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SHORT COMMUNICATION

Position, swimming direction and group size of fin whales (*Balaenoptera physalus*) in the presence of a fast-ferry in the Bay of Biscay☆

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Summary We analyze group size, swimming direction and the orientation of fin whales relative to a fast ferry in the Bay of Biscay. Fin whale groups (≥3 individuals) were on average closer to the vessel than single individuals and pairs ($F_{1,114} = 4.94$, $p = 0.028$) and were more often observed within a high-risk angle ahead of the ferry (binomial probability: $p = 7.60 \times 10^{-11}$). Also, small groups tend to swim in the opposite direction (heading of 180°) of the ferry at the starboard side (binomial test: $p = 6.86 \times 10^{-5}$) and at the portside (binomial test: $p = 0.0156$). These findings provide valuable information to improve shipping management procedures in areas at high risk for collisions.
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1. Introduction

During recent decades there has been a rapid expansion in shipping traffic with a corresponding increased impact to biodiversity at a global scale (Flagella and Abdulla, 2005; IUCN, 2009; Panigada et al., 2008). For large vertebrates, such as cetaceans, ships pose a risk in terms of discharges that may release contaminants into the ocean, noise pollution that can affect marine mammal distributions and behavior, and direct physical harm caused by collisions (Evans, 2003; Laist et al., 2001; Mayol et al., 2008; McGilivary et al., 2009; Panigada and Leaper, 2010). Previous studies have shown the impact of ship-related events on the distribution and behavior of many cetacean species, including North Atlantic right whales (*Eubalaena glacialis*), fin whales (*Balaenoptera physalus*) and sperm whales (*Physeter macrocephalus*) (Evans, 2003; Laist et al., 2001; Mayol et al., 2008; McGilivary et al., 2009; Panigada and Leaper, 2010; Panigada et al., 2008).

The vulnerability of a given species to ship traffic mainly depends on their behavior and on the spatial-temporal characteristics of shipping traffic in a given area (David, 2002; Evans, 2003). For North Atlantic right whales, mortalities due to ship collisions have led to a significant decline in their populations (Jensen and Silber, 2004; Kraus et al., 2005; Laist et al., 2001; Nowacek et al., 2004). It has been hypothesized that the observed slow recovery in population numbers for these whales is due to the cumulative effects of several anthropogenic factors (Jensen and Silber, 2004; Kraus et al., 2005; Laist et al., 2001; Nowacek et al., 2004).

On a global scale, the fin whale is the most commonly recorded species to collide with ships (David, 2002; Laist et al., 2001). Yet contrary to other baleen whales, fin whales are fast swimmers (Laist et al., 2001; Panigada et al., 2006). This suggests that fin whales have the physical capability to avoid colliding with ships; albeit, if the vessel is detected in sufficient time for the whale to change course and/or swim away from the vessel. The high occurrence of these accidents may be related to aspects of this species' behavior rather than swimming speed. For example, cetaceans engaging in activities such as feeding or breeding have been shown to be less responsive to vessel approach (Dolman et al., 2006; Richardson et al., 1995).

The Bay of Biscay is navigated by fast ferries that connect England, France and Spain (Kiszka et al., 2007; ORCA, 2013). We performed a monthly monitoring program in the Bay of Biscay on board a commercial fast ferry in order to understand behavioral patterns of fin whales in relation to ships. Our aim was to identify factors that affect the risk of collisions between fin whales and fast ferries, considering that fin whales are the most recorded species hit by ships (David, 2002; Laist et al., 2001).

The Bay of Biscay is an ideal location for this study because it is an area with both high diversity and abundance of cetacean species and heavy ship traffic. Fin whales are present in the Bay mainly during the spring and summer months. In this study, groups of four observers performed monthly monitoring of fin whales (group size, swimming direction, orientation and positions) from a 21 m high steering house. Through this assessment of the data collected during the surveys, we examine the behavior of fin whales and evaluate the implications for future management decisions in relation to ship collisions.

