Fin Whale Project and Biodiversity on the Catalan coast

EDMAKTUB Association

Contribution to improving knowledge of the fin whale off the coast of Catalonia

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Contenido

EDMAKTUB Association

The EDMAKTUB association, for the Study and Dissemination of the Aquatic Environment, especially cetaceans, is a non-profit organisation based in Barcelona. It was founded in 2000 by Dr. Eduard Degollada.

EDMAKTUB develops its activities on the basis of different research projects, either through its own initiatives or in collaboration with other institutions. The interest is always to deepen the knowledge of the sea and the marine fauna in a global way, in order to preserve its richness and biodiversity.

The EDMAKTUB association has a complete research platform, the central axis of which is a catamaran equipped with reflex cameras, drone, hydrophone, echo sounder, thermal camera, material for collecting biological samples and other instruments for collecting images, sounds and records of sightings and maritime traffic.

The association's team is made up of a group of scientists and specialists in different fields: biology, veterinary science, environmental sciences, audiovisual techniques, etc. Volunteers and university students are a crucial part of the team, allowing research projects to move forward with effort and hours of dedication.

Since 2013, the association has focused its activity on the Rorqual Project, which has been authorised by the Directorate General for the Sustainability of the Coast and the Sea of the Ministry of Agriculture, Food and the Environment to approach cetaceans for scientific purposes along the Catalan coast and the Balearic Sea (rf116/3662).

www.edmaktub.org

Presentation of the Fin Whale Project

During the months of February to June, an extraordinary phenomenon occurs on the Catalan coast which, although it has been reported for decades by fishermen in the area, was little known in the field of research: the presence of fin whales.

With the scientific name of *Balaenoptera physalus*, the fin whale is a whale that can reach up to 24 metres in length and is the only whale that regularly inhabits the Mediterranean. The fin whale is a filter-feeding animal that feeds on fish and plankton, especially krill, which it swallows in large quantities[1].

It is also a protected species and in a vulnerable conservation status (according to the IUCN) [54].

Fin whale photographed by the research drone as it surfaced to breathe off the coast of Garraf.

With the dual aim of increasing knowledge about the presence of this whale on our coasts and promoting its preservation, the Rorqual Project has been underway since 2013, an initiative of the EDMAKTUB association. The Rorqual Project is a project that from the outset was conceived as a long-term project, as many seasons are required to understand the presence of fin whales on our coasts and the variables that affect their distribution.

The Rorqual Project is a pioneering research project because it is the first to study whales on the Catalan coast, and also because it uses new technologies such as drones to capture images and their subsequent analysis and development of new sampling techniques.

This project also includes the study of the biodiversity of the Catalan coast, including the remaining 7 species of cetaceans, seabirds, sea turtles, fish and hydrozoans, among others.

This Project counts on the collaboration of the Club Nàutic de Vilanova, Ports de la Generalitat, the Dirección General de Pesca de la Generalitat de Catalunya, the Institut de Ciències del Mar (ICM-CSIC), the Ajuntament de Vilanova i la Geltrú, and the Catalan fishing and nautical sectors. Recently, two new collaborations have been made; with the company TimeZera, a nautical software company, and FLIR, a thermal camera company. he Lighthouse and Plastic Ocean foundations have also been collaborating in the Rorqual 2022 Project.

Main objectives of the Fin Whale Project

The Fin Whale Project has three main aims:

1. **To improve knowledge of the fin whale** and the oceanographic conditions that favour its seasonal presence on the Catalan coast. Specifically, the project proposes:

    a. To draw up **maps of the presence and distribution** of the fin whale along the Catalan coast, analysing the number of individuals, their behaviour patterns and possible migratory routes.

    b. **Photo-identify the animals** observed, expanding the catalogue of fin whales sighted in the area. This catalogue will later be compared with catalogues of other Mediterranean and Atlantic associations in order to establish the possible migratory routes of fin whales in the Mediterranean.

    c. Determine the **oceanographic characteristics** of the area; chlorophyll and nutrients, temperature, salinity, and altimetry of the sea and their relationship not only with the presence of fin whales, but also with the great biodiversity of the Catalan coast.

    d. Collect **acoustic records** of the whales' vocalisation during their stay in the area.

    e. Determine the most abundant **plankton** species in the area and their relationship with oceanographic conditions and the presence of fin whales.

    f. Determine the **microplastic** conditions in the area and how it may affect whales in the study area.

    g. **Assess the risk of collision** between whales and merchant vessels, identify areas of particular risk and identify new techniques and regulations for the protection of fin whales to minimise the risk.

h. Implementation of a new **drone survey technique for cetacean identification** and the development of an artificial intelligence algorithm to automate this recognition.

i. Use of **stable isotopes** to determine diet and migratory route.

j. **Genetic analysis** to determine the sex, the population of fin whales inhabiting our coast and the possible kinship among them.

k. **Hormone analysis** to determine the level of stress, reproductive status, among others.

l. **Satellite tagging** to determine the movements of fin whales in the Mediterranean and the possible migratory routes they follow.

m. To draw up maps of the presence and distribution of biodiversity in the area of the Garraf coast and the relationship of these with the presence of fin whales and the oceanographic conditions of the area.

2. **To raise public awareness and promote the conservation of the marine environment**. The knowledge acquired about the species and its habitat allows us to determine the critical parameters for its conservation and to make recommendations. Through information, we contribute to making people, both at an individual and collective level, more willing to participate in environmental conservation. In the field of awareness and preservation, these are the objectives of the project:

    a. To demonstrate the special **ecological importance of the Catalan coast**, not only for the presence of whales but also for its remarkable richness in other marine species.

    b. Maintain a **network of contacts with fishermen and sailors** in the area and obtain information on their sightings.

    c. **Marine stewardship**: to involve the different entities and people who make use of the area, making them protagonists of the conservation tasks (not only fishermen and sailors, but also institutions and citizens of nearby towns). All of them are an essential part of establishing a network of marine stewardship of the Garraf coasts, with the common objective of conserving the area and its rich biodiversity.

    d. **Promote the designation of the Marine Mammal Protected Area** (MPA) for the Garraf Marine Area and other areas with a special presence of fin whales along the Catalan coast.

3. **Improve ethical standards** in cetacean field research.

    a. Develop **new research protocols**, defining new techniques and methodologies that are more effective and, at the same time, less invasive and less disturbing for the animals.

    b. To contribute in this way to **raising awareness among researchers** of the importance of wildlife welfare.

In order to achieve the objectives described above, three areas of action are carried out: research, education and dissemination.

Highlights of the Fin Whale Project 2022

2022 has been the eighth season of the Fin Whale Project, a season with a high number of sightings, in which the weather has once again been one of the main protagonists and in which new equipment has been obtained that has allowed us to make progress in the study of the fin whale. The highlights of the season are listed below:

- The 2022 season has been particularly **marked by the weather**, with strong winds **restricting scientific surveys in March**, allowing only 4 days of the campaign to be carried out this month. These adverse conditions, however, have also had a positive aspect, affecting water mixing and plankton blooms on the coast, **extending the season until the end of May**. The rest of the season the weather conditions have been more favourable and have allowed regular trips during the months of April, May and June. From the end of June to the beginning of July, the season has been extended in the coasts of Denia.

- There has been a **high presence of whales**, with a total of **117 sightings and 166 animals sighted**, continuing the trend of 2021. In this case, the wind and the rains in March favoured the production peaks and the presence of plankton, the main food of the fin whales, in April and May.

- **Feeding behaviour was observed in 70% of the sightings on the Garraf** coast, while travelling behaviour was observed in less than 1% of the cases. In contrast, **travelling behaviour was observed in all the animals sighted on the coast of Denia**, all the animals were heading south-west and at a constant speed.

- An **echo sounder** has been installed, which has been used for **the detection of masses of organisms, possibly plankton, in the areas where we have found fin whales feeding**. In-depth sampling is necessary to be able to determine the organisms that form these dense patches on the echo sounder and on which the fin whales are probably feeding.

- At the end of March 2022, a **thermal camera** was installed on the mast of the research catamaran, the Maktub, with the aim of assessing its viability for **remote detection of fin whales**, in order to determine whether it is a useful tool for minimising collisions, the main threat to whales worldwide. During this season, several hours of thermal camera footage has been collected with the fin whales. **Being able to detect fin whales up to 1000 metres away**. These preliminary results are very promising, but we need more hours of study to be able to determine their viability.

- The **TimeZero software** has **facilitated our cartographic, oceanographic and navigational work, as well as the visualisation of the thermal camera and the echo sounder**, allowing us to download daily weather and oceanographic forecasts which have been used to predict the presence of whales in the different areas of the study zone. This software has also facilitated the **collection of traffic data** and has allowed us to store the information in a much more efficient format.

- The **professional fishermen** of the Catalan coast, especially the trawling fleet, have once again been great collaborators of the project, reporting sightings, fishing and oceanographic conditions along the Catalan coast. This season, the collaboration of **8 fishermen's guilds** has been maintained, the same as in the last 4 years, and a total of **95 sightings of fin whales** have been reported.

- This season, **five satellite tags** have been deployed, with **the collaboration of Dr. Simone Panigada of the Tethys Research Institute**. These tags are used to **track the fin whales, allowing the tagged animals to be monitored during the month of May and the beginning of June**. During this time the animals **have been roaming the Catalan coast and the Gulf of Lions**, marking possible feeding areas.

- A total of **26 biopsies** have been taken, which will be used to carry out **genetic, hormonal and stable isotope studies** that will allow us to determine basic aspects such as sex, kinship, the time of the reproductive cycle and the level of stress, as well as the areas and type of feeding.

- A total of **86 animals have been identified through photo-identification by fin and a total of 102 animals with the drone identification technique**. This increases the overall **fin whale catalogue to 244 individuals identified by fin and 235 individuals identified with drone images**. The drone photo-identification technique is a pioneering technique initiated in 2015 and systematically implemented in 2021. It is giving excellent results and is being used season after season to optimise this identification process. Of the animals identified this season, **24 of them have been sighted on more than one occasion within the same 2022.**

- **Collisions with vessels are the main concern for the conservation of fin whales** along the Catalan coast. The data collected, together with the animals showing collision marks and the high level of maritime traffic, indicate the high threat that vessels represent for this species. It is also worth mentioning the **disturbance caused by the harassment of recreational vessels, which are irresponsible, insensitive and unaware of the law that protects cetaceans and prohibits their approach** (Royal Decree 1727/2007, of 21 December, which establishes measures for the protection of cetaceans).

- **During our stay in Denia we were able to identify 3 animals that had previously been sighted feeding on the Catalan coast**. This proves that some of the animals that frequent the Catalan coast at the end of the season head south towards the Atlantic, passing very close to the coast of Denia on their migratory route. At the end of the feeding season on the Catalan coast, the whales move to offshore areas and in mid-June the Atlantic animals begin their migration southwards, passing very close to the capes of Denia, Cabo de Palos, Cabo de Gata and the Strait of Gibraltar[7,22,37,38]. These recaptures corroborate the hypothesis put forward that part of the fin whale population, which feeds in Catalan waters, is from an Atlantic population. However, this does not rule out the possibility that fin whales from the Mediterranean population also feed in this area, which in turn, in summer, will head towards the Ligurian Sea, the protected area of the Pelagos Sanctuary[43,44,46,51,52,53]. These data make the feeding area of the Catalan-Balearic Sea, and especially the Catalan coast, one of the most important areas for fin whales in the Mediterranean, and worthy of consideration for any conservation plan for this species.

Methodology

For the development of the marine campaigns of the Fin Whale Project, **random transects** are carried out on board the Maktub, the research vessel of the EDMAKTUB association. It is a Catana 47 sailing catamaran, 14.15 metres long and equipped with all the material necessary to carry out the research.

The marine campaigns are carried out **daily from the beginning of March to the beginning of June**, weather permitting. During the trips, random transects and a sighting effort are carried out in which four researchers cover 360 degrees of the vessel and record all the biodiversity, meteorology, oceanographic conditions and merchant ships that are observed along the transect [62].

When cetaceans are sighted, the effort is stopped and the environmental conditions, time, GPS data, distance and angle to the vessel, species, number of animals, interaction with the vessel, behaviour and whether photographs and photo-identification have been taken are recorded. In the case of fin whale sightings, a detailed record is made of the behaviour of the animal(s), **the drone is used to obtain a complete record of the behaviour and number of animals**, also using it as a **tool for photo-identification** of individuals through the pigmentation marks of the zenith

zone, the chevron and the blazer. Work is also being carried out to develop the technique for collecting biological samples and satellite TAGs are being fitted.

Fin whale with the research vessel, the Maktub, behind it.

