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SHORT COMMUNICATION

Occurrence of bottlenose dolphins *Tursiops truncatus* in natural gas fields of the northwestern Adriatic Sea

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Abstract

Common bottlenose dolphins, *Tursiops truncatus*, were surveyed in offshore gas fields off Ravenna, Italy, between Spring and Autumn, 2001–2005. These visual surveys provide the first density estimates of bottlenose dolphins in the Northwestern Adriatic Sea south of the Po River. Since no study has examined the distribution of bottlenose dolphins relative to gas platforms, when dolphins were encountered, their distance from the nearest gas platform was estimated and behaviour was assessed. Dolphins were sighted on ca. 36% of survey trips, which varied in duration from 1 to 6 h. Group size ranged from 1 to ~50 individuals, with no seasonal trend evident in the likelihood of encounter. Dolphin density was estimated to be approximately 80% higher within 750 m of gas platforms, relative to densities >750 m from platforms, although variability around the estimates was high. From a limited number of behavioural observations, slightly higher frequencies of feeding and milling behaviour were observed closer to gas platforms, whereas dolphins observed further away exhibited higher frequencies of socialising and travelling. Gas platforms are known to provide habitat for demersal fishes and act as aggregation points for pelagic fishes, and these data provide some support for the idea that bottlenose dolphins may utilise gas platforms opportunistically as feeding sites.

Introduction

Very little is known about the distribution and abundance of the common bottlenose dolphin, *Tursiops truncatus,* in the Mediterranean Sea (Bearzi *et al.* 2004, 2009a,b). Although some studies of residency patterns and group size have been conducted in particular locations (summarised by Bearzi *et al.* 2009b), the only studies done in the Adriatic Sea have been done on the eastern coast off Croatia (*e.g.* Bearzi *et al.* 1997, 1999). Information elsewhere in the Adriatic Sea is generally limited to opportunistic sightings (Notobartolo di Sciara *et al.* 1993; Bearzi *et al.* 2004). It has been suggested that Adriatic bottlenose dolphin populations have probably been reduced by >30% due to accidental and deliberate human action (Bearzi *et al.* 2004), but without robust population size estimates, knowledge of residency patterns and demography, the vulnerability of these populations to future changes brought about by human impacts and climate change remain unknown.

Bottlenose dolphins have been recorded to consume cephalopods and both pelagic and benthic fishes, taken from reef and soft-bottom environments, and are generally considered to be opportunistic foragers (Cockcroft & Ross 1990; Corkeron *et al.* 1990), although there are regional variations in feeding strategy, with certain populations exhibiting selectivity in diet (Berens McCabe *et al.* 2010). Cetaceans are known to form associations with resource islands that may facilitate feeding, including fishers (Corkeron *et al.* 1990; Pace *et al.* 2012), FADs (fish aggregation devices, Brehmer *et al.* 2012) and aquaculture facilities (Díaz López 2006; Pace *et al.* 2012), but we are unaware of any studies that have examined the distribution or behaviour of bottlenose dolphins relative to gas platforms.

Here, we report the results of bottlenose dolphin surveys conducted in the gas fields off Ravenna between 2001 and 2005. Human activities in the marine environment are generally regarded as having negative effects on cetacean populations, and hydrocarbon extraction in particular is generally regarded as an environmentally harmful undertaking (Olsgard & Gray 1995; Patin 1999). However, the presence of such structures may aggregate both schooling and demersal fishes (*e.g.* Love *et al.* 1999; Soldal *et al.* 2002; Fabi *et al.* 2004), which may provide foraging opportunities for dolphins (Todd *et al.* 2009). In the Adriatic Sea, bottlenose dolphins have been recorded to prey primarily on sparid fishes, hake (*Merluccius merluccius*) and cephalopods (Kovacic & Bogdanovic 2006), all of which have been shown to occur in heightened densities near to platforms (Fabi *et al.* 2004). We explored the possibility that dolphin distribution may be influenced by these resource islands by recording the approximate position of dolphin pods relative to the platforms, their group size, and behaviour. There are no published studies on bottlenose dolphin occurrence in the Western Adriatic Sea south of the Po River, and this study provides the first density estimates from this area.

