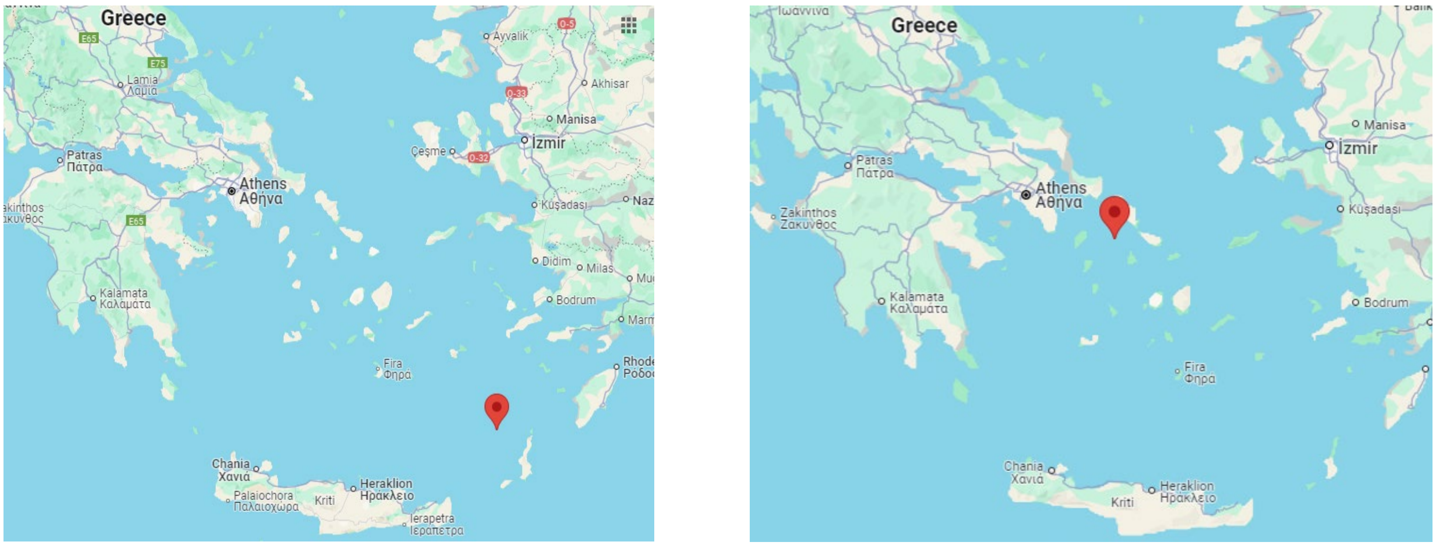

Figure 3. The location of the islands of Astakida (left) and Gyaros (right), the two main breeding locations for Mediterranean monk seals.

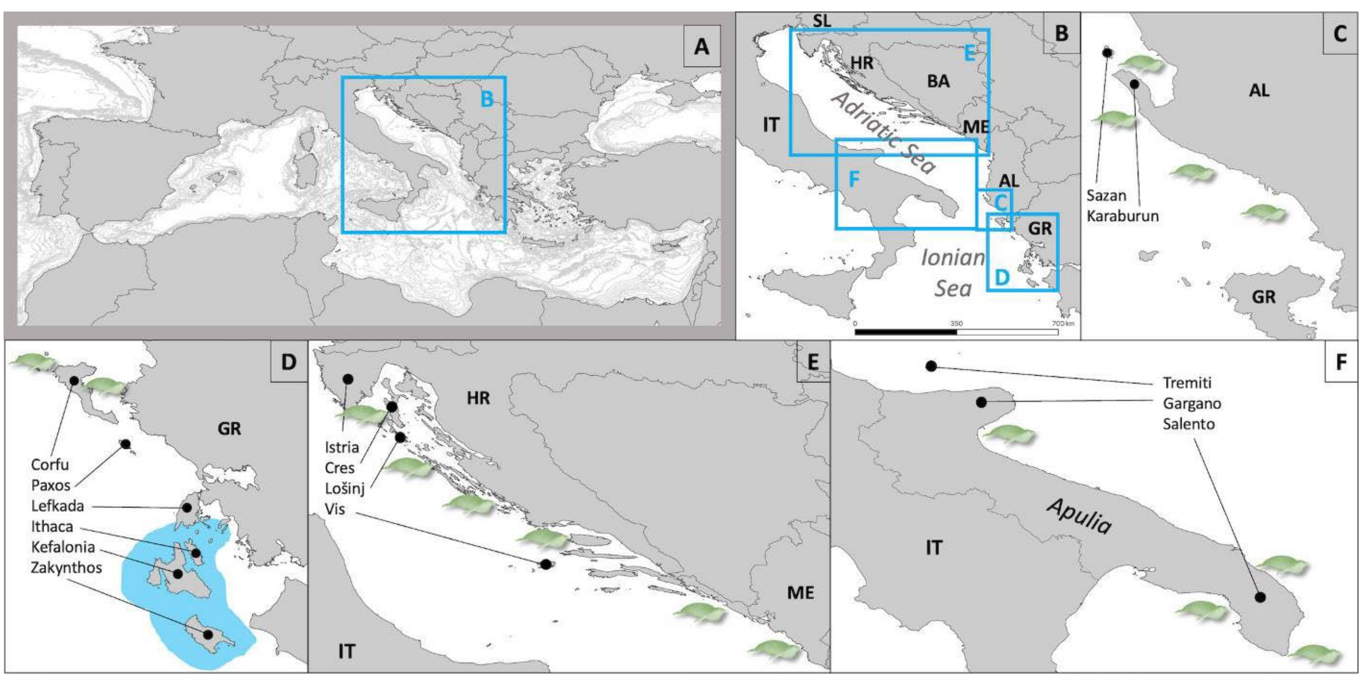

Figure 4. The distribution of the permanent reproductive population of Mediterranean monk seals in the Ionian Sea is shown in blue. Seal icons indicated areas where Mediterranean monk seals have been sighted (source: Panou *et al.* 2023).

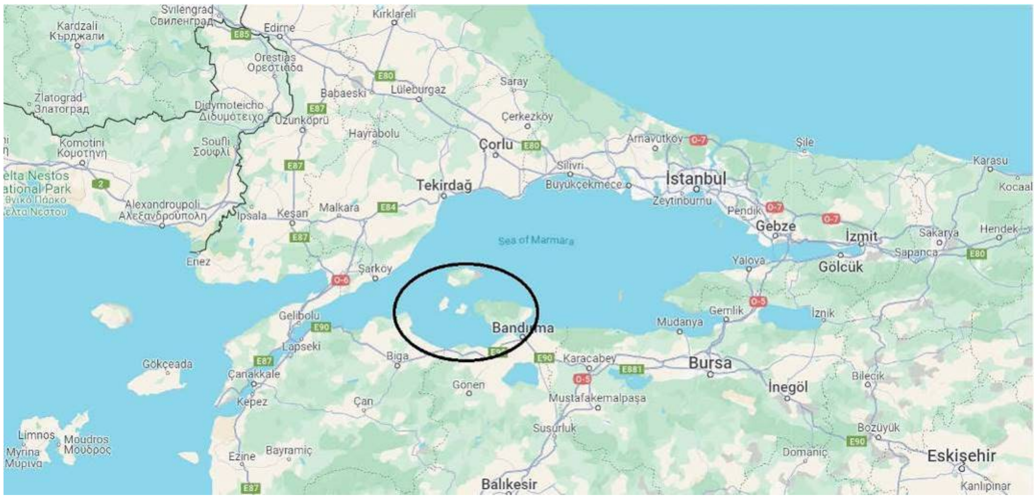

Figure 5. The locations of Mediterranean monk seal sightings in the Sea of Mamara.

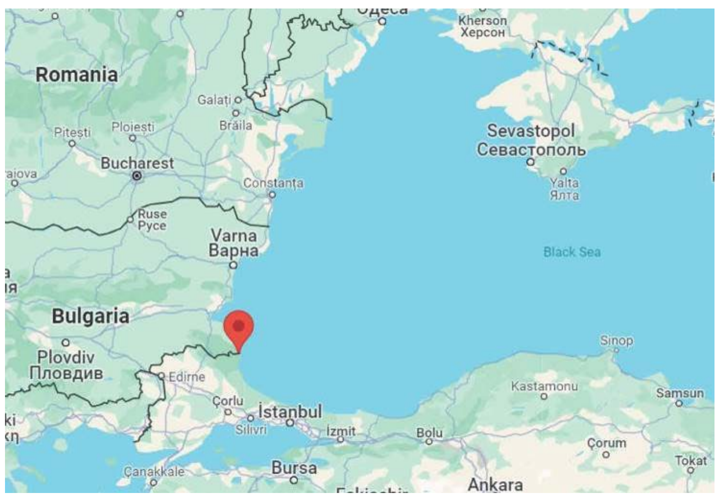

Figure 6. Location of a Mediterranean monk seal sighting (1996) on the Bulgarian coast of the Black Sea.

Table 3. Historic distribution of Mediterranean monk seals by country and indication of whether sightings, breeding, or an extant breeding population has been recently document in the country (modified from Karamanlidis 2024a).

Country	Recent Sightings	Recent Breeding	Extant Population
Albania	x	x	x
Algeria			
Azores (Portugal)€			
Bosnia and Herzegovina			
Bulgaria			
Croatia€	x		
Cyprus€	x	x	x
Egypt			
France€			
Gambia			
Georgia			
Greece€	x	x	x
Israel	x		
Italy€	x		
Lebanon	x		
Libya	x		
Madeira (Portugal) €	x	x	x
Malta€			
Mauritania	x	x	x
Monaco			
Montenegro	x		
Morocco			
Palestine	x		
Portugal€			
Romania			
Russian Federation			
Senegal			
Slovenia€			
Spain€	*		
Syria			
Tunisia			
Turkey	x	x	x
Ukraine			
Western Sahara	x	x	x

*Potentially detected in an eDNA study. € Denotes a European Union country.

The various populations and subpopulations of Mediterranean monk seals are highly fragmented. The North Atlantic and eastern Mediterranean populations are separated by a distance of approximately 4000km. Even in the eastern Mediterranean, the subpopulations are small and highly fragmented. For example, Karamanlidis *et al.* (2021b) notes that the Greek subpopulation of monk seals and the Ionian Sea animals have unique genetic characteristics not shared by neighboring Aegean Sea animals. Moreover, there is a high level of inbreeding in the North Aegean and South Aegean subpopulations, indicating a high level of isolation and a lack of interaction (see **Section 2.3.1.3**).

Kurt *et al*. (2017) modelled the effect of dispersal on four theoretical populations of monk seals[14] and concluded that without dispersal and interconnectivity the four populations would become extinct. Therefore, the high degree of population and subpopulation fragmentation, and the lack of interbreeding between subpopulations, could hinder the conservation and recovery of Mediterranean monk seals.

2.3.1.5.1 Mediterranean monk seal Distinct Population Segments

In the previous status review Doss and Nedwell (2017) noted that the Mediterranean monk seal could potentially be considered to consist of two Distinct Population Segments (DPSs):

(i) a Northeast Atlantic DPS consisting of the Madeira and Cabo Blanco subpopulations; and

(ii) an eastern Mediterranean DPS.

Determining a DPS is based upon the population's *discreteness* and *significance* of the population segment relative to the species as a whole.[15] To be considered discrete, the potential DPS needs tomeet one of the following conditions:

(a) … markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.

(b) … delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.[16]

To determine whether a discrete segment meets the significance criterion of the DPS Policy, we evaluate the biological and ecological importance of the population segment to the taxon to which it belongs. Factors considered in this evaluation include, but are not limited to the following:

(c) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon;

(d) Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon;

[14] Using the VORTEX software (Lacy and Pollak 2023). See https://scti.tools/vortex/.

[15] NMFS and USFWS jointly published a policy regarding the recognition of DPSs of vertebrate species under the Endangered Species Act (61 FR 4722, February 7, 1996).

[16] *Ibid*.

(e) Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or

(f) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.[17]

The eastern Mediterranean population is separated from the two North Atlantic populations by approximately 4,000 km, which is approximately the distance between New York and Los Angeles (2,446 miles or 3,936 km).

