PATHWAYS TO COEXISTENCE BETWEEN LARGE CETACEANS AND MARITIME TRANSPORT IN THE NORTH-WESTERN MEDITERRANEAN REGION:

Collision risk between ships and whales within the proposed north-western Mediterranean Particularly Sensitive Sea Area (PSSA), including the Pelagos Sanctuary

MBPC partners:

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Authors:

Fortuna, C., Sánchez-Espinosa, A., Rodríguez-Rodríguez, D., Abdul Malak, D, Podestà, M., Panigada, S.

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Layout: Latte Creative

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Introduction

ECOLOGICAL IMPORTANCE OF THE NW MEDITERRANEAN FOR LARGE CETACEANS

The ecological significance for marine biodiversity of this Mediterranean subregion is evident given a wealth of global, regional and national protection designations. The area encompasses 12 SPAMIs[1], including two large ones dedicated to cetaceans - the Pelagos Sanctuary[2] and the Spanish Cetacean Corridor[3]. In addition, it includes two EBSAs[4], two UNESCO World Heritage Sites[5], hundreds of coastal and marine European Union Natura 2000 sites, a number of nationally and regionally designated marine protected areas (MPAs), and three IUCN Important Marine Mammal Areas[6] (Figure 1).

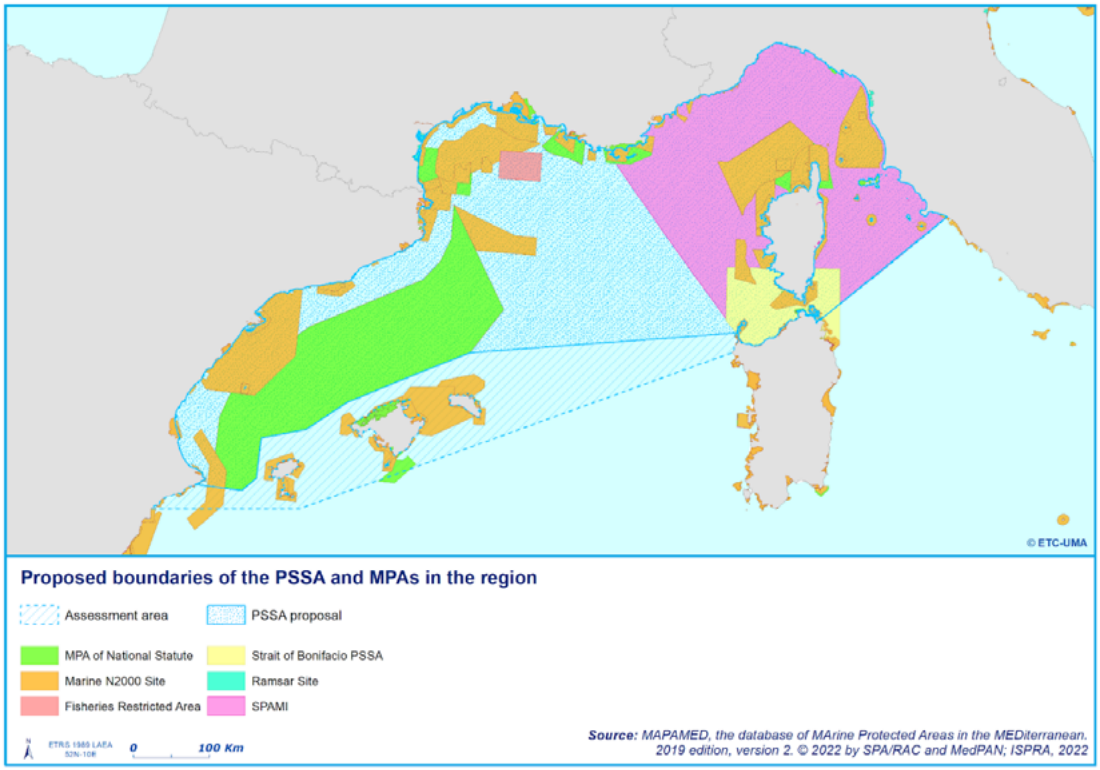

***Figure 1**: Proposed boundaries of the NW Mediterranean PSSA and surrounding region and the distribution of other legally binding marine protected areas in the region.*

The ecological importance of the NW Mediterranean for fin whales is well known. In summer, this area includes up to 70% of the whole Mediterranean fin whale population. In addition, two out of three of its known Mediterranean seasonal feeding grounds[7] occur here. In summer, this region also hosts about 50% of the whole Mediterranean population of sperm whales.