Methods

Study area

The Ravenna gas field is situated ca. 50 km south of the Po River delta, beginning near the port of Marina di Ravenna and extending south to Cesenatico (Fig. 1). Current systems in the Adriatic generally result in an anti-clockwise circulation pattern (Montanari *et al.* 2006) meaning that water and sediments from the Po and other river systems are transported southwards along the coast (Ravaioli *et al.* 2003). Bottom sediments are thus dominated by silty mud and clay of terrestrial origin to beyond the 30 m depth contour (Willis *et al.* 2005), which in the study area occurs at >20 km from the coast. Operational gas platforms occur between 8 km offshore (*e.g.* PCW-A) to ca. 30 km from the coast (Fig. 1) where depths are generally 35–40 m.

Field methods

We built a preliminary photo-identification library of bottlenose dolphins during the summers of 2001–2002 from platforms of opportunity (fishing or diving charter

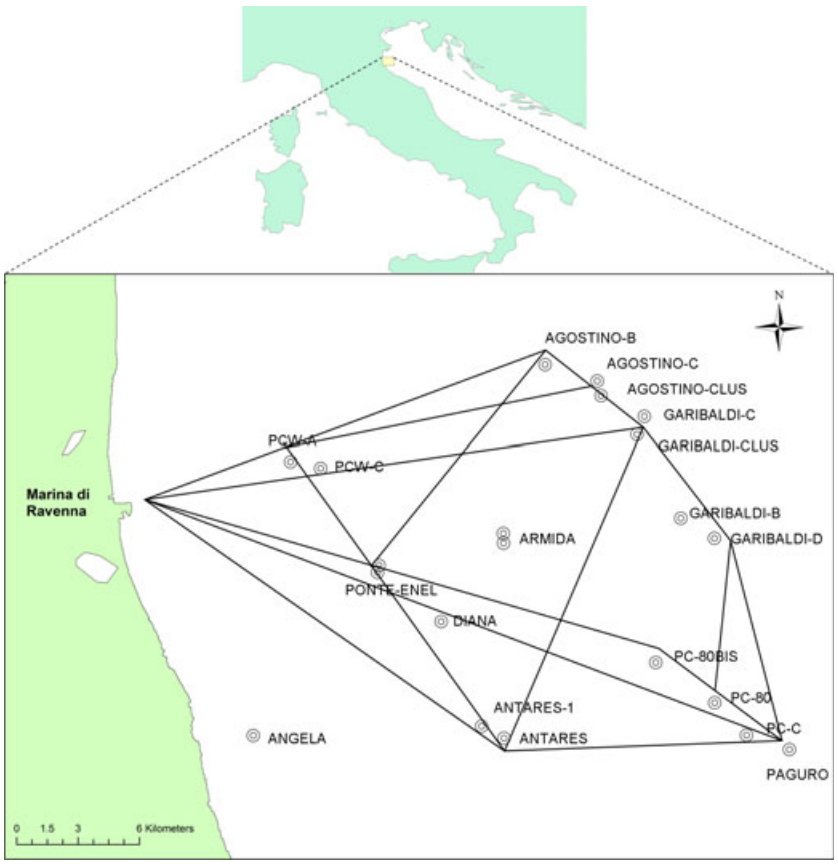

Fig. 1. Map of the study area, showing the positions of gas platforms and the extent of the area surveyed. Survey effort was greater in the southern part of the zone, *e.g.* the track from Marina di Ravenna to Paguro via PC80-bis was travelled 37 times as a return voyage, and a further 11 times as part of extended cruises that included the Agostino platforms (nine cruises).

and private vessels) generally between Marina di Ravenna and the Agostino, Garibaldi, or PC platforms or the wreck of the Paguro platform (Fig. 1). While captains of these vessels reported many additional sightings of dolphins, only data collected from observations by one of us (F.T.) were used in subsequent analyses. From 2003 to 2005, data were collected using a 7-m inflatable boat twice a week (weather permitting) between May and September. Cruise time varied from 1 to 6 h, depending on weather conditions and whether dolphins were sighted and followed for behavioural assessment. When dolphins were encountered, the group size was estimated and position noted. Density estimates of dolphins relative to gas platforms were then made by calculating the area surveyed (an expression of survey effort) by plotting trip records in ARCMAP® assuming that dolphins were detected if present within a 500-m wide strip along the vessel track. This assumption is not unreasonable because surveys were only conducted in very calm sea conditions. Since sampling effort was unequal because a low proportion of the sampled area fell close to platforms (476 km^2, *versus* 1170 km^2 'far' from platforms), we then calculated the proportion of each survey cruise conducted within 750 m of any platform. Dolphin density was expressed as dolphins km^{-2}, and densities near to platforms compared with those far from platforms using a log-linear model. This was fitted using maximum likelihood by the SAS procedure GENMOD.

