

Short Note

Mediterranean Monk Seal (*Monachus monachus*) Behavior at Sea and Interactions with Boat Traffic: Implications for the Conservation of the Species in Greece

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Amidst a global biodiversity crisis (Butchart et al., 2010), marine mammals are facing numerous threats (Schipper et al., 2008), such as disturbances caused by increased boat traffic, including traffic related to tourism and leisure activities. Boat traffic can influence social communication and behavior and affect energetic requirements and reproductive success in marine mammals, which may ultimately lead to displacement (Henry & Hammill, 2001; Bejder et al., 2009; French et al., 2011; Atkinson et al., 2015; Cates & Acevedo-Gutiérrez, 2017). Furthermore, continued exposure to boat traffic may also lead to harmful behavioral habituation and decreased wariness to human presence or natural predators (Boren et al., 2002). As marine mammal responses to boat disturbance may vary widely (Boren et al., 2002), it is important to investigate marine mammal–boat interactions on a case-by-case basis to evaluate the impact of disruption (Bejder et al., 2006) and formulate effective management and conservation measures.

The Mediterranean monk seal (*Monachus monachus*) is the only resident pinniped in the Mediterranean Sea. With fewer than 700 individuals surviving (Karamanlidis et al., 2016), the species is listed as “Endangered” by the International Union for Conservation of Nature (IUCN) (Karamanlidis & Dendrinis, 2015) and is considered one of the most endangered marine mammals on Earth. The largest Mediterranean monk seal subpopulation occurs mainly at the islands of the Aegean and Ionian Seas and along the coasts of mainland Greece in the eastern Mediterranean Sea. Despite encouraging signs of partial subpopulation recovery, the species is still threatened by various factors (Karamanlidis et al., 2016). Improving our understanding of the species’ behavior and the threats to its survival is necessary to design and implement effective conservation

measures that will safeguard the recovery and future of the Mediterranean monk seal in Greece.

Little is known about Mediterranean monk seal behavior at sea or their interactions with boat traffic in the eastern Mediterranean. Monk seals in the region have been reported to travel long distances in short time periods (Adamantopoulou et al., 2011); to dive for up to 18 min (Kiraç et al., 2002) and to depths of up to 200 m (Dendrinis et al., 2007); and to occasionally sleep in the water (Karamanlidis et al., 2017). Due to their shyness, however, they have never been reported to regularly interact with boats in the eastern Mediterranean. Herein, we examine the behavior of the Mediterranean monk seal at sea and how this is affected by tourism- and leisure-related boat traffic by evaluating whether (1) time of day and boat traffic had an effect on monk seal presence at sea, (2) boat traffic had a differential effect on behavior based on monk seal age, and/or (3) boat traffic had a differential effect on specific monk seal behavior.

The study was carried out at the Lichadonia islets off the northwestern end of the island of Evia in Greece. The marine environment of the study area is characterized by shallow waters, strong currents, and diurnal tides. The islets are uninhabited, and human activity in the area throughout the year is very low, except in the summer when tourism and leisure activities increase considerably. The study was carried out between 8 June and 13 July 2018 from 1000 to 1700 h (time recorded in decimal time), when sea conditions permitted (i.e., 0 to 2 Beaufort). A total of 75 h of field work was spread across 17 d and 34 sessions (average 2 sessions per day; average duration/session 3.5 h) during the study period. Observations of monk seal abundance and behavior (Table 1), and number of boats were recorded while floating in a Wilderness Tarpon 140T tandem kayak

using a Nikon D7200 DSLR with a Nikkor zoom 70-300mm (f/4) lens by Nikon, or from the shore of one of the islets using a Vivitar 500-mm telephoto fixed lens (f/8) on a tripod. Each observation of monk seal abundance, behavior, and number of boats represented total counts and dominant behaviors across a 15-min period. During observation at sea, a minimum distance of 50 m to any given monk seal was kept, which resulted in a lack of response by the seals. Individual monk seals were identified using standard photo-identification techniques (Forcada & Aguilar, 2000) based on the morphological age-classes defined by Samaranch & González (2000). Photo-identification results were collated with information from previous photo-identification surveys in the area (Karamanlidis et al., 2015).

