First observation of fin whale (*Balaenoptera physalus*) courtship behaviour in the Mediterranean sea

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A - Research concept and design, B - Collection and/or assembly of data, C - Data analysis and interpretation, D - Writing the article, E - Critical revision of the article, F - Final approval of the article

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Abstract:
The fin whale (*Balaenoptera physalus*) is a regular species in the Mediterranean Sea, where its population has been described as nomadic opportunist. Individuals are known to concentrate in specific areas with recurrent high prey availability, and appear to disperse for non-foraging activities. In this study, we report the sighting of three fin whales within the Pelagos Sanctuary, an area recognized for its importance as a feeding ground. The sighting occurred unusually close to the coast compared to typical species distribution and involved notable inter-individual interactions. Drawing on a comprehensive review of the literature, we examined the observed behaviours and explored their potential link to reproductive activity. While courtship behaviours in fin whales have been sporadically documented in different oceans, they have not yet been described in the Mediterranean Sea. Given the species' vulnerability, sharing these observations with the scientific community is crucial, as it enhances our understanding of fin whale ecology and behaviour in this region.

Keywords: reproduction, socialising, surface behaviour, mysticetes, fin whale.

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Short title
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MANUSCRIPT BODY

Fin whales (*Balaenoptera physalus*) are cosmopolitan mysticetes with a predominant pelagic distribution (Aguilar and García-Vernet, 2018). Baleen whales generally present seasonal migrations between high-latitude, very productive feeding grounds and low-latitude, warm-temperate breeding and calving grounds (Mackintosh 1965, Kellog 1929). Fin whales, however, exhibit less clear movement patterns, with populations undertaking non-traditional migratory behaviours (Geijer et al. 2016). Similarly to blue whales (*Balaenoptera musculus*), fin whales seem to breed dispersed, in offshore areas, without congregating in distinct breeding grounds (Eichenberger et al. 2023, Simon et al. 2010).

The Mediterranean Sea hosts a resident and genetically isolated subpopulation of fin whales, recently reassessed as 'Endangered' by the IUCN Red List (Panigada et al. 2021) due to its small size and continuing decline in numbers caused by strong levels of anthropogenic pressure in the basin (e.g. ship strikes: Sèbe et al. 2023; chemical pollution: Marsili et al. 2018 ; marine litter: Fossi et al. 2016; review about threats: Espada et al. 2024). Fin whales from the Atlantic Ocean have also been identified in the western portion of the basin, up to the Provençal basin, through genetic (Palsbøl et al. 2004, Bérubé et al. 1998), acoustic (Castellote et al. 2012) and stable isotopes analyses (Giménez et al. 2013). Therefore, there are areas where overlap between the two subpopulations may occur (Castellote et al. 2012), which could explain the limited, but still present, male mediated gene-flow observed in Mediterranean fin whale genotypes by Berube et al. (1998). In the Mediterranean Sea, the species has been described as a nomadic opportunist (Notarbartolo di Sciara et al. 2016), with individuals moving between sites of recurring high prey concentration and dispersing throughout the basin for physiological activities other than feeding. No mating or calving grounds have been identified. This supports the hypothesis that the basin's small size, combined with the long-range calls produced by fin whales, enables the individuals to locate each other without needing to congregate at specific sites (Notarbartolo di Sciara et al. 2003). Conversely, hotspots related to foraging needs have been identified, including the Gulf of Lion and the Corso-Liguro-Provencal Basin (Tepsich et al. 2020, Druon et al. 2012, Notarbartolo di Sciara et al. 2003), particularly in the summer months. To a lesser extent, hotspots also occur in the central Tyrrhenian Sea during the summer (Arcangeli et al. 2014) and around Lampedusa Island in the Ionian Sea during the winter months (Aïssi et al. 2008, Canese et al. 2006). The Corso-Liguro-Provencal Basin's importance for the sustainment of this and other cetacean species led to the establishment of the Pelagos Sanctuary which, along with the Gulf of Lion and the Spanish Corridor, was recently designated as a Particularly Sensitive Sea Area (PSSA). Extensive research on fin whales in the Sanctuary and surrounding areas underscores its significance as a foraging ground, since oceanographic processes sustain high primary productivity and lead to dense krill aggregations in the area (Druon et al. 2012, Aïssi et al. 2008, Notarbartolo di Sciara et al. 2003). At the same time,

sightings of mother-calf pairs and strandings of young individuals highlight the Sanctuary's role as a breeding habitat (Orsi Relini and Vallarino 2017, Espada et al. 2024).

