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Effectiveness of Pingers on the Harbour Porpoise *Phocoena phocoena relicta* Abel, 1905 (Cetacea: Phocoenidae) in Turkey as Revealed by Shore-based Observations

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Abstract: The aim of the present study was to assess the effectiveness of pinger devices on the Black-Sea harbour porpoises *Phocoena phocoena relicta*. The study was carried out in Sinop, Turkey, between 16 July and 22 October 2016. A buoy without a pinger device was placed and observations were carried out during 26 days (53.2 hour) throughout the control period. Subsequently, a pinger was placed on the buoy and 28 days (58 hour) of experiment period was performed. During the study, the average distances, closest observed approaches (COA) and frequency of porpoise sightings in the zone of vulnerability, a 100 m buffer around the buoy, have been calculated and compared between the two periods. According to this, the average distance increased from 775.35 ± 38.96 m during the control period to 1536.05 ± 81.33 m during the experiment period ($p<0.05$). Distances of COA were calculated for control and experiment periods, respectively, 443.86 ± 94.18 m and 724.34 ± 98.89 m. Porpoises entered the zone of vulnerability significantly more frequently during the experiment period as compared to the control period ($p<0.05$). Pingers used in the study were found to be effective on keeping porpoises away from the area. However, a possible habituation effect can be revealed depending on the long-term use of these devices.

Key words: by-catch, Black Sea, fishermen – marine mammals conflict prevention

Introduction

Marine mammals are top predators and are one of the largest and longest-lived organisms in the marine ecosystem. A large part of marine mammals are endangered or critically endangered, they have a very wide geographical distribution with low density (Vishnyakova & Gol'din 2015). However, they are not distributed randomly in this wide area. Various factors, such as depth, water temperature and variable oceanographic conditions, play an important role in this distribution (Jefferson et al. 1993). Marine mammals often encounter humans, mainly fishermen. Therefore, there is an interaction based on a long history, probably dating back to the time when people first began to catch fish with net from the sea (Bearzi 2002). Within these interactions, both marine mammals and fishermen are exposed to negative effects.

Considering the marine mammals in the Black Sea, it can be argued that the encounter of fishermen and dolphins is expected owing to the fact that their needs and target prey species (i.e. anchovy and sprat) are similar (Birkun 2002). Damages to fishing gear and to fish caught by net and representing the fishing pressure on targeted commercial species are among the effects of dolphins on the fisheries (Fertl & Leatherwood 1997). On the other hand, the incidental catch of marine mammals in fishing gears, lack of food resulting from overfishing and habitat loss triggered by anthropogenic factors are the main effects of fisheries on marine mammals (López 2006). Besides, until the 1980s those interactions were rather “a conflict” than competition due to the commercial hunting of marine mammals in the Black Sea by fishermen. Although the commercial hunting of marine mammals in the Black Sea has been banned with international agreements, Öztürk (1996) reported that it is estimated that at least 2000-3000 individuals of dolphins and porpoises are bycaught in the Turkish Black Sea each year.

Among the measures that can be taken to reduce the interaction between marine mammals and fisheries, is keeping the marine mammals away from the fishing area using pingers, which represent acoustic deterrent devices (Larsen et al. 2002, Rowe 2007). The Black Sea harbour porpoise *Phocoena phocoena relicta* Abel, 1905 is a large part of incidentally caught marine mammals along the Turkish Black Sea coast (Tonay & Öztürk 2003).

The aim of the present study was to explore the effects of pinger devices on harbour porpoises in Turkey based on shore-based observations.

Materials and Methods

The study was carried out at Sinop between 16 June and 22 October 2016. The observation point (42°0’54.91”N, 35°11’29.35”E) has a viewing angle of about 150°; the altitude is 18.36 m (Fig. 1). In order to determine the observation point, a preliminary study was carried out for about three months before the study and observations were made from different locations in the region. At the end of the preliminary study, Sinop/Karakum area was chosen, considering factors such as the frequency of dolphin sighting, sunrise and sunset angle and viewing angle (Fig. 2).

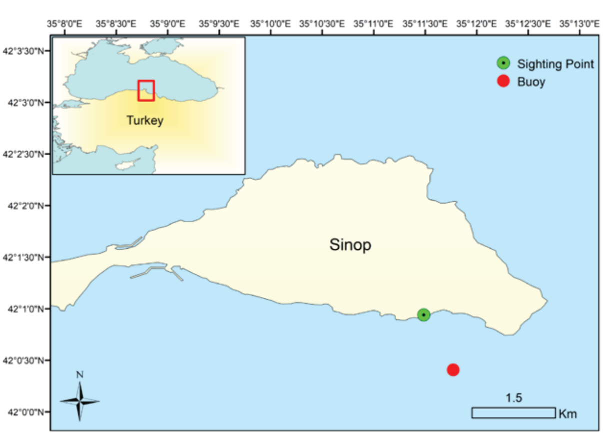

Fig. 1. Study area.

