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Short Note

Movements of Mediterranean Monk Seals (*Monachus monachus*) in the Eastern Mediterranean Sea

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Pinnipeds (the carnivorans in the families Otariidae, Odobenidae, and Phocidae) are mammals that spend their lives in both terrestrial and aquatic environments; thoroughly studying activity patterns in both environments is essential to fully understand their biology and consequently to define effective management and conservation actions (Harwood & Croxall, 1988; Thompson, 1989; Thompson et al., 2001). Studying individual activity patterns of seals at sea (i.e., estimating movements, calculating dive depth, identifying feeding locations, etc.) has relied mainly on telemetry and tagging; both methodologies have been applied successfully for a wide range of geographical locations and species (e.g., Grey seals [*Halichoerus grypus*], McConnell et al., 1999; Hooded seals [*Cystophora cristata*], Hammill, 1993; Northern fur seals [*Callorhinus ursinus*], Ream et al., 2005; South African fur seals [*Arctocephalus pusillus pusillus*], Oosthuizen, 1991; Southern elephant seals [*Mirounga leonina*], McConnell et al., 2002; Bester, 2006) and also included endangered species such as the Hawaiian monk seal (*Monachus schauinslandi*; Henderson & Johanos, 1988; Parrish et al., 2002).

In the case of the critically endangered Mediterranean monk seal (*Monachus monachus*) (International Union for Conservation of Nature [IUCN], 2010) and despite a number of studies that have been conducted in the western (i.e., Archipelago of Madeira and Cabo Blanco region [Gazo & Aguilar, 2005; Gazo et al., 2006; Pires et al., 2007]), as well as in the eastern part of the species range (i.e., Greece and Turkey [Reijnders & Ries, 1989; Kiraç et al., 2002; Dendrinos et al., 2007a]), our understanding of the activity patterns of this species at sea is still incomplete. Especially in Greece, where the biggest population of monk seals still survives (Johnson et al., 2006; MOm, 2007), studying individual activity patterns of this species at sea has been hampered by the difficulty of tagging animals due to their endangered status, the inaccessibility of their habitat, and the difficulties encountered in satellite telemetry, particularly when haul-out sites are located near steep cliffs (Jay & Garner, 2002; Dendrinos et al., 2007a; MOm, unpub. data). Given that individual activity patterns define spatial structure and resource use on a population level (Turchin, 1998), this is a significant gap in our understanding of the biology of the species (Bergman et al., 2000).

In 1991, MOm/Hellenic Society for the Study and Protection of the Monk Seal established the Rescue and Information Network (RINT), a national network of informants with the aim of monitoring the status of the Mediterranean monk seal in Greece. RINT covers geographically the entire coastal and insular part of the country and is based on the voluntary participation of more than 1,800 members (i.e., local inhabitants; members of local authorities such as Port Police and veterinary authorities; and fishermen) who provide information on sightings of dead and alive monk seals. This information is received by mail, e-mail, or telephone via a 24-h line known throughout the country as the Monk Seal Hotline. After receiving monk seal sighting details, the observer is contacted directly, and the validity of the information is evaluated, based on predefined criteria (Adamantopoulou et al., 1999). Follow-up actions include monitoring the distribution of the individuals or subgroups of the species in the country (Adamantopoulou et al., 1999); performing necropsies in cases of dead animals and evaluating causes of mortality (Androukaki et al., 1999; Karamanlidis et al., 2008); and rehabilitating sick, wounded, and orphan seals (Androukaki et al., 2002).