1. Special Protected Areas of Mediterranean Importance under the Barcelona Convention

2. A trilateral Agreement between France, Italy and Monaco.

3. https://www.miteco.gob.es/es/prensa/ultimas-noticias/el-corredor-de-migraci%C3%B3n-de-cet%C3%A1ceos-del-mediterr%C3%A1neo-declarado-%C3%A1rea-marina-protegida/tcm:30-479873

4. Ecologically and/or Biologically Significant Marine Areas under the Convention on Biological Diversity (1993): i.e. the "North-western Mediterranean Pelagic Ecosystems" and "North-western Mediterranean Benthic Ecosystems".

5. Portovenere, Cinque Terre and its Islands in Italy and Gulf of Porto in Corsica.

6. Important Marine Mammal Areas: i.e. "Shelf of the Gulf of Lion", "North-west Mediterranean Sea, Slope and Canyon System", "Western Ligurian Sea and Genoa Canyon".

7. Canese et al. 2006; ACCOBAMS 2022; Panigada V et al. 2022.

MARITIME TRAFFIC IN THE NW MEDITERRANEAN

Within the Pelagos Sanctuary[8] and the wider proposed NW Mediterranean PSSA, maritime traffic for goods runs between bigger continental ports, whereas passenger transport occurs mostly between continental and insular ports. This region is also a flourishing cruise tourism area[9]. The proximity to large and tourist islands promotes intense seasonal passenger traffic, as well as widespread recreational boating. Figure 2 shows the summer traffic including all categories of ships in 2018 based on EMODNET data.

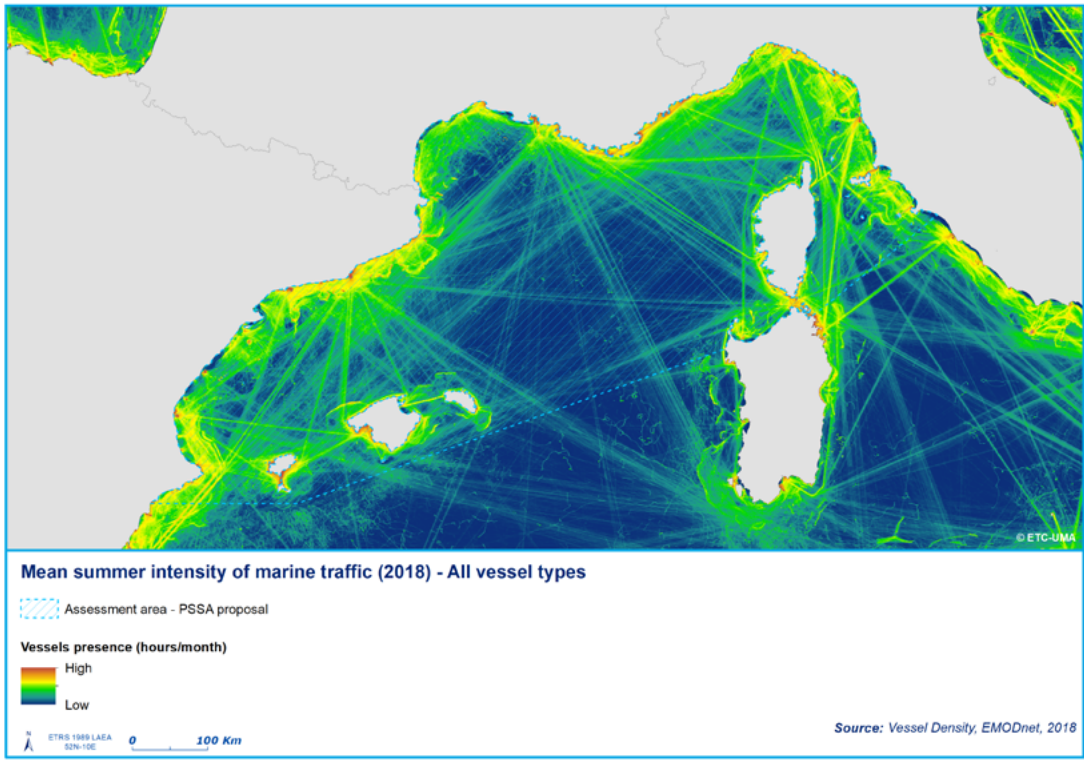

***Figure 2**: Mean summer maritime traffic intensity in the proposed NW Mediterranean PSSA, based on EMODnet data for 2018.*