A number of sampling points have been identified for the collection of oceanographic and plankton samples. Including the collection of samples in areas where fin whales are present whenever possible and considered relevant to the research.

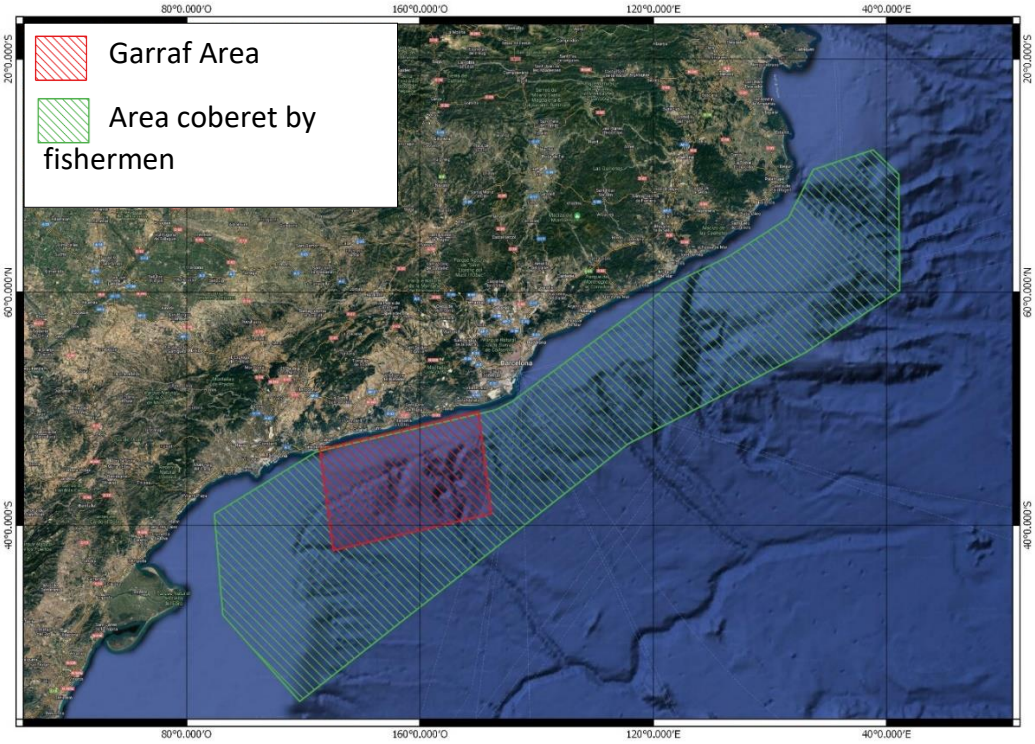
Study area

The Fin Whale Project mainly covers the coastal area between Barcelona and Tarragona. This area comprises a **marine strip of 1944 km^2 located between the towns of Castelldefels and Torredembarra, extending 12-15 miles out to sea**. The base port for the project's marine campaigns is Vilanova i la Geltrú. In order to increase our knowledge of the presence of fin whales on the Catalan coast, in recent seasons the project has expanded the study area, carrying out transects along the Catalan coast and the Catalan-Balearic Sea, focusing on the area of Blanes and Palamós mainly at the end of May and beginning of June. **In 2017 and 2022, expeditions have been carried out on Denia** to monitor the population of fin whales that migrate towards the Atlantic in summer.

The Garraf coast is an area characterised by a short coastal platform, which reaches up to 5 nautical miles out to sea, and by the presence of two submarine canyons, the Foix submarine canyon, which is located between Vilanova i la Geltrú and Sitges, and the Cunit - Cubelles canyon. The area is also within the influence of the Llobregat river and the Garraf streams.

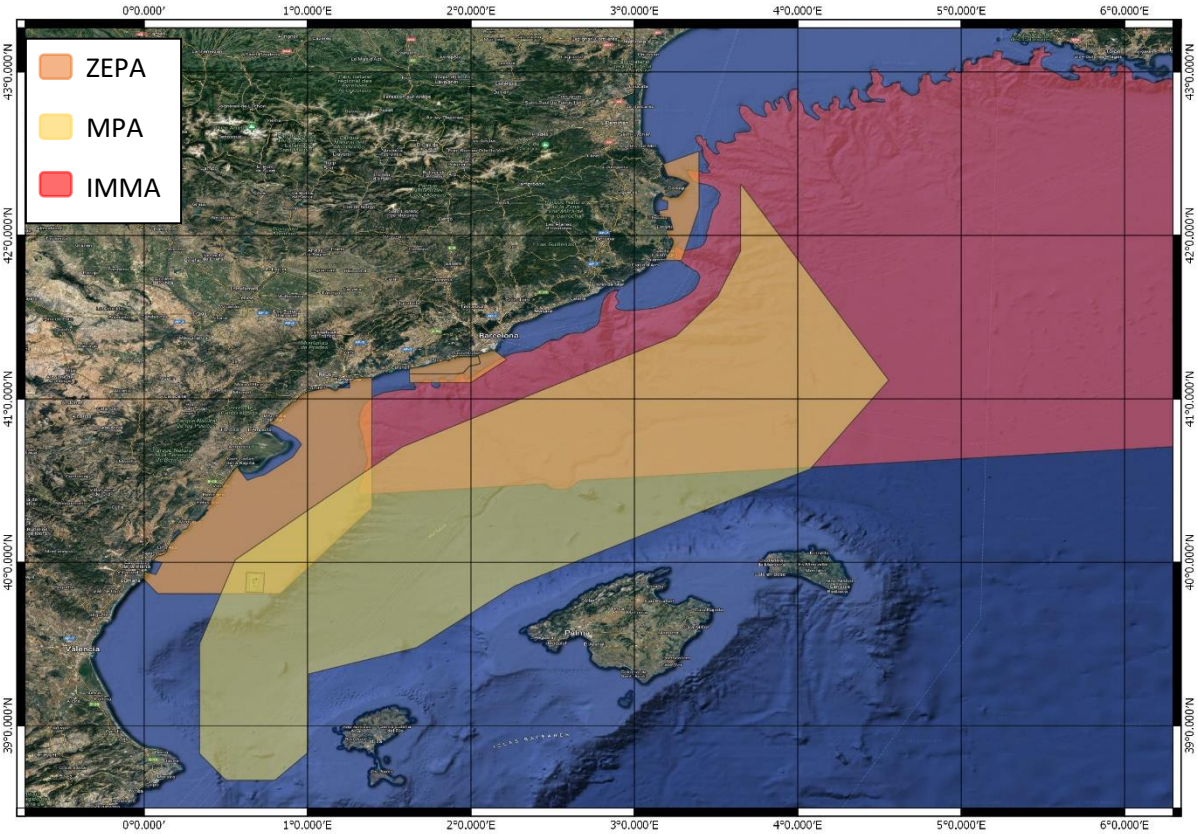
The **submarine canyons** are involved in a series of oceanographic dynamics that generate upwellings of water from the seabed, which is loaded with nutrients[56]. This phenomenon combined with the input of nutrients from the coast[59] makes this area a **high production area** which favours a high biodiversity of seabirds and also cetaceans, including the fin whale.

The **network of contacts established with fishermen and sailors** in the area allows us to know the ecological situation and the presence of cetaceans, especially fin whales, in the area between **Palamós and Ametlla de Mar**. It also provides us with information on the Balearic basin, on a more occasional basis.



Area of maximum effort of the fin whale project marked with a red rectangle with stripes and the area of the coast regularly covered by the fishing boats that collaborate with the project, green rectangle with stripes

This study area is an area of recognised ecological importance: it is part of an area declared as a Site of Community Importance (LIC) and Special Protection Area for Birds (SPA) of the Garraf coast, belonging to the Natura 2000 Network, the SPA area of the Baix Llobregat - Garraf marine area, it belongs to the Network of Marine Protected Areas of Spain (RAMPE), and to the Plan for Areas of Natural Interest (PEIN). A new Important Marine Mammal Area (IMMA) of the northwest Mediterranean, the system of submarine slopes and canyons, has recently been incorporated. Outside of the study area of the Fin Whale Project is the migratory corridor of cetaceans, established as a Marine Protected Area (MPA) in 2019.



Map showing the protected areas on the Catalan coast. In orange are represented the SPA areas (Special Protection Areas for Birds), in yellow is represented the cetacean corridor MPA, and in red is represented the Important Marine Mammal Area (IMMA).

The fin whale

The fin whale (*Balaenoptera physalus*) is a species of cetacean, which belongs to the suborder of the mysticetids (baleen whales). It is the second largest animal in the world (up to 24 metres in length), and is the only species that regularly inhabits the Mediterranean Sea[4,48].

Fin whale swimming off the coast of Garraf.

Fin whales are pelagic filter-feeding whales that feed mainly on krill (small crustaceans of the order Euphausiacea, which are part of the zooplankton) but also on copepods, small fish (mackerel, anchovies and sardines) and squid[1].

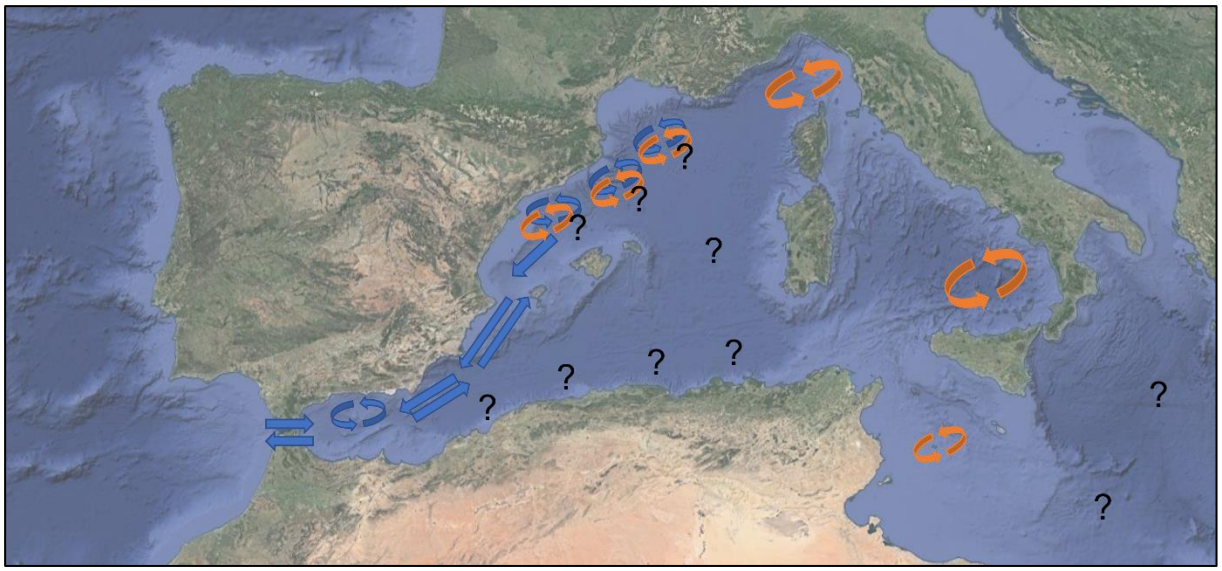
The appearance is slender, with a pointed snout and a dorsal fin set back in the dorsal area, proportionally the largest dorsal fin in the rorqual family. It has a characteristic facial asymmetry: the colouring of the jaw is white on the right side of the head and black on the left side[1]. As mentioned above, it is a species about which little is known and which is endangered according to the IUCN[54].

Right facial image of fin whale showing the white right jaw, the blazer, on the right side of the head and behind the blowhole, and the beginning of the chevron further back from the blazer.

Like all balenopterygids, it migrates for breeding or feeding, moving seasonally to low, temperate latitudes in winter and to colder, more productive waters with abundant food in summer[1]. This migration has recently been called into question in the Mediterranean, however, attributing the presence and movements of fin whales to the abundance of food[48]. The fin whale is characterised by its high swimming speed, which can exceed 30 km/h.

Distribution of fin whales in the Mediterranean

There are considered to be two populations in the Mediterranean, one Atlantic and one Mediterranean[8,49]. The Atlantic population enters through the Strait of Gibraltar mainly from December to February and leaves again from June to September [7,22,29,37,38]. On the other hand, the Mediterranean population remains within the Mediterranean all year round, being found in the Ligurian Sea in summer in greatest concentration, from July to September [29,31,43,44,46,51,52,53,55] in the area of the island of Lampedusa [23] in winter and in the area of the Tyrrhenian Sea in spring and autumn [2].



Map showing the migration patterns of fin whales in the Mediterranean. The Mediterranean population is represented in orange, while the Atlantic population is represented in blue. The question marks are due to lack of knowledge.

