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# ANALYSIS OF THE PRESENCE OF FIN WHALE (*B. PHYSALUS*), SPERM WHALE (*P. MACROCEPHALUS*) AND CUVIER'S BEAKED WHALE (*Z. CAVIROSTRIS*) IN THE GULF OF GENOA: IS ANYTHING CHANGING?

## *ANALISI DELLA PRESENZA DI BALENOTTERA COMUNE (*B. PHYSALUS*), CAPODOGLIO (*P. MACROCEPHALUS*) E ZIFIO (*Z. CAVIROSTRIS*) NEL GOLFO DI GENOVA: QUALCOSA STA CAMBIANDO?*

**Abstract** - *Since 2007, Fondazione Acquario di Genova, in collaboration with Golfo Paradiso Whale Watching, has been carried out a research activity on cetacean presence and distribution in the Pelagos area off the coast of Genoa. The aim of this study is to analyse the presence and distribution of fin whale, sperm whale and Cuvier's beaked whale in 2023, comparing the results with the time series from 2007 to 2022. Data were collected from May to October 2023 during daily surveys on board the whale watching boats. Four principal components were analysed: sampling effort, distribution of sightings, encounter rate (ER=number of sightings/km of effort) and the concentration of chlorophyll-a (Chl-a, mg/m$^3$) in surface waters. Among the results obtained, sightings of fin whale recorded in 2023 were far more numerous than those recorded in previous sampling years and Chl-a concentration in the study area was lower in 2023 compared to previous years (2010-2022).*

**Keywords**: *Pelagos area, cetaceans, distribution, habitat, chlorophyll*

**Introduction** - Since 2007, Fondazione Acquario di Genova, in collaboration with Golfo Paradiso Whale Watching, has been carrying out research on the presence and distribution of cetaceans in the Pelagos Sanctuary, off the coast of Genoa. The study area is characterized by two deep submarine canyons, furrowing the seabed in continuity with the Bisagno and Polcevera streams. The aim of this study was to analyse the presence and distribution of the fin whale, *Balaenoptera physalus* (Linnaeus, 1758), sperm whale (*Physeter macrocephalus* Linnaeus, 1758), and Cuvier's beaked whale (*Ziphius cavirostris* Cuvier, 1823) in 2023, comparing the results with the time series from 2007 to 2022. Specifically, we analysed the possible relationships between the distribution of these species and static environmental parameters (bathymetry, presence of canyons, distance from the coast) and dynamic parameters (primary production) that could influence the distribution and presence of these species, also in relation to climate change. The study area is located within the Pelagos Sanctuary (Specially Protected Area of Mediterranean Importance), the only international marine area dedicated to the protection of marine mammals and their habitats in the Mediterranean Sea, covering an area of 87,500 square kilometres. The Pelagos Sanctuary has a high biodiversity, thanks to its dynamic bathymetric profile and upwelling currents that re-circulate nutrients, favouring primary production (Gnone *et al*., 2023). The western portion has typically rocky coasts, crossed by steep and deeply incised submarine canyons, with a narrow and steep continental shelf, briefly connected with a broad bathyal plain (2,500-2,700 m); the eastern area, on the other hand, is characterized by a wide and gently sloping shelf, with typical sandy/muddy ecosystems

(Vassallo *et al.,* 2020). Of particular importance for this study is the Gulf of Genoa, characterized by the two submarine canyons mentioned above, which extend approximately 70 km in length and 20 km in width, reaching a depth of 2,400 meters (Gambardella *et al*., 2021). Since the early 1990s, this area has undergone significant changes in thermohaline circulation, with an increase in temperature and salinity in the intermediate and deep layers. According to Grossi *et al*. (2024), in the Pelagos Sanctuary area the highest levels of primary production were reached in 2008, while in subsequent years a sharp decline was recorded.

**Materials and methods** - Data were collected from May to October 2023 during daily surveys on board the whalewatching boats of the company "Golfo Paradiso Whale Watching". Sampling tracks and sighting points of the target species were recorded by means of a GPS device. For sightings and species identification, Nikon binoculars model 662AA CF Action EX 7x50 were used, which allow spotting at approximately 3 miles from the boat. When analysing the data, we used QGIS 3.34 to produce a map of the sampling effort over the period 2007-2023, a map of the distribution of sightings in 2023, and a map of the encounter rate (ER=number of sightings/km of effort) per sampling cell (2x2 km) over the period 2007-2023. We also calculated the annual ER from 2007 to 2023 and investigated possible time trends with Spearman's rank correlation test. Finally, we analysed the concentration of chlorophyll-a (Chl-a, mg/m$^3$) in surface waters (data from Copernicus), comparing the average value of 2023 with the average value of previous years (2010-2022).