THE DYNAMICS OF SHIP WHALE STRIKES

The dynamics of whale ship strikes are still not fully understood. The type of interaction between cetaceans and vessels and the subsequent risk of mortality vary in relation to species' behaviours and shipping features. Some ships can attract small cetaceans (e.g. striped and bottlenose dolphins) that enjoy bow riding[10] or surfing on ship generated waves. However, when it comes to larger cetaceans such as fin whales (*Balaenoptera physalus*) or sperm whales (*Physeter macrocephalus*), this interaction seems to be mostly deadly. In between deep foraging dives, whales spend relatively long periods at the surface recovering, resting still or swimming slowly. These behaviours make them particularly vulnerable to ship strikes. A collision may result in various degrees of injuries for the whales and damage for the boats, depending on the speed and the size of the boat, similar to pedestrians and vehicles[11]. According to national and international legislation on species protection and conservation, any source of human-induced mortality on protected species needs to be mitigated, this includes ship strikes.

8. Sanctuary for the Marine mammal protection created via a trilateral Agreement among France, Italy and Monaco in 1999, which was designated as a SPAMI in 2001.
9. https://www.senat.fr/rap/r13-108/r13-108_mono.html
10. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/bow-riding
11. https://injuryprevention.bmj.com/content/26/1/85

IMPACTS OF MARITIME TRAFFIC ON FIN WHALES IN THE NW MEDITERRANEAN

Collisions between vessels and large whales, in the majority of cases, end with the death of the whale. For some species and in some areas, ship strikes may reach levels that threaten their conservation status. However, the actual impact of mortality caused by shipping at the population level is difficult to assess and quantify. Direct observations are scarce and sparse, as accidents generally happen offshore and are rarely noticed by seafarers, especially by those on large ships. Furthermore, collisions are not always reported, and large whales may sink after the strike and go unnoticed. Because of this, data on long-term monitoring programmes and strandings networks can complement information on these incidents. Based on all these types of accounts, a study showed that between 1971 and 2001, over 80% of reported Mediterranean fin whale ship strikes occurred in the NW Mediterranean[12].

Besides contributing to building and maintaining the International Whaling Commission global database on ship strikes, several scientists have focused their efforts on studies quantifying speed-risk relationships and relative ship strike risk reductions through speed restrictions[14 15].

ACTIONS TO MITIGATE WHALE SHIP COLLISION RISK

Consistent with regional data on species densities and collision events, at its last meeting, the IWC Scientific Committee stressed that 'action needs to be taken to reduce ship strike risks to the Mediterranean populations of fin and sperm whales' (IWC 2022). After a thorough analysis of the issue and a negotiation spanning several years, in September 2022, the Governments of France, Italy, Monaco and Spain submitted a Proposal for the "Designation of a Particular Sensitive Sea Area in the North-Western Mediterranean Sea to protect cetaceans" for approval at the 79th session of the Maritime Environment Protection Committee (London, December 2022) of the UN International Maritime Organization. The ultimate aim of this proposal is 'to protect cetaceans from collision risk, ship-generated pollution and to increase awareness on a critically important area for the fin whale and the sperm whale'.

By establishing effective 'associated protective measures' and committing to develop stricter 'prospective protective measures' mitigating ship-induced mortality, the proposed PSSA will potentially help protecting almost 70% of the whole fin whale population and 50% of the sperm whale's population, both listed as Endangered by the IUCN, increasing their likelihood of survival[16]. This would represent a major positive outcome to meet obligations linked to the UN Sustainable Development Goal 14.

12. Panigada S. et al., 2006.

13. https://iwc.int/management-and-conservation/ship-strikes

14. See e.g., Conn and Silber, 2013; Silber et al., 2010; Wiley et al., 2011.

15. See e.g., Gende et al., 2011; Harris et al., 2012.

16. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T16208224A50387979.en

Regulatory options to reduce collision risks from shipping

There are various options to address the impact of maritime traffic on fin whales, sperm whales and other large cetaceans, including the designation of Marine protected areas (MPAs), Other Effective Area-Based Conservation Measures (OECMs) and Particularly Sensitive Sea Areas (PSSAs).

A protected area is *'a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values'.* MPAs are a widespread tool aiming to reduce the impact of human activities on the marine environment via prohibition or limitation of certain activities.