Recently, the migration of fin whales in the Mediterranean has been questioned as variations in their latitudinal distribution have been found, mainly linked to the presence of food. For this reason, it is currently being confirmed that the migration of fin whales in the Mediterranean is a constant movement in the search for food, which marks these movements [30,40,48].

Regarding the Catalan coast and the Balearic Sea, thanks to the fin whale project, it has been discovered that these individuals concentrate in this area in the spring to feed. It is not yet known to which population these individuals belong, but the main hypothesis at present is that both populations are found, the Atlantic population, which is seen travelling south along the coasts of Denia mainly in June and July, and the Mediterranean population, which would go to the Ligurian Sea at the end of the feeding season along the Catalan coast

Presence of fin whale on the Catalan coast

Throughout the 9 years of the project it has been possible to describe a situation not previously described, **the presence of fin whales on the Catalan coast during the spring months to feed.**

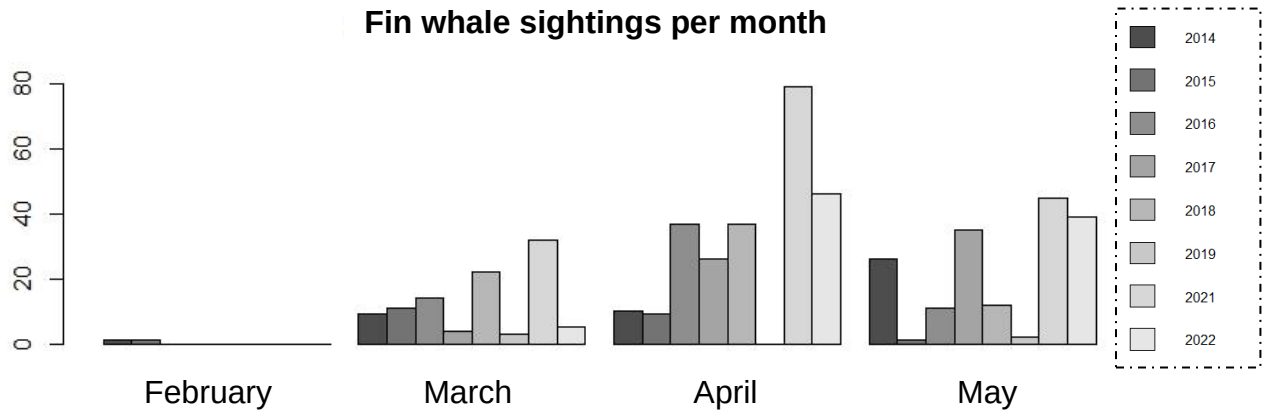
In these years we have been able to observe variations in the presence and distribution of fin whales on our coasts. 2021 was the year with the highest number of sightings and 2019 the year with the fewest sightings. 2022 has been a year with a high number of sightings, following the trend of 2021, taking into account the weather restriction in March, in which only 4 trips could be made.

Descriptive table with the results of the Fin Whale Project, including the two pre-seasons 2011 and 2013.

Season	Days of campaign	Km covered	Number of sightings	Number of animals sighted	Number of sightings fishermen and sailors
2011	14	---	11	14	---
2013	11	---	9	13	---
2014	51	2.289	46	62	16 / 4
2015	61	2.532	22	29	21 / 2
2016	51	1.919	62	100	170 / 13
2017	50 / 3 / 10	1.844	65 / 7 / 5	84 / 11 / 8	144 / 11
2018	48	2.133	71	99	109 / 5
2019	36	2.618	5	5	35 / 1
2021	53	3.852	165	204	68 / 9
2022	**47 / 9**	**4.250**	**110 / 7**	**146 / 20**	**90 / 5**
Total	**422 / 3 / 19**	**21.437**	**566 / 7 / 12**	**756 / 11 / 28**	**653 / 50**

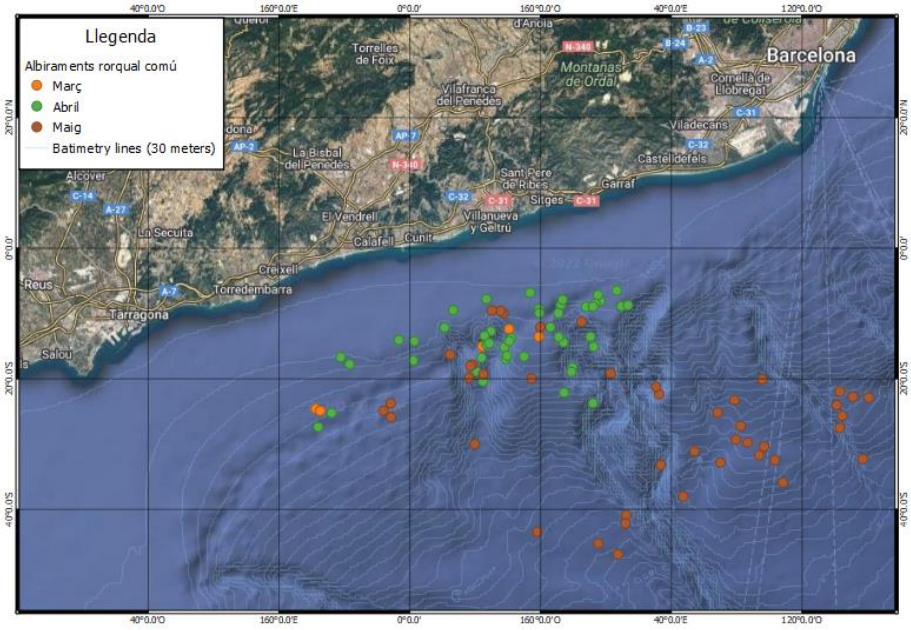
**The days of the fin whale project on the Catalan coasts are written. In 2017 there are two separations " / " referring to Mallorca and Denia while in 2022 there is one separation referring to the stay in Denia. The total sightings are written on the Catalan coast " / " Balearic Islands " / " Denia.*

This variation is also reflected in the monthly distribution of sightings over the years, with April being the most regular month with the highest number of sightings.

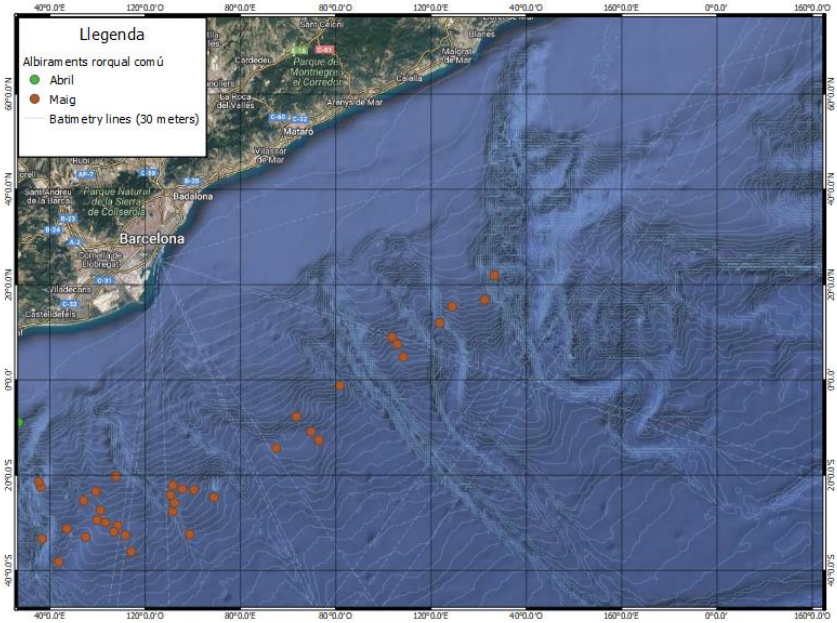


Graph showing fin whale sightings per month over the seasons.

In March and April the whales concentrate more in the 50 to 200 metre deep areas, at the edge of the shelf and the heads of submarine canyons. These are areas with a high nutrient flux, which will make them very productive and therefore rich in food for fin whales. In May and June, on the other hand, due to rising temperatures and stratification of the seawater, the fin whales move into deeper waters, frequenting areas between 500 and 1000 metres. There is also a latitudinal shift more towards the north of the Catalan coast as the season progresses, especially in May and June.



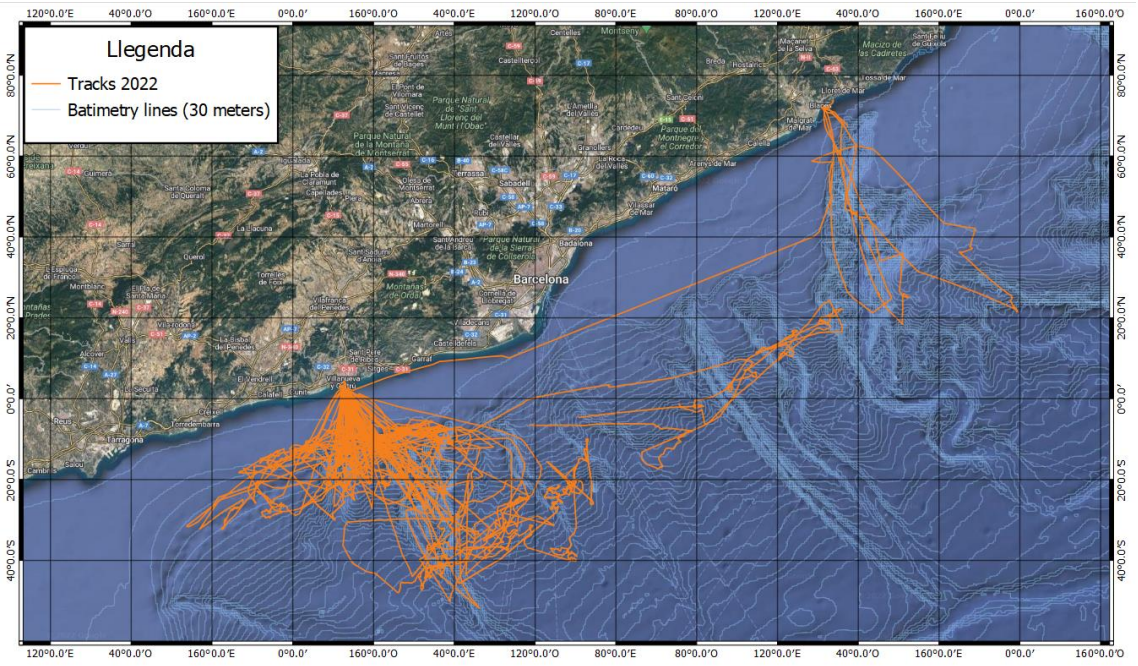
Sightings map of the Garraf coast area, between Barcelona and Tarragona. The bathymetric lines are drawn every 30 metres.



Map of sightings in the area between Barcelona and Blanes. The bathymetric lines are drawn every 30 metres.

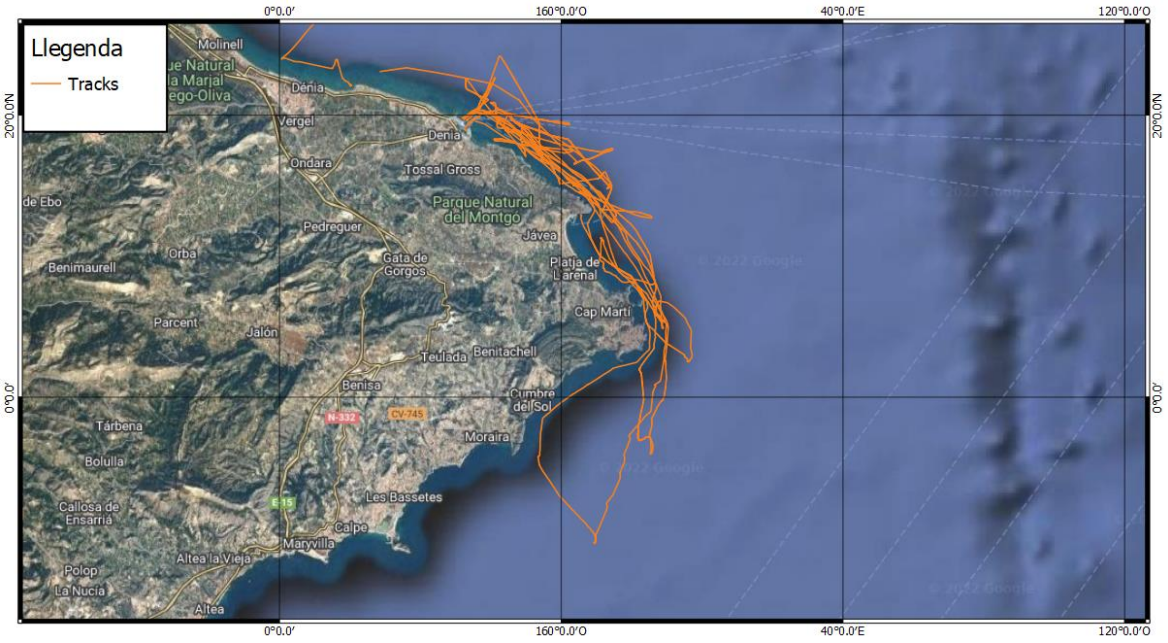
The effort has been concentrated in the Garraf area, between Castelldefels and Torredembarra, especially in the area of the edge of the shelf and in the submarine

canyons. The trips in the areas of 1000 metres and the area between Barcelona and Blanes in May and June are due to the variation in the distribution of fin whales.



