A note on the acoustic assessment of bottlenose dolphin behaviour around fishing gears in the Asinara Island National Park, Italy

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ABSTRACT

Common bottlenose dolphins co-exist with artisanal fisheries in the Asinara Island National Park area (northwestern Sardinia, Italy) and are blamed for damage to some fisheries. To investigate this, two T-POD echolocation loggers were used between July 2003 and October 2004 to monitor the occurrence and behaviour of dolphins in the proximity of three different fishing gear types. With the support of local fishermen, the T-PODs were opportunistically deployed on trammel nets set for striped red mullet or for lobster and on bottom traps set to catch benthic fish species. Inter-click Intervals (ICI) and the Pulse Repetition Frequency (PRF) have been adopted as indicators of dolphins echolocation behaviour in the proximity of fishing gears (Leeney and Tregenza, 2006). PRF values were found to be consistently higher in proximity to trammel nets for striped red mullets compared to the other gears. Moreover, ICI values in the proximity of red mullet trammel nets were found to be statistically lower than those recorded both around trammel nets for lobster ($p<0.01$) and around traps ($p<0.01$). These findings suggest that feeding related activities by dolphins could be absent or take place at very low levels in the proximity of traps and, to a lesser extent, in the proximity of trammel nets set for lobster, but may occur more regularly around nets for striped red mullet. The results show that static acoustic monitoring can detect significant differences in dolphin echolocation behaviour around different fishing gears. The findings seem to be consistent with previous evidence of interactions between bottlenose dolphins and fishing gear types in the area.

KEYWORDS: VOCALISATION; FEEDING; ACOUSTIC; EUROPE; FISHERIES; COMMON BOTTLENOSE DOLPHIN; ECHOLOCATION; NORTHERN HEMISPHERE; FOOD/PREY

INTRODUCTION

Problems associated with actual or perceived dolphin fishery depredation represent a major challenge to fisheries management today (Reeves *et al*., 2001). Such problems include removal of fish from nets, spoiling of fish in the nets, damaging of the nets and reduced catch rates. In response, fishermen often adopt aggressive methods to keep cetaceans away from their gears (Reeves *et al*., 2001).

This is a documented problem in a number of artisanal fisheries in Mediterranean coastal areas and there is evidence of recent increase in these interactions: Greece (Casale *et al*., 1999); Spain (Brotons and Grau, 2005; De Stephanis, 2004; Gazo *et al*., 2001; Lopez *et al*., 2000); Tunisia (Naceur Lofti, 2000); Morocco (De Stephanis, 2004); Lybia (Hamza, pers. comm.); Cyprus (Reeves *et al*., 2001); Italy (Cannas *et al*., 1994; Diaz Lopez, 2006; Lauriano *et al*., 2004; Quero *et al*., 2000; Tringali *et al*., 2004). The bottlenose dolphin (*Tursiops truncatus*), believed to be the most commonly involved cetacean species (Reeves *et al*., 2001), is the only species regularly reported along the Italian coast (Notarbartolo di Sciara and Demma, 1997).

Assessing and monitoring the quantitative nature of depredation is difficult, due in part to the diversity of the fishing techniques commonly employed on the Italian continental shelf, which is characterised by a wide range of habitats. There is a complex pattern of local adaptations of fishing gears, according to both the target species and local traditions, which has contributed to the current lack of knowledge about actual and perceived interactions.

At Asinara Island and its surrounding waters, the bottlenose dolphin occurs regularly (Lauriano *et al*., 2003) and depredation by this species has been reported for the striped red mullet (*Mullus surmuletus*) fishery by Lauriano *et al*. (2004). In 2003, fishermen decided to adopt measures they believed would reduce depredation, including the use of acoustic deterrent devices (ADD or pingers). This note reports on work to expand that of Lauriano *et al*. (2004) and to gather preliminary data on the use of pingers.