Here we present a notable sighting that occurred within the Pelagos Sanctuary, during a systematic survey conducted as part of the Delfini del Ponente Research Project, aimed at monitoring coastal wildlife in the western Ligurian Sea (Fontanesi et al. 2024, Ascheri et al. 2022). On 6 October 2023, at 10:05, a group of three fin whales was spotted in coastal waters, on the continental platform, approximately 3.1 km from the shore of Alassio (Figure 1), at a depth of 100 m. This habitat is atypical for the species in the Mediterranean Sea, where fin whales are generally associated with pelagic environments (Notarbartolo di Sciara et al. 2003). In addition to the unusual proximity to shore, the sighting occurred during autumn, a season when fin whale presence in the area is generally less frequent, with higher abundances usually recorded in spring and summer (Notarbartolo di Sciara et al. 2003). The group was approached by the zodiac, aiming at reducing the disturbance and allowing the collection of unbiased behavioural data.

Throughout the 52-minute observation, researchers captured 574 photographs using a Canon 6D with a 100-400mm L-series lens; video recordings taken with mobile phones (visible online at https://www.youtube.com/watch?v=MmHHJgyWfVw); and took handwritten notes on data forms. The photographs were then used to identify the three animals and compare them with the research group's catalogue, consisting of 14 individuals. The three whales were designated as Whale A, B, and C to aid in the behavioural description. Except for one highly marked individual (Whale A), the whales were not distinguishable in the field. However, upon reviewing the images, it was possible to differentiate the three animals based on distinctive natural marks and the shape of their dorsal fins. No matches were found with the Delfini del Ponente catalogue.

From 10:05 to 10:21, during the first 16 minutes of observation, the three whales generally maintained a westward direction, parallel to the coastline, at an average speed of 5.5 km/h, with short dives lasting approximately 2-3 minutes. During this time, they followed each other, frequently surfacing with their heads and chins out of the water, producing large water mass displacements on their sides. Once during this time span, a single whale briefly moved in the opposite direction, East, at 10:18.

At 10:24, Whale A moved towards offshore waters, crossing the path of Whale B, while the individual further West (Whale C) maintained its direction and increased its distance from the others (Figure 2). In the subsequent photos, all three animals were again moving westward, with Whale C positioned farthest to the West, followed at a distance by Whale B and Whale A, respectively. After five minutes, at 10:30, the three whales changed direction to move towards the coast, passing to the right of the zodiac, slowing down, and floating at the surface. After two minutes of this slow activity, the whales abruptly accelerated further towards the coastline, and Whale B was observed turning on its right side, exposing half of its fluke out of the water. A similar behaviour was then displayed by Whale A, which resurfaced with its head out of the water (Figure 3), mouth closed, turned onto its

right side, exposing part of its left-side fluke, and then changed its direction by about 90 degrees. Whale B crossed the path of Whale A, which was still swimming on its side, and then followed Whale A (Figure 4). Soon after, Whale B again crossed the path of a whale, not identifiable from pictures and videos, and resumed traveling westward (Figure 5).

At 10:36, the three whales again showed a clear movement pattern towards West, still performing changes in direction and speed. In particular, photographs and videos show Whale B moving parallel to shore and accelerating to dive in response to a whale narrowly crossing its path (Figure 6).

At 10:45 the animals' behaviour changed to a more compact formation with a slower pace of around 9 km/h and with coordinated dives. The animals were last observed at 10:59, continuing their westward journey at a constant speed of 9 km/h, at which point the team resumed their efforts to search for other wildlife.