Genetic studies have repeatedly reported on significant difference between the Northeast Atlantic and eastern Mediterranean subpopulations (Stanley and Harwood 1997, Pastor *et al.* 2007, Karamanlidis *et al*. 2016; 2021b; **Section 2.3.1.3**). The two populations also have morphological differences (van Bree 1979). This would appear to address the issue of discreteness.

Moreover, there are major differences in policy, conservation resources and management between the populations, as well as the threats faced by monk seals in host countries. For example, in Madeira some types of fishing gear that could entangle monk seals are banned, but in other areas they are not.

Both of the populations are significant and the loss of either of the discrete population segments would leave a significant gap in the range. The Cabo Blanco population was recently nearly extirpated by a disease outbreak (**Section 2.3.2.3.1**), and its loss would have meant the oceanic segment of the species would be nearly extinct. The eastern Mediterranean population is wholly within the enclosed Mediterranean Sea ecosystem, as opposed to the opean ocean habitat of the North Atlantic population. The loss of either population would mean the extirpation of an isolated population adapted to a specific, unique habitat (*i.e*., Mediterranean or oceanic ecosystem) with unique genetic characteristics. Due to the distance between the populations, reestablishment by individuals from the other population would be highly unlikely. The extirpation of either population would essentially reduce the population by roughly half.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem)

Coastal development has led to a loss of substantial areas of historical Mediterranean monk seal habitat. For example, Pires *et al.* 2023, noted how the area where monk seals were first reported on Madeira, and where they were most abundant historically – so much so that the village was named Câmara de Lobos (Chamber of [sea] wolves) – is now devoid of seals. This historical seal habitat has become built up and is now an active fishing port.

Mediterranean monk seals seek out coastal sea caves, which provide shelter, resting places and refuges for breeding and nursing their young (Bareham and Furreddu 1975). However, the coastal caves that monk seals use for breeding and resting are becoming scarcer due to a combination of natural factors such as coastal erosion and cave collapses, and anthropogenic factors such as coastal development and construction. For example in the Cabo Blanco peninsula there are only three coastal caves that are used

[17] *Ibid.*

as hauling out sites and breeding areas (Fernández de Larrinoa *et al*. 2021).

Kurt *et al.* (2018) used infrared cameras monitor sea cave use by three subpopulations of monk seals in Turkey. Seal behavior was categorized as “sheltering,” “resting” and “nursing” with and the duration of these activities was recorded. Human activities in close proximity to the caves was also recorded, with these classed into: “tourism;” “fishing;” “agriculture;” and “industrial”. The researchers found that cave use varied seasonally and regionally. Seals tended to enter caves in the late afternoon and rest overnight, leaving the caves early the next morning. In the summer, caves located in areas of high tourism and industrial activity were used less frequently compared to caves in a Marine Protected Area (MPA). Moreover, some caves that had intense tourism activity that were occupied in the winter, were deserted during the summer months, with seals moving to caves in an MPA. Kurt *et al.* (2018) conclude that this highlights the importance of MPAs for protecting monk seals.

Panou *et al*. (2019) reported on surveys of Greek islands in the Ionian Sea[18] (conducted 1985-2002) during which 140 marine caves and overhangs were surveyed regularly to assess their use by monk seals. In total, 20 caves were used at least once by seals with 16 caves being used regularly, with pups born in five. Nearly two decades later, in 2018, as in the study above, infrared cameras were installed in a selection (n=8) of these caves. The study found that seven of the eight caves were still being used. However, four of the of the 16 previously regularly-used caves were no longer being used and the authors suggested that this was because these caves (in western Ithaca) were exposed to coastal development and tourism. Three out of the five known pupping sites were still being used for breeding - including one cave not monitored by cameras. Moreover, up to six animals were observed using the caves at once, whereas in the previous surveys a maximum of only three animals were observed in a cave simultaneously.

Panou *et al.* (2022) continued this work monitoring the 16 regularly-used caves and reported six monk seal births in 2018, two in 2019, 11 in 2020 and another 11 in 2021. In addition, a new cave was used for breeding in 2020, and two new caves in 2021. Moreover, some of the vacant caves were found to have monk seals resting in them occasionally. Panou *et al.* (2022) considered that this might indicate some recovery in the Ionian Sea population.

Antichi *et al.* (2019) conducted land-based surveys on monk seals in Mykali Bay Samos, a Greek island in the northeastern Aegean Sea. Habitat mapping and identification of fish in the locale was also undertaken. Behavioral observations from this study are summarized in **Section 2.3.1.1.4** with the fish and feeding behavior observed summarized in **Section 2.3.1.1.5**. In terms of habitat mapping, the substrate of the bay was cobbles[19] (60%) and sand[20] (24%) with sparse patches of the seagrasses *Cymodocea nodosa* (4%) and *Posidonia oceanica* (3%).

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[18] Including Kefalonia and Ithaca and the smaller islands of of Atokos, Formicula, Kalamos, Kastos and Meganisi.

[19] Cobbles are rock particles in substrates that are defined under the Udden–Wentworth scale as having a particle size of 64–256 millimeters (2.5–10.1 inches).

[20] Sand is defined as (loose) grains of minerals and rock that are between 0.06mm and 2.1 mm (0.006-0.08 inches).

Fernandez De Larrinoa *et al.* (2019) attached tags to four monk seals from the Madeira population. GPS positions of the tagged seals showed that the seals moved around the Desertas Islands and the Madeira main island, but stayed within the 200m depth contour. This suggests that monk seal foraging habitat is within this coastal shelf area - a total area of only 743 km^2. Diving behavior reported in this tagging study can be found in **Section 2.3.1.1.6.**

Generally monk seals refuge in marine caves that have entrances above or below water level with a corridor leading to an internal pool and a beach that provides a dry haul-out area. Gonzalvo *et al*. (2020) reported upon seal behavior in a different sea cave environment in the Ionian Sea area that was being monitored by an underwater camera. This cave was nearly fully submerged with only a small air filled space and no area to haul out onto. Over 15 days of monitoring, seals were observed on 12 days, for periods of up to three hours. During this time, seals were floating at the surface or sleeping underwater with their eyes shut. It is possible that seals may have been in the cave during the night, but video could not be taken due to a lack of light. It is known that monk seals do not rest exclusively in caves (hauled out onto beach areas or ledges in these caves), as they have been observed sleeping while floating in the water and/or lying on the seabed (Karamanlidis *et al.* 2017; **Section 2.3.1.1.5**). However, this study highlights that nearly submerged caves that do not have dry haul out areas may be used by monk seals for resting purposes, and may be a new type of habitat.

Saydam *et al.* (2022) reported on finding a cave that contained typical features of a resting cave, except that a dry ledge that seals could haul out upon was absent. Therefore, an artificial ledge was constructed to see if this would then be used by seals. A camera trap installed after ledge construction documented one juvenile seal using the cave four times to rest at night (420 minutes in total). This suggests that similar alterations could modify other sea caves to make suitable habitat for monk seals.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range

2.3.2.1.1 Contamination/pollution

2.3.2.1.1.1 Plastics

The Mediterranean Sea is a global hotspot for plastic debris (Marcuso *et al.* 2023) – a situation that is exacerbated by the high urban population and commercial activity along the Mediterranean coastline, a high level of fishing activity, and the enclosed nature of the sea. Notably microplastics[21] are ubiquitous in the Mediterranean and have become incorporated into the food web, with microplastics being found in fish species throughout the Mediterranean basin (e.g., Digka *et al.* 2018; Kilic and Yücel 2022; Mistri *et al.* 2022; Pittura *et al.* 2022; Valente *et al.* 2022; Bonerba *et al.* 2024). As top

[21] Microplastics are small plastic pieces less than five millimeters long. See: https://oceanservice.noaa.gov/facts/microplastics.html#:~:text=Microplastics%20are%20small%20plastic%20pieces,our%20ocean%20and%20aquatic%20life.

predators in the Mediterranean, monk seals ingest microplastic contaminated prey species and accumulate this type of pollutant.

Bundone *et al.* (2022) found plastic fibers in the scat (feces) of monk seals in Albania. A total of 14 microfibres were classified as anthropogenic materials of which two each were identified as polypropylene, polyethylene terephthalate and polyamide, as well as one acrylic fiber. Eight fibers were identified as cellulose and the bright color of the fibers suggested that this was anthropogenically-modified cellulose. There was also a piece of nylon that was likely from a fishing net and many small "clear" fragments that could not be identified.

Hernandez-Milian *et al.* (2023) also used monk seal scat to investigate microplastic consumption. Twelve scat samples were collected from marine caves in Zakynthos Island, Greece. A total of 166 microplastic particles were identified, with three-quarters of the particles being smaller than 3 mm. Most of the plastic particles were filaments (85 %), followed by fragments (14.6 %), and one plastic sphere. A piece of net was also found in one of the scat samples. The most common polymer identified was polyamide (73%), followed by polycarbonate (15.5 %), then polypropylene (6.5 %).

Nine phthalates were also detected in scat samples. Phthalates are plasticizers that can have hormone-mimicking effects, which can impact reproduction and development (Lyche *et al.* 2009). There was a strong statistical correlation between the number of microplastic particles and the concentration of phthalates in the scat samples. Total phthalates levels ranged from 250.37 to 5709.92 ng/g dry weight (mean: 1358.18 ± 585.10 SE ng/g dry weight). Three porphyrins were also detected (average total porphyrins: 38.29 ± 9.9SE pmol/g of analyzed feces): coproporphyrins (mean: 4.30 pmol/g ± 1.2 SE); uroporphyrins (1.09 pmol/g ± 0.4 SE); and protoporphyrins (32.91 pmol/g ± 8.9 SE). Porphyrins can be used as an indicator of exposure to organochlorine pesticides and other pollutants (Cassini *et al*. 2002; Walker *et al.* 2012).

Pietroluongo *et al.* (2017) examined microplastics in two monk seals (among other species) that stranded on Samos, Greece (in 2018-2019). In total, 538 plastic fibers and fragments were reported from these seals. The majority of the plastic particles were fibers rather than fragments of plastic with blue, followed by black, as the dominant colors. Blue fibers in marine species are often derived from fishing gear and is a likely source for the microplastics observed in this study.

McIvor *et al.* (2017, 2021) collected 18 scat samples from monk seals in Madeira (between 2014 and 2021) and microplastic particles were found in all of the samples. A total of 390 microplastic particles were found in these samples, ranging from 0.2 to 8.9 particles.g^{-1} dry weight (mean 1.88 ± 2.20 particles g^{-1}) per sample. Of these, 69% were fragments (69%) of various sizes and polymer composition including polyethylene, polystyrene and polyethylene terephthalate (PET). The researchers noted that this is one of the highest prevalence of microplastics so far recorded from the scat of pinnipeds.

Finally, Danyer *et al.* (2018) reported a 40cm^2 piece of fishing net found in the stomach of a monk seal stranded in Turkey, showing that not only ingestion of microplastics is a problem for monk seals, but also ingestion of larger pieces of plastic debris.

2.3.2.1.1.2 Trace elements

Trace element levels were analyzed in monk seals from Greek islands in the Ionian and Aegean Sea by Formigaro *et al*. (2107). They found that trace element levels were relatively low (**Table 4**) and they considered that these levels were unlikely to be high enough to cause toxic effects. They did note, however, that one adult female seal had a relatively high level of mercury in liver tissue (24.88 $mg.kg^{-1}$ wet weight).

Table 4. Concentrations of trace elements in Mediterranean monk seal tissues collected from 1990 to 2013 in Greece. Values are expressed as mean ± standard deviation $mg.kg^{-1}$ wet weight (source: Formigaro *et al.* 2017).

Tissue	Arsenic	Lead	Cadmium	Mercury	Selenium	Chromium	Nickel
Liver	0.79 ± 0.62	0.17 ± 0.15	0.87 ± 1.90	4.09 ± 7.57	17.33 ± 33.24	0.77 ± 2.56	33.37 ± 11.41
Kidney	0.79 ± 0.59	0.12 ± 0.10	2.46 ± 4.03	1.45 ± 2.28	2.84 ± 2.46	1.15 ± 2.47	3.49 ± 7.03
Blubber	0.69 ± 0.55	0.23 ± 0.90	0.02 ± 0.01	0.21 ± 0.22	0.34 ± 0.44	0.26 ± 0.51	1.22 ± 2.74

McIvor *et al*. (2017) reported on trace element levels from two adult female monk seals (found dead in 2021) from Madeira. The authors noted that trace element levels were generally lower than levels found in monk seals from the eastern Mediterranean except for lead levels which were comparable (0.57 ± 0.14 $mg.kg^{-1}$ wet weight in liver tissue). Generally the trace element levels were low and similar to other pinniped species.