**Results** – We carried out 35 daily surveys, totalling 2,678 km of sampling effort (Fig. 1A). We sighted the Cuvier's beaked whale 14 times, the sperm whale 5 times and the fin whale 31 times (Fig. 1B). Sightings of the fin whale recorded in 2023 were far more numerous than those recorded in previous sampling years (37 sightings over a 12-year period from 2007 to 2022).

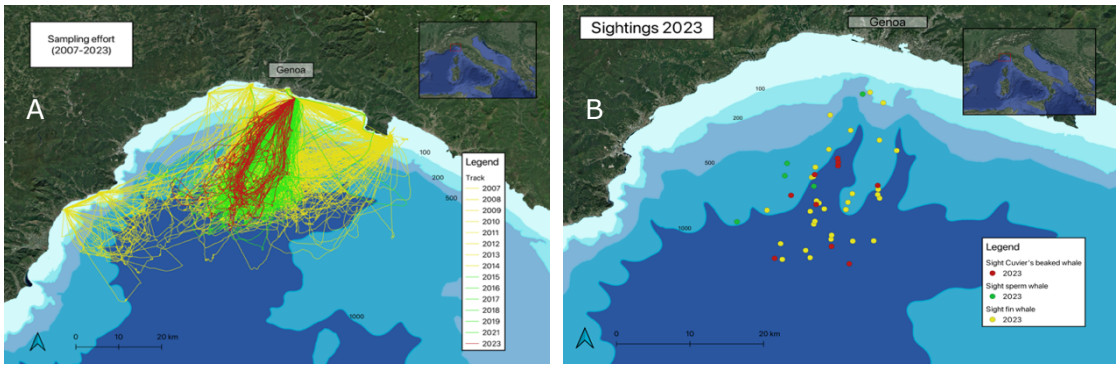


Fig. 1 – (A) Study area with sampling tracks in the different years (2007-2023).
(B) Sightings of Cuvier's beaked whale, sperm whale and fin whale (2023).
*(A) Area di studio con i tracciati di campionamento effettuati nei diversi anni (2007-2023).*
*(B) Avvistamenti di zifio, capodoglio e balenottera comune (2023).*

The encounter rate maps (Fig. 2) show the preferred habitat of each species within the study area: the Cuvier's beaked whale shows a clear preference for the deep portion of the canyons (Fig. 2A); the sperm whale seems to prefer the deep portion of the continental slope, outside the canyons (Fig. 2B); the fin whale seems to prefer offshore waters >1000 m depth but can also be sighted over the continental slope and platform (Fig. 2C).

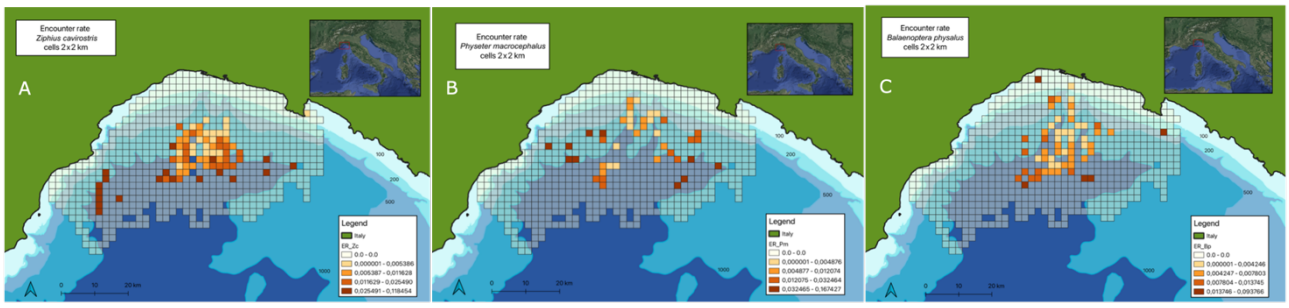


Fig. 2 – Encounter rate of Cuvier's beaked whale (A), sperm whale (B) and fin whale (C) in the study area.
*Tasso di incontro di zifio (A), capodoglio (B) e balenottera comune (C) nell'area di studio.*

In relation to the annual ER (Fig. 3), the sperm whale shows a (slight) positive trend ($R=0.560$; $p<0.05$); the Cuvier's beaked whale shows a clear positive trend ($R=0.692$; $p<0.01$); the fin whale shows no significant trend ($R=0.518$; $p>0.05$).