In order to understand the potential purpose of the described behaviours, existing literature was analysed and several experts were consulted to review videos and pictures captured during the sighting. According to the standardized ethogram by Mann (2000), behaviours can be classified as travelling, resting, foraging or socialising. Given the frequent change of direction, the interactions observed among the whales and the surface behaviours exhibited, our focus was on foraging and socialising activities. Initially, we considered the possibility of a surface lunge feeding event, but this hypothesis was dismissed due to the absence of key characteristics typically associated with this behaviour, such as the mouth being agape or partially opened while swimming on a side and closing once engulfing the prey, synchrony between whales engaged in feeding, and the extended throat (Herr et al. 2022, Canese et al. 2016, Ingram and Rogan 2007, Aïssi et al. 2008). In the described sighting, the whales kept their mouths fully closed while moving on their side, ruling out the possibility of filter feeding, and no synchronized behaviours were observed. Instead, while one whale was seen swimming rotated, the other was showing its dorsal fin and frequently crossing the other's path. Despite being a behaviour performed in other areas of the Mediterranean Sea (e.g. Lampedusa Island - Canese et al. 2016, Garraf coast – Eduard Degollada, pers. comm.), fin whales in the Pelagos Sanctuary are known to feed primarily at depth during the day (Panigada et al. 1999, Notarbartolo di Sciara et al. 2003), due to the distribution of their main prey species *Meganyctiphanes norvegica* (Sardou et. 1996). To our knowledge, surface feeding has never been recorded in this part of the basin.

Fin whales in the Mediterranean Sea are strictly connected to areas of recurrent high productivity, where they congregate for feeding purposes (Tepsich et al. 2020, Notarbartolo di Sciara et al. 2016, Druon et al. 2012, Notarbartolo di Sciara et al. 2003). However, they do not exhibit specific breeding grounds and periods, with breeding occurring whenever physiological conditions are favourable (Notarbartolo di Sciara et al. 2016, Notarbartolo di Sciara et al. 2013). Nevertheless, it appears that a peak in birth occurs in autumn (Espada et al. 2024, Orsi Relini and Vallarino, 2017, Notarbartolo di Sciara et al. 2016) and newborns are more frequently registered in the western part of the basin

(Espada et al. 2024, Notarbartolo di Sciara et al. 2016). Given that the species' gestation period is approximately 11 months (Aguilar and García-Vernet 2018), it is reasonable to expect an increased frequency of mating events in autumn. This is further supported by an acoustic study conducted on fin whales in the Ligurian Sea using bottom recorders, which found higher detection rates of whale calls between October and December, possibly linked to a shift in the animals' behaviours from feeding to searching for mating opportunities during these months (Pintore et al. 2021).

Socialising behaviours in fin whales have not been extensively documented in literature; nevertheless, some similarities with previously published sightings were found. Previous studies describe 'chasing behaviours', with whales swimming at speed in a line formation (Ireland - Baines et al. 2017, Canada - Delarue et al. 2009), as well as physical interactions (Canada - Delarue et al. 2009, Mexico - Carone et al. 2019). All the sightings involving these unusual behaviours have been interpreted by the authors as reproduction-related (Delarue et al. 2009; Baines et al. 2017; Carone et al. 2019). Despite the limited knowledge of the species' reproductive behaviour, their anatomy—characterised by relatively small testes compared to body size—suggests that direct male–male competition is a more likely mating strategy (Delarue et al. 2009; Baines et al. 2017) than the sperm competition typical of some other mysticetes (e.g. North Atlantic right whale, Mate et al. 2005). The association between chasing behaviours and reproduction is further supported by sex assessments in previous studies, which identified females as the leading individuals and males as the flanking, more impetuous whales (Delarue et al. 2009; Carone et al. 2019). Carone et al. (2019) provided detailed descriptions of two observations in the Gulf of California in which whales swam and breached in close proximity, with their heads fully out of the water, crossing paths, rolling onto their sides, and exposing half of their fluke and a flipper. These were characterised as courtship behaviours, involving two or three males competing for a female exhibiting high progesterone levels in her tissues (Carone et al. 2019).