2. Material and methods

We study group size, swimming direction, orientation and positions of 228 fin whales relative to a commercial fast ferry with routine operations in the Bay of Biscay. Opportunistic observations were made on board of the *Brittany Ferries*' largest ferryboat — *MV Pont-Aven* (184.60 m) during the Portsmouth & Plymouth to Santander crossing (Fig. 1). No observations were performed during crossings over the English Channel given the low abundance of fin whales in those areas (ORCA, 2013). Given an average travel speed of 25 knots and the large size of the ship, the *MV Pont-Aven* ferry is among the group of vessels that has a high probability of involvement in severe or fatal ship—whale strike events (Laist et al., 2001; Panigada et al., 2006; Vanderlaan and Taggart, 2007).

Data on group size, swimming direction, orientation and positions was collected during monthly surveys from August 2006 to October 2008. Each monthly survey was conducted for 3 consecutive days (representing a return trip Plymouth-Santander-Portsmouth). Surveys were carried out from dawn to dusk from a 21.75 m high steering house, in sea states of 4 or less (based on the Beaufort Sea State table). Observations collected during winter months (November to March) were not analyzed due to the scarcity of data. In winter, fin whales are not present in the Bay of Biscay as they migrate to more southern locations. The study generated data for a total of 39 survey days.

Groups of fin whales were highly conspicuous even at a far distance. The data recorded for each sighting of an individual or group of whales included date, time of the day (GMT), GPS coordinates, distance, group size, angle at which animals were spotted and their heading (using an angle board — 0° to 360°) (see for example Littaye et al., 2004). Observations were recorded along a linear transect between 45°56.3′N—4°29.6′W and 43°41.2′N—3°49.4′W. Following the suggestions of Weinrich et al. (2010), in that detection of cetaceans is enhanced by the presence of trained and dedicated observers, the observation team consisted of four trained observers positioned on the navigation bridge. No observations were collected between 90° and 270° due to access restrictions on the navigation bridge. The search for cetaceans was therefore limited to scanning ahead of the ship (9° to either side of the bow). Scanning was performed using the naked eye and binoculars while species identification and distance measurements were performed with binoculars (Steiner® reticle binoculars of 7x50).

Perception bias (bias due to observer's inability to detect an animal when it is present) can influence the amount of data acquired during surveys. Perception bias by observers is due, for example, to long observation times and insufficient training. Although bias by observers cannot be ruled out completely in studies of marine mammals, several precautions were taken in the present study to minimize it. Firstly, all observations were made within a 4 km distance of the ship. Given the height of the navigation bridge, this distance was also the visible range to the horizon, which was estimated to be around 10 km (ORCA, 2013). In addition,