OECMs are *'a geographically defined area other than a protected area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in situ conservation of biodiversity, with associated ecosystem functions and services and where applicable, cultural, spiritual, socio–economic, and other locally relevant values'.*

PSSAs are areas *'that needs special protection through action by IMO because of its significance for recognized ecological, socio-economic, or scientific attributes where such attributes may be vulnerable to damage by international shipping activities' (IMO 2006).* PSSAs must have associated protective measures (APM) regarding shipping, including Areas To Be Avoided, Traffic Separation Schemes, speed reduction and other mandatory and voluntary navigation codes to minimise the risk of shipping accidents and undesired negative impacts on the marine environment. In this sense a PSSA can represent either a multiple-use MPA or an OECM.

OBJECTIVES OF THIS FACTSHEET

Based on ACCOBAMS Survey Initiative data on the 2018 summer fin whale's distribution and EMODNET 2018 maritime traffic data, this factsheet aims to:

- Provide an update on the existing records of whale ship strikes for the Western Mediterranean.
- Identify maritime routes and high-density traffic areas that are potentially dangerous for fin whales within the proposed PSSA, with a focus on the Pelagos Sanctuary.
- Stimulate focused scientific and technical discussions within the relevant Pelagos working groups, to explore further options for additional potential *'prospective protective measures'* to mitigate the risk of collision between ships and large cetaceans.

17. Dudley, 2008.

18. CBD, 2018

19. The International Maritime Organization (IMO) is the United Nations specialised agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.

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Methods

STUDY AREA AND BOUNDARIES OF THE PROPOSED PSSA

The southern boundary of the proposed PSSA was mainly set due to administrative reasons. This represents the line connecting and including already agreed southern boundaries of the Spanish Cetacean Corridor and of the Pelagos Sanctuary. The proposed PSSA includes all waters north of this line up to the French, Monegasque and Spanish coasts and wholly includes these two SPAMIs.

SPATIAL APPROACH: INTEGRATING MARITIME TRAFFIC INTENSITY, FIN WHALE DENSITY AND RECORDED COLLISION DATA

This factsheet focuses only on the 2018 ACCOBAMS data on summer fin whale's distribution and relevant EMODNET 2018 maritime traffic data.

The pressure of maritime traffic on fin whales, as areas of potential high risk of ship strikes, was considered in two ways:

1. Overlapping areas of high intensity of shipping with areas of high/medium density of fin whales to identify potential "restriction" and "sensitive" areas; and
2. Comparing maritime traffic for passenger ships and cargos with routes with the highest number of recorded whale ship strikes.

Both analyses considered three classes of vessel traffic (i.e., cargos, passenger boats and high-speed crafts) extracted from the EMODnet Vessel Density Maps (EMODNET, 2017-2021) for 2018. This dataset aggregates AIS (Automatic Identification System) records in cells of 1 km2 and measures the maritime traffic intensity as total time of vessel presence in each cell per month.

Since seasonality has an important effect on both the distribution of whales and the intensity of certain types of traffic, particularly that of passenger ships, and the data available on distribution of whales was collected in summer, the same year and season were considered for retrieving maritime transport data. Hence, the mean maritime traffic for 2018 summer months (June to September) was calculated and reclassified in four traffic intensity classes using the thresholds in Table 1. A similar approach was used with the spatial data on fin whale distribution, based on the modelled density range from the ACCOBAMS Survey Initiative effort, carried out in the Mediterranean in summer 2018 (ACCOBAMS 2021).

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DENSITY CLASS	Summer traffic intensity (hours/km2)	Whale density (individuals/ km2)	Route summer traffic intensity (hours/route)	Recorded collisions/route
Null	0	0	0 - 1,000	*Not applicable*
Low	0 - 0.5	0.01-0.03	1,000 - 2,000	*1*
Medium	0.5 - 1	0.04-0.06	2,000 - 3,500	*2*
High	0 > 1	> 0.06	3,500 - 7,500	*3*
Very High	Not applicable	Not applicable	7,500 - 13,303	*>3*

***Table 1**. Categories of pixel traffic intensity, pixel fin whale density, intensity of traffic along main maritime routes, 'dangerous routes' and their corresponding thresholds*

Under the coordination of ISPRA and within the framework of the activities carried out by the Pelagos Working Group on Impacts and the International Whaling Commission Scientific Committee, an updated archive on all reported collision events occurred in the Western Mediterranean was created. This archive includes: (a) records contained in the IWC ship strike database; (b) new records from scientific publications; (c) events recorded by the French, Italian and Spanish national stranding networks; and (d) events reported by newspapers. "Confirmed" and "Highly likely" events were used to visualise routes with higher numbers of collision events reported (Table 1).

