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Damage by monk seals to gear of the artisanal fishery in the Foça Monk Seal Pilot Conservation Area, Turkey

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Abstract

The present study examines the operational interaction between critically endangered monk seals *Monachus monachus* and artisanal fisheries in the Foça Pilot Monk Seal Conservation Area, Turkey between 1994 and 2002. One to four permanent researchers collected the data on this interaction during the seal sighting data inquiries. Interviews with the fishermen provided 142 direct interactions with monk seals around the fishing gear. Among these encounters damage to fishing gear, including gill nets (53%), trammel nets (37%), longlines (9%) and a lure (1%) was recorded 90 times. However, no difference was found in damage between gill and trammel nets. Although, the damage inflicted by seals per occasion was found to be substantial (maximum 462.5 USD per occasion), the overall annual economic impact on the artisanal fishery was found to be modest. Limitation in soaking time of nets; long-line use instead of nets in MPAs where monk seals survive; and low interest credits to be given to those fishermen who suffer monk seal damage, are proposed as appropriate management practices.

Keywords: Aegean Sea; İzmir Bay; Operational interaction; Endangered species; Marine mammal; *Monachus monachus*

1. Introduction

Marine mammals have popularly been viewed as man's competitor for protein resources in the oceans (Lavigne, 1982). One of the reasons that they have been viewed as competitors is their frequent interaction with fisheries since antiquity (Johnson and Lavigne, 1999; Bearzi, 2002). Unfortunately, the nature of this interaction has negative effects for fishermen; not only do marine mammals attempt to take the catch, but they may also damage the fishing gear while doing so (Northridge and Hofman, 1999; Moore, 2003; Lauriano et al., 2004). Over the years, two explanations have been given as to why seals attack fishing nets. One view suggests that this behaviour is due to the nature of the species, and the other is that the animals are forced to resort to such behaviour because of external influences, such as a lack of food as a result of overfishing (Johnson and Karamanlidis, 2000; Moore, 2003). Whatever the reason may be, because of the financial losses they cause by attacking the nets or getting entangled in fishing equipment, they have been persecuted and deliberately killed (Northridge and Hofman, 1999; Güçlüsoy et al., 2004a). In the case of a critically endangered species such as the Mediterranean monk seal *Monachus monachus* (Hermann, 1779) (IUCN, 2002), which is protected by the Bern (Appendix II), Bonn (Appendix I and II), CITES (Appendix I), Barcelona (Fourth protocol species), and Biodiversity (Eligible species) Conventions, these problems have also to be considered from a conservation point of view.

The monk seal, the only seal species present in Turkish waters, has an estimated population of 100 along the Turkish coasts (Güçlüsoy et al., 2004a). This species has been officially protected in Turkey since 1977 and 1978 by the Ministry of Environment and Forestry, and the Ministry of Agriculture and Rural Affairs, respectively. Along with the species of cetacean – including common dolphin *Delphinus delphis*, striped dolphin *Stenella coeruleoalba* and bottlenose dolphin *Tursiops truncatus* – occurring in the study area (Güçlüsoy et al., 2004b, 2005), the monk seal has been recorded in and around Foça town since antiquity (Johnson and Lavigne, 1999). In the second half of the last century, the species' occurrence at and around Foça was reported by Mursaloğlu (1964), Berkes et al. (1979), Öztürk and Dede (1995), and by Güçlüsoy and Savaş (2003a). In the most recent study, Güçlüsoy and Savaş (2003a) estimated the pop-

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ulation of monk seals as nine individuals over a 5-year period between 1994 and 1998. These authors also reported that the islands off Foça town provide suitable habitats, and play a key role in the survival of species.