The effect of boat traffic on Mediterranean monk seal presence was evaluated using General Linear Models (GLM) with a binomial family. The presence (1) or absence (0) of a monk seal per observation was modelled as the response variable, and the number of boats per observation was modelled as a continuous explanatory variable. The time of day (decimal day) was included as an additional explanatory variable to account for the possibility of diurnal variations in monk seal behavior (Dendrinos et al., 1994; Pires et al., 2007). The possibility of adults and subadults responding differently to boats were also tested using GLM. The presence (1) or absence (0) of behavioral responses per observation (when a monk seal was present) was modeled as the response variable, and the age-class of the monk seal (subadult or adult) was modeled as a categorical explanatory variable. The effect of boat traffic on specific seal behaviors was evaluated using a Cumulative Link Model (CLM). Behavioral responses per observation were ranked in order of increasing intensity of response (1 = Sleeping, 2 = Resting, 3 = Aware and Alert, 4 = Swimming, or 5 = Fleeing), with their respective number representing

the response variable. The number of boats per observation was again modelled as a continuous response variable. The probability of seal presence and behavior as a function of number of boats were estimated from GLM and CLM parameters. Chi-squared tests were used to test for the significance ($p < 0.05$) of these relationships, and analyses were performed in *R Studio.Ink 2011* (R Core Team, 2018) using the 'ordinal' package (Christensen, 2018).

Mediterranean monk seals were present in 67% of observations, totaling 50.25 h of observations with monk seals present and 24.75 h with monk seals absent. A total of nine monk seals were identified. Five of these individuals had also been identified previously in the area. Boats were recorded on 62% of total effort. Boat traffic (i.e., tour and leisure vessels) increased during the study period (June to July 2018), showing peaks of activity during the weekends. Boats were also recorded trying to interact with monk seals (i.e., trying to spot and photograph monk seals or tourists trying to swim with them; Figure 1C & 1D) in 17% of total observations.

The probability of observing a Mediterranean monk seal decreased significantly during the course of the day, with encounters predicted to be approximately three times higher at 0900 h than at 1800 h (GLM: $\chi^2 = 199.40$; p value < 0.001 ; Figure 2A). After accounting for these diurnal patterns, the probability of observing a monk seal was found to decrease as boat activity increased, with seal encounters predicted to be approximately four times higher during the lowest rather than the highest boat traffic (GLM: $\chi^2 = 301.02$; p value < 0.001 ; Figure 2B). There were significant differences in behavioral responses between ages (GLM: $\chi^2 = 140.67$; p value = 0.006), with subadults 25% more likely to respond to boats than adults (Figure 3).

In the absence of boat traffic, resting at sea was the most frequently observed Mediterranean monk seal behavior (36%), followed by underwater activity

Table 1. Mediterranean monk seal (*Monachus monachus*) behavior at sea and responses to boat traffic recorded during the study

Monk seal behavior at sea	Description
Underwater activity	A seal dives sharply and remains under water.
Sleeping	A seal is floating, either vertically or horizontally, on the sea surface with its eyes closed (Figure 1A).
Resting	A seal is slowly swimming horizontally at the sea surface with its eyes open while occasionally closing them.
Swimming	A seal is actively moving from reef to reef or out of the study area.
Fleeing	A seal is swimming under water or it is swimming on the surface, visibly responding to human presence.
Aware and alert	A seal is aware of the boat presence and begins to swim away at the sea surface while keeping eye contact with the boat (Figure 1B).



Figure 1. (A) A Mediterranean monk seal (*Monachus monachus*) sleeping at sea; (B) a monk seal being aware and alert of the presence of humans; (C) a tourist boat approaching a monk seal while people are trying to photograph the animal; and (D) a tourist boat at anchor while a tourist is trying to approach a monk seal. (Photo credits: Elena Mpougas/MOM)

(27%), sleeping (20%), and swimming (17%). When boats were around, aware and alert (47%) and fleeing (23%) were most often observed, followed by resting (18%), swimming (10%), and sleeping (2%). The probabilities of observing *vigilant* behaviors (i.e., fleeing, swimming, and aware and alert; Figure 4A, B & C) increased whereas those of *relaxing* behaviors (i.e., resting and sleeping; Figure 4D & E) decreased significantly with higher boat traffic (CLM: z value = -3.874 ; p value < 0.001).

Mediterranean monk seals are considered to be among the most elusive marine mammals, shying away from humans and seeking the solitude of inaccessible marine caves to rest and reproduce (Karamanlidis et al., 2016). In recent years, however, monk seals in Greece appear to be recovering slightly (Karamanlidis & Dendrinos, 2015); this recovery is often associated with individual seals being more trusting and tolerant towards human presence. This new conservation reality has enabled, for the first time, the study of the behavior of the Mediterranean monk seal at sea in Greece and how this behavior is affected by tourism- and leisure-related activity. Our results indicate that monk seals are more active at sea during the early morning hours and that this activity is negatively affected by boat traffic; such traffic is likely to affect subadults more than adult seals. Monk seals are more vigilant in general due to the tourism- and leisure-related boat traffic.