In this study, we report movements of Mediterranean monk seals in the eastern Mediterranean Sea collected by RINT from 1990 to

2010. The data used in the study are based on sequential observations of individual monk seals that were observed at least once by a MOm researcher (i.e., sighting of an individual), who recorded in detail the external appearance of the animal; whenever possible (i.e., during direct handling in rehabilitation or during a necropsy), detailed measurements of an individual were also taken. However, the majority of the data originated from members of RINT, who identified the animals from characteristic features of their external appearance (i.e., resighting an individual). Whenever possible, such information was also validated through the examination of photographs or videotapes provided by observers. Observations of seals were mapped using *ArcGIS 9.0* (Environmental Systems Research Institute [ESRI], Redlands, CA, USA); the straight distance covered was estimated and the home range defined as the marine area included in the minimum convex polygon defined by sequential observations.

During the study period, RINT received information that provided evidence of the movements of five different Mediterranean monk seals in five different regions of Greece (Figure 1). Detailed information for each case study follows.

Case 1

The first case involved a male subadult Mediterranean monk seal (total length [TL]: 180 cm) found orphaned in October 1990 at the island of Skopelos in the Northern Sporades; this individual was subsequently rehabilitated (MOm/SRRC, 1991). Following release at the island of Kyra Panagia in the National Marine Park of Alonissos, Northern Sporades (NMPANS), and due to the prolonged rehabilitation process, the monk seal exhibited habituation to humans and hauled-out in the vicinity of human settlements. In order to terminate this acclimation to humans, the monk seal was captured again and released on 17 July 1992 at the easternmost, uninhabited island of the NMPANS. Based on distinctive scars on the head and hind flippers (Figure 2), the monk seal was easily identified and was sighted four times in the following 5 mo (Figure 1). During this time, it traveled a total distance of ~133 km, while the longest straight distance covered was 52 km. On one occasion (i.e., between observations 2 and 3), the monk seal covered a straight distance