2.3.2.1.1.3 PAHs and organochlorines

Capanni *et al.* (2024) analyzed organochlorine[22] and polyaromatic hydrocarbon (PAH) levels in the blubber of seals from Greek islands in the Ionian and Aegean Seas - the levels are summarized in Table 5. The samples were taken between 1995 and 2013 the researchers noted a statistically significant decrease in DDT and HCB levels over this time, but despite a global ban on PCB production, levels of these contaminants appeared to increase. There was no temporal trend with PAH levels, except that carcinogenic PAHs increased over time. The sale of the pesticide DDT was banned in Europe in the 1970s and its use in agriculture was prohibited in 1983, whereas HCB was banned in 1981. PCBs were used in electrical and hydraulic equipment but were banned by the European Union in 1987. However many older ships may contain high levels of PCBs, and the high level of shipping and number of shipyards in the eastern Mediterranean could be a possible source of new PCBs entering the environment.[23] PAHs are produced by the burning of fossil fuels and aluminum smelting, amongst other processes. The rise in carcinogenic PAHs might be due to patterns of fossil fuel use in power plants and industry in the eastern areas of Europe, as well as increases in road traffic, amongst other factors. Capanni *et al.* (2024) concluded that the levels of organochlorine contaminants and PAHs could potentially have toxic effects upon Mediterranean monk seals. These contaminants are known to negatively impact reproduction, as well as suppressing the immune system (see **Section 2.3.2.3.1**), and

[22] Polychlorinated byphenyls (PCBs), the fungicide hexachlorobenzene (HCB) and the pesticide dichlorodiphenyltrichloroethane (DDT) and its derivatives.

[23] https://www.epa.gov/pcbs/polychlorinated-biphenyls-pcbs-ships.

may be a cause of concern for Mediterranean monk seals.

In addition to these pollutants, monk seals may be threatened by other, as yet untested, chemical contaminants. For example, high levels of fluorinated alkyl substances have been found in dolphins in the Mediterranean (Sciancalepore *et al.* 2021; Garcia-Garin *et al.* 2023). If these top predators are accumulating high levels of this contaminant, it is likely monk seals may also be vulnerable.

Table 5. Organochlorine compound levels in the blubber of Mediterranean monk seals from the Ionian and Aegean Seas. ΣPCB, ΣDDT and HCB levels are expressed as $\mu g.g^{-1}$ lipid weight and ΣPAH levels as $ng.g^{-1}$ dry weight (source: Capanni *et al.* 2024).

	N	Mean	Range
ΣPCB	49	95.8	2.38-1610
ΣDDT	49	79.1	2.28-893
HCB	49	216	n.d. -1.06
ΣPAH	55	637	69.1–7890
Σcarcinogenic PAH	55	19.7	1.77–121

2.3.2.1.1.4 Oil

Mediterranean monk seals may also be at risk from oil spills due to increased oil tanker traffic in their habitat. For example, at least three oil spill incidents in Turkey have affected Mediterranean monk seals and their habitat (Kıraç 1998; Kıraç *et al*. 2022). Exposure to oil can have multiple impacts on the health of seals including (Engelhardt 1983; EPA 1999; Helm *et al*. 2015):

- inhaling toxic, volatile hydrocarbons that can damage the respiratory system;
- seals grooming when coated with oil can damage the gastrointestinal system and lead to the consumption of toxic contaminants;
- oil and volatile compounds in the oil can damage the skin, eyes, and mucus membranes; and
- consuming contaminated prey can cause the uptake of toxic hydrocarbons.

Oil-related contaminants can cause reproductive failure; immune system suppression; organ damage; cancer; and other health problems in pinnipeds. Therefore, the risk of oil spill and oil-related pollution is an additional stressor for this endangered species.

2.3.2.1.2 Aquaculture

Aquaculture sites are likely to be sited in shallow, sheltered, nearshore waters that may also be used by Mediterranean monk seals. Pinnipeds are known to be attracted to aquaculture sites (especially finfish facilities and) and often damage and tear through fishfarm nets to get to the stock contained within (Bath *et al.* 2022). However, fishfarms may also cause local fish to aggregate around the cages. For example, Bonizzoni *et al.* (2014) reported that in the Mediterranean, dolphin abundance increased around fish farm sites as they fed on the fish that clustered around fishfarm cages. So, seals seen in proximity to fishfarms may not necessarily be attacking and damaging the cages in order to access fish.

To try to prevent pinnipeds from damaging fishfarm cages and consuming or damaging their stock, companies may use anti-predator nets which can potentially entangle seals

(Bath *et al*. 2022). There has been at least one known fatal entanglement of a monk seal in a Turkish fishfarm net (Güçlüsoy and Savas 2003).

In addition to anti-predator nets, aquaculture facilities can use acoustic harassment devices (AHDs), acoustic deterrent devices (ADDs), or "seal scarers" to displace marine mammals from aquaculture sites. These loud acoustic devices, are designed to repel pinnipeds, and could displace them from their habitat.

Gomes Camacho (2023) tested the use of an ADD and how it influenced monk seal behavior at a fish farm site in Madeira. They found that the seal did not leave the area when the ADD was in use, but rather it swam at the surface – this type of behavior has been exhibited before with seals as they raise their heads above water to avoid the acoustic disturbance underwater. The seal tended to approach the aquaculture site when fish were being fed. It is possible that fish feed may attract wild fish to the aquaculture cages and the seal was pursuing these aggregating wild fish rather than the caged fish. Akyol *et al*. (2019) reported that local fishing activity in Turkey often concentrated around fish farms because they attract wild fish, leading to conflict between fishing and aquaculture operations.

Other possible impacts of aquaculture include waste and fish food passing through fish farm cages and accumulating beneath. This waste and fish food then decomposes on the seabed. This can cause anoxic or "dead" zones that are depleted of oxygen near the sites (Gillibrand *et al.* 1996). In addition, the excess nutrients from waste and fish feed can unbalance food webs in local ecosystems and also cause algal blooms that can be toxic to marine mammals (Flewelling *et al.* 2005; Broadwater *et al.* 2018). Borrell *et al*. (2020) reported that hypoxic and anoxic events associated with fish farms, and other sources of nutrient pollutions in the Gulf of Ambracia (which opens into the Ionian Sea) has reduced fish diversity and degraded the local marine habitat. This, in turn, may have promoted marine mammals depredating fishfarms and local net fisheries.

In addition, aquaculture sites sometimes use anti-sea lice treatments that could be toxic to marine life, or use antimicrobials and antibiotics, which could alter the microbial ecology of surrounding areas, including promoting antibiotic resistant bacterial strains (Okede *et al.* 2022).

Conflict with fishfarm operators is another threat to monk seals. As noted above, Mediterranean monk seals have been reported interacting with fishfarms (Güçlüsoy and Savas 2003). For example, between 1992 and 2000, monk seals predated on fish at 11 marine finfish farms in the Turkish Aegean. The fish farms were holding gilthead sea bream (*Sparus auratus*) and European sea bass (*Dicentrarchus labrax*) in cages. The seals damaged the cages, leading to fish escapes during most interaction events. Antipredator nets did appear to prevent depredation events, but such nets do pose an entanglement problem and risk of mortality for the endangered seals (as noted above).

Akyol *et al*. (2019) noted that Turkish aquaculture operators reported monk seals causing damage to fishfarm enclosure nets, with seals eating fish contained within the nets, but the damaged nets also causing fish to escape. This depredation and net damaged was reported by 18% of fish farmers in Muğla and 40% in Izmir, southeast Turkey. In Muğla most depredation events were caused by sharks and Bluefin tuna, however. Whereas, in Izmir fish farmers reported dolphin and monk seal predation.

The fish farm companies have tried to deter the seals using non-lethal methods ("warning" gun shots; making noises; use of lights; and anti-predator nets; Güçlüsoy and Savas 2003). However, the fishfarm companies have also used lethal means (Güçlüsoy and Savas 2003): poisoning the seals with pesticide-laced fish and also shooting seals.

Despite Mediterranean monk seals being listed under Appendix II of the European Habitats Directive (see **Section 2.3.2.5**) - which prohibits disturbing, injuring or killing monk seals - deliberate killing of seals by fishfarm workers still occurs (see also Section **2.3.2.4.4**). For example, Stickland (2022) reported that a monk seal had been killed at a fishfarm site near Milina, Greece (an EU country).[24]

Aquaculture is developing rapidly in the Mediterranean. For example, the industry is rapidly growing in Greece,[25] with many sites in areas inhabited by monk seals (such as Kefalonia). Bundone *et al.* (2022) reported evidence of monk seal caves on the coast of Albania in close proximity to 7 finfish aquaculture sites (gilthead sea bream and European sea bass). Therefore, these fishfarm sites may pose a risk to this newly established subpopulation of seals. Although the monk seal caves are within a marine protected area, if the seals investigate the nearby fishfarm site they would be outside the protected area.

The potential impact of fishfarms on monk seals is an issue that warrants further study.

2.3.2.1.3 Development

The Mediterranean's 46,000 kilometers of coastline has been transformed by coastal development, which includes tourism, port development, and expanding urban areas.

Around one in three people in the Mediterranean live in coastal regions, and 40% of the coastal zone is covered by man-made structures (UNEP 2018). The Mediterranean is the number one tourist destination, with over a third of a billion tourists visiting annually primarily for coastal vacations (UNEP 2018; Tovar-Sánchez *et al.* 2019). Much of the coastal development in the Mediterranean involves the infrastructure to support this major industry (hotels, roads, restaurants, marinas etc.).

Nearly three decades ago, along the 656 km of the Côte d'Azur (France) coastline, nearly 106 km had been built over, including 31 km^2 that had been turned into ports, dikes, landfills and artificial beaches. It was estimated that 15% of the shallow water area between 10 m deep and the shore had been irreversibly destroyed due to construction (Meinesz *et al.* 1991). Subsequently habitat destruction due to coastal development has continued to increase.

More than 80% of beaches (*i.e.*, potential seal haul-out sites) in the Aegean archipelago (a major monk seal habitat) are associated with tourism-related infrastructure (hotels, shops, roads, accommodation etc.), with 33% of these beaches being heavily developed (e.g., tower block hotels; Monioudi *et al.* 2017).

In addition to tourism-associated development, the construction of ports and shipping

[24] In the Pagasetic Gulf on the east coast of mainland Greece, northern Agean.

[25] https://www.fao.org/fishery/en/facp/grc.

terminals, industrial areas, and urban sprawl are permanently altering coastal areas.

Ok *et al.* (2019) and Yigit *et al.* (2019) documented a case in which a large docking facility for a cement factory was constructed less than 500m (0.3 miles) from a well-known breeding cave in Yeşilovacık Bay, Turkey, despite sea caves being designated as "First Degree Natural Assets"[26] in Turkey, which should be protected from deliberate damage and illegal construction/development. Cave use was monitored before, during, and after construction occurred. During construction the number of seals using the cave was dramatically reduced. Two seal pups were born during the construction period but the carcass of one pup was found in an emaciated state nearby the cave. No further breeding activity has been subsequently recorded in the caves.

Vessels servicing the concrete factory are greater than 30,000 GRT[27] in size and manoeuver in front of the cave. It was estimated that underwater noise levels from shipping would be 174dB re 1 μPa and, therefore, high enough to cause a major disturbance to breeding seals.

2.3.2.1.4 Climate change

As noted in the previous status review (Doss and Nedwell 2017) it is expected that as sea levels rise, the number of, and available space within, breeding and resting marine caves will likely become increasingly scarce (Otero *et al.* 2013). Climate change has also caused an increasing number of marine heatwaves - of increasing intensity - in the Mediterranean (Garrabou *et al.* 2022). These heat waves have been associated with a number of mass mortality events of marine species – including ecologically imparts species such as reef building corals and seagrass beds (Garrabou *et al.* 2022). It is also predicted that the Mediterranean region may experience more intense storms (Gaertner *et al.* 2007; Davolio *et al.* 2009; Cioni *et al*. 2018; Ranasinghe *et al.* 2021) up to hurricane strength "medicanes" (Cavicchia *et al.* 2014). Considering the habitat of monk seals, such storms could flood and damage caves as well as present a direct risk to hauled out monk seals.