Marine survey tracks of the Fin Whale Project 2022.

At the end of June, the project travelled to Denia to monitor the animals migrating towards the Atlantic. By making a few trips very close to the coast.



Marine survey tracks done off the coast of Denia at the end of June.

In Denia the animals pass very close to the coast travelling in a southerly direction at a speed of between 4 and 7 knots, mostly. They usually go in groups of 2 to 5 animals following the perimeter of the coast at a depth of about 30 metres.

Map with sightings recorded off the coast of Denia in June 2022.

Picture of two fin whales sailing off the coast of Denia, heading south and very close to the coast.

Meteorology and Oceanography

As it is a feeding area, the presence and distribution of fin whales is linked to the oceanographic and meteorological conditions of the area. The variables that have been identified as the main factors explaining the presence of fin whales are: rainfall, temperature, chlorophyll (as an indicator of production), bathymetric contour and surface currents produced by the wind.

The supply of nutrients from rivers and streams has proven to be crucial for the production of the area, due to its proximity to the coast[59]. It has been observed that in years with a strong drought, such as 2019, the distribution and presence of whales changed radically, being the season with the fewest sightings in the entire history of the project.

Primary production in the seas and oceans is estimated through the concentration of chlorophyll, present in phytoplankton [5,63]. This concentration can be related to the presence and abundance of zooplankton, the main food of whales in this area[30,31,43,46].

Wind and temperature also play a crucial role in the production of the area as they mark the stratification[59]. For an area to be productive, it must have nutrient inputs and a large mixing layer that allows the nutrient-rich bottom waters to mix with the surface waters, where primary production takes place. By stratifying, not as many nutrients reach the surface layers and these are impoverished, reducing their production. Cold and/or windy winters and springs promote mixing layers that are maintained for longer, extending the conditions that favour food for the whales, as was the case in 2022, a year in which the strong winds prevented practically no outings during the month of March but in which the season was extended until the end of May on the coasts of Garraf and until mid-June in the north of Catalonia. On the contrary, in warm and/or not very windy winters and springs, the stratification of the water column occurs earlier, causing an impoverishment of the area, reducing the whales' feeding season, as happened in 2015.

Chlorophyll, water temperature and wind-driven currents are obtained from satellite maps. Water column temperature is obtained by displaying different points of the coastline routinely using a CTD.

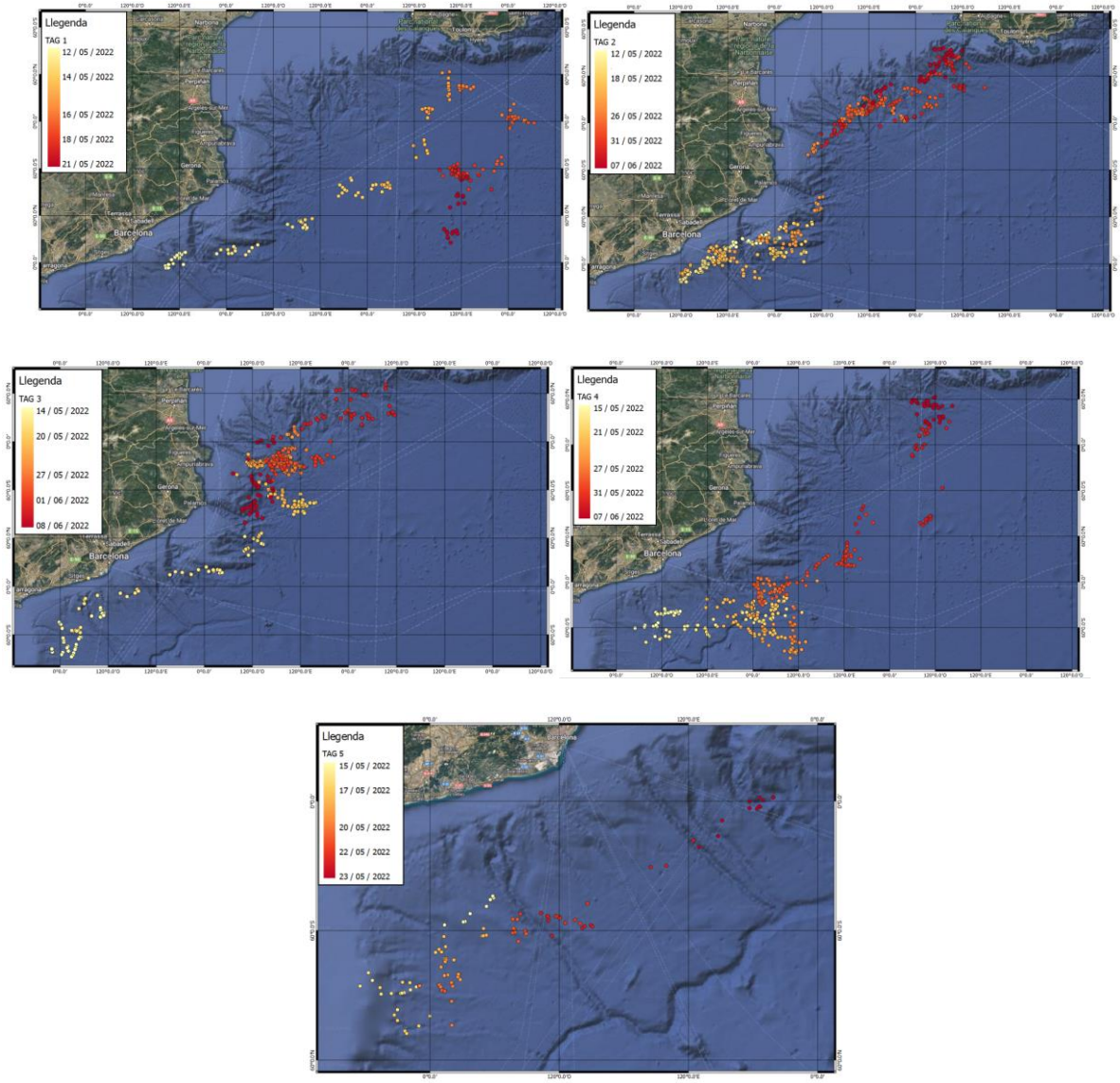
In the northern part of the Catalan coast and the Gulf of Leon, there are strong north-westerly winds during the spring that allow the water to remain cooler during the months of May and June. This fact, together with the supply of nutrients from the great European rivers, mainly the Roine, which is loaded with water and sediments from the Alps, generates a very productive area, especially in May and June. It has been observed that from March to the beginning of May there is a high concentration of whales between Tarragona and Barcelona, but from mid-April onwards the concentration of whales begins to increase in the area from Barcelona to Palamós until mid-June.

Satellite tags

The routes along the coast were also observed in 2021 and 2022 for the satellite-tagged fin whales, with the most animals tagged in 2022, a total of 5. **Between 2018 and 2022, a total of 9 TAGs** were placed in **collaboration with Dr. Simone Panigada**, director of the Thetys Research Institute. These TAGs are placed on the dorsal fin and are transmitting information of the animal's position through the ARGOS system[53]. These tags **have been transmitting for 7 to 32 days**.

Table with the transmission days of the TAGs placed between 2018 and 2022.

	2018	2021			2022				
	TAG1	TAG1	TAG2	TAG3	TAG1	TAG2	TAG3	TAG4	TAG5
Placement date	16/05	06/05	07/05	08/05	**12/05**	**12/05**	**14/05**	**15/05**	**15/05**
Transmission days	7	32	25	15	**10**	**27**	**26**	**9**	**24**



Maps showing the route of the 5 satellite-tagged animals along the Catalan coast during the 2022 Fin Whale Project. Yellow indicates the initial positions of the first days, this colour intensifies, and the dark red dots are the last positions sent by the TAG before the animal loses it

As can be seen in these maps, the fin whales marked at the beginning of May remain on the Catalan coast, moving towards the north of the Catalan coast and the Gulf of Leon, showing movements that are related to feeding patterns.

Fin Whale feeding area

In order to determine the behaviour of the fin whales and to establish the area as a feeding ground, **the sighted animals are monitored by recording their breathing, their location in relation to the vessel and the position of the animal in relation to the vessel** as well as the parts of the body that it shows during each breath.

These records are complemented by **drone videos** which give us a lot of information related to the behaviour of the animal near the surface. Thanks to the drone we have been able to record feeding episodes and describe them, recorded for the first time in 2015. We have also been able to observe interactions between animals of the same species and between different species such as striped dolphins and bottlenose dolphins. This season **2022 we have been able to observe interactions with** both species of **dolphins several times** throughout the season. A curious fact about this interaction, especially with striped dolphins, is the excitement that the dolphins seem to have when the fin whale is approaching the surface to breathe, a fact that has helped us on several occasions to position the boat before the first breath of the fin whale.

Image of a fin whale coming up for air with a group of striped dolphins swimming overhead.

We have found that the majority of animals, **between 70 and 75 percent of the whales observed on the Catalan coast and the Balearic basin**, follow non-linear trajectories (circular, zigzag, etc.) related to **foraging or feeding patterns**, and that these differ from those of individuals that are travelling, which follow linear trajectories

at a constant speed[42]. This **travel behaviour** has been observed in the **individuals sighted off the coast of Denia**, all following a south-westerly course and a constant speed.

Secuence of a fin whale feeding near the surface.

On some occasions, reddish spots in the water corresponding to a high concentration of krill can be observed from the drone. It is also possible to see, when they eat at the surface, how the krill jumps out of the whale's mouth trying not to be caught by the whale.

Image of a fin whale surface feeding and a krill spot. You can see how the water in front of the mouth is reddish in colour and the krill is jumping out of the animal's mouth.

Individuals sighted in the area are usually alone, although they sometimes aggregate to form small groups of 2 or 3 animals for short periods of time. It is not known whether these associations are motivated by gregarious feeding behaviour or by social behaviour. These groupings are not necessarily formed by the same individuals, therefore, they cannot be attributed to family structures. The highest concentrations of animals are related to the weeks with the highest concentration of food, as indicated by oceanographic conditions. During these weeks in different seasons, up to 8 animals have been observed feeding for hours in the same area.

These aggregations of animals have also been observed with resting behaviour at the beginning of the day, in particular on 15 May 2022 when 6 animals were sighted resting together and separating after a few hours to start feeding.

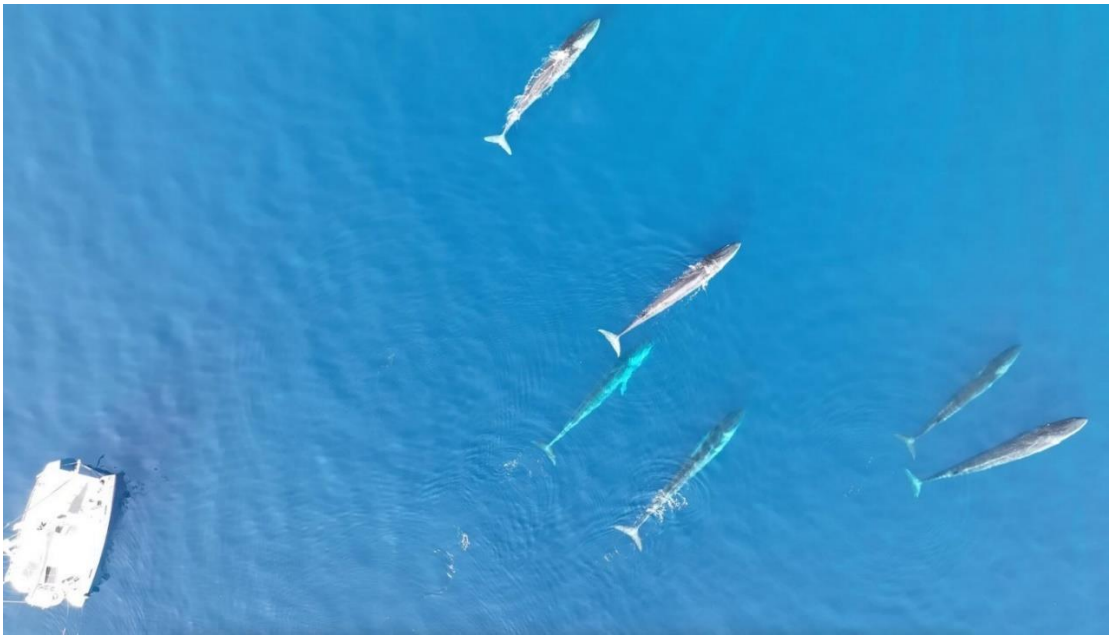


Image of 6 fin whales resting.