The Foça coastal zone obtained a special protection status in 1991, as the Foça Pilot Monk Seal Conservation Area (Foça PMSCA), where no purse-seining and trawling is allowed (Güçlüsoy and Savaş, 2003a). Though coastal waters off Foça incorporating the Foça PMSCA are banned to industrial fishing operations and only allow an artisanal fishery, it is one of the biggest fishing harbours in the Turkish Aegean for trawlers and purse-seines fishing outside the Foça PMSCA (Ünal, 2002). The interaction between monk seals and fisheries is, therefore, an issue which has to be dealt with carefully, if fishermen and monk seals are to coexist peacefully in this region. At the last experts meeting regarding the implementation of action plans for marine mammals adopted within the Mediterranean Action Plan of the United Nations Environment Programme, it was determined that there was a lack of studies on monk seal damage to fishing gear (Anonymous, 1998). Therefore, the purpose of this study is to examine the operational interaction between monk seals and fisheries. Moreover, it seeks to discover whether the widespread view among the fishing community, that the monk seals inflict a considerable amount of damage upon fishing gear, and thus to profits (e.g. Glain et al., 2001), is acceptable.

2. Study area and methods

The Foça Archipelago is situated at the entrance of the İzmir Bay on the central Aegean coasts of Turkey, about 50 km north of the İzmir metropolitan area. A fleet of approximately 41 artisanal fishing boats – comprising 26 operating full time (FT) and 15 part time (PT) – is based at the port of Foça (Ünal, 2001, 2003), reaching north to Şıra Island (N38°44.5′E 27°45.6′) and south to Kırdeniz (N38°35.8′E26°48.0′). Fishermen usually work between the coastline and the 60 m isobath. Most boats are open-hulled, smaller than 10 m in length, and powered by inboard engines – 5–28 hp – with a 0.5–1.5 tonne capacity. Fishing trips usually last between 4 and 12 h at night. The average number of fishing days for FT artisanal fishermen was calculated as 203 days and for PT artisanal fishermen as 136 days for 1999 and 2000 fishing season (Ünal, 2001, 2003). For this season, the average gross cash flow (GFC) – value of landings minus all expenses except depreciation and interest – for the former group using nets ($n = 19$) was calculated as 2281 U.S. dollars (USD) per annum, and for the latter group using nets ($n = 12$) this was – 646 USD – computed from (Ünal, 2001, 2003).

Among the fishing gear used are trammel and gill nets and bottom long lines. The lengths of the trammel and gill nets used in Foça PMSCA are usually 600–1200 m and 600–1500 m, respectively. The characteristics of these nets are given in Tables 1 and 2.

Bottom long lines are set on or close to the sea bed, and consist of a series of baited hooks – either with size no. 8 or no. 14 – on a line. The hook size that is used depends on the targeted species: no. 8 sized hooks mainly for Common Dentex (*Dentex dentex*), and, rarely, Groupers *Epinephelus*

Table 1
Trammel nets used in the Foça PMSCA between 1994 and 2002

Net type code	Target species	The price of the gear per section (100 m)	Months used	Properties of inner layer netting	Properties of outer layer netting
T1	Red Mullet (*Mullus barbatus* & *Mullus surmuletus*)	90 million TL, (67 USD), (80 m^2)	All	Knot to knot mesh size: 20–22 mm, Nylon thread diameter: no. 1–2, Height: 40–50 meshes	Knot to knot mesh size: 100–110 mm, Nylon thread diameter: no. 4–6, Height: 6–7 meshes
T2	Various benthic species such as: Salema (*Sarpa salpa*), White Seabream (*Diplodus sargus*), Common two-banded Seabream (*Diplodus vulgaris*), Sharpsnout Seabream (*Diplodus puntazzo*), Gilthead Seabream (*Sparus aurata*), Grey Mullet (*Mugilidae*), Blotched Picarel (*Spicara maena*) and Octopus (*Octopus vulgaris*)	180 million TL, (133 USD), (300 m^2)	All	Knot to knot mesh size: 28–34 mm, Nylon thread diameter: no. 2–3, Height: 80–100 meshes	Knot to knot mesh size: 125–140 mm, Nylon thread diameter: no. 4–6, Height: 10–20 meshes
T3	Sole (*Solea* spp.)	90 million TL, (67 USD), (140 m^2)	All	Knot to knot mesh size: 32–48 mm, Nylon thread diameter: no. 2–3, Height: 50–60 meshes	Knot to knot mesh size:140–160 mm, Nylon thread diameter: no. 4–6, Height: 6–7 meshes
T4	Shrimps (*Penaeidae*)	170 million TL, (126 USD), (210 m^2)	From April to October	Knot to knot mesh size: 20 mm, Nylon thread diameter: no. 0, Height: 50 meshes	Knot to knot mesh size: 100 mm, Nylon thread diameter: no. 3–4, Height: 6 meshes