2.3.2.1.5 Summary

A long history of pollution in the Mediterranean coupled with the monk seal's role as a top predator makes them vulnerable to accumulating significant pollutant loads. This could act as a synergistic stressor with other threats, and coupled with their low genetic diversity, these pollutants could reduce their levels of successful reproduction and make them more vulnerable to disease.

The high level of coastal development in the Mediterranean is also a significant issue, not only in terms of loss of habitat but also the noise and disturbance caused. In particular, coastal development related to tourism synergistically to the threat that this sector poses – *i.e.*, increasing disturbance and harassment by tourists, tourism activities and boat traffic (see **Section 2.3.2.2.2**).

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[26]https://www.fao.org/faolex/results/details/en/c/LEX-FAOC150437/#:~:text=Law%20No.-,2863%20on%20the%20protection%20of%20cultural%20and%20natural%20assets.,for%20their%20management%20and%20protection.

[27]Gross registered tonnage, which represents the total internal volume of cargo vessels. 1 GRT = 100 cubic feet ≈ 2.83 cubic metres.

The rapid increase in aquaculture is also an issue that warrants monitoring as, in addition to the habitat degradation it causes, there is deliberate harassment and killing of seals associated with this industry (see **Section 2.3.2.4.4**). A code of practice for aquaculture across the Mediterranean, coupled with non-injurious mitigation for seal depredation (such as multiple, rigid nets around fish farm sites) and severe penalties for killing or injuring monk seals might help to reduce conflict.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes

2.3.2.2.1 Commercial utilization – harvesting and trade

There has been a long history of hunting and exploitation of monk seals in the Mediterranean (**Section 2.3.1.3**; Johnson and Lavigne 1999; Johnson 2004). However, no new threats related to overutilization have been identified for Mediterranean monk seals since the previous 5 year status review (Doss and Nedwell 2017). Moreover, Mediterranean monk seals are listed under Annex IV of the EU Habitats Directive which means that for many potential range States[28] their deliberate capture and killing is prohibited.[29]

2.3.2.2.2 Tourism

Kerametsidis *et al*. (2022) used social media to investigate information on Mediterranean monk seals and possible disturbance by tourists. They searched five social media platforms for images and videos (from 475 posts) of monk seals (from 2010 to 2020) and three independent researchers analyzed them to assess the level of disturbance that occurred in the videos. Major and minor disturbances were observed in 21% and 36% of the videos, respectively. Whereas, 38% of the videos did not seem to show any evidence of disturbance (the reviewers disagreed on 5% of the videos). The highest percentage of videos showing major disturbance (25%) were taken in the Aegean Sea (*i.e*., Greece, eastern Turkey), whereas in the Northern Levantine Sea (*i.e*., Cyprus and southern Turkey) nearly half of the videos (49.5%) showed no disturbance. Greece is an EU country and, therefore, Mediterranean monk seals should be protected from deliberate disturbance.[30]

Since 1990, there has been an increase in SCUBA diving tourism to monk seal caves in Turkey.[31] Diving companies have been taking tourists to breeding and resting caves with underwater entrances. This had led to concerns about the disturbance of seals and the abandonment of caves.[32] Entering these caves is prohibited, but their remoteness makes it difficult for these sites to be monitored. This type of tourism is particularly prevalent in the Bodrum, Marmaris, Fethiye, Kemer, Kaş and Alanya regions of Turkey.[33]

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[28] Including France, Italy, Croatia, Cypus, Greece, Malta, Portugal, Slovenia and Spain.

[29] Art 12 1(a) of the EU Habitats Directive.

[30] For example under Art 12 1(b) of the EU Habitats Directive.

[31] SAD-AFAG (Underwater Research Society – Mediterranean Seal Research Group). https://sadafag.org/en/mediterranean-monk-seal/.

[32] *Ibid.*

[33] *Ibid.*

Mpougas *et al.* (2019) conducted observations of monk seals in Greece (June-July 2018) - boats (tourism and recreational boats) were recorded in the vicinity of the seals 62% of the time. Boat operators also tried to interact with seals 17% of the time. Seal occurrence decreased later in the day, but adjusting for this it was found that seal occurrence declined as boat vessels increased. Seal presence was four times more likely during low boat traffic periods, as opposed to times with high traffic levels. When boat traffic was absent, "resting" was the most commonly observed behavior (36%), followed by "underwater activity" (27%) and "sleeping" (20%). When boats were present, the most observed behavior was being "alert" (47%), followed by "fleeing" (23%). "Resting" was also observed, but at less than half the rate as when boats were absent (17%). "Relaxing" behaviors (e.g., resting and sleeping) significantly decreased with higher boat traffic, whereas "vigilant" behaviors increased.

2.3.2.2.3 Scientific monitoring

No threats related to scientific monitoring have been identified for Mediterranean monk seals since the previous 5 year status review (Doss and Nedwell 2017).

2.3.2.3 Disease or predation

2.3.2.3.1 Disease

Disease has been considered to be major issue for the conservation of the Mediterranean monk seal in the past (Doss and Nedwell 2017). Notably, in 1997, there was a mass mortality event at Cabo Blanco that killed nearly two-thirds of the Mediterranean monk seal population (Forcada *et al.* 1999), which was possibly due to a virus outbreak (Harood 1998; Osterhaus *et al*. 1992, 1997; van de Bildt *et al.* 1999) or a harmful algal bloom[34] (Hernández *et al.* 1998).

Several genetic studies have demonstrated that Mediterranean monk seals have gone through population "bottlenecks"[35] and populations have very low genetic diversity (**Section 2.3.1.3**). This low genetic diversity may have compromised the seals' immune systems - a condition that has negatively impacted other threatened mammal populations (e.g., Miller *et al.* 2011; Murchison *et al.* 2012; Dobrynin *et al.* 2015; Gibson 2022).

However, other factors may compromise marine mammal immune systems, such as trace element exposure (Bennett *et al*. 2001; Cámara Pellissó *et al*. 2008); organochlorine pollutants (Aguilar and Borrell 1994; Ross 2002 Schwacke *et al.* 2012; Hall *et al*. 2018); and chronic stress (Curry 1999) - such as the stress caused by anthropogenic noise exposure (Wright *et al.* 2009, 2011; Rolland *et al.* 2012). These genetic and anthropogenic threats should be considered as synergistic factors when it comes to diseases and Mediterranean monk seals.

2.3.2.3.1.1 Parasites

A monk seal stranded in the Pagasitikos Gulf (Greece), in 2019, was found to have a nematode (roundworm) in its digestive system that was genetically identified as the

[34] Dinoflagellate-produced saxitoxins.

[35] *i.e.*, reduduced to 50 or fewer animals.

species *Pseudoterranova bulbosa* (Koitsanou *et al.* 2021, 2022). The discovery of this parasite was unusual as it is normally found in the deep waters of the Atlantic. The researchers that found the nematode suggested that it might have been acquired by consuming infected Atlantic cod (*Gadus morhua*), or passed into the Mediterranean ecosystem by another marine mammal that travels into cooler Atlantic waters, such the long-finned pilot whale (*Globicephala melas*). This is the first time that this species of parasite has been reported from the Mediterranean. Koitsanou *et al.* (2022) expressed concerns that a novel parasite in a species with such a low genetic diversity as monk seals, could potentially threaten the health of the species.

Another stranded monk seal in the Pagasitikos Gulf was found to be infected with the nasal mite *Halarachne halichoeri* in its lungs (Athinaiou *et al.* 2023). This arachnid parasite is also normally found in the Atlantic Ocean and carried in seal species such as the grey seal (*Halichoerus grypus*). *Halarachne halichoeri* has recently appeared in seals in Germany after nearly a century of being absent from the country (Reckendorf *et al.* 2019), which researchers have attributed to the recovery of the grey seal population – leading to this host species carrying the parasite into new areas as its range expands. An infection by this parasite can cause bronchopneumonia and pulmonary emphysema in the infected seal, which could be critical to the health of marine mammals that rely on being able to hold their breath in order conduct essential behaviors, such as foraging. As with the parasite noted above, the low genetic diversity and disease susceptibility of the Mediterranean monk seal makes the report of a new parasite a cause for concern.

Danyer *et al.* (2018) describes necropsies of three female seals from Turkey: a pup that was found with nematodes in its intestines; another animal that had an ulcerated and hemorrhagic stomach and cestodes (tapeworms) in its intestines; and third animal with nematodes, cestodes and acanthocephalan (spiny headed worms) parasites in its stomach and intestines. The latter also had hemorrhagic (bleeding) lungs with an accompanying heavy mite infestation. Although these mites were not identified it is possible that they could also be *Halarachne halichoeri* (as found by Athinaiou *et al.* 2023).

Danyer *et al.* (2017) described and identified parasites found in two males and a female monk seal from Turkey stranded between 2013 and 2014. One male, a pup, had the mite *Orthohalarachne diminuata* (Arachnida: Halarachnidae) around its nostrils, with nematodes (*Anisakis* sp.) and cetodes (*Diphylobothrium* sp.) in its oral cavity. The female had the trematode (fluke) *Braunina cordiformis* attached to its stomach wall. There was no parasitic infestation in the adult male monk seal. The nematodes, cestodes and flukes found in the above seals can cause gastritis, ulceration, enteritis, diarrhea, dehydration, and anemia. These conditions can potentially be fatal to their seal hosts. This study notes that it is the first time that either *Orthohalarachne diminuata* or *Braunina cordiformis* have been reported in Mediterranean monk seals.

Fecal samples from orphan seal pups in a rehabilitation facility (collected from 22 different locations in Greece) were all found to contain hookworm (*Uncinaria hamiltoni*) eggs or adults (Komnenou *et al.* 2021). Hookworms have been known to cause anemia, hemorrhagic enteritis, reduced growth and susceptibility to other diseases. They have also been linked to high levels of mortality in young pinnipeds – with reports of mortality rates of up to 70% of the infected pups (Keyes 1965; Fujiwara *et al.* 2006; Castinel *et al.* 2007; Spraker *et al*. 2007). It was suggested that hookworm infection could have a serious impact on monk seal pup survival due to nutrient and energy loss from gastrointestinal hemorrhage. This is emphasized by the fact that Komnenou *et al.* (2021) reported that half of the seal pups died shortly after entering the rehabilitation facility.

2.3.2.3.1.2 Toxoplasmosis

Toxoplasma gondii is a protozoan (single-celled) parasite that is most commonly found in cats. It is a zoonotic parasite, *i.e*., it is able to pass to other species including domesticated animals, marine mammals and humans (Ross *et al.* 1996; Dubey 2010; Tenter *et al.* 2000). The parasite has been reported in several dolphin species in the Mediterranean (Di Guardo *et al.* 2010; Traversa *et al.* 2010; Grattarola *et al.* 2016; Bigal *et al.* 2018). It is also a significant cause of mortality for Hawaiian monk seals (*Monachus schauinslandi*; Barbieri *et al.* 2016), with at least fifteen of this latter species having died from toxoplasmosis as of 2023.[36]

Toxoplasmosis can negatively affect reproductive rates by causing fetal abnormalities and stillbirths (Tenter *et al*. 2000). It is also known to be sometimes fatal in marine mammals (Herder *et al.* 2015; Dubey *et al.* 2020). Generally, the parasite only causes disease in animals with a compromised immune system. However, a number of pollutants can impact marine mammal immune systems, such as trace element exposure (Bennett *et al*. 2001; Cámara Pellissó *et al*. 2008) and organochlorine pollutants (Aguilar and Borrell 1994; de Swart et al. 1996; Van Loveren *et al.* 2000; Ross 2002). Moreover, chronic stress (Curry 1999), such as that caused by anthropogenic noise exposure (Wright *et al.* 2009, 2011; Rolland *et al.* 2012) can also lead to immune system impairment. However, the extreme lack of genetic diversity in Mediterranean monk seals would likely make them vulnerable to this pathogen – as seen in other threatened mammal populations (e.g., Miller *et al.* 2011; Murchison *et al.* 2012; Dobrynin *et al.* 2015).

The parasite can be spread into the marine environment by the waste of feral or outdoor cats being transferred into the ocean via, surface runoff or from cat litter deposited in landfills/flushed into the sewage system (Shapiro *et al*. 2019).