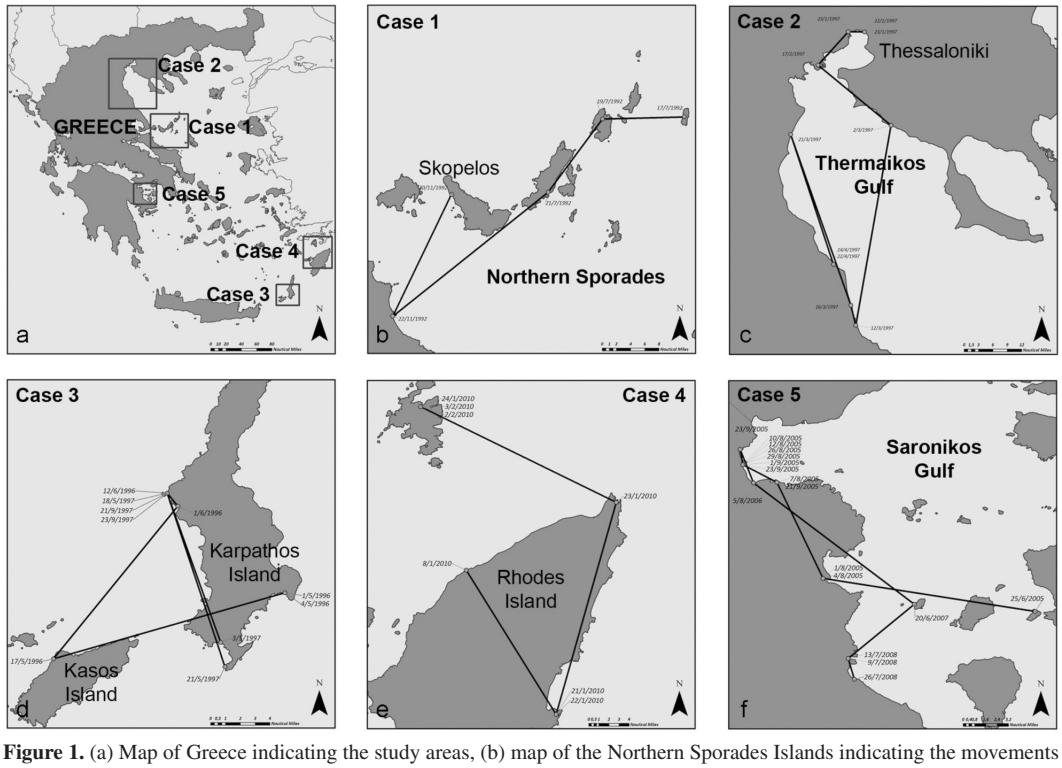

Figure 1. (a) Map of Greece indicating the study areas, (b) map of the Northern Sporades Islands indicating the movements of Case 1, (c) map of the Thermaikos Gulf indicating the movements of Case 2, (d) map of the Karpathos–Kasos Islands complex indicating the movements of Case 3, (e) map of the southern Dodecanese Islands indicating the movements of Case 4, and (f) map of the Saronikos Gulf indicating the movements of Case 5.

Figure 2. Images of four Mediterranean monk seals tracked in the eastern Mediterranean Sea (1990 to 2010): (a) Case 1, (b) Case 2, (c) Case 3, and (d) Case 4; the white circles indicate distinctive external features used in the identification of each individual.

Table 1. Summary of events recorded during the tracking of five Mediterranean monk seals in the eastern Mediterranean Sea

Individual	No. of observations	Total distance traveled (km)	Longest straight distance (km)	Home range (km^2)
Case 1	5	132	52	466
Case 2	10	280	78	1,145
Case 3	10	142	30	148
Case 4	7	112	40	458
Case 5	17	104	28	122

of ~12 km/d. The home range of the monk seal was estimated at 466 km^2 (Table 1).

Case 2

On 22 January 1997, an adult female Mediterranean monk seal (TL: 230 cm) was sighted in the harbor of Thessaloniki, Gulf of Thermaikos, Northern Aegean Sea. The monk seal had a distinct bleeding ulcer posterior to the right eye and was molting (Figure 2). Over a 3-mo period, the monk seal was sighted 10 times, often in locations atypical for the species (i.e., a river delta, stream banks) and was treated twice for its injuries (17 & 23 February 1997) (MOm, 1998). During this time, the monk seal traveled a total distance of ~280 km while covering a straight distance of 78 km in 10 d (i.e., between observations 5 and 6) and of ~70 km in 5 d (i.e., between observations 7 and 8; average 14 km/d). The home range of the monk seal was estimated at 1,145 km^2 (Figure 1; Table 1).

Case 3

On 1 May 1996, an adult male Mediterranean monk seal (TL: 243 cm) was sighted on the southeastern part of the island of Karpathos in the southeastern Dodecanese Islands in the southern Aegean Sea. The monk seal had a fresh purulent injury (~50 × 30 cm) on its right side and distinct scars on the front and hind flippers (Figure 2). Over a period of 16 mo, the monk seal was sighted on 10 different occasions until it was killed after a tourist tried to approach it and was attacked. The necropsy of the animal indicated that it had been killed using dynamite (MOm, 1998). During this time, the monk seal traveled a total distance of ~142 km, with ~31 km the longest straight distance covered by the animal between consecutive

sightings within a 13-d period (i.e., between observations 2 and 3). The home range of this individual was estimated at 148 km^2 (Table 1).

Case 4

The fourth case involves a female subadult Mediterranean monk seal ~4 y old that was found as an orphan pup in December 2006 along the Turkish coast of the Aegean Sea and was rehabilitated at a facility in Foça (H. Güçlüsoy & C. Kiraç, pers. comm., 31 October 2010). Following release, the animal showed habituation to humans and was subsequently captured and released on several occasions. On 6 January 2010, the animal was released in the Bay of Gökova at the southern part of the Turkish coast of the Aegean Sea and was sighted on 21 January 2010 at the northwestern part of the Greek island of Rhodes. The monk seal had a distinct mark above its left eye (Figure 2), was sighted on seven occasions over a period of a month, and traveled a total distance of 112 km. It is noteworthy that in 2 d this animal covered a straight distance of ~81 km before returning on 4 February 2010 back to Turkey (H. Güçlüsoy & C. Kiraç, pers. comm., 31 October 2010). The home range of the monk seal was estimated at 459 km^2 (Figure 1; Table 1).