Table 2
Gill nets used in the Foça PMSCA between 1994 and 2002

Net type code	Target species	The price of the gear per section (100 m)	Months used	Properties of netting
G1	Red Mullet (*Mullus barbatus* & *Mullus surmuletus*)	75 Million TL, (55 USD), (80 m^2)	All	Knot to knot mesh size: 20–22 mm, Nylon thread diameter: no. 1–2, Height: 40–50 meshes
G2	Bogue (*Boops boops*) & Blotched Picarel (*Spicara maena*)	100 Million TL, (74 USD), (300 m^2)	From October to June	Knot to knot mesh size: 20–22 mm, Nylon thread diameter: no. 1–2, Height: 120–200 meshes

marginatus and *E. costae*, and no. 14 hooks for White Seabream *Diplodus sargus*, Two-banded Seabream *Diplodus vulgaris*, Striped Bream *Lithognathus mormyrus*, Saddled Bream *Oblada melanura*, Common Pandora *Pagellus erythrinus*, Common Seabream *Pagrus pagrus*, Black Seabream (*Spondyliosoma cantharus*) and Gilthead Seabream *Sparus aurata*. The price for the 1000 m bottom long lines are 37 USD for a line with 280 hooks of size no.8, and 60 USD for a line with 100 hooks of size no. 14.

2.1. Data collection

Information on the interactions between monk seals and fishermen was collected between the 1st of January 1994 and the 31st of December 2002, during on-site daily interviews with artisanal fishermen in Foça PMSCA. Prior to the commencement of the main study, a preliminary study to setup a continuous monitoring programme for *M. monachus* – by using standard questionnaire forms – including interaction with the fisheries, was carried out over 7 months by Güçlüsoy and Savaş (2003a). One to four permanent researchers, from the Underwater Research Society – Mediterranean Seal Research Group (SAD-AFAG), collected the information on *M. monachus* during the seal sighting data inquiries. Further details on this monitoring programme, such as the kind of data collected and the data validation were previously published by Güçlüsoy and Savaş (2003a). For the present study, the data specifically collected were the following: the number of interactions between fishermen and seals, the type of fishing gear used during these interactions and, if any, the amount of the damage caused by the monk seals. However, during the preliminary study period, because fishermen began asking for compensation for fishing gear damages when researchers approached them, it was foreseen for the main study period that data regarding attack could not be collected for all fishing trips. Therefore, for the main study period the researchers set their daily interviews by asking all the fishermen if they had seen any seals during their fishing trip and, if the answer was positive, only then inspected their fishing gear for damages, and inquired about basic data on the encounter. All the collected data was therefore restricted to occasions on which seal sightings were recorded. Therefore, this impeded the calculation of overall fishing effort for the whole fleet. Interactions were defined as sightings when monk seals were reported to have observed within 400 m of fishing gear.

During net inspections, when a typical monk seal damage pattern (as described by Karavellas (1994) and Berkes et al. (1979)) was found by the researchers on the net, following the sighting of a seal in the location where the fishing net was set, the occasion was recorded as a seal attack. According to Karavellas (1994), monk seals leave behind a characteristic three-hole pattern with one large hole (usually smaller than that caused by dolphins) and two smaller peripheral holes, presumably at the position at which the flippers grasped the net. The holes which monk seals tear in the net while snatching fish from it were reported to be 20–30 cm in diameter by Berkes et al. (1979). During net inspections, the cetacean damages described by Öztürk and Dede (1995) were excluded to prevent miscalculation of the monk seal damages. According to these authors cetacean damages are identified by the large irregular shaped tears stretching vertically from the floating rope side of the net at the top to the lead sinkers side at the bottom. If the torn part of the net is twisted like a wick, this is also considered as a cetacean damage. The sighting of a seal taking the caught fish from the hooks, or breaking off the hooks from the main line, or a number of half eaten fishes left on the hooks; represent a monk seal damage to bottom lines.

