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Mid-distance re-sighting of a common bottlenose dolphin in the northern Adriatic Sea: insight into regional movement patterns

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*Understanding animal movement patterns is not only important for providing insight into their biology, but is also relevant to conservation planning. However, in aquatic and wide-ranging species such as cetaceans, this is often difficult. The common bottlenose dolphin (*Tursiops truncatus*) is the most common cetacean in the northern and central Adriatic Sea and has been the focus of long-term studies in some areas. All of the studied local populations show a relatively high degree of site fidelity, but their movements, ranging patterns or connectivity are not well understood. On 24 and 26 April 2014 a single adult bottlenose dolphin was observed and photographed alive off the Slovenian coast. The same individual was found dead on the shores of Goro, Italy, on 5 May 2014, about 130 km from the two sighting locations. The well-marked dorsal fin made the identification straightforward. The dolphin was found freshly dead, suggesting it had died very recently prior to being found. This indicates that the reported movement was a real one, rather than an artefact of currents. Although single cases cannot provide the basis for making population-level inferences, our observation shows that northern Adriatic bottlenose dolphins can make substantial movements in short periods of time and suggests that such movements could be more common than currently documented. Comparisons among photo-ID catalogues and stranding events can be highly informative, as they can provide useful information with implications for the cross-border conservation of mobile marine predators.*

Keywords: movements, photo-identification, bottlenose dolphin, *Tursiops truncatus*, Adriatic Sea

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INTRODUCTION

Understanding animal movement patterns is not only important for understanding their biology, but is also relevant to conservation planning. This information is vital for species listed in Annex II of the EU Habitats Directive (Council Directive 92/43/EEC), for which Natura 2000 sites need to be designated. However, in aquatic and wide-ranging species such as cetaceans, this is often difficult. One way of tracking them and studying their movements and ranging patterns is to equip them with tracking devices such as satellite transmitters (Ropert-Coudert *et al.*, 2009; Bograd *et al.*, 2010; Block *et al.*, 2011). However, this is not always practicable or possible. Alternatively, cetaceans can be identified by natural markings (Hammond *et al.*, 1990) and their movement patterns inferred through re-sightings of identified individuals.

The common bottlenose dolphin (*Tursiops truncatus*, hereafter 'bottlenose dolphin') is the most common and widespread cetacean in the northern and central Adriatic Sea (Bearzi *et al.*, 2004; Fortuna *et al.*, 2011) and has been the focus of long-term studies in some areas. These include the Cres-Lošinj (Kvarnerić) archipelago in Croatia, northern Adriatic (since 1987; Bearzi *et al.*, 1997; Fortuna, 2006); the Slovenian, Italian and Croatian waters of the Gulf of Trieste, northern Adriatic (since 2002, Genov *et al.*, 2008); and the Vis-Lastovo archipelago in Croatia, central Adriatic (since 2007; Holcer, 2012). All of these local populations show relatively high degree of site fidelity, but their movements and ranging patterns are not well understood. Available evidence based on comparison of photo-identification data (Genov *et al.*, 2009; Pleslić *et al.*, 2015) and molecular markers (Gaspari *et al.*, 2015a, b) suggests some of them may be fairly distinct units.

Bottlenose dolphins inhabiting the Gulf of Trieste and adjacent waters (Figure 1) have been studied since 2002 (Genov *et al.*, 2008), primarily through photo-identification (Würsig & Würsig, 1977; Würsig & Jefferson, 1990; hereafter 'photo-ID'). Over 150 individuals have been photo-identified and about half have been encountered on a regular basis over the past decade (Genov *et al.*, 2008; Genov, 2011). The entire range of this local population remains unknown.

In Italy, a volunteer-based cetacean stranding network has been operating since 1986 (Cagnolaro, 1996; Cagnolaro *et al.*, 2012), and from 2005 onwards, an institutional monitoring network for stranded marine mammals was established (Pavan *et al.*, 2013). In recent years, most reported carcasses