MATERIAL AND METHODS

The study area

The study area (Fig. 1), comprised the coastal waters surrounding Asinara Island National Park (northwestern Sardinia). The eastern side of the Island, dominated by a sea grass meadow, is sheltered from the northwesterly prevailing winds, while the western side, dropping quickly to a depth of 45m, is highly influenced by strong waves caused by the prevailing north and northwesterly winds (Delitala *et al*., 1998). Small fishing boats from the Stintino and Porto Torres harbours are allowed to fish from 150m of the island shore, except in the three no take and no entry zones.

Fishing gears

The fishing gears monitored during the study comprised those types most regularly used in the area.

Traps

Traps are used mainly during summer time in order to catch species such as European conger (*Conger conger*), Moray eel (*Muraena helena*), Black sea bream (*Spondyliosoma cantharus*) and Octopus (*Octopus vulgaris*). Traps are of minor economic importance; in part they are used to catch bait for other minor fishing gears (e.g. long lines and hand lines) and/or they are commonly deployed simultaneously with other gears. The traps are commonly deployed at 40m.

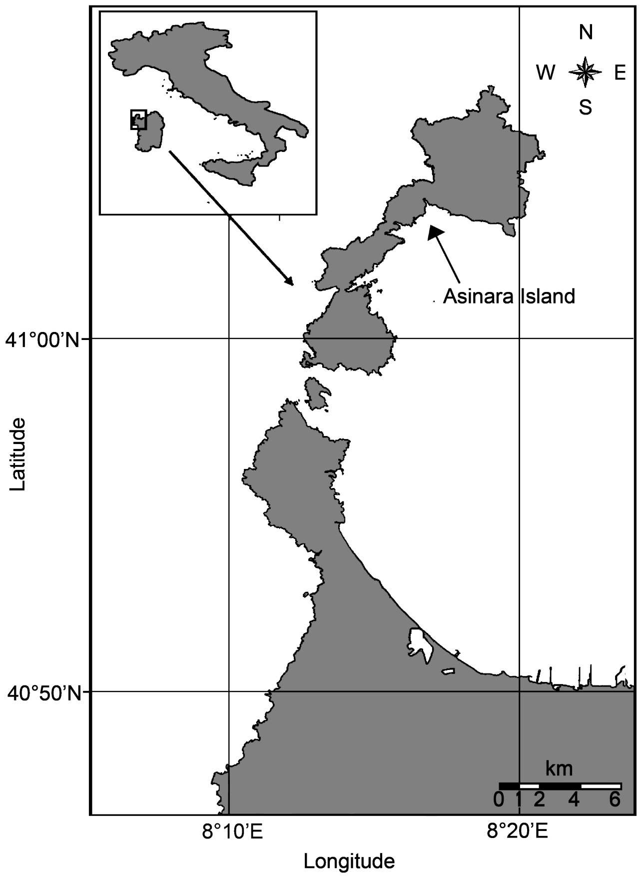

Fig. 1. The study area.

Lobster trammel nets
The target species is the lobster (*Palinurus elephas*) between May and August. The gear has a stretched mesh size of 72mm. The net is left soaking continuously and is inspected every 24 hours or more and is deployed at a mean depth of 63m (Lauriano *et al*., 2004).

Striped red mullet trammel nets
This trammel net targets striped red mullet and is used between September and December. It has a stretched mesh size of 27mm and is normally set before dawn and hauled at the start of sunrise, with a mean deployment time of 172 min. The nets are deployed at a mean depth of 31m (Lauriano *et al*., 2004).

Depredation by bottlenose dolphins has been reported for striped red mullet trammel nets (Lauriano *et al*., 2004) and it is on this gear that from 2003, fishermen decided to attach acoustic deterrent devices. Those used were small, battery-powered devices (High Impact Saver by Savewave[1]), designed to produce broadband ultrasonic signals (5 to 160kHz with a peak source level of 155dB re 1µPa @ 1m).