Between 2003 and 2005 behavioural data were collected. Focal group sampling scored at 3-min intervals was used with both group follows (staying with a group for prolonged periods of time) and surveys (brief assessment of group composition, location, activity) (Mann 1999). The number of observations varied from two to 42 per group, depending on the duration of each encounter. Disturbance to the dolphins was reduced by following them at idling speed and avoiding sudden speed or directional changes. Behaviour was recorded at 3-min intervals, and categorised as travelling, feeding, milling, socialising or resting following Shane (1990) and Bel'kovich *et al.* (1991).

Surfacing dolphins were photographed using a Canon EOS 500 SLR camera equipped with 70–300 mm zoom lenses. Photo-identification was performed following Würsig & Jefferson (1990).

Results

Of 60 survey trips, *Tursiops truncatus* were recorded within the gas field on 29 occasions, giving an overall sighting frequency of 48%. This figure was inflated by a high rate of detection in earlier surveys, with the 2004/2005 sighting frequency at 23%.

Group size varied from one to an estimated 50 animals, although most were of 10 or fewer individuals (Fig. 2). There was no seasonal trend to group size, with groups of more than five animals sighted throughout the study period (Fig. 2). The 29 sightings were made between 9.2 km and 22.2 km from the coast (mean = 14.25 km, SD = 4.14) and 42% were sighted within 750 m of a platform. Accounting for relative survey effort near to, or far from platforms, the density of dolphins sighted within 750 m of platforms was approximately 80% (ratio of 1.799) higher than farther away, although given the high variability associated with dolphin density estimates, this was not statistically significant at $\alpha = 0.05$ ($\chi^2 = 2.61$, df 1,58, $P = 0.106$, Fig. 3).

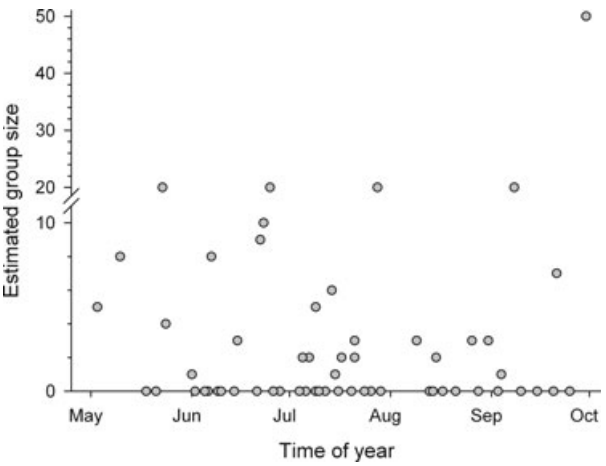

Fig. 2. Group size of *Tursiops truncatus* sighted in and around the Ravenna gas field during structured surveys (2003–2005).

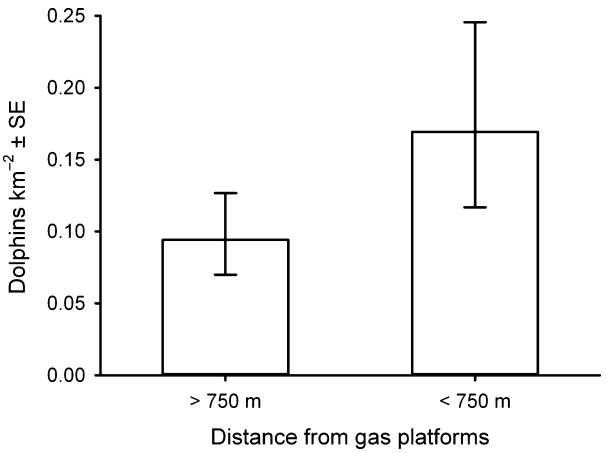

Fig. 3. Density (individuals km^{-2} ± SE) of *Tursiops truncatus* close to (<750 m) and away from (>750 m) gas platforms in the Ravenna gas field. Note that error bars are unequal because they were calculated on the log scale, and are hence multiplicative on the arithmetic scale.

Dolphin behaviour did not change during observation periods, so each set of behavioural observations was distilled into a single independent observation for each of the 26 encounters where behaviour was assessed, and presented as raw frequencies (Fig. 4). The frequency of feeding and milling behaviours were slightly higher nearer platforms (eight near *versus* five distant), whereas the frequency of travelling and socialising behaviours was higher in groups found further away from platforms (three near *versus* 10 distant) (Fig. 4).