2.2. Calculation of the attack preference on the fishing nets

To assess the seal attack preference on the fishing nets, annual numbers of attacks per m^2 of both trammel and gill nets were computed. Firstly, the number of each fishing net type used – only the ones confined to seal interaction could be taken into consideration – was calculated for each year. Then, these numbers were multiplied with the generally used surface area of each net type in Foça PMSCA (Yaşar Balta, pers. commun.) to calculate the total surface area for each net type used annually. The generally used surface area for T2-type net was given as 1800 m^2, for T3-type net as 1680 m^2, for G1-type net as 1200 m^2 and for G2-type as 1800 m^2. And computed total net surface areas used in each year were summed up for trammel and gill nets separately. Finally, the number of annual attacks on both trammel and gill nets were weighted by the annual total surface areas of trammel and gill nets used respectively. As mentioned previously, the data could not be corrected for overall annual fishing time effort of each net type and it was assumed that this was equal for different net types. In addition, it was also assumed that the number of seals using the Foça PMSCA did not change during study period. After these calculations, corrected annual data, the number of attacks per m^2 for gill and trammel nets were analysed by means of the one-way ANOVA test.

Table 3
Number of monk seal sightings around the fishing gear with or without damage around the different types fishing gear in the Foça PMSCA between 1994 and 2002

Type of fishing gear	Number of sightings with damage	Number of sightings without damage	Total number of sightings
Trammel Nets	33	20	57
Gill Nets	48	20	64
Longline	8	3	11
Lure	1	0	1
Unknown[a]	?	?	9
Total	90	43	142

[a] In nine occasions fishermen observed seals around the other fishermen's nets.

2.3. Calculation of the financial losses per attack and per annum

For the calculation of the financial losses to fishing nets, the "number of three-holes (NH)" or "total length of the net segment which could not be used anymore (TLS)" were taken into consideration. According to their magnitude e.g. number of three-holes (see Table 5), information on the number of days required to repair these NH and TLS damages was sought from the Foça Fishing Co-operative. The daily net fixing rate is 18.5 USD for all type of nets used in the Foça PMSCA for 2003 (Yaşar Balta, pers. commun.). For the calculation of the TLS damages, the prices of the net pieces required to fix the damaged nets were taken into consideration (see Tables 1 and 2). Since old nets or remnant net pieces were used while making a new net for NH damages, no financial loss in terms of net piece use were calculated for these. After all calculations, because of high inflation during the study period in Turkey, the financial losses were converted to USD with the exchange rate of 1 USD = 1,352,122 Turkish liras – provided from the Central Bank of The Republic of Turkey as of 23 September 2003. For the calculation of the financial losses to bottom long lines, a package containing 100 hooks (no. 14) was priced at three USD (Soner Çınar, pers. commun.).

For the calculation of the annual financial losses of both the FT and PT artisanal fishing fleet of Foça PMSCA, all the financial losses of damages per seal attack were summed up for the respective year (see Tables 6 and 7). For these calculations, because the damages inflicted upon long lines were negligible, only the damages to fishing nets were taken into consideration.

3. Results

During fishing operations, seals were observed 142 times around fishing gear. Among these encounters, damage to fishing gear was recorded 90 times (63%), no damage was caused to fishing gear 25 times (18%), and for 27 times (19%) it was not possible to verify whether damage to fishing gear had occurred during that particular fishing trip.

All types of fishing gear were subject to damage (Table 3). Among the nets, except T1-type and T4-type nets, all the nets used were attacked by monk seals (Table 4). However, no difference was found in seal attack rates between trammel and gill nets (ANOVA $F = 0.025$, $P > 0.87$).

The magnitude of the damage to fishing nets could be obtained adequately for 50 attacks (Table 5). The damages inflicted by seals per attack were found to be substantial. For example, the maximum financial loss was calculated as 462.5 USD during an attack on a G2-type net (see Table 5). During the five attacks to the bottom long lines – all of them with a no. 14 size hook – it has been reported that 5, 15, 35, 50 and 100 hooks went missing, respectively. The maximum financial loss for the bottom long lines was calculated at 3 USD. The total annual financial losses of the Foça fishing fleet comprised by FT and PT artisanal fishermen are given in Tables 6 and 7.