Acoustic monitoring
Version 3 of the T-POD self-contained cetacean sonar logger (Chelonia Ltd.) was used to collect acoustic monitoring data; analysis of these data was performed using T-POD software v8.1. Although the T-POD was originally designed to detect harbour porpoises (*Phocoena phocoena*), the settings can be adjusted to detect dolphin echolocation and the device's effectiveness in detecting common bottlenose dolphins at sea has recently been demonstrated (Philpott *et al*., 2007). The T-POD logs the times and duration of clicks resembling those from an echolocating target species. Subsequently, the software identifies trains of clicks within the logged data and classifies them as non-cetacean (e.g. boat sonars) or as cetacean trains. Cetacean click trains are further classified by the software into four categories of diminishing reliability (Cet High, Cet Low, doubtful or very doubtful). In this study, all deployments of T-PODs resulted in the logging of many non-cetacean clicks. Data analyses were restricted to the two most reliable categories (Cet High and Cet Low). T-PODs were set to run six successive logging scans of 9.3 seconds each every minute. After an initial phase of testing in the first few days of the study period, during which a range of frequency settings were used, a final setting scheme was developed. The target frequency of the first and fourth scans within a one minute cycle were set to 50kHz and 90kHz was used as the reference frequency; the other four scans had 110kHz as their target frequency and 170kHz as the reference frequency. This scheme was designed to maximise detections, since initial tests indicated that the most reliable dolphin detections occurred using these frequencies.

Deployment was opportunistic, since it depended on help from local fishermen, who attached two T-PODs to their gear in the course of normal fishing operations between 3 July 2003 and 14 October 2004. T-PODs were clamped on trammel nets up to 600m long in the middle of the head rope (Fig. 2a). Traps (lashed in lines of up to 25, giving a total length of up to 250m) were monitored by clamping the T-PODs on the floating rope (Fig. 2b).

Monitoring was conducted both on nets with and without pingers. During the striped red mullet season, onboard observers were employed in order to visually monitor the presence of dolphins around nets.

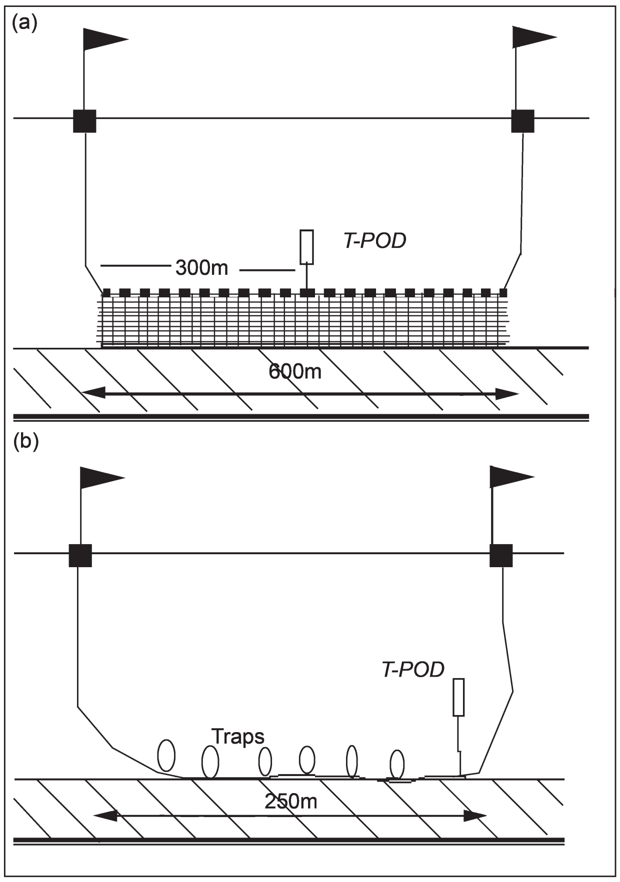

Fig. 2. T-PODs set in the fishing gear: (a) trammel net; (b) trap.