Forty-two individual dolphins were identified and catalogued from photographic records. Of these, six were photographed on a second occasion (Fig. 5): one-first seen on 15 May 2000 was resighted on 7 June 2003 (Fig. 6); two-first seen on 8 July 2001 were resighted on 23 May and 7 June 2003, respectively; and three were resighted in the same month as first photographed – one on 9 and 25 August 2001, and two on 10 and 23May, 2003. There were only five sightings from 22 cruises in 2004–2005, none of which could be photographed with adequate clarity for photo–identification purposes.

Discussion

An understanding of the distribution and habitat use of animals is the first step toward effective management and conservation (Cañadas *et al.* 2005). This study shows that bottlenose dolphins occur regularly within the Ravenna gas field during the Spring–Summer study period, an area where this species has not been recorded previously except through anecdotal observation. The occasional presence of group sizes exceeding 20 individuals may indicate that a substantial, but hitherto unstudied, population may occupy the Northwestern Adriatic coast. Our surveys also constitute the first attempt to examine bottlenose dolphin distributions relative to gas platforms.

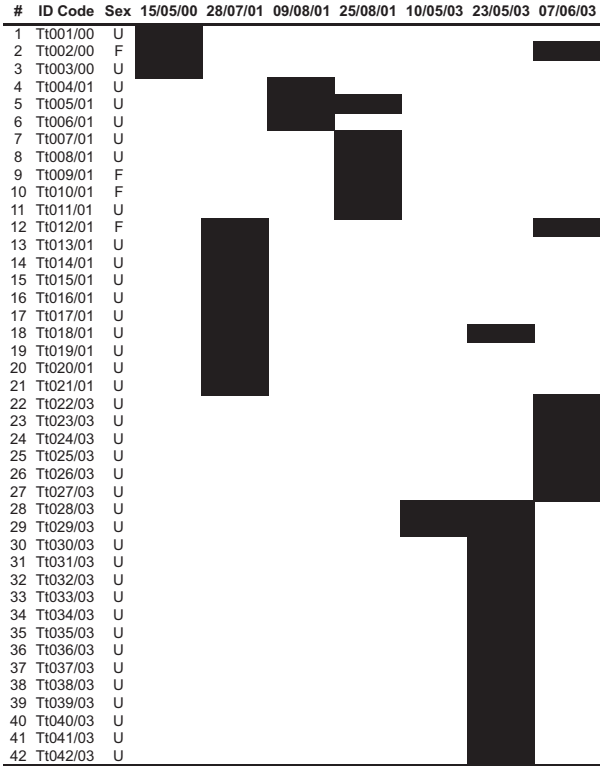

Fig. 5. Capture histories of bottlenose dolphins; date and gender, if known, are indicated.

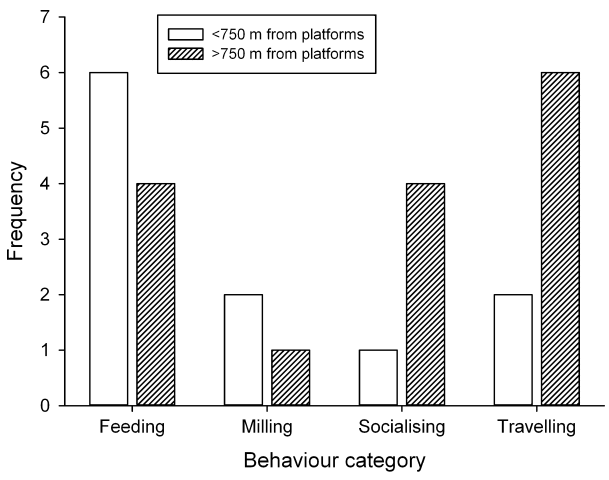

Fig. 4. Frequency of *Tursiops truncatus* behaviours close to (<750 m) and away from (>750 m) gas platforms.

Fig. 6. Individual Tt002/00 (Above) photographed at Paguro on 15 May 2000, and (below) photographed at PC80 on 7 June 2003.