On 34 occasions (24%) fishermen who observed the seals around their fishing nets retrieved their nets immediately. Fishermen who experienced seal attacks on their fishing gear applied one basic method to prevent or reduce them: direct intervention to deter seals with stimuli. Lights, noise generation mainly by striking the wooden boat, and pursuit with boats were the usual tactics (Table 8).

4. Discussion

With this study, the operational interactions between Mediterranean monk seals and artisanal fishery are recorded for the first time on a long-term basis. The species has been previ-

Table 4
Number of nets in use annually and damage to these gears by monk seals in the Foça PMSCA between 1994 and 2002

Year	Number of				Number of seal attack			
	T2-type net	T3-type net	G1-type net	G2-type net	T2-type net	T3-type net	G1-type net	G2-type net
1994	3	2	3	1	0	1	1	1
1995	12	1	4	6	9	0	2	5
1996	8	0	3	12	4	0	3	20
1997	6	0	3	10	4	0	3	0
1998	3	1	3	6	7	1	3	5
1999	7	0	3	3	5	0	0	0
2000	7	0	1	2	0	0	0	0
2001	6	0	0	2	2	0	0	1
2002	5	0	3	4	0	0	0	4
Total	57	4	23	46	31	2	12	36

Table 5
Number of monk seal interactions with damage to specific type of fishing nets and financial losses per attack in the Foça PMSCA between 1994 and 2002

Type of fishing gear	Type of damage	Number of 3-holes (NH) per attack	Number of days required to fix each net (*a*)	Mending price per day (USD) (*b*)	Length (m) of the totally damaged nets (TLS) to be replaced (*c*)	Unit price per 100-m section of specified net (USD) (*d*)	Financial loss for each damage (USD) $(e) = (ab) + (cd)$	Number of sightings with damage (*f*)	Total financial loss (USD) $(g) = ef$
G1	NH	3,4,4	1	18.5	–	–	18.5	3	55.5
	NH	14,15	2	18.5	–	–	37	2	74
	NH	30	3	18.5	–	–	55.5	1	55.5
	NH	100	10	18.5	–	–	185	1	185
	TLS	–	4	18.5	400	55/100	294	1	294
G2	NH	1,2,2,2,2, 4,4,4,6,7,9	1	18.5	–	–	18.5	11	203.5
	NH	15,15,20	2	18.5	–	–	37	3	111
	NH	22,25	3	18.5	–	–	55.5	2	111
	TLS	–	2	18.5	200	74/100	185	3	555
	TLS	–	4	18.5	400	74/100	370	1	370
	TLS	–	5	18.5	500	74/100	462.5	2	925
T2	NH	2,2,2,3,4,5,5,6	2	18.5	–	–	37	8	296
	NH	8,9,9,10,10,10,10,14	3	18.5	–	–	55.5	8	444
	NH	38	5	18.5	–	–	92.5	1	92.5
	TLS	–	3	18.5	40 & 50	133/100	108.7 & 122	2	230.7
T3	NH	4	1	18.5	–	–	18.5	1	18.5

Table 6
The annual financial losses of the artisanal fishing fleet comprised FT fishermen in the Foça PMSCA between 1994 and 2002 (the numbers in parenthesis indicate the number of days required for net mending)

Year	Number of occasions with different type of damages																Total annual financial loss (USD)
	G1-type net					G2-type net						T2-type net				T3-type net	
	NH (1)	NH (2)	NH (3)	NH (10)	TLS (4)	NH (1)	NH (2)	NH (3)	TLS (2)	TLS (4)	TLS (5)	NH (2)	NH (3)	NH (5)	TLS (3)	NH (1)	
1994	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	18.5
1995	–	–	1	–	–	3	–	–	1	–	–	2	2	–	–	–	481.0
1996	2	1	–	–	–	3	2	2	1	1	2	2	1	–	–	–	1942.5
1997	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	222.0
1998	–	–	–	–	1	1	–	–	–	–	–	1	3	–	1[a]	1	656.5
1999	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	92.5
2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0
2001	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	129.5
2002	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0

[a] The damage occasion requiring 50 m net piece for mending (see Table 5).