Despite our inability to determine the whales' sex, several lines of evidence support the hypothesis of a reproduction-related event. First, due to the absence of typical feeding traits – such as an opened mouth, coordinated movements among individuals and extended throat - the possibility of a surface feeding event was excluded. Second, the timing of the sighting is consistent with the known reproductive period of fin whales in the Mediterranean Sea. Finally, the interactions observed show strong similarities with previous records identified as courtship- or mating-related (Delarue et al. 2009; Baines et al. 2017; Carone et al. 2019). Thus, we conclude that the observed encounter is best described as a possible courtship event. The current knowledge on fin whales' reproductive behaviour is quite limited, due to the difficulty to observe these interactions in the wild. The males' strategies to gain access to females so far described are scramble competition (direct competition) and singing (indirect competition) (Eichenberger et al. 2023, Orbach 2019). The observed behaviours may represent examples of direct male-male competition over mating access, falling under the definition of either contest or scramble competition. To the authors' knowledge, this could

be the first ever reported courtship event for the Mediterranean Sea. Knowledge of fin whale reproduction remains limited, owing both to their elusive breeding habits and to research constraints. Any additional information on this topic is therefore invaluable for advancing our understanding of the species' ecology, particularly in regions where populations are declining, such as the Mediterranean Sea.

FIGURE CAPTIONS

Figure 1: Map showing the area, inside the Pelagos Sanctuary, where the sighting occurred. Full line indicates the period when the whales were seen interacting, dash line indicates the switching to travelling mode.

Figure 2: Image of the three whales, in order from left to right: Whale B, Whale A and Whale C. From the sequence of pictures it is evident that Whale A moved offshore and crossed Whale B path, while Whale C kept swimming westward.

Figure 3: Whale A resurfacing with its mouth out of the water, completely closed.

Figure 4: Whale B following Whale A swimming on its side.

Figure 5: Whale B, closer to land, crossing another whale's path.

Figure 6: Whale B (on the right) about to dive, after another whale (on the left), resurfaced very close and in the direction of crossing its path.

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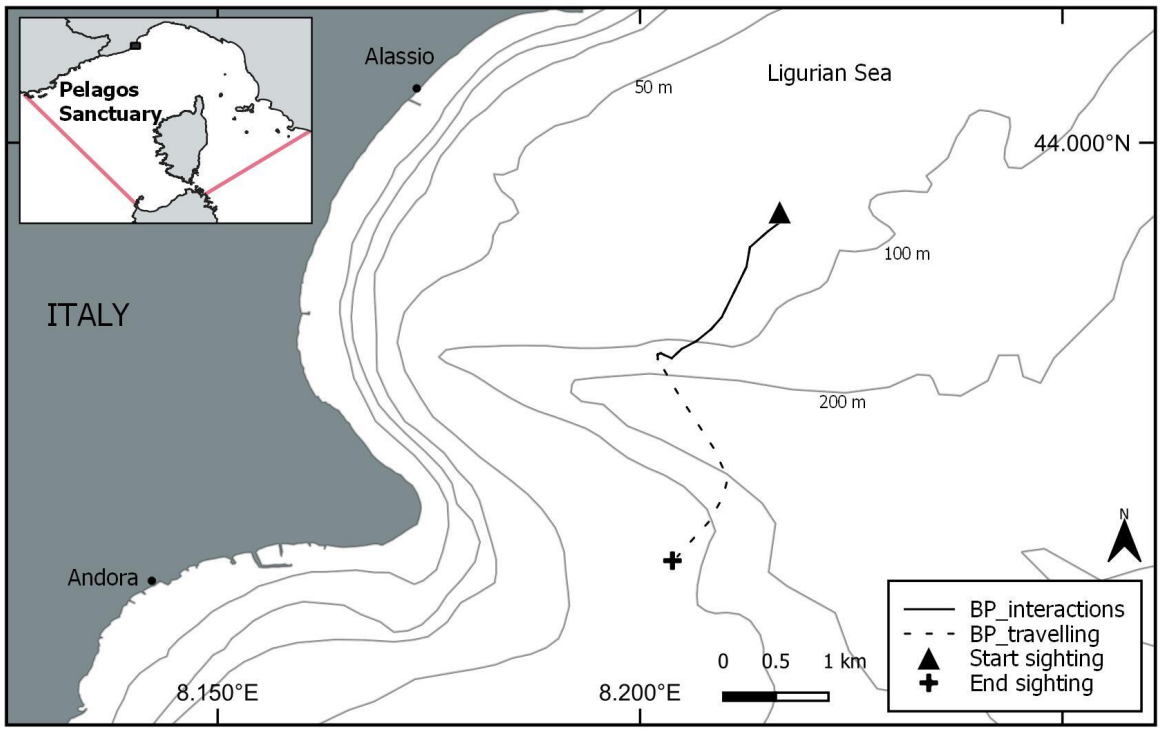

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Figure 3: Whale A resurfacing with its mouth out of the water, completely closed.