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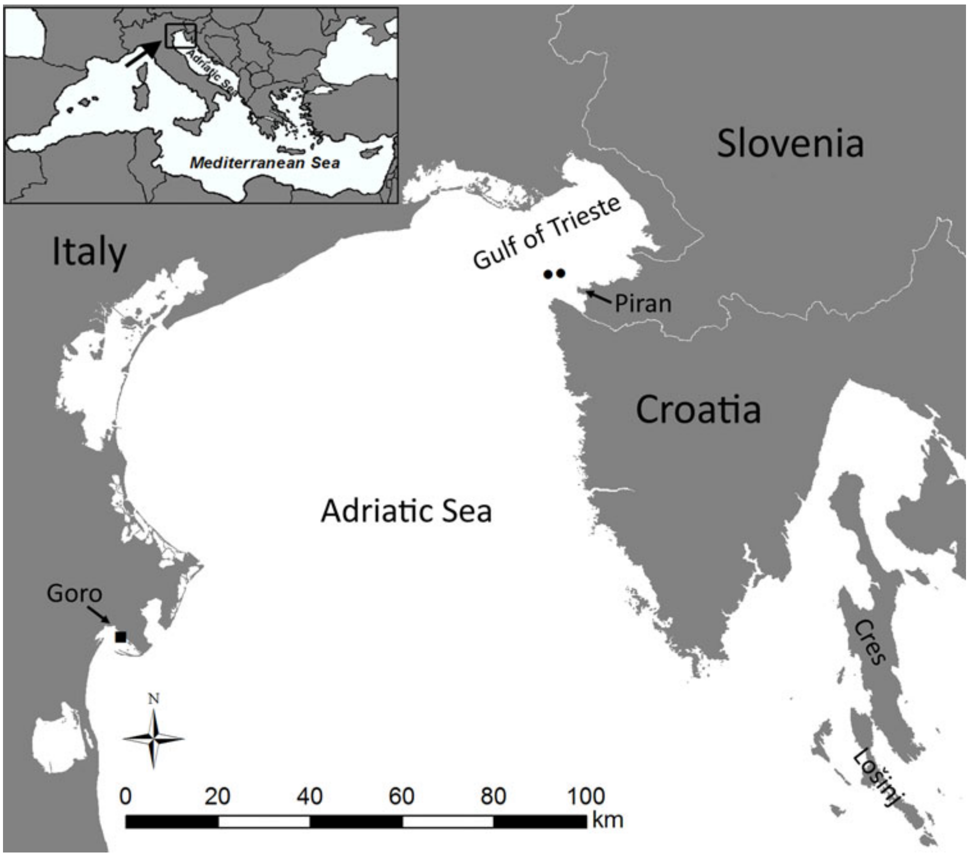

Fig. 1. The sighting (circles) and stranding (square) locations of the photo-identified bottlenose dolphin, with some locations cited in the text.

are recovered and examined following standard necropsy procedures (Geraci & Lounsbury, 2005). On average, about 10 carcasses are recovered annually in the northern Adriatic Sea, with two per year fresh enough to warrant photo-ID comparisons with existing photo-ID catalogues (University of Padova, unpublished data).

In this paper, we report a re-sighting of a bottlenose dolphin observed alive along the Slovenian coast and found dead on the coast of Italy, about 130 km from the original sighting location.

METHODS AND RESULTS

On 24 April 2014 we observed and photographed a single adult bottlenose dolphin off the Slovenian coast (45°33.086′N 13°29.246′E; Figure 1). The individual was not photographed in the area previously, suggesting it was not part of the 'resident' local population. It was also not part of existing photo-ID catalogues in Croatia (D. Holcer, G. Pleslić and N. Rako, personal communication). The dorsal fin of the animal was well-marked (Figure 2), allowing easy identification. In particular, the individual featured a deep but healed cut on the anterior edge of the dorsal fin, suggesting a previous entanglement in fishing gear. In addition, it had an open wound on its left flank, below and posterior to the dorsal fin (Figure 2), roughly 2–3 cm in diameter. Finally, the animal appeared slightly emaciated, but its surfacing movements appeared normal as compared with other conspecifics observed in the area. The mean dive duration was 19.2 s (SD = 4.5, range = 11–28, N = 33). The focal follow of the animal lasted for about 40 min, after which it was terminated to avoid potential disturbance.

Two days later, on 26 April 2014, we observed the same individual again, 2.8 km from the previous location (45°33.244′N 13°31.383′E; Figure 1). As in the previous encounter, its surfacing movements appeared normal. The mean dive duration was 24.7 s (SD = 44.2, range = 4–195, N = 46). We also observed and photographed the dolphin with a fish in its mouth, suggesting successful feeding. While

Fig. 2. Live bottlenose dolphin in Slovenian waters, with a healed lesion in the dorsal fin, suggestive of entanglement in fishing gear. The wound on the flank is of unknown origin. (Photo: T. Genov).

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Fig. 3. Dead bottlenose dolphin found stranded on the Italian coast. (Photo: C. Centelleghe.)

observing the individual for about 50 min, a sub-group of three other bottlenose dolphins appeared in the area. This sub-group was part of a large group containing 30–40 individuals. Although the sub-group and the single animal passed each other at a distance of about 200 m, the single individual continued to swim on its own, in its original direction, and moved away. As we obtained a sufficient amount of photographs for photo-ID of the first individual, we moved on to photograph the new group.