Fig. 2. View from the observation point.

The data file with the sighting points of harbour porpoises created during the preliminary observation period was transferred to geographic information system (GIS). Then the median point of those pre-sightings was determined and selected as the point at which the buoy would be left. The study consisted of two periods, including control and experiment. During the control period, an empty buoy was left at the determined point and subsequently a trial period was carried out by attaching a pinger (Dukane NetMark™ 1000) to the buoy at the same point. The control period was maintained for 26 days and the trial period for 28 days. During the study period, a total of 111.2 hours of observation (53.2 hours during the control and 58 hours during the trial period) were performed.

The research team consisted of two observers. We used 7x50 binocular or naked-eye to scan the survey area for porpoises. When the porpoise group was detected in the survey area, vertical and horizontal angle of sightings were recorded using TopCon® Total Station (angle accuracy – 1.5 mgon). All porpoise individuals observed within a radius of approximately 100 m were referred as a group (Wells et al. 1980). In general, the individual leading the group was followed until the porpoise group left the area or the observers lost sight.

$$\beta = \arctan\left(\frac{X_A - X_B}{Y_A - Y_B}\right)$$

The height of the cliff (h) was calculated from the known distance to an object and the vertical angle as described in Laake (1998). To determine the distance between the sighted object and the buoy, firstly, the heading ($\alpha = 180° - \beta$, considering directions) of the reference point (B) at the sea level was calculated.

Horizontal angle between sighted objects and the reference point (ψ) was measured with theodolite to calculate the heading angle of the sighted object (simply, $\alpha + \psi$). Distance to sighted object (a) was calculated from measured vertical angle declination (ϕ) and cliff height (h), $a = \tan(\phi) * h$ (Fig. 4). Then, UTM coordinates of the sighted object were calculated according to the formulae;

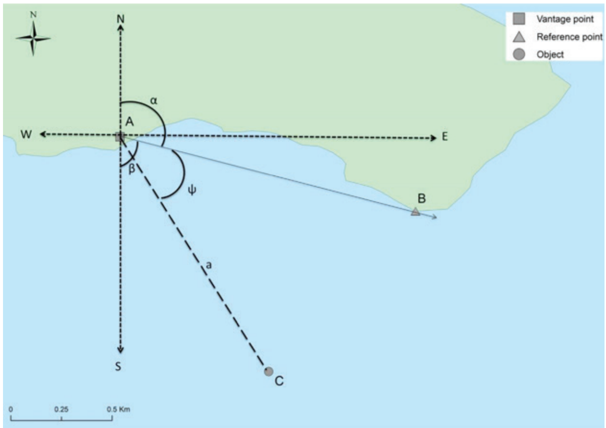

Fig. 3. Scheme showing distance and angle measurements.

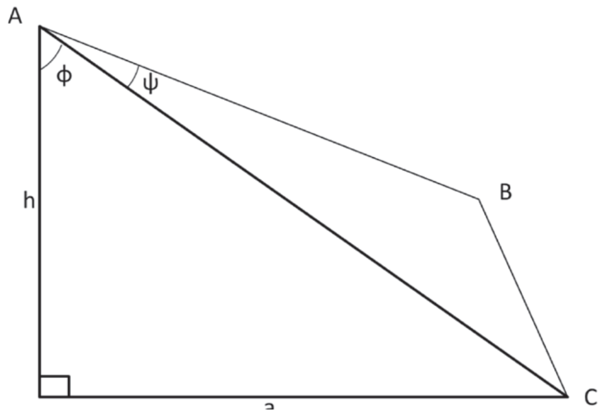

Fig. 4. Distance between observation point and sighted object.

$X_C = X_A + (a*\sin(\alpha+\psi))$, $Y_C = Y_A + (a*\cos(\alpha+\psi))$ (Fig. 3). The distance between sighted object and the buoy was

$$D = \sqrt{(X_{buoy} - X_C)^2 + (Y_{buoy} - Y_C)^2}$$

The Mann-Whitney U test was used to compare average distances of porpoise sightings to buoy between control and trial period. The minimum distance values of each porpoise group for both periods were extracted from the data set and the closest approach distances were calculated and compared with the Mann-Whitney U test. Furthermore, considering that the effective pinger area used in the study was with radius of 100 m, frequencies of porpoise sightings in this vulnerable zone were compared with Chi-square test. SPSS Statistics 21 were used for statistical tests. Maps used in the manuscript were drawn in ArcGIS 10.1 software.