A Mediterranean monk seal pup stranded on the southern Adriatic Italian coast (in January 2020) was found to have simultaneous infections of *Toxoplasma gondii* and cetacean morbillivirus (Mazzariol *et al.* 2021; Petrella *et al.* 2021). The animals was described as having moderate to severe necrotizing myocarditis[37] and a diffuse, chronic interstitial pneumonia,[38] with bronchial epithelial hyperplasia.[39] Necrotizing arteritis[40] in the aorta[41] and major pulmonary (lung) arteries was also found associated

[36] https://www.fisheries.noaa.gov/pacific-islands/endangered-species-conservation/toxoplasmosis-and-its-effects-hawaii-marine.

[37] Inflammation of heart muscles and necrosis (i.e., death) of heart muscle cells.

[38] Inflammation in the spaces between the air sacs (alveoli) and blood vessels in the lungs.

[39] Increased multiplication of the cells lining the windpipe.

[40] Inflammation and death of the cells in artery walls.

[41] The main blood vessel leading from the heart.

with the *T. gondii* parasite. Lymphatic tissues also showed signs of severe depletion of white blood cells. Severe hemorrhagic (bleeding) lesions of meningoencephalitis[42] were also seen in the brain.

Cetacean morbillivirus has been reported previously in monk and harbor seals (*Phoca vitulina*) (Van Bressem *et al*. 2014). In 1997, half of the Mediterranean monk seals inhabiting the shores of Mauritania died and were found to have been infected with cetacean morbillivirus (**Section 2.3.2.3.1**). It has also been found in monk seals in Greek waters (Van Bressem *et al*. 2014). However, simultaneous *T. gondii* and morbillivirus infections have not been observed before in monk seals.

It was suggested that the morbillivirus may have reduced the immune system of the seal in this particular case, leading to fatal toxoplasmosis (Mazzariol *et al.* 2021; Petrella *et al.* 2021). This incidence of fatal toxoplasmosis and morbillivirus raises concerns and, although cases of both diseases are limited, it is a situation that warrants monitoring.

2.3.2.3.1.3 Recue and rehabilitation

Komnenou *et al.* (2019) summarized the rehabilitation program for Mediterranean monk seal pups[43] in Greece, noting that from 1990, twenty-nine pups (14 females and 15 males) had been admitted to the program. These pups ranged in age 1 week-2.5 months, with their weight ranging from 9kg-18kg.

Many of the pups displayed signs of: severe dehydration; malnutrition; mild to severe skin injuries; conjunctivitis; and pale mucosal membranes (often a sign of anemia). Many animals displayed moderate to severe hypoglycemia (low blood glucose) and anemia (low red blood cell counts), as well as infection by nematode parasites (*Uncinaria* spp.). Because of the parasitic burdens and malnutrition issues various gastrointestinal problems were common in the pups. To prepare the pups for release back into the wild, they were trained to catch live fish and contact with humans was minimized to avoid habituation.

Fifteen animals died during the rehabilitation process due to fatal infections, severe anemia, hypoglycemia and malnutrition, as well as respiratory and gastrointestinal issues. Fourteen seals were, however, reintroduced back into the wild. Considering the small size of the Greek monk seal population, these reintroductions represent approximately 4% of the population. Therefore, programs such as this, if successful, could help to reduce the high mortality rates seen in monk seal pups (see **Section 2.3.1.1.2**).

2.3.2.3.2 Predation

Although predation does occur on monk seals, in the previous 5-year status review Doss and Nedwell (2017) concluded that the level of predation does not constitute a threat to monk seal conservation. There has been no new information on predation published about Mediterranean monk seals since the previous status review.

[42] Inflamation of the brain and the membranes lining the central nervous system.

[43] These are typically injured, orphaned, lost or abandoned pups.

2.3.2.4 Other natural or manmade factors affecting its continued existence

2.3.2.4.1 Bycatch and fisheries interactions

Kıraç *et al.* (2020) reported twelve cases of monk seal bycatch or fishery-related incidents in Turkey[44] between 1994 and 2018. Ten of the animals died. However, two animals that were entangled in nets were released. Eleven of these incidents were in set gill nets, and one was a case of dynamite fishing. The information on these bycatches were gathered from members of the public and the fishing community, as well as via field research. Additionally, Danyer *et al.* (2018) reported a stranded monk seal in Turkey with injuries on its body suggesting that it had been entangled in a fishing net. Considering that the size of the Turkish monk seal population is currently estimated to be just 76-103 animals, this is a relatively high level of known bycatch (**Section 2.3.1.2**; **Table 2**; Karamanlidis 2024b).

Danyer *et al.* (2018) also reported that between 1994 and 2014, 32 instances of monk seal entanglement had been discovered - with information coming from researchers as well as reports in the press (Güçlüsoy *et al.* 2004; Danyer *et al.* 2013a, 2013b, 2014). It is unclear, however, whether these entanglements were within the eastern Mediterranean as a whole, or just Turkish waters. Regardless, this is a notable level of bycatch during a period when monk seals were severely depleted in this region.

Ateş *et al.* (2019) interviewed small-scale fishers in Turkey and 6% reported monk seals having become entangled in nets, 4% reported seeing dead monk seals and 58% reported seals causing damage to their nets.[45] Rios *et al.* (2017) likewise reported on negative interactions between Mediterranean marine mammals and small-scale fisheries, with instances of depredation by monk seals reported on 19% of fishing trips. Karamanlidis *et al*. (2020) also investigated monk seal and small-scale fishery interactions in the Aegean and Ionia Sea, conducting questionnaire surveys in ports[46] and interviewing members of the fishing community. The biggest problem facing small-scale fisheries in Greece, according to those surveyed, was net damage caused by marine mammals. Damage to fishing gear occurred on 21% of all fishing trips (Karamanlidis *et al*. 2020).[47] Participants considered that mitigation measures to reduce these interactions were ineffective, but they stated that compensation and/or subsidies (89%) to replace damaged nets could sufficiently remediate for the damage caused. However, 11% suggested that killing marine animals was the most effective solution to prevent interactions (Karamanlidis *et al*. 2020).

There appears to be negative attitudes towards Mediterranean monk seals from a section of the fishing community. This negativity is due to damage caused to nets and perceived competition for fish stocks. These attitudes may potentially hinder conservation impact, and in some cases might lead to the deliberate killing of seals (see **Section 2.3.2.4.4**).

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[44] İzmir (western Turkey), Antalya and Mersin (southern Turkey) provinces.

[45] These values were calculated by back calculating percentages presented in the paper and summing the data between three regions.

[46] Surveys were conducted in the Argosaronic Gulf and the islands of Alonnisos, Chios, Elafonisos, Kalymnos, Karpathos, Kimolos, Kythira, Milos, Oinouses, Psara and Zakynthos.

[47] Although it should be noted that cetaceans were reported as the main cause of fishing net damage rather than monk seals.

Table 6. Number surveyed in each region of the Karamanlidis *et al*. (2020) study noting the population estimates of seals according to interviewees, percentage reporting specific net damage and estimated annual number of entanglements.

Location	n	No of seals	Damage to nets	Annual Entanglement
Alonnisos	17	69.8	94%	0
Argosaronic Gulf	56	18.5	82%	2
Chios	41	14.16	95%	1.4
Elafonisos	26	14.38	100%	3.3
Kalymnos	40	20.3	100%	1.3
Karpathos	14	26.68	100%	1
Kimolos	1	100	100%	0
Kythira	17	11.69	82%	1
Milos	2	67.5	100%	3
Oinouses	5	7.8	100%	1
Psara	13	12.67	92.3%	1
Zakynthos	20	14.76	95%	1.7

In total, the annual estimated entanglement rate in this area of Greece was 16.7 (**Table 6;** Karamanlidis *et al*. 2020) animals a year. If these estimates are correct it would mean that between 3.7%-5% of the Greek monk seal population was being entangled annually.

In Madeira observers onboard fishing vessels (n=20; 2016-2018) monitored levels of monk seal interactions **(**Centenera Martín *et al*. 2019**)**. Two hundred fishing trips from 9 different fishing harbors, using 8 types of fishing gear, were monitored. No interactions with seals were observed, indeed, seals were only observed twice during the study.

The fishing community (n=98 fishers from 45 vessels) was also interviewed to assess their attitudes towards seals (Centenera Martín *et al*. 2019). Nearly half of the participants (47%) stated that they never observed seals while fishing. The lack of interaction may be because fishing is generally restricted close to shore and the majority of species targeted by fishers are pelagic, whereas monk seals tend to forage coastally in shallower waters. Therefore, there is little overlap between monk seals and fishing effort.

Over half (52%) of those interviewed did not want the monk seal population to grow and two-thirds thought that seals harmed fisheries. However, 82% stated that they thought that seals should be in protected areas where fishing was not occurring. Centenera Martín *et al*. (2019**)** noted the fishing community was afraid of being blamed for the decline of monk seals and that although interactions with fisheries in Madeira were low, the fishing community had a negative opinion of seals.

2.3.2.4.2 Vessel traffic

Observations of monk seals in Greece (June-July 2018) found that boats were in the vicinity of the seals 62% of the time. Moreover, boat operators were trying to interact with seals 17% of the time (as noted in **Section 2.3.2.2.2;** Mpougas *et al.* 2019). Moreover, higher boat activity was correlated to less resting and sleeping activity in seals, but also more "vigilant: behaviors (**Section 2.3.2.2.2;** Mpougas *et al.* 2019).

The vessels noted in this former study were primarily recreational and/or tourism vessels. More than 90% of the Mediterranean fleet of all vessels are recreational boats between 2.5 and 24m in length, of which 87% are motorboats and 11% sailboats (Carreño and Lloret 2021). The densities of recreational vessels are very high in the Mediterranean; e.g., in the Gulf of St Tropez (France), more than 350 leisure boats and over 100 super yachts were reported on just one day (Carreño and Lloret 2021).

In addition to the disturbance caused by boat traffic, there is the risk of vessels colliding with seals – Hawaiian monk seals have, for example, been struck by boats (Herreria Russo 2015). Moreover, high levels of boat traffic can induce other environmental impacts (Carreño and Lloret 2021), including: anchors damaging seagrass beds and other benthic habitats; underwater noise; anti-fouling paint contaminants; oil leaks and spills; wastewater discharges; air pollution; stirring up sediments; light pollution; marine debris; and passengers feeding wildlife inappropriate food items. Carreño and Lloret (2021) opine that policy makers tend to ignore the impacts of recreational boat traffic and that management of recreational and tourism vessels tends to be very poor in the Mediterranean. As noted in **Section 2.3.2.2.2**, a lack of management of tourist and recreational boat traffic in Mediterranean monk seal habitats is a cause of concern.

2.3.2.4.3 Acoustic disturbance

Charrier *et al.* (2023) conducted research to measure the sound levels in the underwater habitat of Mediterranean monk seals. The two dominant sounds in the environment were snapping shrimps (100–1000 Hz) and the sounds of boats (20–200 Hz; ~92-115 dB re 1µPa). The sounds produced by monk seals (100-1000Hz; see **Section 2.3.1.1.5**) were smothered or "masked" by boat noise, as they were both of overlapping sound spectrums. Boat "noise" was recorded every day during the study for at least ten hours a day, up to 16.9 hours a day. Whereas, shrimp sounds tended to diminish between 6am and 2pm.

The researchers noted the high levels of anthropogenic noise in this important reproductive area for the Mediterranean monk seal, expressing concern that these high levels of noise might not only impair the communication of the species, but also impact its survival, as chronic noise can induce physiological stress (e.g., Wright *et al*. 2007, 2011). Therefore, they considered that noise was a potential threat for monk seals and its management should be incorporated into conservation planning.

2.3.2.4.4 Deliberate killing

As noted in the above sections on aquaculture (**Section 2.3.2.1.2**) and fishery interactions (**Section 2.3.2.4.1**) there is conflict between the aquaculture and fishing sectors and monk seals, with the latter being viewed as a pest because of the damage they cause to nets, gear and fish.

Danyer *et al.* (2018) reported (between 1994 and 2014) that there had been 49 cases of deliberate killing of monk seals reported (Güçlüsoy *et al.* 2004; Danyer *et al.* 2013a, 2013b, 2014). Danyer *et al.* (2018) also added an additional two animals that had been deliberately killed in Turkey: one in Hatay in 2012 and a second in Antalya in 2013. Yiğit *et al.* 2018 also noted two seals that had been shot, and found on the Gazipaşa coast of southern Turkey. Moreover, it was reported that a half of the monk seal mortalities Turkey observed between 1986-1996 were due to deliberate killing **(**Turkish Marine Research Foundation 2017).