Differences in breathing patterns have been recorded, with dives of 1 to 4 minutes in near-surface feeding, which occurs mainly in March and April, with more near-surface feeding observed at the end of the day, a fact related to the vertical migration of plankton. At midday and in the months of May and June, feeding is detected at greater depths, with dives lasting 8 to 10 minutes.

Two fin whales feeding near the surface. One is feeding vertically and the other horizontally with the white side facing the bottom.

The feeding of the whales is also confirmed by the direct observation of defecations, which stain the water with a reddish colour. **This season, defecation has been observed on more than 8 occasions**.

Defecation of a fin whale.

Fin whales have been observed to approach vessels without apparent fear, whether they are fishing vessels, large merchant ships or recreational craft. This fact makes maritime traffic one of the main threats to fin whales worldwide.

Photo-identification of the fin whale

Photo-identification is one of the main techniques used to study cetaceans[58,64]. It consists of identifying an individual and being able to recognise it on another occasion and in another place and year. This identification, for this species, is usually done by **analysing the shape, colouring, notches and scars on the dorsal fin**. It is therefore very important to obtain photographs with a good resolution and at a 90-degree angle to the individual[58,64]. However, it also gives us individual information on their **characteristic pigmentation patterns, called chevron and blaze**[1], which are highly identifiable thanks to the zenithal images obtained with the drone. It is also important to obtain images of the individual's characteristic features, such as scars, parasites, malformations, etc. These can be permanent or temporary, in the latter case, it can help us to identify individuals in the short term (within the same season).

The **photo-identification of fin whales by drone** is a pioneering technique developed for the EDMAKTUB association over the years and is giving excellent results. The automation of this technique has allowed us to recognise the animals in a much more efficient and reliable way, as **the pigmentation of the chevron and blaze does not change over the years, while the fin can be modified** with new marks that can make it difficult to identify the individual between seasons[3,32,57].

Image showing individual Bp_045, an individual sighted over several seasons and which appeared with a new mark on the fin in 2021, thanks to the identification through the chevron it was possible to determine that it was the same animal.

Currently, we have a fin catalogue of 244 individuals, and a drone catalogue of 235 individuals. Having identified in 2022 a total of 86 individuals per fin and 102 individuals through drone imagery.

Thanks to photo-identification we have been able to recognise the presence of the same individuals throughout the seasons, having animals that have been seen almost every season in which the Fin Whale Project has been carried out. A clear example would be the individual Bruixa, a male that has been sighted repeatedly throughout the seasons, within the same year and in consecutive years: 2011, 2014, 2015, 2016, 2017, 2018, 2021 and 2022.

Each year more individuals are recaptured, **reaching 22% inter-annual recaptures and 28% intra-annual recaptures in 2022**. These numbers still give a high number of new individuals each season; this fact and the fact that this is a migratory species with a very wide distribution area makes it very difficult to calculate the abundance of the species.

Marine traffic

Maritime traffic is one of the main dangers faced by fin whales worldwide, being quite high in the Mediterranean due to the density of traffic[50,62].

The Catalan coast is a very busy area, mainly due to the ports of Barcelona and Tarragona. This presence of commercial vessels together with the presence of whales and **the predominant feeding behaviour in the area makes the risk of collisions in this area particularly high**[62].

Over the seasons there have been many occasions when we have photographed whales close to merchant vessels, which pass through the feeding grounds of fin whales.

Image of a fin whale with a cargo vessel behind it.

Animals with injuries caused by interactions with boats have also been recorded on several occasions. The most serious injury was observed in two animals sighted in different years with lumbar scoliosis, a deformation of the spine just behind the dorsal fin. In 2022, the animal that was first sighted in 2018 with this deformation has been sighted twice feeding on our shores indicating that this is an injury that the animal can adapt to and survive.

Image of a fin whale off the coast of Garraf with a deformity on the back of the spine, just after the dorsal fin. This deformity has been caused by a collision with a boat.

The results can be found described in more detail in the open source article published earlier this year called *Ship Strike Risk for Fin Whales (Balaenoptera physalus) Off the Garraf coast, Northwest Mediterranean Sea*. This article presents the risk of fin whale

collisions in the Garraf area, analysing the year 2021, and characterises the most frequent type of traffic in the area and the areas with the highest risk.

The main conclusions obtained are that there is a **significant overlap between maritime traffic and the whale feeding grounds**, the main risk being in April on the Garraf coasts and in May on the Garraf coasts and in the central area in the north of Catalonia, encompassing the area between Barcelona and Palamós, **especially in the area of the edge of the shelf and inside the submarine canyons**, which is where the animals are concentrated and where the main traffic routes to France and Italy pass through[62].

Finally, it is also worth **mentioning the disturbance caused by the harassment of recreational boats, which are irresponsible, insensitive and unaware of the laws that protect cetaceans and prohibit their approach** (Royal Decree 1727/2007, of 21 December, which establishes measures for the protection of cetaceans).

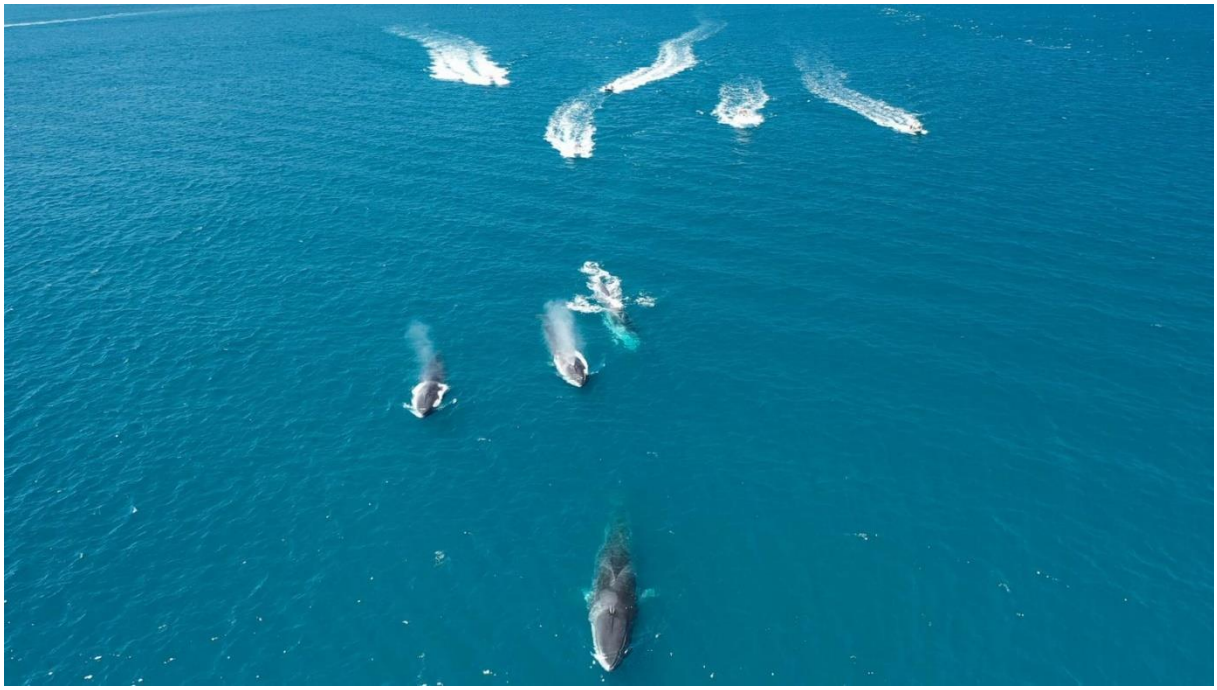


Image showing 4 fin whales being chased by 5 motor boats off the coast of Denia.

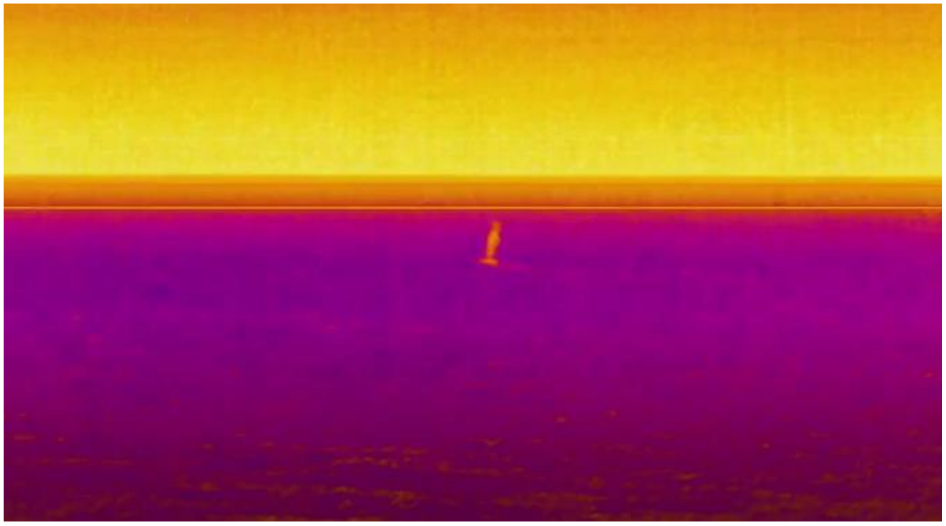
Thermal camera

In 2022, a thermal camera, FLIR's M364C LR, has been installed to determine if, under what conditions and at what distance, fin whales can be detected. **The main objective is to demonstrate its validity as a technique for detecting whales** on merchant ships and to take measures to reduce the risk of collisions.

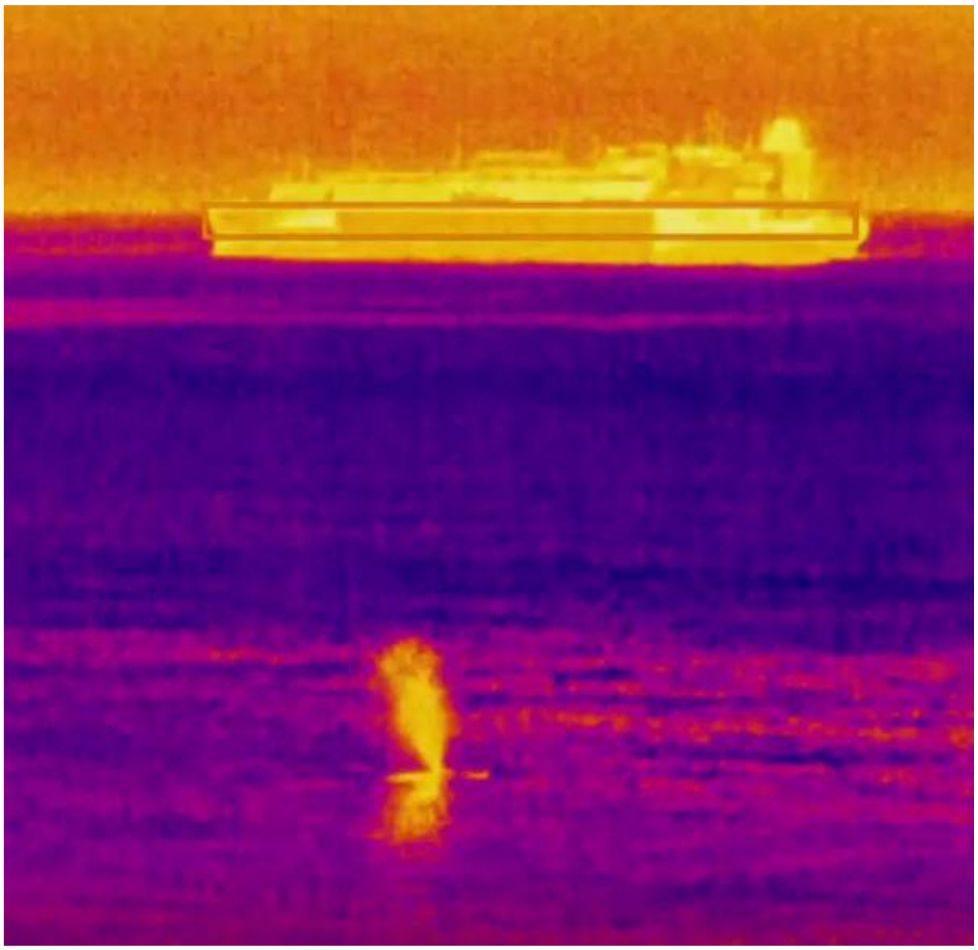
The thermal camera was installed on top of the catamaran's mast, at a height of 21 metres above sea level, at the end of March. TimeZero software was used to display and control the images transmitted by the camera.