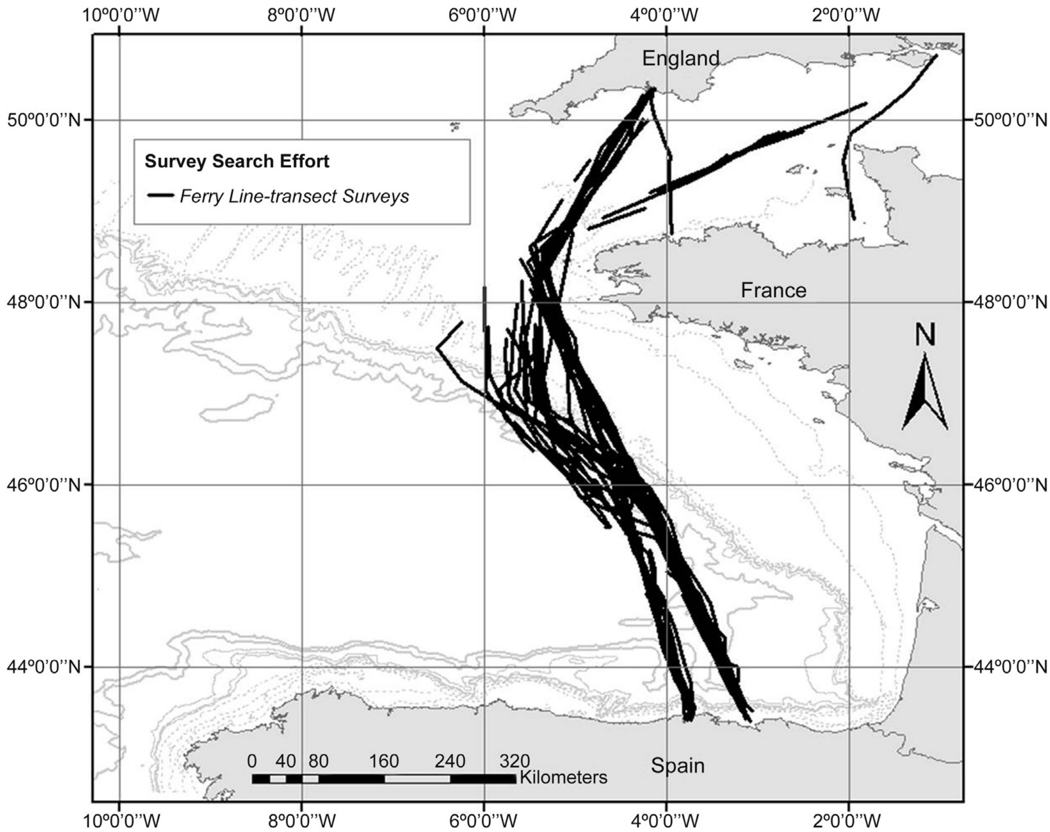

Figure 1 Survey effort of transects performed in the Bay of Biscay. Survey effort of transects between England (top) and Spain (bottom), crossing the Continental Shelf (200 m) to the Gascogne Golf (4000 m).

the observers changed positions every 30 min, and observations were terminated after 4—5 h to avoid fatigue-related bias.

A General Linear Model (GLM) was formulated to analyze the relationship between whales and the response variable, distance from the ship. The variables, observer and presence/absence of calves, were included in the model as random factors. Covariates in the GLM were date, time of day and group size. In addition to the GLM, binomial tests were performed on the variables swimming direction (heading) and angle of identification (orientation) of whales relative to ship's orientation. Orientation measurements were made at first surfacing, while heading measurements were recorded as the angle between the first and second time the whale was observed surfacing. Heading measurements were recorded among four values (0°, on the ferry route; 90°, starboard; 180°, opposite the ship route; 270°, portside). All statistical tests were conducted using Minitab 12.1.

3. Results

A total of 228 fin whales (in 129 groups) were observed along an estimated total transect length of 4537 km surveyed during this study. We analyzed which factors explained significant variation in the animals' distance to the ship using a GLM. No significant variation was explained by the observer ($F_{12,114} = 0.72$, $p = 0.734$), presence/absence of calves ($F_{1,114} = 0.97$, $p = 0.327$) and time of day ($F_{1,114} = 0.36$, $p = 0.551$). However, the group size did explain significant variation ($F_{1,114} = 4.94$, $p = 0.028$), with large groups of fin whales ($N \geq 3$ individuals) being recorded significantly closer to the ship than small groups (i.e. pairs and singletons). Furthermore, whereas the headings of large groups were random relative to the ship (binomial test: $p = 0.109$), headings of small groups appeared not to be random (Fig. 2). Closer inspection of the data showed that small groups tended to swim in the opposite direction (heading of 180°) of the ferry at the starboard side (18 out of 33 observations, binomial test: $p = 6.86 \times 10^{-5}$) and at the portside (26 of the 38 whales, binomial test: $p = 0.0156$). As a result, the distance between these small groups of whales and the ferry generally decrease during surveys. Fin whale sightings recorded at the front starboard side (between 0° and 45°; $N = 107$) are similar to the number of sightings made at the front portside (between 270° and 360°; $N = 116$) (binomial test: $p = 0.296$) (Fig. 2). However, significantly more individuals were observed in the quadrant in front of the ship's bow (315—360° and 0—45°; $N = 169$) than in the remaining quadrants of the port (270—15°) and starboard (45—90°) sides combined ($N = 54$) (binomial probability: $p = 7.60 \times 10^{-11}$).