[1] *www.savewave.net*

Data analysis

In order to gain insights into the presence of dolphins and their behaviour around the nets, the following parameters were considered for the analysis:

Detection Positive Minutes (*DPM*): number of minutes per day that contain at least one dolphin click train;

Pulse Repetition Frequency (*PRF*)*:* number of clicks placed in trains, per second;

Inter-Click Interval (*ICI*)*:* time (in $s \cdot 10^{-5}$) between two consecutive clicks within a train (reciprocal of PRF);

No. of encounters: an encounter was defined as a series of click trains with no silent period over 10 minutes in length. A silent period of 10 minutes in order to distinguish between subsequent encounters has been generally adopted in other studies (Carlström, 2005; Carstensen *et al*., 2006; Philpott *et al*., 2007) and was considered appropriate for the purposes of this study.

RESULTS

The number and duration of deployments (Table 1) were largely determined by the fishing techniques and weather conditions during the different fishing seasons. The longest deployments were recorded on traps (mean=2,413.6min – equivalent to more than 40 hours), followed by trammel nets for lobsters (mean=1,450.4min – more than 24 hours); deployments on trammel nets for red mullets were significantly shorter (mean=178.3min – less than 3 hours). In 2 out of 58 deployments the T-POD stopped functioning shortly after deployment.

Table 1

Sampling effort (recording times in minutes).

		n	Total rec. time
Trammel nets	Red mullet	19	3,388
Trammel nets	Lobster	30	43,513
Traps	-	9	21,722
Total	-	58	68,623

Reliable dolphin detections were recorded during 28 out of the 58 T-POD deployments (Table 2). All dolphin detections on mullet nets were on gears equipped with pingers (number of monitored nets, *n* = 2).

Dolphin detection rates, expressed as the number of click trains per day, were highest on trammel nets for lobster (mean=19.5; SE=4.75; *n*=29), followed by trammel nets for striped red mullet (mean=8.62; SE=6.52; *n*=18) and by traps (mean=1.78; SE=1.78; *n*=9). However, the sample size is too small to adequately compare the detection rates between gear types, or to draw conclusions on the existence of different patterns of dolphin presence in proximity to each gear type.

Table 2

POD deployments with reliable dolphin detections: summary statistics.

	n	No. of encounters	No. of trains	DPM	Trains per DPM
Red mullet	2	4	17	9	1.89
Lobster	25	137	604	310	1.95
Traps	1	19	50	32	1.56

Comparison of average ICI values (Table 3) using multiple t-test showed that values recorded in the proximity of trammel nets for red mullet were significantly lower than those recorded for trammel nets for lobsters ($p<0.01$; df=613.52) and traps ($p<0.01$; df=49.11; *t*-test for unequal variances, Welch's approximation). No statistically significant difference was found between ICIs recorded around nets for lobster and around traps ($p=0.354$; df=652 – *t*-test for equal variances; Multiple comparisons overall significance level: $p<0.05$; single *t*-test significance level – Bonferroni correction: $p<0.01667$).

Table 3

Average inter-click intervals in train positive minutes (ICIs – s^{-5}/click). PRF indicates the corresponding average Pulse Repetition Frequency (= 100,000/ICI) in clicks per seconds.

Fishing gears	ICI	No. of trains	SE	PRF
Red mullet	4,296	17	202.0	23.28
Lobster	56,569	604	1,968.0	1.77
Traps	63,125	50	6,229.3	1.58

The cumulative percentage of dolphin click trains relative to mean PRF values for each of the three types of gear (Fig. 3) show that click trains around striped red mullet fishing gears were concentrated around PRF values of 210-280 clicks s^{-1}. PRF values of less than 140-150 clicks s^{-1} were never recorded around this gear. Around other gear, click trains were mostly at PRF values of less than 40 clicks s^{-1}. No concentrations were found at other PRF values, especially around traps, where about 80% of clicks had PRF values below 40 clicks s^{-1}. Around lobster nets the pattern was similar, although a small proportion of click trains (about 23% of the total) were evenly distributed within a PRF of 100-360 clicks s^{-1}.