Location of the thermal camera on top of the Maktub mast.

The results show that the **thermal camera can detect fin whales down to 1000 metres**, under the installation conditions described above, and with oceanographic conditions less than or equal to 3 on the Beaufort scale.



Thermal camera image showing a blow from a fin whale at a distance of about 700 metres.



Thermal camera image showing a blow from a fin whale at a distance of 350 metres and a merchant ship behind at a distance of 1000 metres.

The **usefulness of these cameras has also been tested at night**, when it is not possible to detect the animals with the naked eye from the boat.

Biological samples

Since 2018, biopsies have been taken to determine genetics, hormone status and stable isotope concentrations. In some cases, it has also been possible to collect faecal samples, which will be used to determine the feeding habits of the fin whales in the area, their genetics, and the presence of microplastics.

All animals are identified by drone and dorsal fin before being sampled in order to avoid biopsying an animal more than once and also to be able to have the results and information of the biopsied animals well classified.

In 2018, a total of 9 biopsies were performed, in 2021, 38 biopsies were performed and **in 2022, a total of 26 biopsies were performed**, **making a total of 73 animals biopsied**. Initially the biopsies were carried out by approaching the animal with a pneumatic, however, in the last two years, **thanks to the help of the drone** for identification and approach, **90% of the biopsies have been carried out from the catamaran, reducing the disturbance and reaction of the biopsied animals**.

The results of these samplings are being analysed in collaboration with different teams and research centres and we hope to have results in a short period of time. The only results we currently have are the gender of the biopsied individuals, which seems to be fairly balanced, with a **similar number of males and females**.

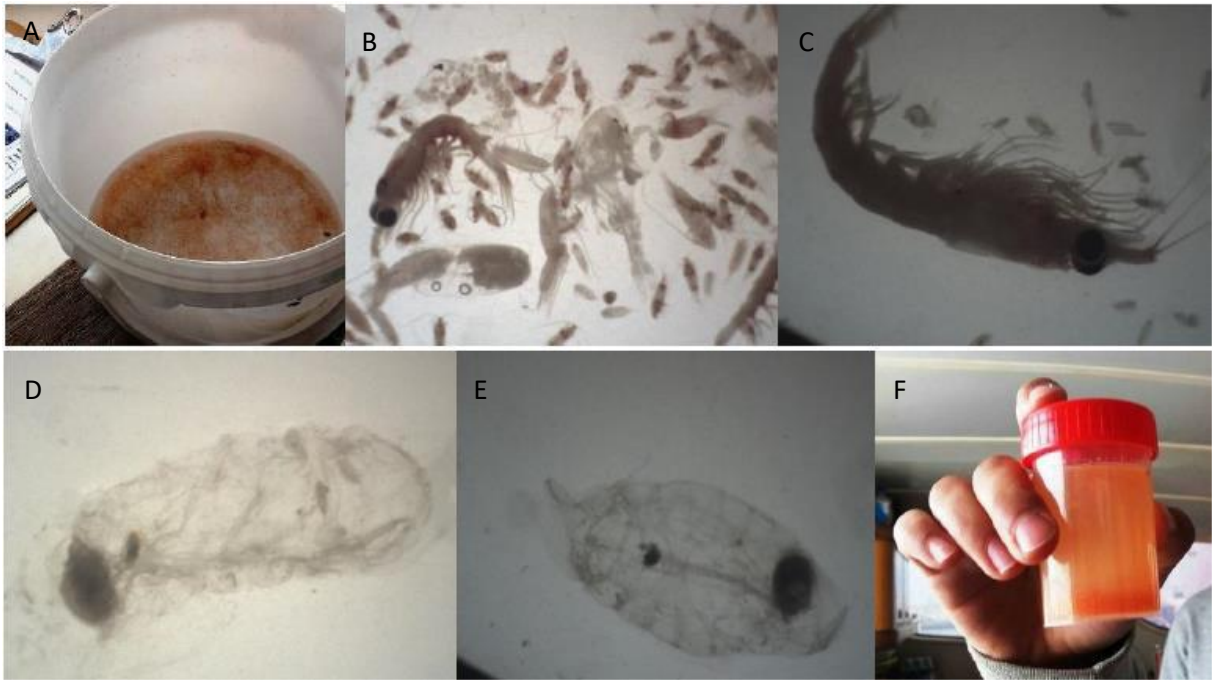
Zooplankton and Microplastics

In order to describe the plankton species present in the area, periodic sampling is carried out at different points along the coast and in areas where we find fin whales feeding. In 2022, with the incorporation of the echo sounder, it has been possible to obtain more information on the grouping of plankton as well as the depths at which they are concentrated. This detection has occurred with great frequency in the areas where we were with feeding fin whales.

Echosounder screen capture, on the right of the image, showing a high-density spot (yellow, green and red colours), a concentration of plankton, at a depth of between 30 and 45 metres. This capture was made in an area where the fin whale was feeding. On the left side of the image, you can see the track of the vessel.

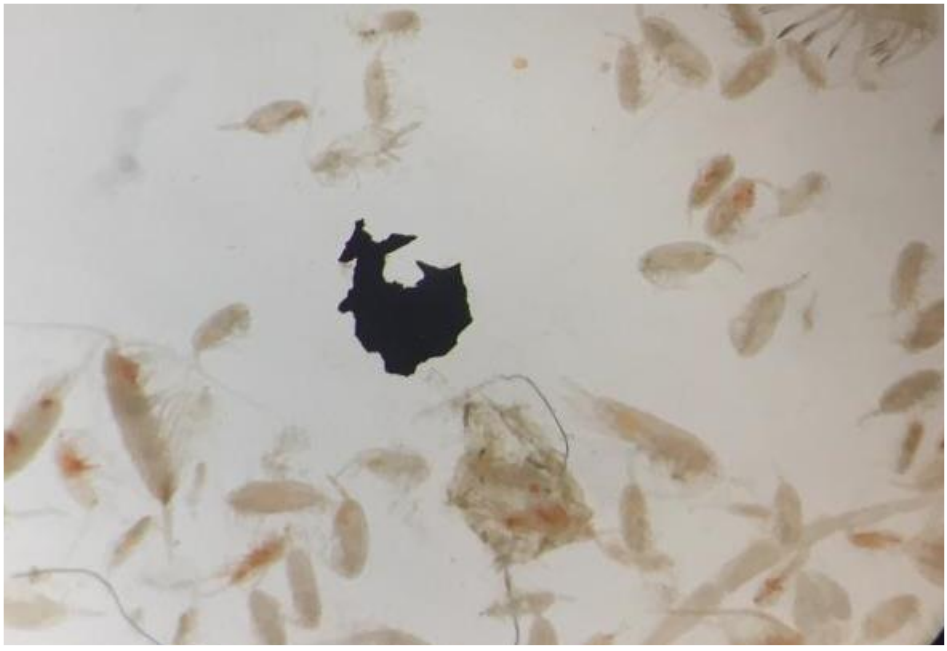
With reference to the species found in the plankton samples, it is worth highlighting **the presence of copepods in 90% of the samples and krill in between 40 and 55%** of these, except for the 2019 season when krill was only detected on one occasion.

Below are some images of invertebrates that have been found in the plankton samples, in the first images we find copepods, krill and salps, which are the most frequently found organisms.



Images of some of the samples collected throughout the seasons. In these we find krill (images a, b, c and f), copepods (images a, b and c) and salps, images d and e.

Whales are filter feeders that gulp large quantities of water, which they then filter using their baleen plates. This way of feeding means that they eat everything they find in this body of water, being able to select only large elements. **They are therefore very likely to ingesting microplastics**[34].



Microplastic collected during plankton sampling. In this image we find together with the copepods a piece of black plastic in the centre and a black filament at the bottom of the picture.

Microplastics have been present in all surface samplings of plankton, with microfibres being the most frequent microplastics.

Other cetacean species

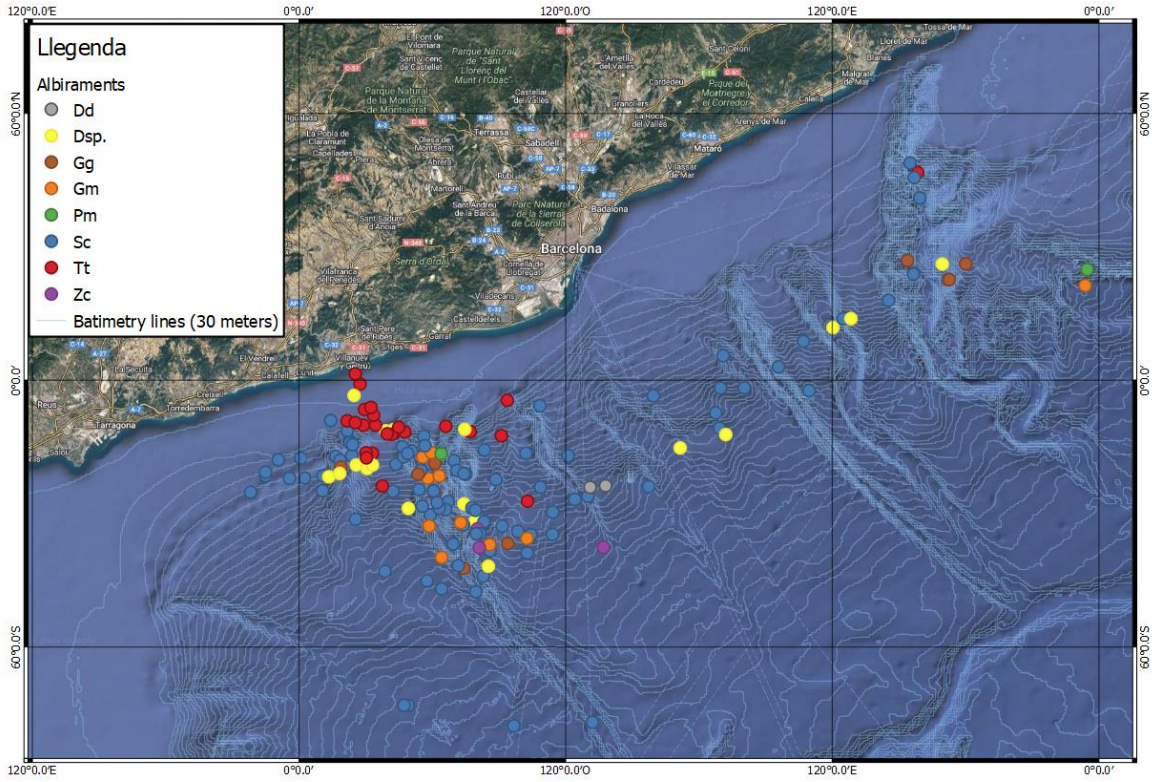
The Mediterranean is home to 7 species of odontocetes; the striped dolphin (*Stenella coeruleoalba*), the bottlenose dolphin (*Tursiops truncatus*), the common dolphin (*Delphinus delphis*), the Risso's dolphin (*Grampus griseus*), the Risso's dolphin (*Globicephala melas*), the sperm whale (*Physeter macrocephalus*) and Cuvier's beaked whale (*Ziphius cavirostris*).

Summary table of the sightings of the cetacean species that can be found off the Catalan coast over the years of the Fin Whale Project. These species are striped dolphin, (Stenella coeruleoalba), Sc, the bottlenose dolphin (Tursiops truncatus), Tt, the common dolphin (Delphinus delphis), Dd, the Risso's dolphin (Grampus griseus), Gg, the long-finned pilot whale (Globicephala melas), Gm, the sperm whale (Physeter macrocephalus), Pm, and the Cuvier's beaked whale (Ziphius cavirostris), Zc.

	2014	2015	2016	2017	2018	2019	2021	2022	Total
Sc	17	15	27	77	76	74	101	**95**	482
Tt	8	13	9	17	11	13	20	**24**	115
Dd	0	0	1	3	0	1	1	**2**	8
Gg	2	5	2	2	6	7	3	**10**	37
Gm	0	0	0	0	0	4	2	**10**	16
Pm	0	0	0	0	0	3	0	**2**	5
Zc	0	0	0	0	3	3	0	**3**	9

The table shows that **the striped dolphin is the most abundant dolphin in the area**, being the most sighted dolphin in all the seasons of the project. The second most sighted species is the bottlenose dolphin. Both species are the most sighted not only because they are very abundant but also because they share the distribution area with the fin whale. The other species are usually found at greater depths, so they are not as frequently sighted during the project's marine campaigns. **This year 2022 has been marked by a high presence of pilot whales in May and June**, with groups of 40 to 60 animals in the areas of the submarine canyons. This concentration of pilot whales has also been a highlight among fishermen, who claim that they have not seen such concentrations of pilot whales in the same area, in the submarine canyons, for years.