In order to verify possible biases due to a greater "observation effort" from ferries, a subset of reported or recorded collision data from ports (e.g, dead whales on the ship's bow or floating dead animals with collision signs) was also used and plotted as collision points (Fig. 5).

The overlap of traffic maps and whale density maps identified two types of areas of potential high risk of collision for whales during the busiest summer months:

- *Sensitive zones*: areas in which High traffic intensity spatially overlapped with Medium whale densities.
- *Restriction zones*: areas in which High traffic intensity spatially overlapped with High whale densities.

For the analysis of traffic routes and collisions with fin whales, a spatial layer of lines was created drawing the path between ports on the main routes, which are those presenting higher intensity of traffic. These lines were used to account for the total hours with presence of ships along the entire route according to the mean traffic during summer months. The resulting data were reclassified in five categories using the thresholds shown in Table 1.

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Results

HIGH RISK AREAS AND DANGEROUS ROUTES

The ACCOBAMS data showed that the highest density of fin whales in the summer of 2018 is a rather large area off the Gulf of Lion west of the Pelagos Sanctuary, which is partially crossed (mostly to the NE) by an intricate web of busy shipping routes (Fig. 3) connecting many French, Italian and Spanish ports, on both the continent and major and smaller islands. This intricate web of shipping routes is particularly developed within the Western (Pelagos Sanctuary) and Eastern sides (Spanish coast) of the study area. Figure 3 shows potential high risk "sensitive" and "restriction" zones.

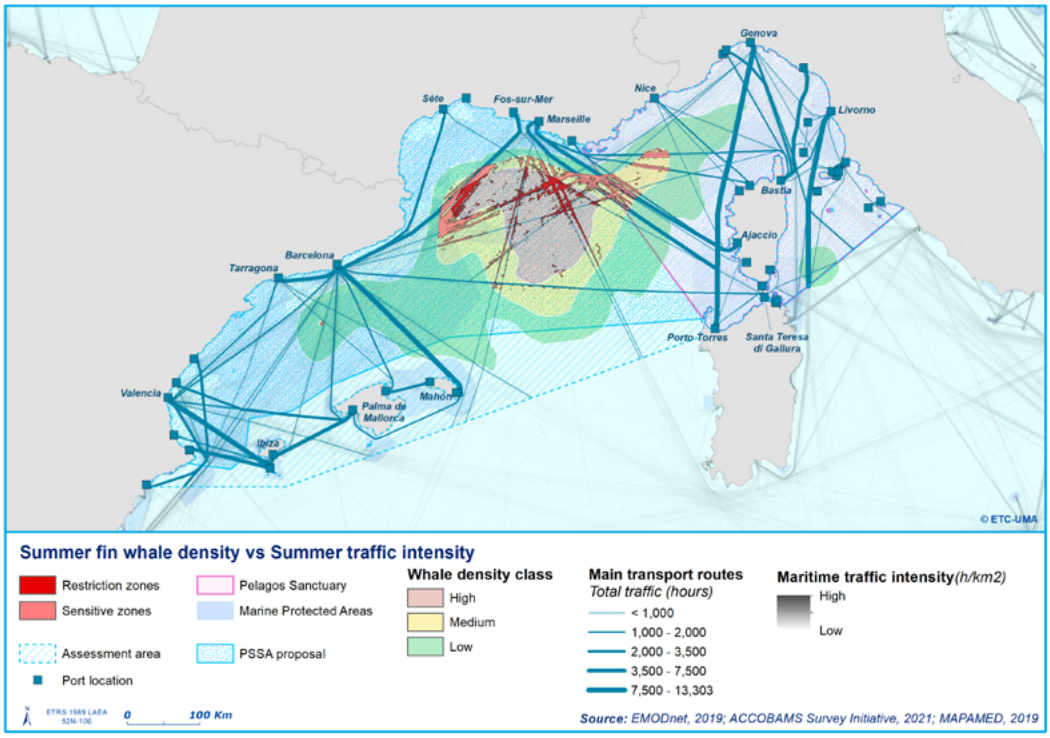

Figure 3: *Overlap between whale density and cargo and passenger traffic intensity in the proposed PSSA and surrounding areas, on main Mediterranean routes*

Figure 4 includes whale density areas, potential risk collision zones, and routes for which whale ship strikes were recorded, showing potentially dangerous routes.