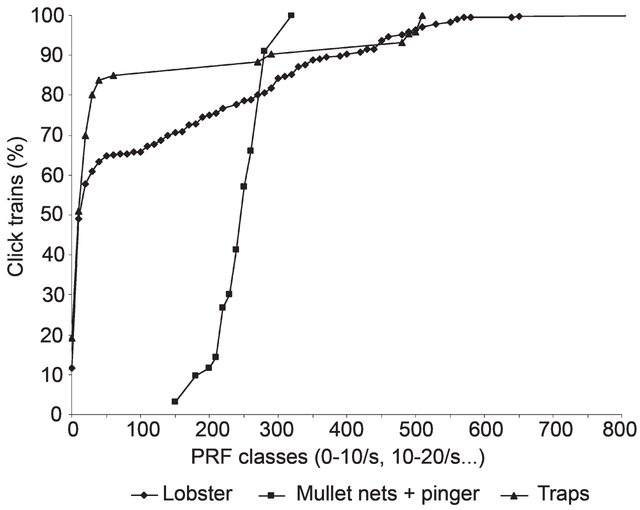

Fig. 3. Cumulative percentage of dolphin click trains relative to mean PRF values for each of the three fishing gears.

DISCUSSION AND CONCLUSION

The use of the T-POD was used to examine it as a potential remote monitoring tool, particularly given the limitations associated with visual assessments during fishing activities, since these often take place at night and/or may last several hours. This opportunistic effort proved successful in detecting significant differences in echolocation behaviour around the different fishing gears.

PRF has been used as a proxy as to how dolphins are using echolocation in a behavioural context (Leeney and Tregenza, 2006). The different distribution patterns of click trains relative to their PRF values found in this study, suggest different echolocation behaviour by dolphins around the different gear types. Although only two nets were monitored for this gear type, in the proximity of striped red mullet nets, the clear prevalence of trains with high PRF values seem to be indicative of feeding related activities. Conversely, the prevalence of lower PRF values around traps and trammel nets for lobsters suggest little or no feeding related activity.

Due to the opportunistic nature of the study, it was not possible to exert control over a number of factors, including locations of deployments and installation of pingers on the nets. This, coupled with the small size of the dataset, does not allow conclusions to be drawn on the extent and nature of the interactions. Although on a few occasions onboard observers assessed the presence of damage on the striped red mullet nets and looked for damaged fish and/or reduced catch rates, the same was not attempted for the lobster nets. Therefore, it is difficult to conclude that depredation was actually occurring on striped red mullet nets, since the results presented here could simply reflect feeding related activities by dolphins in the area where the mullet nets were deployed, regardless of the presence of the nets. However, the study does suggest that the T-POD can be a valuable monitoring tool in the context of a properly designed programme.

One major concern with the use of acoustic deterrent devices is the possibility of habituation (e.g. Cox *et al*., 2001; Northridge *et al*., 2007; Reeves *et al*., 2001). In addition, a 'dinner bell' effect of pingers after prolonged exposures has been recognised as a factor that can eventually augment the presence and level of interactions of dolphins with the gears (Reeves *et al*., 2001).

In the study area, acoustic devices have been deployed in the lobster nets since 2003, despite previous evidence indicating that depredation by dolphins on this gear type is negligible. This practice would have exposed animals to the 'deterrent' stimulus before the introduction of pingers on striped red mullet nets and thus might have contributed to an habituation effect in the area. In fact, all dolphins detected in the red mullet nets were recorded in 2004, one year after the beginning of the pinger deployment. Similar results were reported by Northridge *et al*. (2007) for the same net type and deterrent devices.

Nevertheless, the overall findings of this study show consistency with results from previous research conducted in the area, in which depredation was found to affect the striped red mullet fishery but not the lobster fishery (Lauriano *et al*., 2004).

After this initial experience of pingers, local fishermen applied the devices to the nets only occasionally and only on a small portion of the fleet (De Negri, pers. comm.).

It is essential that well designed experiments are undertaken in order to address the effectiveness of deterrent devices as potential mitigation measures against depredation; T-PODs and acoustic monitoring can prove a valuable tool in such experiments.

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