Mediterranean monk seals that are active at the Lichadonisia islets are part of a newly discovered monk seal colony at the northern part of the island of Evia (Karamanlidis et al., 2015). For reasons not yet clear, they use the marine area around the Lichadonisia islets mainly during the early morning hours which is in accordance to their haul-out patterns in the wider area (Dendrinos, 2011; Karamanlidis et al., 2015). Tourism- and leisure-related boat traffic appears to negatively affect monk seal activity at sea, which has been recorded also in other seal species, such as harbor seals (*Phoca vitulina*; Henry & Hammill, 2001) and New Zealand fur seals (*Arctophoca australis forsteri*; Boren et al., 2002). The fact that boat traffic appeared to have a stronger effect on subadults may be explained by the previous experience of an individual to the disturbing stimuli and a habituation effect. Thus, more experienced adult monk seals are less likely to flee after an encounter with a boat or to flee at a smaller distance (Boren et al., 2002). The increases in alert behavior following an interaction recorded in our study have been recorded in other seal species as well (Henry & Hammill, 2001).

Tourism interest in pinnipeds is increasing in importance, with hundreds of boat-based seal-watching enterprises operating now worldwide (Newsome & Rodger, 2008). Given the negative impacts that tourism/leisure activities can have on

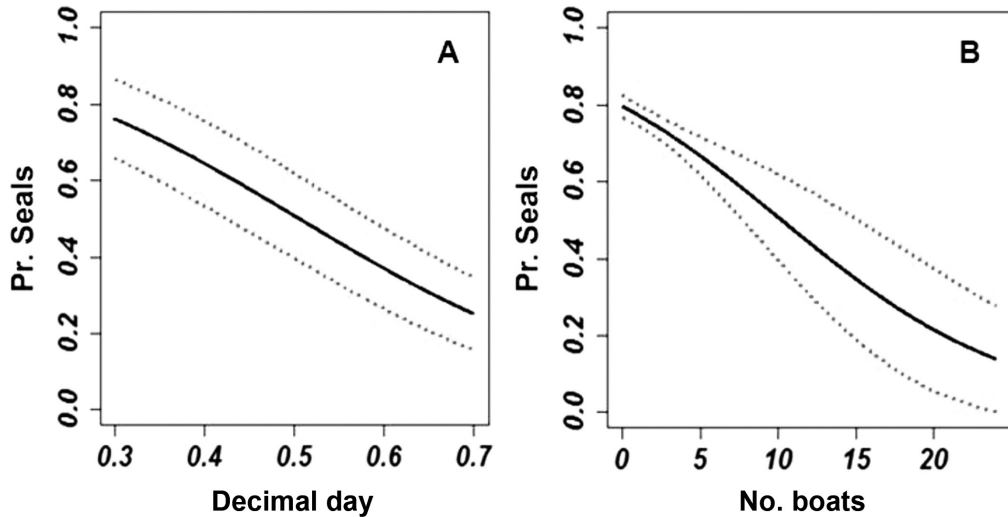


Figure 2. (A) Probability (\pm Standard Error [SE]) of Mediterranean monk seal presence in relation to decimal day and (B) probability of monk seal presence in relation to the total number of boats present at any given moment; PR = probable presence.

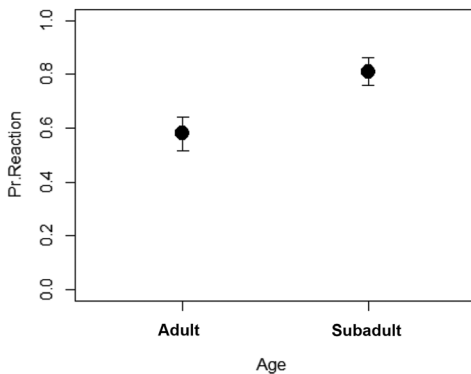


Figure 3. Probabilities (\pm SE) of different-aged Mediterranean monk seals responding to boat presence

seals in general (i.e., displacement, stampedes, boat strikes, and food provisioning; Constantine, 1999; Shaughnessy, 1999) and endangered seals in particular (i.e., Hawaiian monk seals [*Neomonachus schauinslandi*] at Kure Atoll; Gerrodette & Gilmartin, 1990), it is imperative that regulations on (seal) tourism are established to minimize potential long-term negative effects on local seal populations. Although (seal-related) tourism/leisure activities at the Lichadonisia islets are by far not as advanced and commercialized as in other parts of the world, given the endangered status of the Mediterranean monk seal and the fact that seal–boat interactions are not only increasing globally (Jansen et al.,

2015), but also within Greece (i.e., a similar case is developing at the islets of Formicula in the Ionian Sea; MOm, unpub. data), it is imperative that the general guidelines for interacting with the Mediterranean monk seal in Greece (MOm, 2006) are followed.