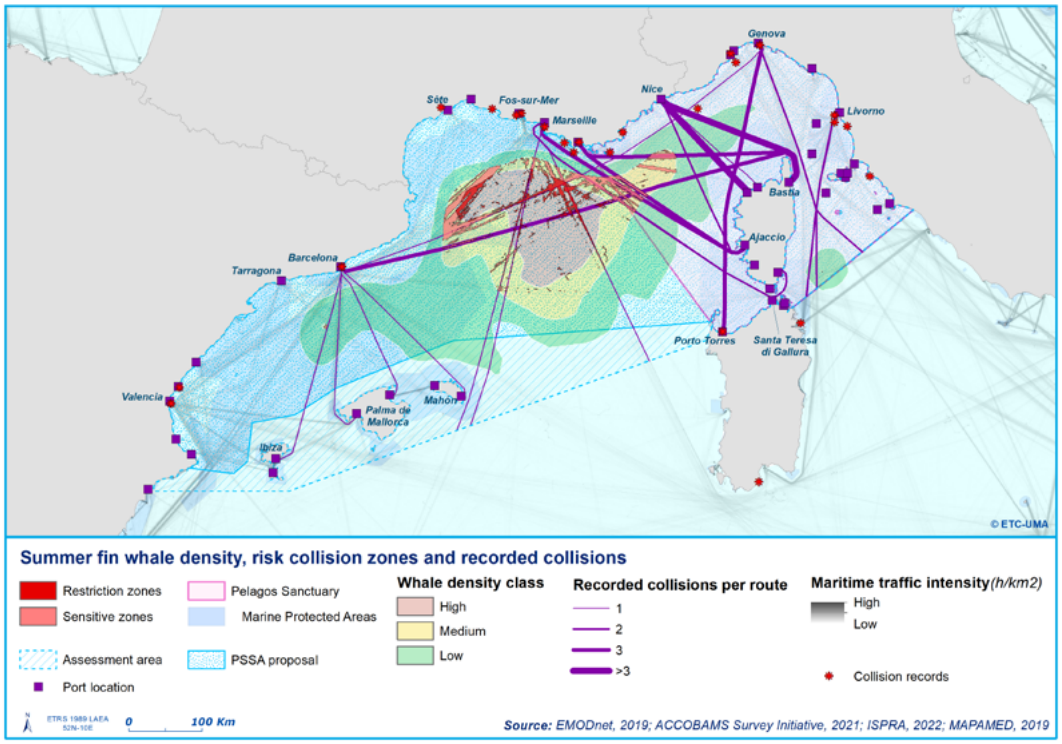

Figure 4: *Whale density (ACCOBAMS summer data), potential risk collision zones and dangerous maritime routes based on collision records.*

WHALE SHIP STRIKE RECORDS IN THE WESTERN MEDITERRANEAN SEA

The review of existing information on cetacean ship strike events yielded 138 records, 123 of which were recorded between 1952 and 2017 in the North-western Mediterranean only. Of these 123, 16 records were discarded because they were classified as duplicates, unconfirmed events or as events actively caused by whales, 4 were assessed as animals "already dead" at the time of collision and 21 were uncertain/unlikely events (some of these are still under evaluation). A total of 58 cases, including 6 of alive fin whales bearing clear marks of collision, were considered "confirmed" and 24 "highly likely" ship strikes. Within these latter two categories, fin whales represented 69 cases (84%) and sperm whales accounted for 8 cases (10%).

In terms of trends, it is worth noting that 74% of events were recorded from the 1980s to the 2000s. During this period, they showed a steady increase, with a peak of 38 records (31%) during the 2000s. However, during the 2010s, records dropped at the same level as for the 1970s (11-12 events per decade, equal to 11-12%). This latter trend is not justified by a difference in monitoring intensity.

VESSEL TRAFFIC CHARACTERISTICS IN RELATION TO COLLISION EVENTS

A summary on whale ship strike events recorded in the NW Mediterranean, with a focus on the Pelagos Sanctuary, is provided in Table 2. For the whole NW Mediterranean, passenger ships and cargos had the highest number of reported events, both 'on route' and in ports. Within the Pelagos Sanctuary, most collisions were caused by passenger ships, whereas outside Pelagos the majority of strikes were caused by cargos.