Case 5

The fifth case involved a subadult, most probably female, Mediterranean monk seal (TL: ~170 cm) with a hook and piece of long-line tightly entangled around its right hind flipper. The monk seal rested on open beaches in close proximity to humans in the Saronikos Gulf in the central Aegean Sea and was sighted 17 times over a period of ~3 y. During this time, the monk seal covered a total distance of ~104 km. The home range of the monk seal was estimated at 123 km^2 (Figure 1; Table 1).

Case Study Overview

All the animals included in this paper, except the monk seal for Case 2, moved across stretches of open sea to areas with depths greater than 200 m. The monk seal for Case 2 did not move across such areas because the sea bottom in the Thermaikos Gulf is less than 200 m deep.

Mark-recapture (through tagging or resighting) studies are commonly used for studying the biological parameters of seals, both on land (Hindell, 1991; McMahon et al., 2003) and at sea (Lewis et al., 1996; Bester, 2006). For the Mediterranean monk seal, tagging individual seals has been possible only in the populous colony at Cabo Blanco (Gazo et al., 1999); in all other areas of the species' current distribution, individual identifications and resightings have relied on the presence of natural, distinct morphological features (Kiraç et al., 2002; Gücü et al., 2004; Pires et al., 2007). Despite the innate caveats of this methodology (i.e., data only from places where humans are, tracking an individual depends on the presence of natural markings that may change through time) and the fact that the data collected arise mostly from injured or rehabilitated animals, which might be expected to display atypical movements, this study has provided the first baseline data on movements of wild Mediterranean monk seals in Greece.

Although only limited field data are available on the behavior of Mediterranean monk seals at sea, the species is commonly regarded as being coastal and sedentary (Berkes, 1978; Boulva, 1979; Panou et al., 1993), although the ability for long-range dispersal has been reported, mostly for juveniles (Salnikov, 1959; Aguilar, 1998; Bayed, 2001). The results of the present study provide direct evidence for movements of monk seals in Greece and are in accordance with our general knowledge on the behavior of the species at sea. Without disregarding the possibility of having travelled extensive distances that were not detected by RINT, the two animals in our study that were monitored for multiple years were always sighted within a small geographical area (i.e., ~130 km^2). It has been suggested that such sedentary behavior of the species is associated with the availability of suitable resting and pupping caves in a given area (Dendrinos et al., 2007b). In the case of the adult male in our study, whose movements were within the ranges suggested for adult males in Turkey (Berkes et al., 1978; Gücü et al., 2004), remaining in the same area might therefore have been an effort to maximize time near important haul-out caves in the pursuit of females (Parrish et al., 2002). The fact that the majority of the monk seals monitored in our study traveled across stretches of open sea while covering distances in the excess of 40 km/d provides testimony to the movement capabilities of this species and might be associated with the recent spate of extralimital sightings of monk seals in areas near Greece such as Croatia and Israel (Gomerčić et al., 2005; Scheinin et al., 2010).

Detailed knowledge of the movements and dispersal abilities of Mediterranean monk seals is of utmost importance for the effective management and conservation of this critically endangered species (Reijnders & Ries, 1989). Given that the newly drafted Action Plan for the Mediterranean monk seal in Greece calls for the establishment of a functional network of Marine Protected Areas in the country for the conservation of the species (Notarbartolo di Sciara et al., 2009), information on the movements of individual monk seals will play an important role in the process of protecting this species. Furthermore, the study provided direct

evidence of the travel patterns of a monk seal across national borders between Greece and Turkey, thus supporting the long-standing assumption of an interconnected population between the two countries (Berkes, 1978) and highlighting the necessity for international cooperation in the protection and management of the species in this region.

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