The results of this and previous monitoring efforts in the area (Karamanlidis et al., 2015) have provided the necessary input for including the study area in the marine NATURA 2000 network of protected areas (MOm, 2015). The Lichadonisia islets are currently managed by the newly established Management Body of the protected areas of the island of Evia. Considering the above, we propose the following conservation measures to safeguard the recovery and survival of the Mediterranean monk seal in Greece:

- *On a local level:* The Management Body of the protected areas of the island of Evia needs to include in its future management plan monk seal-related activities, including (1) strict regulation of boat traffic at Lichadonisia—for instance, constraining the distances at which boats are allowed to approach monk seals and/or moderating boat activities in the presence of monk seals; however, these regulations need to be guided by additional research assessing which boat activities impact monk seals the greatest and at what distances monk seals respond to the boats; and (2) targeted public awareness campaigns to the tour operators and to the tourists visiting the area,

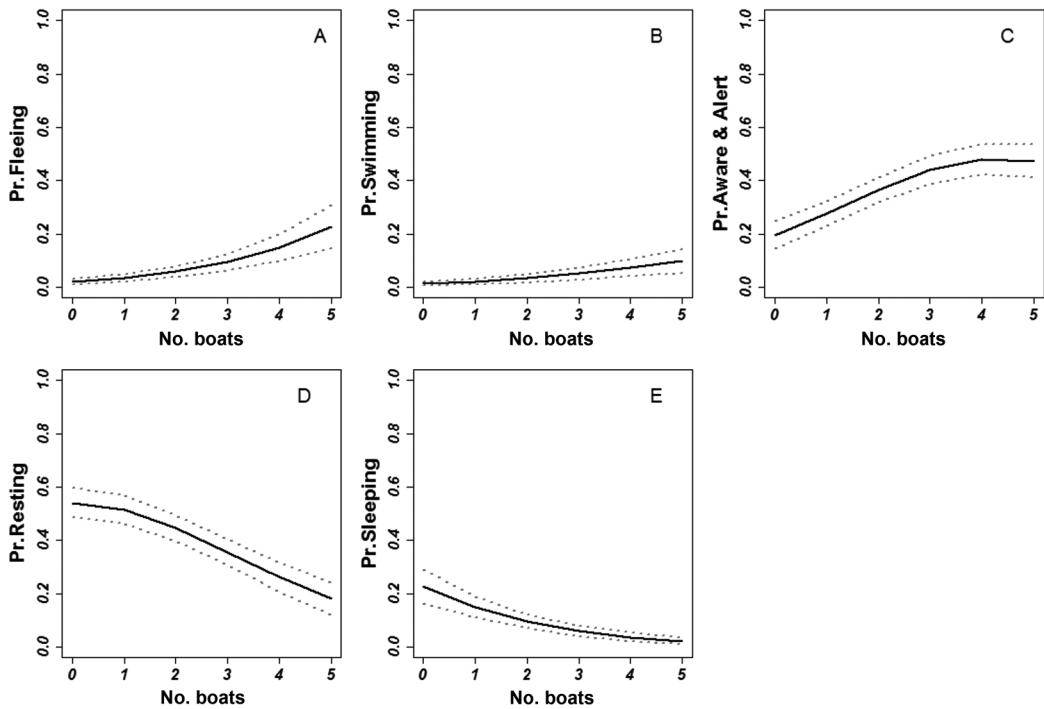


Figure 4. Probabilities (\pm SE) of various Mediterranean monk seal behaviors occurring in relation to boat presence; PR = probable presence.

ensuring that boats adhere to these regulations. A similar approach should be adopted at the islets of Formicula in the Ionian Sea.

- *On a national level:* The awareness that monk seals respond to vessels suggests that the general guidelines proposed for interacting with Mediterranean monk seals in Greece (MOM, 2006) need to be revised. These revisions should then be adopted by the national authorities and integrated in the standard management procedures for the Mediterranean monk seal in Greece.

Acknowledgments

We would like to thank Kimonas Koemtzopoulos for help in setting up the study; and Poseidon Daily Cruises, Hotel Alma, and Boho Beach Canteen for their support with the field work. Line Cordes provided advice on statistical analyses. The long-term study of MOM in the area received funding from the U.S. Marine Mammal Commission and the Mohamed bin Zayed Species Conservation Fund.

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