Repeated sightings of the same animals may indicate that they are either resident, or perform seasonal migrations and return to the same areas for feeding or breeding. Some bottlenose dolphin populations inhabit restricted home ranges (*e.g.*, Shane *et al.* 1986; Lusseau *et al.* 2003). During this study, a few individuals were resighted at intervals of weeks to 3 years. Although limited in number, these observations indicate that some level of site fidelity occurs, which agrees with results obtained in the Pelagos Sanctuary of the Ligurian Sea (Gnone *et al.* 2011). There is certainly scope for further study to determine: (i) whether the dolphins seen in the study area are part of a resident population at scales of 10s to 100s of km and if not, (ii) whether western Adriatic bottlenose dolphins form a distinct population from those found on the Croatian coast (Bearzi *et al.* 1999) or greater Mediterranean populations.

Previous work has shown that dolphin populations often select habitat according to food availability (Allen *et al.* 2001; Hastie *et al.* 2004; Bailey & Thompson 2006) and may use structural features as a means of improving foraging efficiency (Shane 1990; Allen *et al.* 2001). Our behavioural observations suggest that animals occurring closer to gas platforms exhibited an increased frequency of feeding and milling behaviour compared with those followed further away. Milling can be associated with feeding, socialising or resting (Shane *et al.* 1986), and may be exhibited here by dolphins having just completed a feeding bout. Clearly, with only 26 behavioural observations, the evidence for platform-mediated variation in behaviour is not strong, and we present these data here as a hypothesis that requires further examination.

Density estimates of dolphins were ca. 80% higher near platforms than at distances >750 m from platforms. The high proportion of zero counts in the dataset meant that for this comparison, statistical significance at $\alpha = 0.05$ was not achieved, although we might regard this effect size as notable if, as in many environmental effects studies, it is important to minimise Type II error (*i.e.*, failing to detect a significant difference where one does in fact exist) and we set α=0.1. Although firm conclusions are precluded by the high variability in our density estimates, these observations may suggest that bottlenose dolphins frequent the gas fields for the purpose of feeding on fishes aggregated around the gas platforms, a hypothesis that has not been previously examined. Our dataset does have limitations for testing this hypothesis. It is unknown whether bottlenose dolphins frequented the area prior (pre-1960s) to the construction of gas platforms, or how frequently they exhibit the same range of behaviour (as opposed to simply travelling) outside the platform zones. Finally, our surveys were conducted only during daylight hours but recent work has indicated that foraging by harbour porpoises (*Phocoena phocoena*) around platforms may be more intense during the night (Todd *et al.* 2009). Although our observations are indicative, they cannot conclusively attribute the regular presence of dolphins to platforms. If gas platforms, by aggregating demersal and pelagic fishes (Love *et al.* 1999; Soldal *et al.* 2002; Rinaldi & Rambelli 2004; Inger *et al.* 2009), do provide consistent sources of food for bottlenose dolphins, it may be expected that as Adriatic fish stocks continue to decline (Legović 2008), these constructions may provide feeding foci for dolphin populations off the Romagna coast, if they persist.

Bulleri *et al.* (2007) highlight the precautionary approach that any human-induced disturbance should be treated as detrimental until proven otherwise – even in heavily impacted environments. Recent surveys have shown that after recovery from the initial effects of drilling (Currie & Isaacs 2005), gas extraction does not appear to have any consistent long-term effects on macrobenthos – at least within the context of existing sources of disturbance (Willis *et al.* 2005; Terlizzi *et al.* 2008) – which indicates that chemical or hydrocarbon contamination may be minimal or absent. In the scientific literature, discussion of the effects of hydrocarbon extraction does not usually differentiate between oil and gas installations (*e.g.*, Olsgard & Gray 1995; Patin 1999), and it is possible that gas extraction activities may be benign (or even positive for certain taxa) once operational, relative to the strong local effects of hydrocarbon contamination from oil extraction (Olsgard & Gray 1995). One unknown is the effect of noise produced by operating gas installations. Gales (1982) found that the low level noise emitted by platforms is unlikely to interfere with cetacean behaviour but no further research has been done in this area (Richardson & Würsig 1997; Nowacek *et al.* 2007).

There is much scope to extend this study, using a combination of systematic surveys, behavioural assessments by traditional (Shane 1990) or acoustic (*e.g.* Philpott *et al.* 2007; Todd *et al.* 2009) methods, and long-term photo-identification studies to establish whether the same individuals return regularly to forage in the area of platforms. The large-scale meta-population studies needed to determine bottlenose distribution and resource-use within the Adriatic, and the degree of connectivity with greater Mediterranean Sea populations have, to our knowledge, not been undertaken.

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