It can also be seen that this year, as in 2019, when going deeper in search of fin whales, sperm whales and beaked whales have been sighted. In other seasons when we have not gone so far from the coast, these animals have not been sighted.



Map with the sightings of cetaceans, except the fin whale, which has been sighted off the Catalan coast during the course of the 2022 Fin Whale Project.

Striped dolphin

The striped dolphin is the most abundant dolphin in the north-western Mediterranean. It is a pelagic dolphin, which can reach up to 2.6 metres in length and is characterised by its white colouration on the sides and a black line that crosses them from the eye to the genital area and another from the eye to the pectoral fin. It feeds on a wide variety of small fish and cephalopods[25].

Image of two jumping striped dolphins.

It is a cosmopolitan dolphin, found in all tropical and temperate seas and oceans of the world[25]. It is listed as a species of least concern by the IUCN[45].

It is a gregarious animal, generally found in groups of 20-40 individuals on the Catalan coast, but it can also be found in groups of hundreds of individuals. It can sometimes be found associated with other species such as fin whales, common dolphins, sperm whales, Risso's dolphins and pilot whales[25]. In this 2022 season they have been observed interacting with fin whales, Risso's dolphins and pilot whales.

Sightings of striped dolphins, in general, occur from a depth of 70 metres and are distributed all along the coast and the Balearic basin, there does not seem to be any area of special concentration of individuals.

They have started to interact with fishing boats but, from the information we receive from fishermen, it seems to be a sporadic and opportunistic association. There is interaction with boats of all kinds when it comes to bowriding.

Bottlenose dolphin

It is a coastal dolphin, although it can also be found in deep waters. It has a grey colouring, darker on the back and lighter on the sides. It can reach up to 3.8 metres in length. It feeds on a wide variety of organisms, and may eat pelagic and mesopelagic fish, squid and bottom invertebrates in coastal areas[25].

Image of 3 bottlenose dolphins breathing.

It is a cosmopolitan dolphin, found in all tropical and temperate seas and oceans of the world[25]. It is the dolphin species most commonly found in zoos and dolphinariums. It is a species that is listed as a species of least concern by the IUCN[47].

It is an animal that is usually found in small groups of 5 to 30 animals. They are sometimes found in association with other species such as fin whales, Risso's dolphins and sperm whales[25]. Specifically, this season 2022, they have been sighted

interacting with fin whales and pilot whales. Interactions with fin whales are usually positive, with the dolphins playing in front of the whales' heads.

Image of a fin whale breathing with a group of 5 bottlenose dolphins swimming in front of its head.

On the other hand, there are more energetic interactions between bottlenose dolphins and other species. Such is the case of the interaction that took place between a small group of bottlenose dolphins and a large group of pilot whales. When the bottlenose dolphins arrived, the pilot whales took up a defensive position, forming a circle with the calves in the middle, and some adults interacted directly with the dolphins, pushing the small group of bottlenose dolphins away from them.

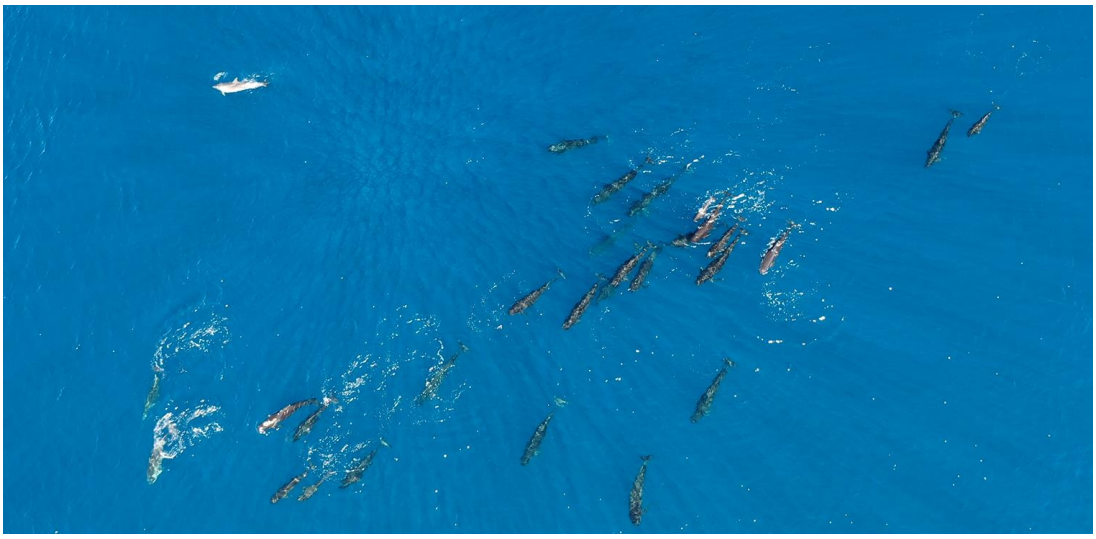


Image showing a group of pilot whales interacting with 4 bottlenose dolphins, the animals seen apart and in front of the group of pilot whales.

Bottlenose dolphins often associate with trawlers for feeding, following the nets and going to feed on fish that escape from the nets. Formerly this association had been a

problem but nowadays this view has changed to a positive interaction. This is why sightings of this species often coincide with the areas where trawlers work.

Common dolphin

The common dolphin is the least common dolphin in the north-western Mediterranean. It is a species that can be found in both coastal and pelagic areas. It can measure up to 2.7 metres and is characterised by its black colouring on the back and yellow and white on the side, forming a pattern that resembles an hourglass. It feeds on squid and small fish[25]. It is a species considered endangered in the Mediterranean, according to the IUCN[6].

Picture of a group of 4 common dolphins, 3 adults and a calf.

It is a gregarious animal that is usually found in the area in groups of 10 to 20 individuals. They are often seen associated with striped dolphins in mixed groups. It has been described that as the population of common dolphins in the Mediterranean has decreased, they have associated with groups of striped dolphins, creating mixed groups[25].

Risso's dolphin

The Risso's dolphin is a species found in deep waters, generally above 300 metres depth. It can reach up to 3.8 metres in length and is characterised by a rounded head, no pronounced beak like the dolphins described above, and a greyish colouring that becomes scarred over the years until it becomes completely white. They feed mainly on squid, although occasionally they may also feed on octopus and cuttlefish[25].

Image of an adult Risso's dolphin breathing.

It is a cosmopolitan species, and can be found in tropical and temperate seas and oceans around the world[25]. The Mediterranean population is not listed in the IUCN due to lack of data[36].

It is an animal that is usually found in groups of 10 to 30 animals. They do not usually approach boats, they are very social animals but not with humans[25].

They are sometimes associated with other species such as striped dolphins or bottlenose dolphins. This season 2022 they have been sighted interacting with striped dolphins.

Long-finned pilot whale

The long-finned pilot whale is a deep-water species, usually found at depths of more than 100 metres. They are completely black in colour, with a white pigmentation mark behind the flipper and another on the ventral area below the head and between the heart-shaped flippers. Its head is rounded, like the Risso's dolphin. It is a species with a great sexual dimorphism, this dimorphism can be seen in size, with males being much larger than females. In the case of the long-finned pilot whale, males can reach 6.3 metres in length and females a maximum of 4.7 metres. They feed mainly on squid and mackerel [25].

Image of a group of pilot whales swimming off the bow of the catamaran Maktub, on the left, and an image of a pilot whale from underwater, on the right

The Mediterranean subpopulation is in an endangered conservation status according to the IUCN[39].

It is a gregarious animal that is usually found in large groups of between 40 and 60 animals, and can reach groups of 100 in specific cases in the Mediterranean. They can sometimes be seen interacting with other species such as striped dolphins and bottlenose dolphins[25].

It is the species of odontocete in the Mediterranean that interacts most with boats; they are very sociable and curious animals that often approach boats to play and out of curiosity.

Sperm whale

The sperm whale is the largest species in the odontocete group. It is found in deep waters and submarine canyons. It is characterised by a brownish-greyish colour, a rectangular body and a large head where the spermaceti is located. Unlike other cetaceans, sperm whales have a blowhole on the left side of their head, which causes their blow to be 45 degrees to the left, unlike other cetaceans where the blow is vertical. They also have a small dorsal fin located 2/3 of the way down the body and often show different pigmentation markings on the body of each individual. There is great sexual dimorphism, with males being much larger than females, reaching up to 18 metres in length, while females measure a maximum of 12 metres. They feed on giant squid, but can also feed on octopus and abyssal fish[25].

Image of a sperm whale resting at the surface.

It is a cosmopolitan animal, and can be found in all seas and oceans of the world in temperate and tropical zones as well as in the north and south in cold water zones[25]. It is a species considered endangered by the IUCN in the Mediterranean[60].

Social groups are family groups formed by females and young, the most frequently sighted in the Balearic Sea. Groups of young males that have just left the family group can also be found. Adult males live alone, or in groups of 2 or 3 males[25].

Sometimes they can be found associated with some species of dolphins such as the striped dolphin and the bottlenose dolphin.

Being a deep-diving animal, they make very long dives, around 45 - 50 minutes but up to 2 hours. When surfacing they need about 10 minutes to rest between dives, during which time they are very vulnerable to collisions with boats as they are standing on the surface resting and preparing for the next dive[25].

Cuvier's beaked whale

Cuvier's beaked whale is the only species of beaked whale described in the Mediterranean. It is found in deep waters, usually from a depth of 500 metres. It is characterised by a short beak with two teeth protruding from the jaw, a whitish head and a yellowish-greyish body. They can measure up to 7 metres in length. They feed mainly on squid[25].

Picture of a Cuvier's beaked whale coming up for air.

It is a cosmopolitan animal that can be found in all seas and oceans of the world, in tropical areas and in cold temperate waters[25]. The Mediterranean subpopulation is listed as vulnerable by the IUCN[24].

It is a rather shy species, not used to approaching boats and sinks quickly if it detects a boat nearby. They usually go in small groups of 3 to 6 individuals. As they are deep-diving animals, they can dive for more than 2 hours[25], and are not sociable with humans, their study is complicated.

Seabirds

The area of the Garraf coast, where the marine campaigns are focused, is an SPA area where up to 22 species of seabirds can be found, some of them in a critical state of conservation. Some of these are residents of the north-western basin and others are migratory.

Table of bird sightings during the Fin Whale Project 2022 season[9-21].

Specie	Scientific name	Nº sightungs	Conservation status (IUCN)
Shearwater sp.	*Puffinus sp*.	1179	---
Balearic shearwater	*P. mauretanicus*	4	En peligro crítico de extinción
Mediterranean shearwater	*P. yelkouan*	---	No amenazada
Cory's shearwater	*C. diomedea*	78	No amenazada
Cormorant	*Phalacrocorax sp*.	2	---
Puffin	*F. arctica*	97	En peligro de extinción
Audouin's gull	*L. audouinii*	213	No amenazada
Little gull	*H. minutus*	280	Casi amenazada
Mediterranean gull	*L. melanocephalus*	44	No amenazada
Gull sp.	*Larus sp*.	6	---
Razorbill	*A. torda*	6	Casi amenazada
Gannet	*M. bassanus*	16	No amenazada
European storm-petrel	*H. pelagicus*	47	No amenazada
Skua sp.	*Stercorarius sp*.	4	---
Great skua	*C. skua*	3	No amenazada
Arctic skua	*S. parasiticus*	2	No amenazada
Pomarine skua	*S. pomarinus*	5	No amenazada
Tern sp.	*Sterna sp*.	65	---

The **most frequently sighted species is the shearwater**, with Balearic and Mediterranean shearwaters being seen throughout the season. They can be found in large groups of dozens of individuals and also in smaller, more dispersed groups. Puffins, Audouin's gulls and Little gulls are also frequently sighted.

There are some of these species that are of special interest to the project as they are directly associated with the fin whale due to the type of diet. This is the case of **the little gull, which feeds on zooplankton and, for this reason, can be found in the same areas where we find the fin whale feeding**.

There are others, such as the puffin and the Cory's shearwater, which are seasonal and mark the changes throughout the season. Puffins can be found on our coasts in

winter and early spring, but when the sea temperature starts to rise, they begin their migration northwards and disappear from our coasts. On the other hand, Cory's shearwater appears in the area at the beginning of May, with warmer waters, when we enter the final stretch of the fin whale season on the Catalan coast.