Table 1. Duration of sightings for both periods (± SE)

	Control	Trial
Duration (days)	26	28
Effort (days)	21	20
Days of encounter (days)	16	16
Number of sightings/hour	3.84 ± 0.75	3.19 ± 0.44

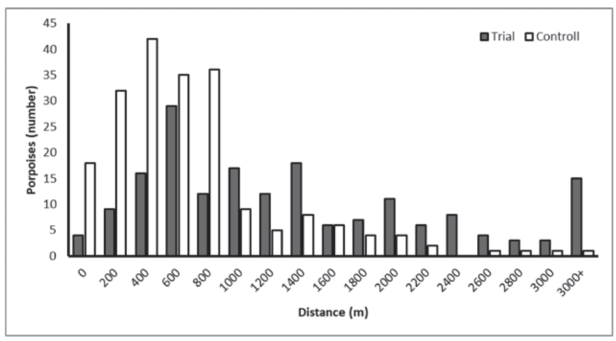

Fig. 5. Distribution of distances of porpoise groups to buoy.

Results

During the study, observations were performed every day, if possible. However, the study was interrupted in the days when weather and sea conditions were not suitable for sightings. The observation duration, the size of the porpoise groups and the number of porpoise groups observed per hour are given in Table 1. Group sizes of harbour porpoises varied between 1 – 6.

Table 2. Closest observed approach (COA) distances (± SE)

	Control (m)	Trial (m)
Average	443.86 ± 94.18	724.34 ± 98.89
Min	27.50	88.71
Max	1851.60	1927.98
Median	296.20	600.04

Distance between porpoise sightings and buoy

Average distances between sightings and buoy for control and trial periods were significantly different ($p<0.05$) and were 775.35 ± 38.96 m and 1536.05 ± 81.33 m, respectively. The median values of distances were 644.53 m for the control and 1252.23 m for the experiment. Distribution of sightings for both periods is shown in Fig. 6. We observed that the number of porpoise groups sighted in the control period within 600 m of distance to the buoy was much higher than those in the trial period (Fig. 5).

When the mean distances were analysed according to the time for both periods, it was clear that the porpoise groups sighted in control period moved away during the experiment period (Fig. 7). The

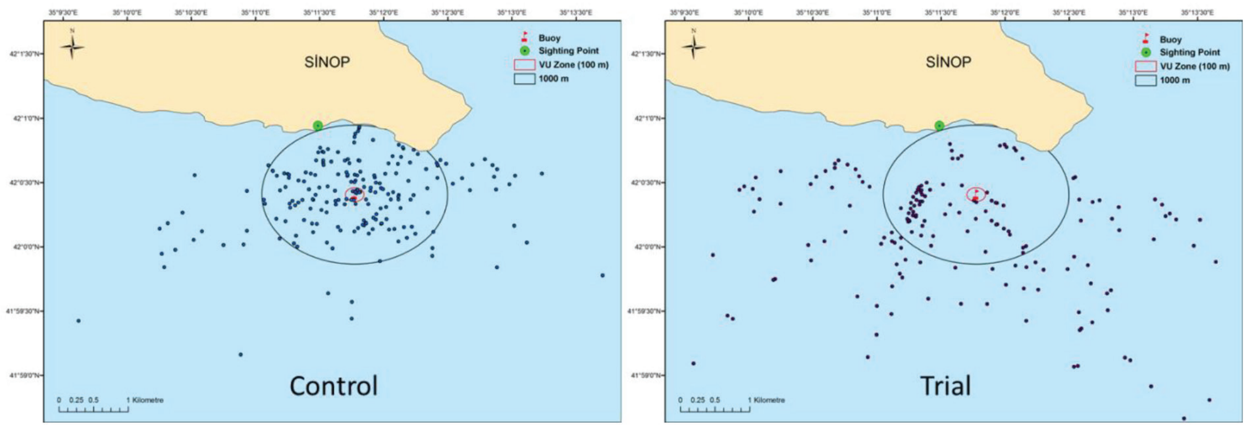

Fig. 6. Distribution of sightings for both periods.