ALL RECORDS (Direct observations and port reports)	**NW Mediterranean (N=50)**		**Pelagos Sanctuary (N=36)**		**Outside the Pelagos Sanctuary (N=14)**	
Passenger ships	26	*52%*	23	*64%*	3	*21.5%*
Cargos	16	*32%*	6	*17%*	10	*71.5%*
Navy & service ships	4	*8%*	3	*8%*	1	*7%*
Tankers	2	*4%*	2	*6%*	0	*0%*
Yachts	2	*4%*	2	*6%*	0	*0%*
PORT REPORTS	**NW Mediterranean (N=33)**		**Pelagos Sanctuary (N=22)**		**Outside the Pelagos Sanctuary (N=11)**	
Passenger ships	64%	*68%*	15	*68%*	1	*9%*
Cargos	17%	*23%*	5	*23%*	10	*90%*
Navy & service ships	8%	*4,5%*	1	*4.5%*	0	*0%*
Tankers	6%	*4,5%*	1	*4.5%*	0	*0%*
Yachts	6%	*0*	0	*0%*	0	*0%*

Table 2. *Whale ship strike events recorded in the NW Mediterranean, inside and outside the Pelagos Sanctuary in relation to the type of ship*

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Discussion

The level of maritime traffic and the intricacy of the network of shipping routes within the Pelagos Sanctuary and the proposed NW Mediterranean PSSA has the potential to put a major pressure on fin whales, which gather here in spring and summer months to feed. In addition, this region encompasses important habitats for fin whales, sperm whales and beaked whales, including a deep-water corridor.

Many of these shipping routes also cross several MPAs, including large Nature 2000 sites. Such level of shipping intensity brings in a number of direct and indirect pressures on cetaceans and their ecosystem, which cause direct mortality (whale ship strikes), disruption of communication (increased underwater noise) and potential impacts on the health of cetaceans and their ecosystem (chemical pollution).

The key proposed '***associated measures***' within the PSSA boundaries are in the form of recommendations on:

1. *'voluntary speed reduction' 'between 10 and 13 knots' 'when and where large and medium cetaceans are present'*; and
2. reporting to relevant authorities of any collision event and sighting of large cetaceans.

Additional '***prospective measures***' are directed to harmonise and facilitate the data collection to:

1. develop precise information for seafarers on whale aggregations to be broadcasted through enhanced digital navigational warnings (e.g., NAVSAT system) and
2. implement more restrictive measures to mitigate shipping pressures on large cetaceans on clearly identified important habitats (e.g., through Areas To Be Avoided; Traffic Separation Schemes, areas with mandatory speed limits, etc.).

In this context, our study suggests three priority areas (below) to inform the process of identifying the most appropriate technological and technical management measures to mitigate the risk of whale ship strikes in the NW Mediterranean. Our results stimulate three key questions, indicate potential answers and further analyses to test our hypotheses and help strengthen the proposed measures.

In general, the priority research questions discussed below should be fully addressed in the context of the implementation of the Pelagos Sanctuary Management Plan, as the ability to answer to some of the following questions would greatly enhance the implementation of mitigation measures within this SPAMI.

Q1: Why "Passenger ships" and "Cargos" are more dangerous for whales than other ships?

Coomber and colleagues (2016) characterised the shipping traffic within the Pelagos Sanctuary as follow:

- In terms of total number of vessels, 42% were cargos, 7% passenger ships, 14% tankers, 3% service ships, 32% pleasure boats/yachts and 3% fishing boats.
- In terms of total number of transits (a proxy for traffic intensity), 26% were made by cargos, 32% by passenger ships, 12% tankers, 10% service ships, 10% by pleasure boats/yachts and 9% by fishing boats.

Assuming that the risk of whale ship strikes is proportional to both the whale density and the intensity of ship traffic, when comparing Coomber and colleagues (2016) numbers to the actual percentages of recorded events from our datasets within the Pelagos Sanctuary (Table 2), it seems clear that, within the Sanctuary, passenger ships pose a risk that is double than expected; whereas cargos are in line with the level of their traffic intensity. Fishing boats pose no risk. Pleasure boats/yachts cause much less collisions compared to their traffic levels and their collisions are not always deadly. Tankers seem to cause half of collisions than predicted (Table 3).

