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Cetacean response to summer maritime traffic in the Western Mediterranean Sea

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ABSTRACT

Maritime traffic is one of many anthropogenic pressures threatening the marine environment. This study was specifically designed to investigate the relationship between vessels presence and cetacean sightings in the high sea areas of the Western Mediterranean Sea region. We recorded and compared the total number of vessels in the presence and absence of cetacean sightings using data gathered during the summer season (2009–2013) along six fixed transects repeatedly surveyed. In locations with cetacean sightings (N = 2667), nautical traffic was significantly lower, by 20%, compared to random locations where no sightings occurred (N = 1226): all cetacean species, except bottlenose dolphin, were generally observed in locations with lower vessel abundance. In different areas the species showed variable results likely influenced by a combination of biological and local environmental factors. The approach of this research helped create, for the first time, a wide vision of the different responses of animals towards a common pressure.

1. Introduction

Cetacean populations nowadays are facing several threats including habitat loss, depletion of resources and interactions with fisheries (Notarbartolo di Sciara and Birkun, 2010). Human disturbance is also represented by ship transport which may affect the marine environment through shipping lanes, collisions and underwater noise and pollution, as indicated in the reference list adopted by the EU Habitats Directive (EC, 1992) (respectively D03.02, G05.11, H06.01, H03 codes). Vessel presence can have a direct disturbance on cetaceans causing long-term changes in distribution (Bejder et al., 2006a; Arcangeli et al., 2015), short-term changes in behaviour in fin whales (Jahoda et al., 2003; Castellote et al., 2012), bottlenose dolphins (Bejder et al., 2006b; Arcangeli and Crosti, 2009) and beaked whales (Aguilar et al., 2006; Tyack et al., 2011), or direct physical injuries due to collisions. Ship strikes are, in fact, reported all over the world and the size and speed of boats seems to be directly related to the severity of the wounds on the animals (Laist et al., 2001; Silber et al., 2010). Additionally, different types of vessels could be implicated in the accidents (Ritter, 2012). The Mediterranean Sea is among the world's busiest waterways and shipping traffic is continuously growing along with the concern for its potential impacts on marine fauna (Notarbartolo di Sciara and Birkun, 2010; Geijer and Jones, 2015). The intensity of traffic is expected to increase over the next few years due to the application of the EU program on "Motorways of the Sea" as alternative to land transport (EC, 2004) and summer months are generally the busiest in terms of naval traffic, especially for the transit of cruise ships and passenger ferries

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connecting tourist destinations (Notarbartolo di Sciara et al., 2008; David et al., 2011; Vaes and Druon, 2013). The main shipping routes often overlap with critical cetacean habitats, so potential conservation/mitigation measures are under discussion at different scientific and political levels, but critical decision making information is still lacking. Cetaceans are wide-ranging animals, mostly pelagic, that perform seasonal movements within almost the whole basin. Indeed, seasonal as well as annual variations in presence and distribution of cetacean species were detected by several studies in different areas of the Mediterranean (Gannier, 2002; Monestiez et al., 2006; Laran and Gannier, 2008; Panigada et al., 2011; Arcangeli et al., 2014a, 2014b) and are generally linked to a variable and synergistic effect of different ecological and anthropogenic driving forces. Human impacts on the marine environment are mostly studied in relation to coastal activities, such as ports, fishing, and pleasure boat traffic (Notarbartolo di Sciara and Birkun, 2010) but very little is reported, especially through direct observations, on high sea areas. Therefore, while a wide and multi-species scale approach is needed to provide conservation/mitigation measures towards this threat at the international level (Geijer and Jones, 2015), data remains extremely scarce and quantitative measures on the effects of maritime traffic on different cetacean species in open seas is missing.