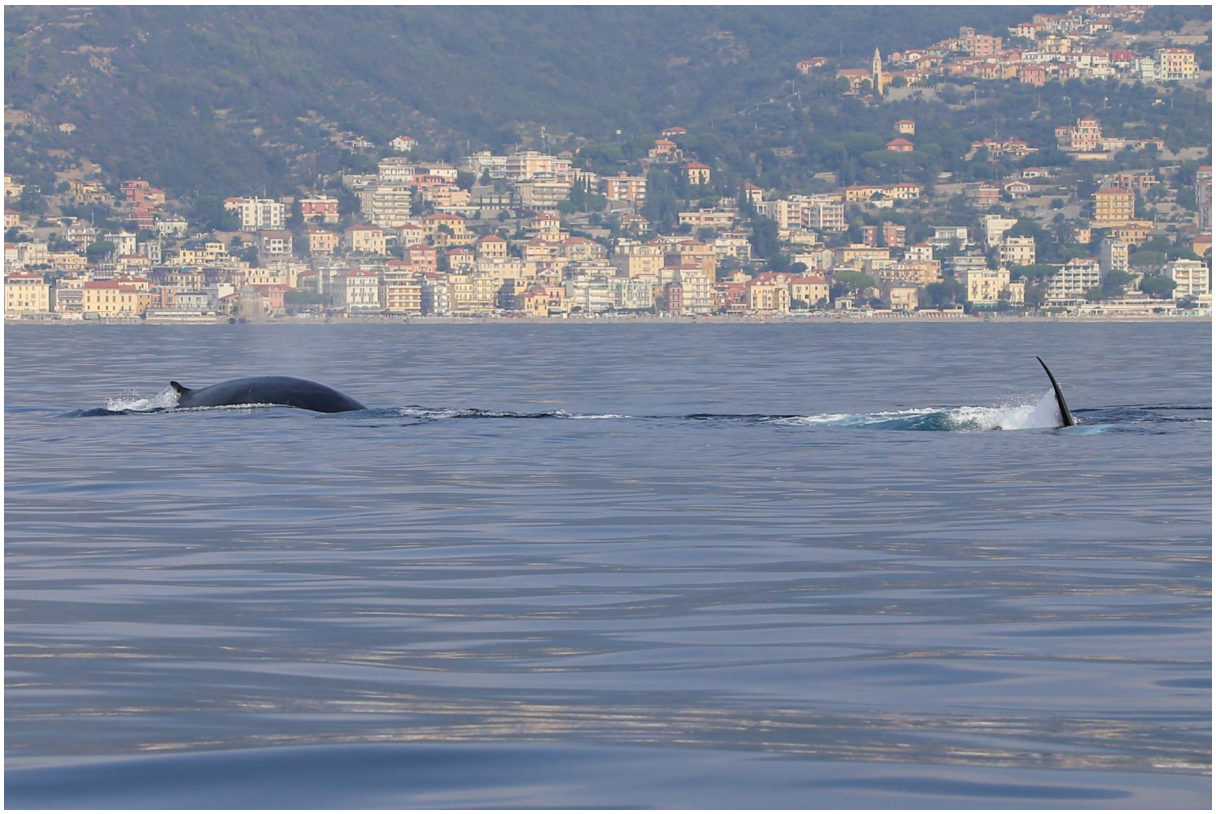

Figure 4: Whale B following Whale A swimming on its side.

Figure 5: Whale B, closer to land, crossing another whale's path.

Figure 6: Whale B (on the right) about to dive, after another whale (on the left), resurfaced very close and in the direction of crossing its path.

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Figures

Figure 1 - Download source file (131.96 kB)
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Figure 2 - Download source file (3.56 MB)
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Figure 3 - Download source file (3.18 MB)
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Figure 4 - Download source file (4.23 MB)
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Figure 5 - Download source file (3.64 MB)
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Figure 6 - Download source file (4.19 MB)
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