Table 7
The annual financial losses of the artisanal fishing fleet comprised PT fishermen in the Foça PMSCA between 1994 and 2002

Year	Number of occasions with different type of damages					Total annual financial loss (USD)
	G2-type net		T2-type net			
	NH (1)	TLS (2)	NH (2)	NH (3)	TLS (3)	
1995	–	–	1	1	–	92.5
1996	2	1	–	–	–	222.0
1999	–	–	1	–	1[a]	145.7
2002	1	–	–	–	–	18.5

[a] The damage occasion requiring 40 m net piece for mending (see Table 5) (the numbers in parenthesis indicate the number of days required for net mending).

ously reported as snatching fish and causing damage to fishing gear while doing so (Berkes et al., 1979; Panou et al., 1993; Karavellas, 1994). Gill and trammel nets had the highest percentage of damage in the Foça PMSCA. The same trend was also observed by Panou et al. (1993) during a study carried out in the Ionian Sea, Greece. In contrast to our findings that no difference was found in seal attack preferences between gill and trammel nets, Panou et al. (1993) reported that trammel nets compared to gill nets were more susceptible to seal damage in the Ionian Sea. This may be due to the different size and composition of the local fish stocks, or to the differences in fishing activities between both regions. Excluding the attack on a lure line – which event was reported for the first time – the bottom long lines, both in the Foça PMSCA and in the Ionian Sea, seem to have suffered the least damage. Therefore, this type of fishing gear should be considered as preferred alternative. At this stage, even though catch size, and thus profit, is the determining factor for selecting a type of fishing gear in a particular fishing ground where monk seals exist, long lines should still at least be considered as the preferred choice alternative gear in Marine Protected Areas (MPAs), with the exception of the no-fishing core zones, since they present almost no entanglement risk to monk seals. However, this may have an impact on catch rates of many targeted fish species. Further, the by-catch of other fauna (e.g. marine turtles) should be considered carefully. The same management practise as proposed above, in the Desertas Islands of Madeira with an additional new long line subsidy in exchange for fishing nets, proved to be applicable and beneficial for the survival of the monk seals (Pires and Neves, 2001).

Among the gill nets used in the Foça PMSCA, G2-type nets were more susceptible to monk seal attacks. This may partly be due to the behaviour of the targeted fish species caught by these types of nets. *B. boops* and *S. maena*, which are targeted by G2-type nets, are gregarious species (Whitehead et al., 1984–1986) and are therefore mainly caught in the nets in large numbers. In contrast, *Mullus* spp., which are targeted by G1-type nets, are aggregated or solitary living species (Whitehead et al., 1984–1986), so that fewer individuals are caught by these nets. It may be that the monk seals are more frequently attracted to G2-type nets due to their accumulated catches. Another reason for the G2-type nets' susceptibility to monk seal attacks may be the abundance of the species targeted. Indeed, for the coasts of İzmir, the total catches of *B. boops* by purse-seines and *Mullus* spp. by trawlers were calculated as 279 and 56 tonnes, respectively (Kara and Gurbet, 1999).

Among the trammel nets used, T2-type nets were more susceptible to monk seal attacks. Although the usage frequencies of the trammel nets were not known during the study period, the selectivity of these types of nets may play an important role in the total catch. In this regard, less selective T2-type nets – presumably with more catch – attracted more monk seals compared to the more selective T3-type nets. In addition, the different depth ranges where these nets were set may also play a role in monk seal attacks. The T2-type nets are normally set at a depth range between 1 and 16 m, whereas T3-type nets are set from 25 to 50 m in the Foça PMSCA (Yaşar Balta, pers. commun.).