4. Discussion

In this 26-month study of fin whale behavior, we examined orientation (position relative to a Bay of Biscay commercial

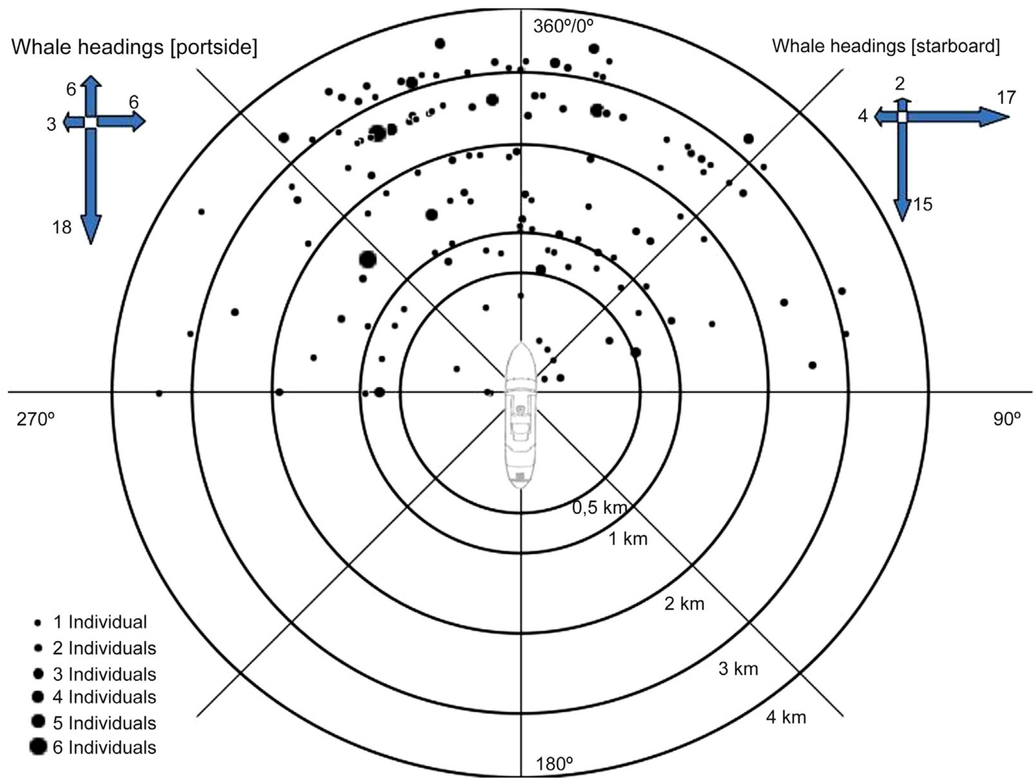

Figure 2 Fin whale sightings around *MV Pont-Aven*. The position of fin whales (dots) and heading (block arrows) in relation to the position of the ferry during surveys in the Bay of Biscay from August 2006 to October 2008.

fast ferry), group size and swimming direction (heading). We examine possible factors leading to the observed patterns and discuss the implications for risk reduction of collisions with ships. The results of this study provide insight on fin whale behavior (orientation, group size and swimming direction) and how information generated through this study may be further developed to support shipping and whale conservation management decisions.