This study was specifically designed to investigate the relationship between maritime traffic and cetacean sightings in high sea waters along some of the main shipping routes in the Western Mediterranean Sea. Data was gathered from a large dataset coming from an international network that, since 2007, systematically samples several transects along the main shipping routes (Arcangeli et al., 2014c) with the purpose of monitoring cetacean populations and their relationship with environmental features and anthropogenic factors, such as maritime traffic and marine litter (Crosti et al., 2011; Arcangeli et al., 2015). This research program provided standardised large-scale data and also recorded information in the high seas where long-term studies are otherwise difficult to conduct. For this study, we collected real-time data on vessel and cetacean sightings during summer months. By recording the total number of ships visible at eyesight from the observation platform both during cetacean sightings and in locations randomly sampled all throughout the monitored transects where animals were not sighted, we aimed to determine if the overall intensity of maritime traffic statistically differed between presence and absence of cetacean sightings. As a consequence of traffic disturbance animals could leave the areas with more vessels with short or large displacements (resulting in true absences) or change diving activity (i.e. longer diving could result in more pseudo-absences) (David, 2002). Thus we hypothesised that a lower number of ships would be recorded where cetacean sightings occurred with respect to the number of vessels observed in the absence of sightings. Once this was tested at different geographical scales, we aimed to also investigate whether different species showed heterogeneous responses to traffic intensity. Finally, we discuss the effect of disturbances in areas of particular relevance, such as the Pelagos Sanctuary, to verify the necessity of additional conservation efforts.

2. Materials and methods

2.1. Study area

This research is focused in high sea areas, because most of the Mediterranean cetacean species are mainly pelagic and there is a general lack of information in these areas. Surveys were conducted along six fixed transects within the main shipping routes connecting Italy, France and Spain (Fig. 1): Toulon-Ajaccio (TOU), Nice-Calvì (NIZ), Savona-Bastia (SAV), Livorno-Golfo Aranci (LIGA), Civitavecchia-Golfo Aranci (CIV) and Civitavecchia-Barcelona (divided in an eastern, EBAR, and in a western section, WBAR). These transects cross, respectively, the Ligurian-Provençal basin, the northern and central Tyrrhenian Sea and the Sardinian and Balearic Seas. These marine regions are characterised by a broad range of topographic and ecological conditions: the continental shelf is wide in the Tyrrhenian and Balearic Seas and less extended along the Ligurian and French coasts, while steep slopes and canyons define a complex sea bottom topography in the areas crossed by TOU, SAV and especially the CIV transects. Waters reach maximum depths in the Balearic Sea and in the abyssal plateau of the Ligurian Sea (around 2700 m deep).

All eight cetacean species regularly occurring in the Mediterranean Sea can be found within all of the study area (Notarbartolo di Sciara and Birkun, 2010): fin whale *Balaenoptera physalus*, striped dolphin *Stenella coeruleoalba*, sperm whale *Physeter macrocephalus*, Cuvier's beaked whale *Ziphius cavirostris*, bottlenose dolphin *Tursiops truncatus*, Risso's dolphin *Grampus griseus*, common dolphin *Delphinus delphis* and long-finned pilot whale *Globicephala melas*.

Two Special Protected Areas of Mediterranean Importance (SPAMI, UNEP, 2010) are crossed by the studied transects (Fig. 1): the Bonifacio Strait, mostly falling within continental waters and the Pelagos Sanctuary, the largest and the only SPAMI established in high sea areas and under international agreement. This latter area is characterised by high levels of primary productivity providing suitable habitats for the breeding and foraging needs of many cetacean species. On the other hand, it is subject to high levels of human pressures due to the presence of coastal cities, ports and tourist destinations (Notarbartolo di Sciara et al., 2008).

2.2. Data collection

The transects were repeatedly surveyed between 2009 and 2013 (Table 1). Consistency of datasets throughout the different areas and research periods was guaranteed by the application of a common protocol for data collection, the experience of the observers and by using research platforms with similar characteristics (deck height, speed). Outbound and return surveys were performed weekly along each transect using ferries (19–25 knots) as observation platforms, where trained observers followed the network data collection protocol to provide standardised records (for further details see Arcangeli et al., 2014a). The effort for both cetaceans and visual ship observations was carried out in favourable weather conditions (Beaufort scale$\leq$3). A sampling protocol was specifically designed in order to provide real-time information on maritime traffic in the presence and absence of cetacean sightings and was applied to all transects during the surveys: scan sampling to count all vessels longer than 5 m and visible by eyesight all around the ferry was performed each time a cetacean sighting occurred (record in presence of cetacean sightings; presence dataset); additionally, scan sampling of vessels was conducted in random locations all throughout the transects when animals were not sighted (absence or pseudo-absence) starting at a random time interval after the effort began and repeating the count approximately every hour (random record in absence of cetacean sightings; absence/random dataset). In order to avoid pseudo-replication, a minimum interval of 15 min was defined between presence and absence records. As surveys were performed from a vessel, the research platform was not included in the ships counts and not considered a source of error in the comparison as it was constant in both datasets. To account for seasonality and to investigate the season with highest intensity of traffic, only surveys carried out between June and September were used for this study.