Sea turtle

The most common turtle sighted along the Catalan coast is the loggerhead turtle (*Caretta caretta*). It is brown in colour and differs from the other species in that it has 4-5 prefrontal plates in the head area and 5 pairs of costal plates on the shell. Hatchlings and sub-adults have a ridge on the spine of the shell that disappears as they grow. It is a species of turtle that can reach 120 cm in length and weigh up to 120 kg. It feeds on a wide variety of organisms: bivalves, gastropods, crustaceans, fish, jellyfish, corals, sponges, algae, polychaetes and echinoderms[61].

Image of a loggerhead turtle sticking its head out of the water to breathe.

It is a cosmopolitan species, found in all the temperate seas and oceans of the world. It has specific breeding areas, which means that there are areas with a greater presence of adult animals and others where mainly young are found. It is a species that in the Mediterranean is classified as a species of least concern by the IUCN[26].

In 2022, 25 specimens were observed. The month of **May has been the month with the highest number of sightings,** with a total of 11, the other months the number of sightings has ranged between 3 and 5. Normally they are not large animals, mainly sub-adults, but in 2022 adult animals have been observed on a couple of occasions.

Other marine species

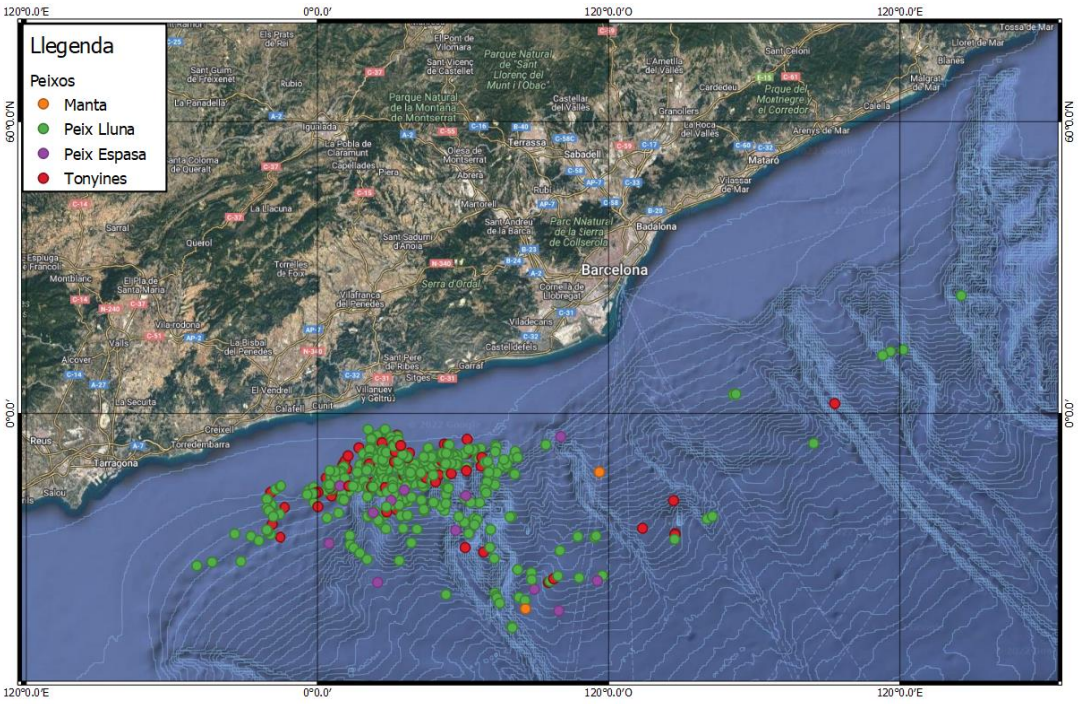
This section mainly refers to the fish, jellyfish and urochordates that are sighted during the marine surveys and that serve as indicators of the health of the ecosystem.

The most frequent fish sighted throughout the rorqual project are sunfish, swordfish, tuna, and occasionally manta rays and basking sharks.

Table with the sightings of fishes sighted during the marine campaigns of the Fin Whale Project 2022.

Common name	Scientific name	Nº Sightings
Sunfish	*Mola mola*	399
Swordfish	*Xiphias gladius*	13
Tuna	*Thunnus thynnus*	96
Manta rays	*Mobula mobular*	2

The most commonly sighted species throughout the season is the sunfish, with groups of tuna also frequent in areas with abundant food. The other species are observed more occasionally.



Map with the sightings of the 4 species of fish that are sighted during the marine campaigns of the Fin Whale Project on the Catalan coast.

The sunfish is an animal that lives in the water column and at this time of year can often be seen near the surface where they are wormed by gulls and feed on velella, among other organisms. **Seasons with a high number of sunfish are also good seasons for sightings of fin whales**.

Drone image of two sunfish swimming close to surface.

Groups of tuna are also very frequent along the coast, they are omnivorous animals, feeding on fish, plankton and other species in the water column. It has been for many years an endangered animal due to overfishing. But it is now frequently encountered, to the point of following trawlers to feed on discards. Areas with high tuna activity are areas with a concentration of food, which can sometimes be related to the presence of fin whales in the same way that they can be associated with the presence of seabirds and also dolphins on some occasions.

Drone image of two tuna near the surface.

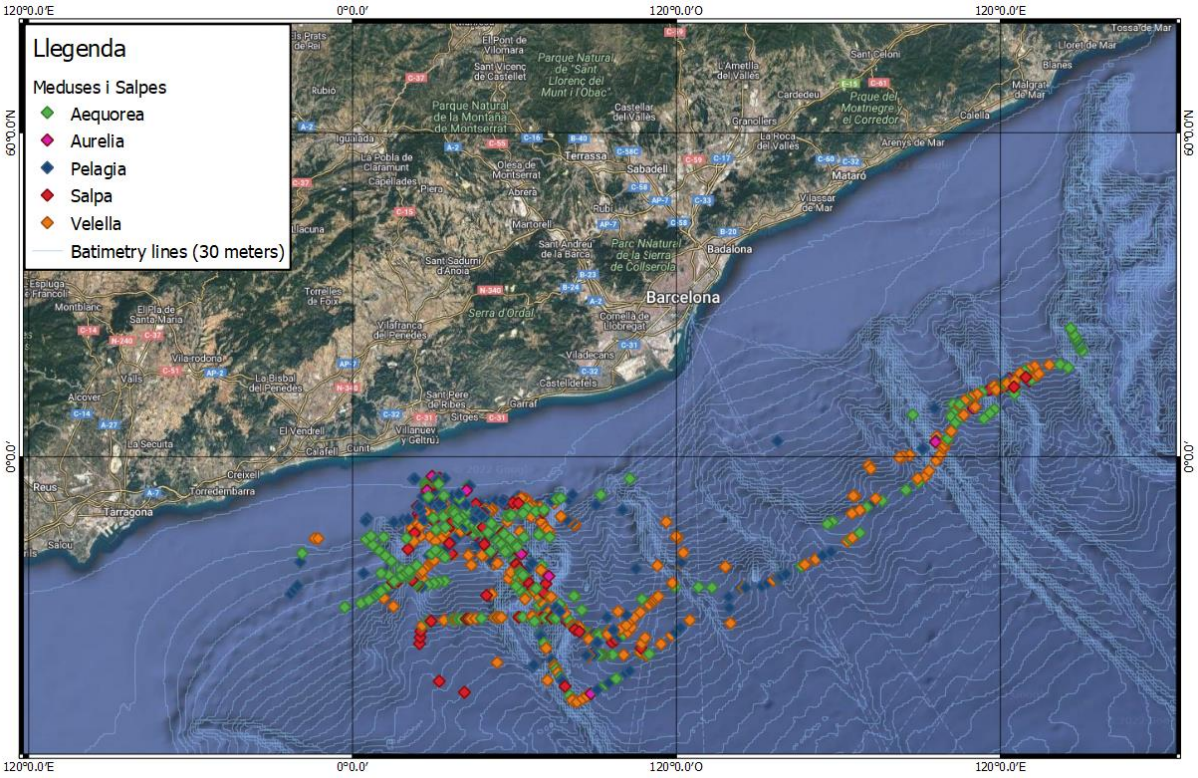
More sporadically, jumping swordfish, manta rays and basking sharks can be observed. Both manta rays and basking sharks are filter feeders that feed on plankton. Sightings of manta rays occur late in the season, in late May and June. Basking sharks are not commonly sighted because they are usually found at depth. Even so, there have been years, such as 2020, in which they have been frequently sighted at the surface, according to data from fishermen.

Image of a manta spotted off the coast of Garraf in May, swimming close to the surface.

As far as jellyfish and urochordates are concerned, the main ones we observed are:

Specie	Scientific name	Nº sightings
Aequorea	*A. victoria*	256
Aurelia	*A. aurita*	17
Jellyfish sp.	---	6
Pelagia	*P. noctiluca*	160
Salp	*Salpidae*	78
Velellas	*V. velelles*	234

Of these organisms, the ones **we have been able to relate to the presence of fin whales are the velella**, which we found in large concentrations throughout the season and in which we have found krill entangled in their tentacles on more than one occasion, and **also salps**, which tend to be abundant in productive years, also **positively related to the presence of fin whales**.



Map with the sightings of jellyfish and salps recorded during the season of the Fin Whale Project 2022.

There does not seem to be a clear distribution with respect to depth, what can be observed is that sightings are abundant within the submarine canyons and at the shelf edge, but the bias that exists due to increased effort in these areas has to be taken into account.

Protocol and use of drone

The research drone has been widely used to perform various functions in the field of cetacean research[29,33,35,41]**, such as behavioural, and photo-identification, previously mentioned. But also, to support approaches to perform biopsies, place satellite TAGs and collect biological samples.**

The protocol followed during marine surveys is as follows. When a whale is sighted, the research drone is prepared and when the whale is at a distance of less than 800 metres, the first approach is made with the drone to identify the animal and try to identify its behaviour.

The drone can be in the air for approximately 20 minutes. Repeated flights are made at a distance of 5 to 10 metres above the animal in order to obtain clear images for identification, record its behaviour and collect samples. The drone can also be very useful to observe the number of individuals in the group of cetaceans sighted, mainly in groups of dolphins.

No adverse reaction to the drone has been observed in fin whales. The animals do not seem to detect or modify their behaviour because of the presence of the drone. Dolphins and sperm whales have been observed to react to rapid approaches with the drone or to turn around to observe the drone when it was at low height. Apart from these momentary behavioural changes, no other reactions were observed in the animals sighted.

Conclusions

The **presence of fin whales feeding along the Catalan coast** is a remarkable fact that makes the area a very important area to conserve. There are many variables that affect the area, and it is heavily influenced by the coast, compromised by meteorological and oceanographic changes linked to the abundance of food.

It is a coastal feeding area in which most of the animals' behaviour is close to the surface, with feedings that are not too deep and immersion periods that are generally short, just a few minutes.

The use of the drone is fundamental for the study of cetaceans, mainly for the study of the fin whale, as it allows us to obtain much more information related to behavioural variables, identification, number of animals, approach to sample collection, etc.

The use of the echo sounder and zooplankton sampling together with stable isotope analysis give a clear picture of the type of feeding of the fin whale, the abundance of feeding and the depths at which it feeds throughout the day.

Maritime traffic is the main problem for the fin whale along the Catalan coast, and urgent measures must be implemented to inform captains, sailors and navigators, and certain restrictions must be agreed upon to minimise the risk of collision between fin whales and merchant vessels. Tests carried out so far indicate that **the installation of thermal cameras on ships could be useful in detecting both fin whales and other cetacean species** and could help to avoid collision with them more efficiently.

Microplastics are also a major problem along our coasts, and are frequently found in zooplankton samples collected. Macroplastics are also found floating on the surface, mainly helium balloons.

It is clear that the **Catalan coast is an area rich in marine biodiversity**, concentrating a great biodiversity of birds, fish, jellyfish and cetaceans. The most abundant during the spring are striped dolphins, sunfish, shearwaters, little gulls and velellas. Almost all of them are related to the presence of fin whales and the good health of the ecosystem. The fin whale, as well as sunfish, velellas and little gulls, feed on zooplankton, the base of the chain after phytoplankton. Changes in the state of health and productivity of the ecosystem impact first on the base of the chain, which is why fin whale monitoring, as well as monitoring of the rest of the biodiversity mentioned above, gives us an early idea of changes in the ecosystem.

Finally, we would like to **highlight the role of citizen science, especially the fishermen** from the different fishermen's guilds along the Catalan coast, who provide us with their knowledge and allow us to know the situation of the sea, the ecosystem and the fin whales, in areas where we cannot reach by boat.

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