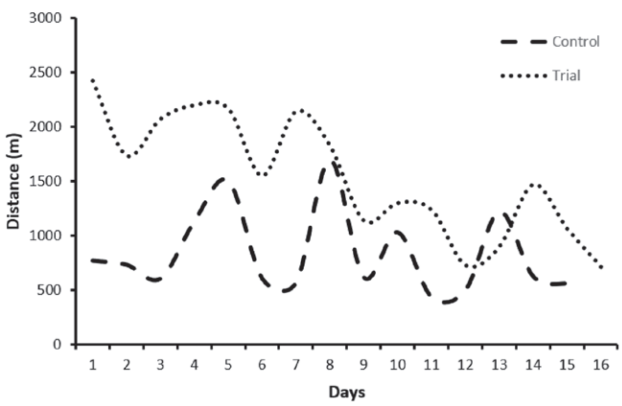

Fig. 7. Change of distances by time.

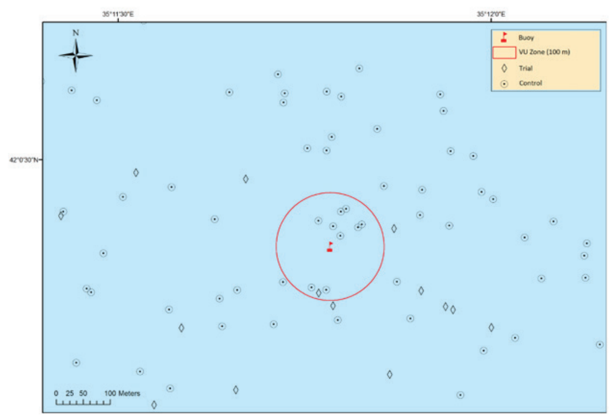

Fig. 8. Sighting frequencies in vulnerable zone of porpoise groups in control and trial period.

Pearson correlation coefficient between the time and distance was calculated as -0.837 for the trial period ($p < 0.01$).

Closest observed approach (COA)

The minimum distance values of each porpoise group for both periods were extracted from the data and the closest approach distances were calculated and compared. Accordingly, the average COA distances were calculated as 443.86 ± 94.18 m and 724.34 ± 98.89 m for the control and trial periods, respectively (Table 2). Difference between COA distances were significant (p=0.015).

Vulnerable zone

The number of approaches to the effective area of pinger device (with a radius of 100 m, i.e. vulnerable zone), was 9 in the control period and 1 in the trial period (Fig. 8). The frequencies of entering the vulnerable zone of the porpoise groups were significantly dependent on the presence of the pinger device (Chi-square test: p=0.022).

Discussion

Based on the preliminary observations performed before the study, the buoy was placed at the selected point and the behaviour of the porpoise groups was examined with shore-based observations within two periods, including control (without pinger) and trial (with an active pinger) periods. As a result, we determined that the pinger device used in the study displaced the porpoises away from the region. The total number of observations was 205 and the average distance to the buoy was 775.35 ± 38.96 m during the control period, while the total number of observations was 180 and the mean distance from the dolphins to the buoy was 1536.05 ± 81.33 m during the trial period.

In Sweden, a similar study was carried out using the same model of pinger, with 49 h of control and 30 h of trial observations. The mean distances and the average COA distances were found to be significantly different, i.e. 653 m for the control period and 961 m for the trial period and 431 m and

752 m, respectively (Carlström et al. 2009). Culik et al. (2001) reported a significant increase in the average COA distance during the trial period in a study performed in Canada using a similar device. Laake et al. (1998) found that the pinger device displaced the porpoises up to 125 m.

Our results indicated that the pinger device, kept porpoises away from the region it had been located. One of the most adverse side effects of such acoustic deterrent devices is the habituation (Franse 2005). Cox et al. (2001) found that the porpoises habituated to pinger devices with time. Our results on the time-dependent variation of the mean distances in the trial period suggested a decreasing trend in mean distances inversely proportional to time. In addition, when the device was active (trial period), correlation coefficient between mean distances and time was -0.84, meaning that the correlation is negative and very strong. The duration of this study could be considered short and the significance of the relationship was affected by the narrow sample size. Nevertheless, there is a strong doubt that the porpoises in the region may become habituated to the pinger devices according to the findings of the study. On the other hand, it should be kept in mind that if the pingers work in the long run and cause the marine mammals in the region to move away from the environment they are in, thus may provoke the problem of habitat loss for marine mammals.

Many fishermen in the region demand the government to provide pingers to them in order to keep small cetaceans away from gillnets. Although it may seem like a reasonable request, it may be difficult to predict the potential effects from the use of pingers by too many fishermen within a large-scale area. Therefore, effectiveness of the pinger devices should be explored in mid and long term and the critical habitats of the subject marine mammals should be identified and appropriate conversation strategies should be realised.

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