Deliberate killing of monk seals has also been a problem in Greece. Stickland (2022) more recently described a female monk seal with gunshot wounds in Valtoudi Bay, Greece and noted another seal killed at a fishfarm site at Milina (Pagasetic Gulf) in the northern Aegean. The latter occurred within a marine protected area. In 2009, an analysis of cause of death of 29 monk seals found in Greek waters determined that the main cause of death for adult seals was deliberate killing (44%). However, recent reports of strandings still describe a high level of human-related mortality (European Commission 2023).

On the Greek island of Alonnisos a local seal called "Kostis", which had become somewhat of a celebrity, was killed with a speargun in 2021 (Mellen 2021). In 2013, a similar celebrity seal called "Duman" was killed in Antalya, Turkey (Turkish Marine Research Foundation 2017). In 2017, a deliberately killed female monk seal was also found killed on the Greek island of Samos (Turkish Marine Research Foundation 2017).

Considering the often remote areas that monk seals inhabit, the likelihood of all of the carcasses of seals deliberately killed by humans being sighted or recovered is very low. Moreover, as killing monk seals in most range States is illegal, it is likely deliberately (or even accidental) deaths of seals would be hidden. Therefore, the actual mortality rate is likely to be much higher.

2.3.2.4.5 Summary

The conflict between seals and the fishing (Section **2.3.2.4.1**) and aquaculture (**Section 2.3.2.1.2)** industries is perhaps one of the most pressing threats to Mediterranean monk seals. Not only is there the risk of accidental entanglement in fishing gear, perceived competition between seals and fisheries fosters negative opinions, which may undermine or hinder attempts to conserve the species at best, and at worse may lead to deliberate killing of animals. Considering the small sizes of subpopulations of monk seals in most of their range, the loss of just a couple of animals could have a significant impact, increasing the risk of extirpation in several locations.

Although there are only a small number of direct mortalities of monk seals because of collisions with boat traffic, as the number of vessels increases in the Mediterranean, (especially those operated by tourists and recreational boaters who may lack the skill to maneuver vessels around marine mammals), the risk of vessel strikes may increase.

2.3.2.5. Inadequacy of existing regulatory mechanisms

The Mediterranean monk seal is legally protected throughout its range through numerous national, regional and international laws and treaties (Table 7).[48]

Two of the most significant international regulations are the European Union[49] "Habitats Directive"[50] the EU "Marine Strategy Framework Directive".[51]

2.3.2.5.1 EU Directives

The Mediterranean monk seal is listed under Annex II and IV of the EU Habitats Directive (Table 7). The former required member nations to establish protected areas of monk seals, whereas the latter makes deliberate disturbance, injury and killing of listed species illegal. In particular Annex IV prohibits:

- Deliberate disturbance during breeding, rearing, hibernation, and migration;
- Deterioration or destruction of breeding sites or resting places.

Although the directive mandates a high level of protection for both monk seals and their vulnerable sea cave habitat, in reality there is a lack of resources, monitoring and enforcement. This is illustrated in a recent assessment, which found that habitats and species protected under the EU Habitats Directive have a predominantly unfavorable conservation status: 81% of habitats and 63% for species, with only 6% of species and 9% of habitats showing improvement.[52]

In terms of the protected areas established by the Directive, there is also concern that they have failed to achieve conservation goals (Puharinen 2023). For example, Mazaris *et al.* (2018) reported that for most EU nations[53] less than 15% of marine protected areas established by the EU Directive have management plans. Notably, in December 2020, Greece was condemned by the European Court of Justice for its improper care of these sites (Gale 2022). As Greece has the most protected areas for monk seals (see **Fig. 7**), this is a concern.

In the Mediterranean monk seal assessment that they authored, Aguilar and Lowry (2008) stated that "[m]ost conservation initiatives occur only on paper and do not translate into real and effective conservation action in the field." It appears there continues to be an issue with a lack of management, monitoring, enforcement and funding for marine protected areas in EU countries.

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48 In addition, United Nations Convention on the Law of the Sea, Dec. 10, 1982, art. 65. Requires that "States shall cooperate with a view to the conservation of marine mammals".

49 EU countries that have potential Mediterranean monk seal habitat include: Croatia, France, Greece, Italy, Malta, Portugal, Slovenia and Spain.

50 Council Directive 92/43/EEC-Natura 2000 on the Conservation of Natural Habitats of Wild Fauna and Flora.

51 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008.

52 https://www.eea.europa.eu/en/topics/at-a-glance/nature/state-of-nature-in-europe-a-health-check/habitats-and-species-latest-status-and-trends#:~:text=The%20European%20Union%20(EU)%20protects,habitats%20and%2063%25%20for%20species.

53 Excluding countries adjacent to the Baltic, Spain and Italy.

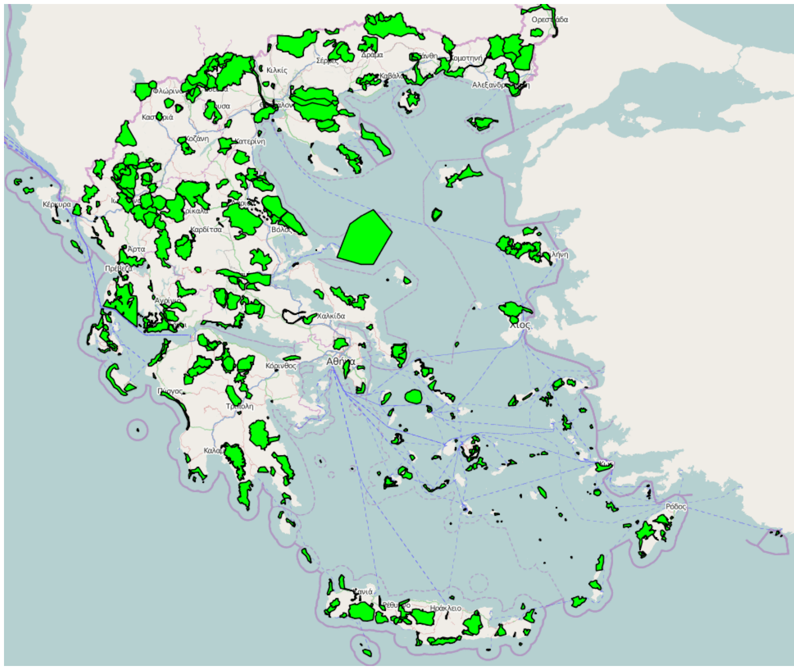

Figure 7. Map showing Natura 2000 areas (protected areas established by the EU Habitats and Birds Directives) in Greece (image credit: geodata.gov).

The Marine Framework Directive directs EU member nations to maintain clean, healthy, productive and resilient marine ecosystems and develop national marine strategies in order to achieve, or maintain, "good environmental status". The Marine Framework Directive also called for a coherent and representative network of marine protected areas. The directive aimed to achieve significant positive impacts on the Mediterranean environment, especially in terms of water quality and pollution levels, by 2020.

However, the Directive failed to deliver a "good" status in any of Europe's marine regions and, to date, has had "little impact in addressing pressures on the marine environment from adverse effects of blue economic activities" (Puharinen 2023, p. 1). This has largely been due to vague requirements and obligations in the Directive coupled with a lack of implementation and enforcement by the European Commission (Puharinen 2023).

2.3.2.5.2 The Barcelona Convention

The Barcelona Convention[54,55] is another regulatory instrument which could help to protect monk seals (**Table 7**). The above EU directives only oblige EU member nations and several key monk seal range countries are not members of the EU - notably Turkey, Albania and the southern Mediterranean coast countries. However, the Barcelona Convention incorporates more Mediterranean coastal states (21 countries in total).

[54] The Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention) was adopted on 16 February 1976 in Barcelona and entered into force in 1978. In 1995 it was amended and renamed the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean.

[55] https://www.unep.org/unepmap/who-we-are/barcelona-convention-and-protocols.

The Barcelona Convention builds off the 1975 Mediterranean Action Plan (MAP)[56,57] to protect the Mediterranean marine and coastal environment. Mediterranean countries and the European Community approved MAP as an institutional framework for cooperation in addressing common challenges of marine environmental degradation.

One of the protocols (the SPA/BD Protocol) [58,59] for the Barcelona Convention lists the Mediterranean monk seal (under Annex II) as an endangered species requiring "maximum protection and recovery". The protocol allows the establishment of protected areas which allow the regulation of boat traffic,[60] and the prohibition and regulation of any activity that might disturb or harm listed species.[61] The protocol also prohibits the killing[62] and disturbance (especially during breeding)[63] of listed species. Moreover, it calls for parties to adopt cooperative measures to protect and conserve listed species.

At the 21st Conference of Parties[64] Decision IG. 24/7 was passed[65,66] which adopted the updated strategy for the conservation of monk seal in the Mediterranean.[67,68]

Moreover, this adopted Decision requested member nations to take the necessary measures to implement this strategy[69] and for the Convention Secretariat to provide technical support and capacity building for the effective implementation of the monk seal strategy.[70]

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[56] Established as a multilateral environmental agreement in the context of the Regional Seas Programme of the United Nations Environment Programme (UNEP).

[57] https://www.unep.org/unepmap/.

[58] Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol)

[59]https://www.unep.org/unepmap/who-we-are/contracting-parties/specially-protected-areas-protocol-spa-and-biodiversity-protocol.

[60] Art. 6(b).

[61] Art. 6(h).

[62] Art. 11 §3(a).

[63] Art. 11 §3(b).

[64] 2-5 December 2019 in Naples, Italy. https://www.unep.org/unepmap/meetings/cop-decisions/cop21-outcome-documents.

[65] Decision IG.24/7 **-** Strategies and Action Plans under the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean, including the SAP BIO, the Strategy on Monk Seal, and the Action Plans concerning Marine Turtles, Cartilaginous Fishes and Marine Vegetation; Classification of Benthic Marine Habitat Types for the Mediterranean Region, and Reference List of Marine and Coastal Habitat Types in the Mediterranean.

[66] https://wedocs.unep.org/bitstream/handle/20.500.11822/31705/19ig24_22_2407_eng.pdf.

[67] Section 3.

[68] Pages 378-394 in UNEP(DEPI)/MED IG.23/24: https://wedocs.unep.org/bitstream/handle/20.500.11822/30095/19ig24_22_eng.pdf

[69] Section 4.

[70] Section 5.

Table 7. International treaties and legislation protecting Mediterranean monk seals.

Treaty/Legislation	Annex
Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora - consolidated version 01/01/2007 (EU Habitats Directive)	Annex II: animal and plant species of community interest whose conservation requires the designation of special areas of conservation.
	Annex IV: animal and plant species of community interest in need of strict protection.
Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)	Annex II: strictly protected fauna species
	Revised Annex I of Resolution 6 (1998) of the Bern Convention listing the species requiring specific habitat conservation measures (year of revision 2011)
Convention on the Conservation of Migratory Species of Wild Animals. (Bonn Convention)	Annex I: migratory species which are endangered and must be protected by Parties
	Annex II: migratory species which have an unfavorable conservation status and which require international agreements for their conservation and management, as well as those which have a conservation status which would significantly benefit from the international co-operation that could be achieved by an international agreement.
Memorandum of Understanding concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) - under Bonn Convention (MSeal)	Not applicable
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Annex I: species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances.
Commission regulation (EU) No 1320/2014, of 1 December 2014, amending Council Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein (EU regulation of trade of fauna and flora)	Annex A includes: All CITES Appendix I species, except where EU Member States have entered a reservation; Some CITES Appendix II and III species, for which the EU has adopted stricter domestic measures; Some non-CITES species
Barcelona Convention Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol)	Annex II: Endangered or threatened species that the Parties shall manage with the aim of maintaining them in a favorable state of conservation. They shall ensure their maximum possible protection and recovery.