4.1. Orientation

The heading of small groups towards the oncoming ship was found not to be random. This suggests that the animals are aware of the presence of the ship and as a result alter their swimming routes. Previous studies on the difference of detections between dedicated observers and ship operators has shown that operators have shorter reaction times in detecting whales in the vicinity of the vessel (Weinrich et al., 2010). At high speed the ability to detect and subsequently avoid whales at distance is thus further hindered. This, together with the possibility for animals to cross the vessels' path creates situations of increased risk of collision. The assistance of whale observers during ferry operations and speed reduction could help in reducing such risk (Panigada et al., 2006; Weinrich et al., 2010).

Additionally, in this study significantly more animals were recorded in the quadrant in front of the ship's bow (from 315—360° and 0—45°), ($N = 169$) than on either side (270—315° and 45—90°) ($N = 54$). We cannot exclude that observers had a greater tendency to survey the sea straight ahead, however, the bow of large vessels can create an acoustic shadow, making vessel sounds indistinguishable from background environmental noise (Gerstein et al., 2002, 2009). This can limit the whales' capabilities of detecting oncoming vessels and explain why there were significantly more sightings in the front of the bow.

4.2. Group size

Our data indicate that large groups of fin whales (≥3 individuals) in the Bay of Biscay remain significantly closer to a ferry compared to small groups (single individuals or pairs of individuals). This finding is in accordance with previous studies showing that whales in active groups have a reduced attentiveness, and as a result, are less likely to respond to the presence of a ship. The resulting lack of awareness of nearby vessels may be due to masking of sensory cues (David, 2002; Jahoda et al., 1996; Richardson et al., 1995), or alternatively less vigilant state in accordance with the "group-size" effect (Elgar, 1989). Cetaceans engaged in biologically important activities, such as feeding have been shown to be less responsive and may not be able to detect environmental sounds (Dolman et al., 2006; Panigada et al., 2006). Given that generally, fin whales are found in pairs or traveling individually and that fin whales are present in the Bay of Biscay for feeding purposes, it is possible that groups detected in this location are indeed conducting collective foraging or socializing, which will thus further hinder their abilities to be vigilant of their surroundings. Other explanations for this reduced attentiveness include the effect of noise propagating from larger vessels such as tankers and container ships. Noise may also impact a cetacean's sensory cues (McKenna et al., 2012) putting them at greater risk for ship strikes (McKenna et al., 2012). The fact that large groups in this study were found to be significantly closer to the ship than small groups is therefore consistent with previous studies on masking effects and whale proximity to vessels (David, 2002; Jahoda et al., 1996; Richardson et al., 1995).

4.3. Swimming direction

Swimming direction was measured as the heading of an animal or animals relative to the ferry. Unlike large groups, small groups showed headings that were significantly different from a random distribution, and tended to swim in opposite direction of the movement of the ferry. We interpret these observations as further evidence that fin whale swimming directions may be influenced by the presence of the ferry. This corroborates previous work in the Mediterranean Sea, that documented interruptions in feeding activities by fin whales in the presence of vessels (Jahoda et al., 2003). Though changes in behavior were not documented in the present study, the fact that fin whales in the Bay of Biscay tend to swim in the opposite direction relative to the ferry's path (maintaining a parallel position), suggests that this finding may be related to a behavioral response. However, additional (unidentified) biological factors such as migratory patterns or prey availability may also play an important role in the swimming direction of fin whales relative to ferries. Though further work is necessary to explore this hypothesis, these results highlight the need for telemetry and disturbance studies to provide more detail in fin whale behavioral reactions to large vessels.

4.4. Management implications

Several authors have suggested that ferry speeds are highly relevant for assessing collision risk (Carrillo and Ritter, 2010; Gende et al., 2011; IWC, 2009; Mayol et al., 2008; McGilivary et al., 2009; Panigada and Leaper, 2010; Panigada et al., 2006; Silber et al., 2010; Van Waerebeek and Leaper, 2007; Weinrich, 2004). The present study suggests that this risk is also warranted for fin whales in the Bay of Biscay. Hence, we reiterate suggestions made in the literature that speed reduction is an important management measure that should be taken into consideration by shipping authorities (Panigada et al., 2006; Vanderlaan and Taggart, 2007).

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