ALL RECORDS	**All events (A)**	**Port events (B)**	**Traffic intensity (C)**	**'Reality' All records (A/C)**	**'Reality' Only port records (B/C)**
Passenger ships	64%	68%	32%	*Double than expected*	*Double than expected*
Cargos	17%	23%	26%	*35% less than expected*	*10% less than expected*
Navy & service ships	8%	4,5%	10%	*20% less than expected*	*65% less than half than expected*
Tankers	6%	4,5%	12%	*Half than expected*	*60% less than half than expected*
Yachts	6%	0	10%	*40% less than expected*	*None*
Fishing boats	0%	0	9%	*None*	*None*

Table 3. *Whale collision records versus predicted strikes based on different types of maritime traffic intensity within the Pelagos Sanctuary*

Coomber et al 2016 provided also an overview of the characteristics of these different types of vessel types:

- fishing and service ships are small and slow vessels (mean length: 21-37 m; mean transit speed: 5-6 kn);
- pleasure boats are small but faster than fishing and service ships (length: 21m; speed: 11kn);
- tankers and cargos are large vessels (of about the same length: 171-174m), but tankers are on average slightly slower (9kn) than cargos (11kn);
- passenger ships are slightly smaller than tankers and cargos (156m), but they are the fastest ones (mean: 15±4 kn).

Combining all these factors and considering that fin whales represented 92% of the considered subset, it seems straightforward to conclude that "high speed" by "very large vessels" is a deadly combination for this species. These preliminary conclusions should be further tested, and specific prospective measures should be identified to minimise the impact caused by this combination.

Q2: Why within the Pelagos Sanctuary and its surrounding regions some passenger routes seem more dangerous irrespective of their traffic density?

Looking at the distribution of passenger ship traffic and routes where whale strikes were recorded, it seems that some routes might be more dangerous for whales compared to others (Fig. 4), irrespective of the level of traffic (Fig. 3). This seems true within the Pelagos Sanctuary and the adjacent region of the Gulf of Lions, and it is likely related to the distribution of whales seasonally. However, the 'shipping route network' within the Pelagos Sanctuary is more intricate than in other parts of the PSSA and this could also affect the risk of collision in this sub-region.

Current distribution and density maps for fin whales are still not sufficiently refined to fully test this hypothesis and novel modelling and simulation approaches need to be considered. New inference and predictive models are necessary to identify and implement the PSSA prospective measures.

Q3: How does the third (depth) and forth (time) dimensions affect the risk of whale ship strikes?

When looking at distribution maps for cetacean species, one should remember that they should be three dimensional and that, on average, the time that these species spend at or near the surface is rather limited compared to the time that they spend deep underwater. This reduces the risk of being struck by a ship. However, since time at depth or at surface varies in relation to their species-specific behavioural features, which are affected by regional oceanographic features, distribution of prey and physiological needs, the time spent in a potential risk area can increase considerably under certain conditions. It is also important to consider the traffic area of the most dangerous ships and include it into 3-dimensional risk models.

METHODOLOGICAL REMARKS

Spatial overlap between maritime traffic and modelled whale density can be used as a proxy for the risk of collision, but limits on how data were collected both on whale ship strikes and maritime traffic need to be considered. For example:

- Ship strikes recorded for all boats (including those collected from ships/ferries) and ship strikes recorded at the port (data independent from 'observers' on ships) have both caveats related to "presence-only data".
- Shipping-independent data may also be biassed in relation to species, as it appears that sperm whales do not get stuck to the ship bulb as opposed to Mysticetes. Sperm whales might be underrepresented because of hydrodynamic features related to their body and how it behaves in an impact with the ship bow. In addition, different species may have very different probabilities to get struck by a ship also in relation to their social diving, feeding and resting behaviours.
- The observation effort, based on field researchers, stranding networks and newspaper articles may have varied over time as it developed and as the issue of whale ship strikes became of interest for the public.
- The identification of 'sensitive' and 'restriction' zones needs to take into consideration that traffic intensity can be detrimental also at low levels when overlapping critical habitats.

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THE MEDITERRANEAN BIODIVERSITY PROTECTION COMMUNITY

A collaborative Mediterranean community representing around 300 institutions are bringing together their work to identify the most effective mechanisms to manage and protect Mediterranean biodiversity.

The results of MBPC projects (ACT4LITTER, AMARE, CONFISH, ECOSUSTAIN, FISHMPABLUE2, MEDSEALITTER, MPA-ADAPT, MPA NETWORKS, MPA ENGAGE, PHAROS4MPAS, PLASTICBUSTERSMPAS, POSBEMED, TUNE UP, WETNET) are being streamlined to offer holistic solutions that bridge science, practice and policy to priority environmental challenges through an action roadmap implemented by several working groups.

The overall aim of the Biodiversity Protection Community is to increase the current understanding, knowledge and awareness of multiple environmental threats and promote best practices and Ecosystem-based Management tools as a response to address cumulative pressures and impacts affecting protected areas and functional ecosystem units in the Mediterranean.

Interreg Mediterranean BIODIVERSITY PROTECTION

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