On 5 May 2014, the same dolphin was found stranded on the shores of Goro (the Po River delta, Italy; 44°49.260′N 12°19.920′E; Figure 1), about 130 km from the two sighting locations. The well-marked dorsal fin, in combination with the flank wound, made the identification straightforward (Figure 3). The post-mortem examination showed that the animal was a 3.1 m male. The animal was found freshly dead, in condition code 2, according to carcass decomposition evaluation criteria (Geraci & Lounsbury, 2005) and as evaluated by an expert veterinarian. The necropsy results and associated analyses of samples showed that the animal was in poor body condition, and likely died due to a severe endotoxic shock caused by haemolytic *E. coli*. The animal was apparently old, based on age-related lesions observed during necropsy. Moderately digested remains of an angler fish (*Lophius piscatorius*) of about 15 cm were found in its gastric chambers and oesophagus.

To assess the potential effects of sea currents on passive drift of the carcass, we ran simulations using Langrange's drift trajectories (Griffa *et al.*, 2007) in a prognostic numeric model. Based on the date, time and position of the last confirmed live sighting, and the date, position and freshness of the carcass, we ran two simulations of drift: forward (from the last sighting) and backward (from the stranding). Specifically, we used two models (Figure 4). The first was the Adriatic Forecasting System, AFS (Oddo *et al.*, 2005, 2006; Guarnieri *et al.* 2008, http://oceanlab.cmcc.it/afs/), with a horizontal resolution of 1/45° (approximately 2.2 km). The model utilizes atmospheric data from the European Centre for Medium Range Weather Forecast (ECMWF) and the Mediterranean Forecasting System, MFS (Pinardi *et al.*, 2003; Tonani *et al.*, 2008; http://medforecast.bo.ingv.it/), resulting in daily mean velocities of sea currents, sea surface height, temperature and salinity. The second model was the North Adriatic Princeton Ocean Model, NAPOM (Malačič *et al.*, 2012) with a horizontal resolution of about 600 m. The model includes tidal dynamics and utilizes atmospheric data from the ALADIN/SI model by the Slovenian Environmental Agency, and the aforementioned AFS model. NAPOM results are composed of hourly values of sea currents, sea surface height, temperature and salinity. To calculate Lagrange's trajectories we used a procedure developed by Jarle Berntsen (Institute of Marine Research, Norway, http://www.ccpo.odu.edu/POMWEB/contrib-code/tracer.f), assuming that objects only drift at the surface (depth 0–1 m). Data on wind conditions in the period of interest were derived from the oceanographic buoy Vida (Marine Biology Station Piran, http://www.nib.si/mbp/en/buoy).

Both models produced similar trajectories and showed that the reported movement was highly unlikely to be a result of

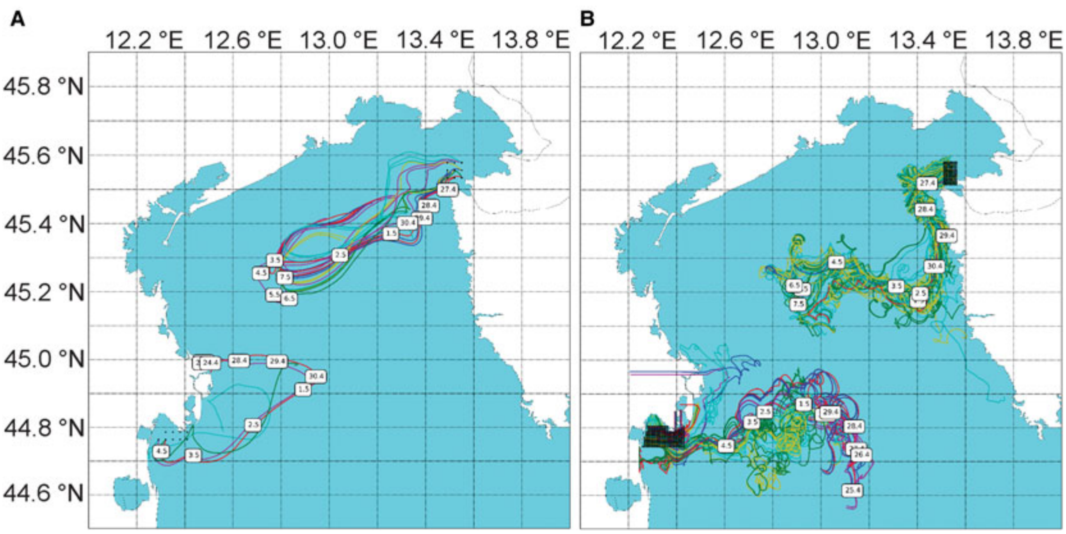

Fig. 4. Clusters of Lagrange's trajectories of the two numerical models: A, Adriatic Forecasting System (AFS); B, North Adriatic Princeton Ocean Model (NAPOM). The upper right cluster represents 'forward' trajectories from 26 April 2014, while the lower left cluster represents 'backward' trajectories from 5 May 2014. Boxes show the dates of the position on the trajectories ('dd.m', where 'dd' is the day in month and 'm' is the month). See main text for details.

passive drift (Figure 4). The backward trajectories, together with the carcass condition, suggest that the animal was likely less than 30 km from the Po River Delta at the time of death (Figure 4). Likewise, the forward trajectories show that a dolphin carcass would not reach the shores of Goro by the stranding date, assuming it died at the time and location of the initial sighting (Figure 4).