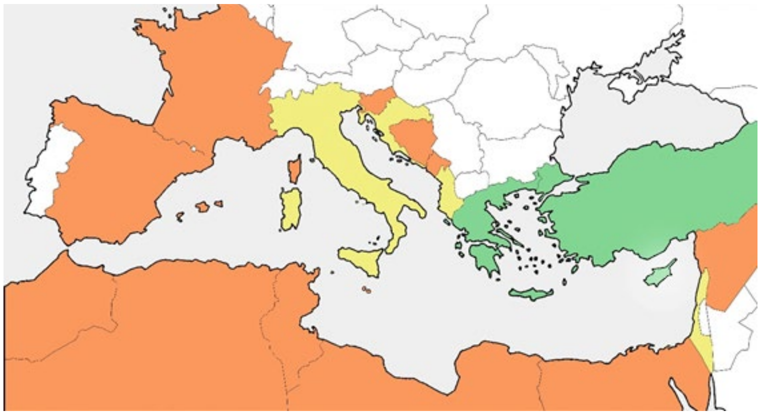

Figure 8. Categorization of Mediterranean countries in the Barcelona Convention's updated strategy for the conservation of monk seal in the Mediterranean. "Group A" countries are in green: countries where monk seal breeding has been reported after year 2010. "Group B" countries are in yellow: countries where no monk seal breeding is reported, but where repeated sightings of seals (>3) have been reported since 2010. "Group C" countries are in orange: countries where no monk seal breeding is reported, and where very rare (<3), or no, sightings of monk seals have been reported since 2010.

The strategy for the conservation of monk seal in the Mediterranean splits Mediterranean countries into those that currently have breeding populations of monk seals (group A), those where seals have been sighted repeatedly (group B) and historic range countries for the monk seal (group C) where sightings are rare or absent (**Fig. 8**). The goals of the strategy are summarized in **Table 8**. They revolve around the designation of protected areas, capacity building and training, and then the reestablishment of breeding population throughout the Mediterranean range of the monk seal.

Several activities have already been conducted under auspices of this strategy including a workshop in December 2019, the World Marine Mammals Conference (Barcelona, Spain) to assess national knowledge gaps and discuss implementing monitoring programs for monk seals. In September 2023, a regional workshop was conducted in Sami, Greece to provide training for sea cave surveys to identify potential seal habitats and to discuss monitoring techniques such as camera-trapping and photo-identification.

In addition, the project "Med Monk Seal: Enhancing knowledge and awareness of monk seal conservation in the Mediterranean"[71] was developed to raise awareness and conduct capacity building in Algeria, Egypt, Italy, Libya, Morocco, Syria, and Tunisia. NGOs have also been feeding into these efforts: fundraising and donating to support local and regional monitoring and training.[72] Although ambitious, the activities under the auspices of the Barcelona Convention do appear to be attracting funding to support important grassroots-level work.

However, achieving the goals in the monk seal strategy (Table 8) will require long term, sustained funding at substantive levels. Moreover, it will require multiple nations to enact legislation and establish protected areas for Mediterranean monk seals and, importantly, to monitor and enforce these protections. As noted above, enforcement

[71] https://www.monksealalliance.org/en/projets/med-monk-seal-project-enhancing-knowledge-and-awareness-on-monk-seal-in-the-mediterranean-00559.

[72] https://www.monksealalliance.org/en/telechargements//medias_upload/moxie/Brochure/2024-MSA-Brochure.pdf.

of conservation laws and the establishment of protected areas in the Mediterranean, at least for EU countries, is problematic (**Section 2.3.2.5.1**).

Table 8. The goals of the Barcelona Convention's updated strategy for the conservation of monk seals in the Mediterranean.

Goal 1	Mediterranean Range States implement this Strategy in pursuance of the Vision, through the expeditious development and adoption of appropriate national policies and administrative frameworks, and with the effective, coordinated support from relevant international organizations and civil society.
Goal2	Monk seal breeding nuclei in sites located in "Group A" countries are effectively protected from deliberate killings and habitat degradation, so that seal numbers in such sites increase and seals are able to disperse to and re-colonize the surrounding areas.
Goal 3	Monk seal presence in sites where they are repeatedly seen today in "Group B" countries is permanently established, and breeding resumes. "Group B" countries are upgraded to "Group A".
Goal 4	Monk seal presence is reported repeatedly in the species' historical habitat in "Group C" countries, and these "Group C" countries are upgraded to "Group B". Once all "Group C" countries are upgraded, Group C is deleted.
Goal Target 1.1	A framework for the implementation of the Mediterranean Monk Seal Conservation Strategy is established by the Mediterranean Range States. The framework will include the establishment of a Monk Seal Advisory Committee (MSAC).
Goal Target 1.2	Based on this Strategy, the MSAC provides support to SPA/RAC[73] in the development and implementation of specific conservation actions having a regional scope.
Goal Target 2.1	Maintain and secure monk seal presence in Important Marine Mammal Areas (IMMAs) identified by the IUCN Marine Mammal Protected Areas Task Force6, with special attention to the following locations: a) Greek Ionian islands (Lefkada, Kefallinia, Ithaca, Zakynthos, and surrounding islets and seas); b) Northern Sporades; c) Gyaros; d) Kimolos and Polyaigos; e) Karpathos-Saria; f) Turkish Aegean and Mediterranean coasts; g) Cyprus. Breeding nuclei in the locations listed above are effectively protected from deliberate killings and habitat degradation, so that seal numbers in such sites increase and young seals are able to disperse and re-colonize the surrounding areas.
Goal Target 2.2	Implementation of Goal Target 2.1 is enabled through appropriate capacity building activities.
Goal Target 3.1	Monk seal presence in Albania is confirmed and permanently established.
Goal Target 3.3	Monk seal presence in Italy, in areas with recurrent sightings, habitat availability and proximity to nearby breeding colonies, is permanently established, and monk seal breeding resumes.
Goal Target 3.4	Monk seal presence in Lebanon is permanently established.
Goal Target 3.5	Monk seal presence in Israel is permanently established.
Goal Target 3.6	Monk seal presence in Montenegro is permanently established.
Goal Target 3.7	Implementation of Goal Targets 3.1 - 3.6 is enabled through appropriate capacity building activities and sub-regional cooperation.
Goal Target 4.1	Monk seal presence in locations of the Maghreb's Mediterranean coasts and annexed islands in Algeria, Morocco, Tunisia, and the Chafarinas Islands (Spain) is repeatedly reported and permanently established.
Goal Target 4.2	Monk seal presence in the Balearic Islands, Spain, is repeatedly reported and permanently established.
Goal Target 4.3	Monk seal presence in Bosnia Herzegovina and Slovenia repeatedly reported and permanently established.
Goal Target 4.4	Monk seal presence in Corsica is repeatedly reported and permanently established.
Goal Target 4.5	Monk seal presence is reported again from continental France.
Goal Target 4.6	Monk seal presence in Libya and nearby western Egypt is repeatedly reported and permanently established.
Goal Target 4.7	Monk seal presence is reported from Malta.
Goal Target 4.8	Monk seal presence in Syria is repeatedly reported and permanently established.
Goal Target 4.9	Implementation of Goal Targets 4.1 - 4.8. is enabled through appropriate capacity building activities and sub-regional cooperation.

2.3.2.5.3 State level regulatory mechanisms

As discussed in **Section 2.3.1.5.1** there are major differences in policy, conservation resources and management between the three populations of Mediterranean monk seals. Range countries span from high income EU member states to low middle income non-European states. Just considering the eastern Mediterranean population, there is a mix of both EU and non-EU countries and economic levels.[74] The Cabo Blanco population is in Mauritania and Western Sahara (which is administered by Morocco and as lower-middle income countries are likely to have fewer resources and less infrastructure for conservation).[75] Although, financial resources do not necessarily

[73] Specially Protected Areas Regional Activity Centre https://www.rac-spa.org/

[74] Albania and Turkey are considered to be upper middle income countries (gross per capita income $4,516 - $14,005) as are Libya and Montenegro, both of which have occasional sightings of monk seals in their waters.

[75] Low middle income countries have a gross per capita income of $1,146 TO $4,515.

guarantee conservation action and vice versa.

In Madeira, conservation actions and research have been conducted since 1988 (Pires *et al*. 2020). Moreover, EU funding has helped support more recent research activities. All marine caves used by monk seals in the Madeira archipelago are within Natura 2000/EU Habitats Directive protected areas (Pires *et al*. 2020). In 2020, a Strategy for the Conservation of the Mediterranean Monk Seal was also approved by the Government Council of Madeira (Pires *et al.* 2020).

In the Cabo Blanco Peninsula there are several coastal and marine protected areas, as well as by "no take" reserves where fishing is prohibited. Moreover, the monk seal population has been monitored by an international conservation program since 2000 (Karamanlidis *et al.* 2023). Conservation actions include the development of a social aid program for local artisanal fisheries, as well as awareness and outreach activities for the local community, including local fisheries.

Greece has an action plan for the conservation of Mediterranean monk seals. EU funding has supported recent research and grassroots activities (Dendrinos *et al*. 2020). Moreover, a substantive number of protected areas have been established via the EU Habitats Directive (**Fig. 18**). However, Greece has also been criticized and taken to the European Court of Justice for the Government's failure to adequately manage these protected areas (Gale 2022), as noted above (Section **2.3.1.5.1** and **Section 2.3.2.5.3).**

In Turkey, in 2004 five coastal locations were adopted as monk seal priority conservation zones.[76] There are also active public awareness and outreach efforts. As noted previously (**Section 2.3.2.1.3**), breeding caves in Turkey are designated as "First Degree Natural Assets"[77] in Turkey, which should protect caves from deliberate damage and illegal construction/development.[78] However, as noted in **Section 2.3.2.1.3,** a loading facility for a cement factory was constructed just 500m from an occupied seal breeding cave. Moreover, although entering seal caves is forbidden, there are tourist trips to caves that companies actively advertise (**Section 2.3.2.2.2**). Therefore, despite laws to protect seals, there is a concerning lack of monitoring and enforcement in Turkey.

In Cyprus, the monk seal has been legally protected since 1971.[79] Recent conservation activities include the development of a National Action Plan, public outreach, and the development of a monitoring protocol. Moreover, recent EU funding has also assisted research efforts.

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https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

[76] Gökçeada, Foça-Karaburun, Alaçatı-Sıgacık, the Bodrum Peninsula and the Cilician coast.

[77]https://www.fao.org/faolex/results/details/en/c/LEX-FAOC150437/#:~:text=Law%20No.-,2863%20on%20the%20protection%20of%20cultural%20and%20natural%20assets.,for%20their%20management%20and%20protection.

[78] https://www.ilkercolak.com.tr/protection-of-cultural-and-natural-assets-under-turkish-law/.

[79] Via the Fisheries Law and Regulations of 1971.

2.3.2.5.4 Conclusion

There is a relatively high level of "grass roots" conservation activity related to the Mediterranean monk seal in some areas, which has been aided by EU funding. Moreover, the Barcelona Convention and the recent strategy for monk seals is helping to promote Mediterranean-wide conservation activities for monk seals.

In addition, despite limited resources in some range states have had some conservation successes. For example, there have been a number of important conservation research projects that have collected vital data at Cabo Blanco. Moreover, the subpopulation has been recovering from a mass mortality that decimated the population.

However, some of the conservation actions are somewhat undermined by a lack of monitoring, management, regulation and enforcement at a national level (in some countries), as well as at the EU level.

It is hoped that the ambitious monk seal strategy developed by the Barcelona Convention will help to reestablish monk seal populations throughout the Mediterranean, but it will take serious commitment (both financial and in terms of management and enforcement) by monk seal range states.

2.3.2.6 Summary

There are a number of laws and protected areas in place that prohibit disturbance and injury to Mediterranean monk seals. However, many of these protections are not effectively implemented and enforced (**Section 2.3.2.5**). For example, despite strict levels of protection, tourism continue to advertise visits to monk seal caves (**Section 2.3.2.2.2**), and tourists film themselves harassing seals without impediment. Additionally, large construction projects have been permitted to occur on the doorstep of breeding caves (**Section 2.3.2.1.3).**

Particularly concerning is the high rate of entanglement and deliberate killing of seals. In Greece, interviews suggest fishery entanglement rates may be as high as 5% of the national population annually (**Section 2.3.2.4.1**). Known instances of deliberate killing from fisheries and aquaculture (**Section 2.3.2.4.4**) are also concerning. As aquaculture develops in the Mediterranean, instances of harassment and mortalities are likely to increase, unless major efforts are made to monitor and mitigate seal interactions with aquaculture sites and fishing gear.

The Mediterranean is a hotspot for pollution, with a long history of industrial discharge into this enclosed sea (**Section 2.3.2.1.1**). Seals still demonstrate notable levels of legacy pollutants such as PCBs and DDT, in addition to newer toxic contaminants. The rapid increase in plastic pollution in the Mediterranean is particularly a growing issue of concern (**Section 2.3.2.1.1.1**).