The overnight damage inflicted upon a trammel net by a monk seal was found to be substantial in the Ionian Sea (Panou et al., 1993). The same observation was also made in the present Aegean study. The financial loss per attack to the fishing nets ranged from 18.5 to 462.5 USD. However, when annual financial losses of the FT and PT fishermen were compared with the total annual income of 1999–2000 fishing season (Ünal, 2001) – with the assumption that each year's income is about the same – these losses were not found to be substantial. For example, although these losses were confined to ones with seal encounters, thus producing underestimated ratios, the maximum financial loss in 1996 for FT fishermen was less than 5% of their total annual income. The same process regarding underestimated loss in 1996 for PT fishermen was even calculated to be less than 3%. Another important aspect to be considered is the value of the unmarketable catch that was taken or damaged by seals. If this loss of financial profit could be prevented, the maximum pecuniary losses would be lower than the 3 and 5% as calculated above. The fishermen from Foça had the same goal in this direction, and therefore, they practised basic deterrence methods. Of the methods used, namely, lights, noise generation, and pursuit with the boats, only the last method appears to be effective in preventing monk seal predation. However, further study is required. Lights and noise generation to deter the attacking monk seals were also found to be ineffective in the marine fish farms situated along the Turkish Aegean coast (Güçlüsoy and Savaş, 2003b). Chasing

Table 8
Effectiveness of seal deterrents on fishing gears in the Foça PMSCA

Deterrent	Fled	Moved away and returned	Remained
Noise	4	–	7
Light	1	–	1
Boats	9	5	1

and scaring *A. pusillus doriferus* with high powered boats was also found to be one of the effective preventive methods that are used in Tasmanian marine fish farm operations (Pemperton and Shaughnessy, 1993). However, this method is not practical for the fishermen operating at the location of this present study. In order to reduce such types of interaction, a variety of non-lethal acoustic devices to deter marine mammals has been developed for use in fisheries and marine fish farm operations (Reeves et al., 2001). However, Reeves et al. (2001) reported that "Acoustic deterrents could affect monk seals in at least two ways. The noise could keep them away from the preferred haul-out areas, or attract them to nets (the 'dinner-bell' effect), and thus contribute to entanglement or exacerbate conflict with fishermen. Further, noting that the breeding and haul-out areas of Mediterranean monk seals are extremely circumscribed, the workshop strongly recommend that "any use of acoustic devices in or near such areas should be considered carefully".

Although monk seals can inflict substantial damage upon fishing gear – e.g. G1 and G2 types – in a day (see Table 5), it is important to note that, overall, fishing gear damage over a full year is small. However, a compensation scheme for incurred damage exceeding 100 USD has been suggested so as to reduce the burden carried by small-scale subsistence fishermen. This scheme could be implemented by the local Foça Fishing Cooperative where these fishermen are also shareholders. By emphasizing a compensation scheme rather than by referring to a subsidy, I refer to low-interest credits to be provided by the Cooperative. Moreover, I do not think that this would put an excessive financial burden on the Cooperative because the total number of attacks of the aforementioned kinds does not exceed two occasions per year. This figure is extrapolated from the adequately inspected number of attacks associated with seal sightings; a mere seven instances of damage out of 50 attacks in 9 years. In computing this figure, the number of seal sightings not linked to attack is deducted from the number of seal sightings around fishing gear ($n = 117$). Since this is an underestimated figure, the Panou et al. (1993) monk seal attack ratio of 4:6 (with or without seal encounters), can be applied to this figure; this gives us only four attacks per annum. Another important constraint is to put the compensation scheme in place. The criteria and court for damage assessment would have to be very well defined and explained to fishermen very clearly so as to avoid other nonapplicable damage compensations.

5. Conclusion

Since monk seals, are severely limited in numbers and confined to specific locations throughout their distribution range, thus being critically endangered; from the limited information within the present study only the following conclusions can be drawn. Since the monk seal is an opportunistic feeder, with no preference for the type of nets attacked, it is suggested that fishermen lower the soaking time of the nets. This can be achieved by setting /collecting nets both at dusk and dawn for a period of 2–3 h each. However, the financial implications of this type of action, such as fuel expenses, require further study. None the less, this is not an unfamiliar practise to fishermen in Foça, as well as in other fishing grounds in Turkey where monk seals survive. The practise is likely not only to lower the chance of attack but also of entanglement. If feasible, with a subsidy from a relevant authority, long lines could be promoted as alternative fishing gear in the MPAs instead of nets. Low interest credits, such as those provided by fishing cooperatives should be considered for such fishermen as suffer from monk seal attack – and for whom each predation costs more than 100 USD.

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