DISCUSSION

In north-western Greece, Bearzi *et al.* (2011) reported several round-trips of bottlenose dolphins between areas up to 265 km apart, showing that despite their relatively high degree of site fidelity, the Mediterranean bottlenose dolphins are capable of considerable movement. Moreover, Gnone *et al.* (2011) showed that some bottlenose dolphins in the Ligurian Sea make movements between locations as far as 427 km apart. Therefore, although often philopatric (Natoli *et al.*, 2005), Mediterranean bottlenose dolphins can make substantial movements over short periods of time, as has been shown elsewhere for this species (Wood, 1998; Wells *et al.*, 1999; Silva *et al.*, 2008; O'Brien *et al.*, 2010; Robinson *et al.*, 2012; Cheney *et al.*, 2013).

Knowledge on movements of Adriatic bottlenose dolphins is still limited at best. Available photo-ID data suggest that there is no or little mixing between dolphins from the Gulf of Trieste and those from the Cres-Lošinj archipelago, about 150 km apart (Genov *et al.*, 2009). Similarly, Pleslić *et al.* (2015) reported only five matches (0.8%) between the Cres-Lošinj archipelago (594 identified individuals) and the Kornati archipelago (81 individuals), about 80 km apart. All of the above suggests a reasonably strong site fidelity in these local populations, a notion supported also by genetic evidence (Gaspari *et al.*, 2015a, b). However, the entire ranges of these local populations remain unknown (Genov *et al.*, 2008; Pleslić *et al.*, 2015). Temporary emigration (Fortuna, 2006) and the occurrence of transient or visitor animals (Genov *et al.*, 2008) have been reported, but there are currently no data that would allow photo-ID comparisons with other, unstudied areas within the northern and central Adriatic Sea. The area surrounding the Po River delta is one such unstudied area. This area and the Gulf of Trieste are separated by about 130 km, with no islands or geographic barriers between them, and minimal variability in depth. Bottlenose dolphin habitat use (Cañadas & Hammond, 2006; Torres *et al.*, 2008), foraging specializations (Connor *et al.*, 2000; Bearzi *et al.*, 2008) and genetic population structure (Gaspari *et al.*, 2015a; Louis *et al.*, 2014) are often strongly linked to particular habitat characteristics. It is therefore possible that movements of bottlenose dolphins between these two areas are more common than is currently known.

Information on stranded animals, if not used cautiously, can bias inferences on their biology, including movements (Williams *et al.*, 2011). We considered this here. In particular, the main currents in the northern Adriatic move in a cyclonic fashion, going northward along the eastern shores of the basin, turning counter-clockwise and then returning southward along the western side (Mauri & Poulain, 2001). As bottlenose dolphins have a positive buoyancy at the surface (Williams *et al.*, 2000; Kipps *et al.*, 2002), the animal might have died close to its initial sighting location, and then drifted with sea currents until reaching the final stranding location. However, the dolphin was found freshly dead, in condition code 2 (Geraci & Lounsbury, 2005). This indicates that it died very recently prior to being found (24–48 h) and suggests that the reported movement is a real one, rather than an effect of currents. The simulations (Figure 4) strongly support this. Next, the single case presented here may indeed reflect the rare nature of such movements, and the apparently poor health of the individual may have affected its behaviour. Hence, the reported movement may not be generally representative of free-ranging bottlenose dolphins in the northern Adriatic Sea. However, the rareness of similar records may simply indicate that such information, for the large part, is still generally missing, and that such movements may be occurring undetected.

The aim of this paper is not to draw conclusions on bottlenose dolphin movement patterns. Instead, it highlights the need for a better understanding of these patterns and the need for collaboration and data sharing. The power of photo-ID is sometimes underestimated, but this simple method can provide valuable insight into a number of important issues, including regional and long-distance movements of cetaceans (Frantzis *et al.*, 2011; Stevick *et al.*, 2011; Genov *et al.*, 2012), particularly in species with high mark rates, such as the bottlenose dolphin. Photo-ID comparisons, both of live and dead animals, can provide highly useful information and should therefore be encouraged. Furthermore, additional photo-ID data should be collected in previously unsurveyed areas, to facilitate a better understanding of movement patterns in Adriatic bottlenose dolphins. This has implications for the conservation of mobile marine predators such as the northern Adriatic bottlenose dolphin population, which ranges across borders of three countries.

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