In the wake of the mass mortality event at Cabo Blanco, the vulnerability of monk seals to disease is a major problem (**Section 2.3.2.3.1**). Reports of morbillivirus, toxoplasmosis and lethal burdens of parasites are of concern. However, the high pollutant burdens seen in monk seals, their lack of genetic diversity, as well as their biology and behavior (*i.e.*, aggregating at a limited number of breeding sites) make them vulnerable to disease contraction and infection.

In summary, there are a number of both anthropogenic and natural threats that pose a major risk to the Mediterranean monk seal and its populations.

2.4 Synthesis

The Endangered Species Act (ESA) calls for a review of listed species every five years[80] to determine whether the listing status of the species remains accurate.[81]

The ESA defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range".[82] We evaluated the status of the species and the factors identified in Section 4(a)(1) of the ESA and found that the Mediterranean monk seal remains at risk of extinction and/or extirpation of its component populations due to: (i) the present or threatened destruction, modification, or curtailment of its habitat or range; (ii) disease; (iii) inadequacy of existing regulatory mechanisms; (iv) a high degree of fragmentation, small subpopulation sizes, inbreeding and lack of genetic diversity;[83] and (v) bycatch and the deliberate killing of seals.

New information available since the previous 5-year review indicates tourism-related disturbance is increasing in Mediterranean monk seal habitat, including in sensitive breeding and resting habitats. Tourism is an additional stressor that warrants further monitoring to determine the levels of harassment occurring and whether it is having an impact on the species' survival and recovery.

2.4.1 Abundance and population trends

In 2008, the estimated number of mature Mediterranean monk seal individuals was just 350-450 (Aguilar and Lowry 2008). In 2015, the species was deemed to be "increasing," but the estimated size of the mature population remained static, *i.e.*, 350-450 mature individuals (Karamanlidis and Dendrinos 2015).

In 2023, although the estimate for the population size (441-539) was slightly higher than in 2015, different methods were used to estimate the population size (Karamanlidis *et al.* 2023). In 2023, the "pup multiplier" method was used for the first time. As described further in **Section 2.3.1.2**, the "pup multiplier" estimate involves somewhat arbitrarily picking a number to use as a multiplier. However, the reliability and accuracy of this method has not been validated for Mediterranean monk seals with empirical data.

Section 2.3.1.1.3 notes that although the Cabo Blanco population has a positive intrinsic rate of growth of 5.8% per annum at present, the Madeira population has an intrinsic rate of growth of -0.2%. Detailed demographic data on recent survivorship, rates or growth and mortality rates for the eastern Mediterranean population are currently lacking. Moreover, although there are mortalities in fishing gear (**Section 2.3.2.4.1**), and deliberate killing of seals associated with fishing and aquaculture (**Section 2.3.2.1.2, Section 2.3.2.4.1** and **Section 2.3.2.4.4),** the total scale of this

[80] Section 4(c)(2)(A)

[81] Section 4(c)(2)(B).

[82] Section 3(6).

[83] *i.e.*, Section 4(a)1 parts (A), (C), (D) and (E).

anthropogenic mortality is still unknown.

While there appear to be more sightings of monk seals in some areas, the data are insufficient to conclude whether this actually the result of a real increase, due to a lack of regular, systematic surveys. The increase in sightings could potentially be due to more local research and greater public awareness about seals in recent years.

It is, therefore, premature to state that the adult monk seal population recovering.

2.4.2 Population fragmentation and genetic diversity

As noted in **Section 2.3.1.5** and **Section 2.3.1.5.1**, the distribution of the Mediterranean monk seal is extremely fragmented, with the eastern Mediterranean population separated from the two North Atlantic populations by approximately 4,000 km. Moreover, genetic data support a high level of isolation (**Section 2.3.1.3**), such that adjacent subpopulations in the Ionian and Aegean Sea, or even the north and south Aegean subpopulations, demonstrate a high level of inbreeding and isolation (Karamanlidis *et al*. 2021b; **Section 2.3.1.3**). Moreover, the high level of isolation and lack of dispersal between subpopulations increases the likelihood of local extinctions **(**Kurt *et al*. 2017).

The high degree of population fragmentation, small subpopulation sizes, inbreeding, and a lack of genetic diversity also contribute to extinction risk. These characteristics make subpopulations particularly vulnerable to stochastic events and the Allee effect (**Section 2.3.1.3**), which may impact reproductive rates (**Section 2.3.1.2** and **Section 2.3.1.3**) and promote vulnerability to disease (**Section 2.3.2.3.1**). This high degree of fragmentation exacerbates threats to the seals and warrants recognition when considering the conservation status of the Mediterranean monk seal.

2.4.3 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

Although the breeding habitat of the Mediterranean monk seal (i.e., sea caves; **Section 2.3.1.6**) is theoretically protected in many range states, this habitat is often subject to disturbance from tourism (**Section 2.3.2.2.2**), development (**Section 2.3.2.1.3**), and other human activities. Moreover, threats may not be monitored or enforced (**Section 2.3.2.5.1, Section 2.3.2.5.3** and **Section 2.3.2.5.4**). Additionally, throughout the Mediterranean pollutants are an issue, including legacy pollutants (such as DDT; **Section 2.3.2.1.1.3** and trace elements; **Section 2.3.2.1.1.2**), more recently recognized pollutants (such as PAHs; **Section 2.3.2.1.1.3**), and microplastics (**Section 2.3.2.1.1.1**). Disease decimated the Cabo Blanco population of monk seals in 1997 (**Section 2.3.2.3.1**) and still remains a potential threat with recent reports of toxoplasmosis (**Section 2.3.2.3.1.2**), morbillivirus, and parasite-related fatalities (**Section 2.3.2.3.1.1**). The high pollutant burden of monk seals may potentially be increasing monk seals' susceptibility to disease (**Section 2.3.2.3.1**), in synergy with their lack of genetic diversity (**Section 2.3.1.3**).

Finally, there is known to be a high rate of entanglement in fishing gear in some areas (**Section 2.3.2.4.1)**, as well as conflict with the fishing (**Section 2.3.2.4.1**) and aquaculture industries (**Section 2.3.2.1.2**), with frequent reports of the deliberate killings of monk seals (**Section 2.3.2.4.4**).

In the more recent evaluations of the Mediterranean monk seal, there appears to be optimism for the species: grants were provided under the EU Life program for monk seal outreach and research projects, and protected areas are being established (e.g., Karamanlidis *et al*. 2023). However, although there have been considerable efforts to establish protected areas, develop regulations, and formulate action plans for the conservation of Mediterranean monk seals, in several areas there is a lack of monitoring, implementation, and enforcement (e.g., see **Section 2.3.2.5.1** and **Section 2.3.2.5.3**) - in particular with respect to protected areas established by the EU Habitats Directive and environmental actions related to the Marine Framework Directive (**Section 2.3.2.5.1**).

2.4.4. Summary

Although there may be some evidence of Mediterranean monk seals starting to be resighted in areas that they historically occupied (**Section 2.3.1.5**), and eDNA analysis shows some evidence of potential repopulation of areas (**Section 2.3.1.3.1**), there is still a large part of this range where they have been extirpated (**Section 2.3.1.5**). Even in areas where there has been some recent increase in seal numbers, the populations and subpopulations are still very vulnerable and subject to the significant variety of threats noted above. Therefore, it is concluded that the Mediterranean monk seal remains in danger of extinction throughout its range and should continue to be listed as an “endangered species” under the ESA.

3.0 RESULTS

3.1 Recommended Classification

______Downlist to Threatened
______Uplist to Endangered
______Delist *(Indicate reason for delisting per 50 CFR 424.11):*
______The species is extinct
______The species has recovered to the point at which it no longer meets the definition of an endangered species or a threatened species
______New information that has become available since the original listing decision show the listed entity does not meet the definition of an endangered species or a threatened species
______New information that has become available since the original listing shows the listed entity does not meet the definition of a species
__X__No change is needed

3.2 New Recovery Priority Number

Not Applicable

3.3 Listing and Reclassification Priority Number

Not Applicable

4.0 RECOMMENDATONS FOR FUTURE ACTIONS

The range of the Mediterranean monk seal falls solely outside the jurisdiction of the United States. However, Section 8 of the ESA allows, and encourages, international cooperation to protect listed species.

It is recommended that NMFS, in coordination with the State Department, help to support monk seal range countries to train local researchers and educators/outreach specialists and help develop and fund research, and otherwise provide professional expertise. This could be particularly valuable to nations that have local scientists and conservationists that may need conservation training in monitoring methods or resources to conduct research.

It is recommended that such international cooperation include into agreements with range state countries and regional NGOs to provide assistance to help the realization of their conservation action plans.[84]

In order to better assess the status of the Mediterranean monk seal, there are many data gaps that need to be filled. Although there has been some valuable research on the use and abandonment or recolonization of breeding caves in some countries (typically using camera traps or video) it is recommended that similar research be expanded to other range countries.

Photo-identification techniques have likewise been used in some countries to identify individual animals and it is recommended that this be expanded to allow capture-recapture modelling for estimating population sizes, as well as developing a Mediterranean-wide photo-identification catalogue so that the movement of individual animals could be monitored.

There is a lack of data on survival rates in the eastern Mediterranean. It is recommended that data on the survival rates of seals, including number of orphan pups that have rescued, and survivorships of rehabilitated and released animals and the mortality rates of parents, be collected.

Levels of bycatch in fishing gear and aquaculture nets and levels of mortality from deliberate killing are essential metrics to which measure the level of risk that Mediterranean monk seals face. Therefore, observer programs or onboard videos to monitor fishing vessels and aquaculture sites are also recommended.

Research into the compliance with regulations (notably regulations related to disturbance and tourism activity) is likewise recommended, as well as metrics on the effectiveness of protected areas. Similarly, data on enforcement actions for deliberate disturbance, injury or killing of Mediterranean monk seals.

The 1996 rule[85] implementing the import provisions of the Marine Mammal Protection Act, which came into force in 2022, states that trade partners must show that killing or injuring marine mammals incidental to fishing activities, or bycatch, in

[84] For example, the Specially Protected Areas Regional Activity Centre (https://www.rac-spa.org/) is leading several Mediterranean monk seal activities related to the Barcelona Convention SPA/BD Protocol and associated monk seal strategy (see Section 2.3.2.5.2).

[85] 81 FR 54390, August 15, 2016.

their export fisheries does not exceed the United States' standards. Under this rule a nation must demonstrate: (1) it has prohibited the intentional mortality or serious injury of marine mammals in the course of commercial fishing operations;[86] and (2) its regulatory program with respect to incidental mortality and serious injury of marine mammals is comparable to the United States' regulatory program. The United States imports fish products from a number of Mediterranean monk seal range states, and this rule could be used to encourage countries to address bycatch and deliberate killing in fisheries and aquaculture.

To reduce the impact of aquaculture on monk seals, fishfarm sites should not be sited near important monk seal habitat, and the Habitats Directive and local laws need to be enforced so that fishfarm companies that harass or kill seals are prosecuted. Moreover, it is recommended that research should be conducted to evaluate and mitigate the conflicts between aquaculture sites and seals. Due to negative opinions in the fishing community regarding Mediterranean monk seals, it it recommended that public outreach and education activitieis recommended, in order to proactively discuss mitigation measures to reduce net damage caused by seals, and ways to reduce conflict with local fisheries.

[86] Unless the intentional mortality or serious injury of a marine mammal is imminently necessary in self-defense or to save the life of a person in immediate danger.

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NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW

Mediterranean monk seal (*Monachus monac*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

- [ ] Downlist to Threatened
- [ ] Uplist to Endangered
- [ ] Delist
- [x] No change is needed

Review Conducted By (Name and Office):

Chris Parsons - Office of Protected Resources

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, NOAA Fisheries

Approve____ Date: ________

Cooperating Regional Administrator, NOAA Fisheries

[ ] Concur [ ] Do Not Concur [ ] N/A

Signature____ Date: _______

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

[x] Concur [ ] Do Not Concur

Signature RAUCH.SAMUEL.DEAN.1365850948 Digitally signed by RAUCH.SAMUEL.DEAN.1365850948 Date: 2024.11.04 09:54:17 -05'00' Date: _______