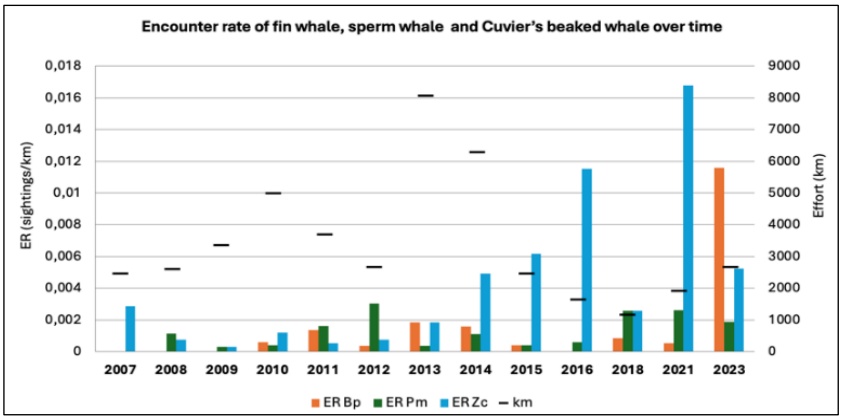


Fig. 3 – Annual encounter rate (ER) of fin whale (Bp), sperm whale (Pm) and Cuvier's beaked whale (Zc) in the study area.
*Tasso di incontro annuale (ER) di balenottera comune (Bp), capodoglio (Pm) e zifio (Zc) nell'area di studio.*

Finally, the Chlorophyll-a concentration in the study area (Fig. 4) was lower in 2023 compared to previous years (2010-2022).

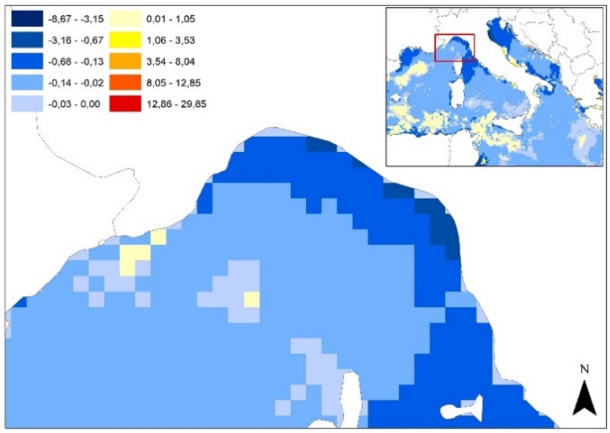


Fig. 4 - Chl-a concentration (mg/m$^3$) in surface waters: average value 2023 compared to average value 2010-2022. In red gradient positive difference, in blue gradient negative difference.
*Concentrazione di clorofilla-a (mg/m$^3$) nelle acque superficiali: valore medio del 2023 rispetto al valore medio del periodo 2010-2022. Il gradiente rosso indica una differenza positiva, il gradiente blu una differenza negativa.*

**Conclusions** - All species analysed are regularly present in the study area. The Cuvier's beaked whale shows a positive temporal trend in the ER, possibly overestimated by the sampling effort, focusing on the canyon area preferred by this species (Fig. 1, 2A). The sperm whale shows a slight positive trend, possibly underestimated by the same sampling pattern over time (Fig. 1, 2B). The fin whale does not show a time trend in ER, but its sightings are extraordinarily high in 2023 (Fig. 3). Our first hypothesis was that *B. physalus* aggregated in the study area due to exceptional food availability, but analysis of primary production does not support this hypothesis. The results obtained highlighted the opposite phenomenon, namely a generalized decrease in primary production throughout the basin and especially in the study area (Fig. 4). We then formulated a second hypothesis, namely that fin whales, in search of feeding grounds, may have moved to the northernmost part of the basin, following the contour of submarine canyons and aggregating in exceptional numbers in the study area.

Changes in migratory patterns, both spatial and temporal, have already been described in cetaceans living in other areas of the globe and seem to be functional in compensating for (or taking advantage of) the effects of climate change (Moore and Laidre, 2006; Ramp *et al.,* 2015). But for cetaceans living in the Mediterranean Sea, this ability of compensating for environmental changes is limited by the characteristics of the basin itself, enclosed between Africa and Eurasia. Climate change, which seems to have among its effects a decrease in primary production, especially in the northern Mediterranean (Ludwig *et al.,* 2010), could therefore have severe consequences for cetaceans. Further studies are needed to verify this hypothesis.

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