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PROGRESS IN REVISING CETACEAN CRITICAL HABITATS

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Presented by Léa David, Task Manager on Marine Protected Areas

Issue: progress in revising the Cetacean Critical Habitats (CCH) in the ACCOBAMS Area

1. Action requested

The Scientific Committee is invited to:

a. **note** the information provided on progress in revising CCH in the ACCOBAMS Area
b. **advise** on the revision of CCH in the ACCOBAMS Area.

2. Background

According to the ACCOBAMS Conservation Plan (Annex 2 of the Agreement), Parties shall endeavor to establish and manage specially protected areas corresponding to the areas which serve as habitat of cetaceans.

Resolution 6.24 requests the Scientific Committee, in particular the Task Manager on CCH, to:

- revise the existing CCH, taking into account (i) the candidate IMMAs proposed and the Areas of Interest identified during the first workshop on the Identification of Important Marine Mammal Areas (IMMAs) in the Mediterranean Sea, and (ii) the threat-based management approach;

- evaluate the effectiveness of adequate management of protected areas within CCH through existing initiatives, such as MedPAN; and

- revise and update adequate management tools for areas within CCH, subsequently to the implementation of an assessment.

DRAFT DOCUMENT
Progress report CCH process – Ongoing

Aim

Cetacean Critical Habitat = potential manageable area where attention has to be drown/focused (no straight limits) because there exists a threat for cetaceans.

The CCH is a science-based process whose results will be displayed on a free accessible web-based GIS, Netccobams, and be useful for communication toward stakeholders and decision makers at the regional level, as an interface between science and policies

Where the threat is known, the CCH will be the area where to focus to find the relevant measures of mitigation, from place-based to sectorial-based and act.

Is complementary to national analysis and initiatives of any science, management and measures of conservation

Limits

CCH = still an on-going process that has to be fed by new consequent results when they are available.

Exercise needing precise quantitative geographic information from different reliable and renown sources, merging them, and then simplify it through a generalisation of the shapes (degrading information) to highlight the main areas where the cetaceans are threatening in their habitat.

CCH is not an MPA.

List of data providers used for habitat design

Model of cetacean habitat:

- ACCOBAMS, ASI & CeNoBS
- Duke University Marine Geospatial Ecology Lab, Durham, North Carolina

IMMA:

- IUCN Marine Mammal Protected Area Task Force

Human activity data:

- SINAY
- Global Fishing Watch
- ACCOBAMS
- Halpern *et al*. 2008

SUMMARY

FIGURES

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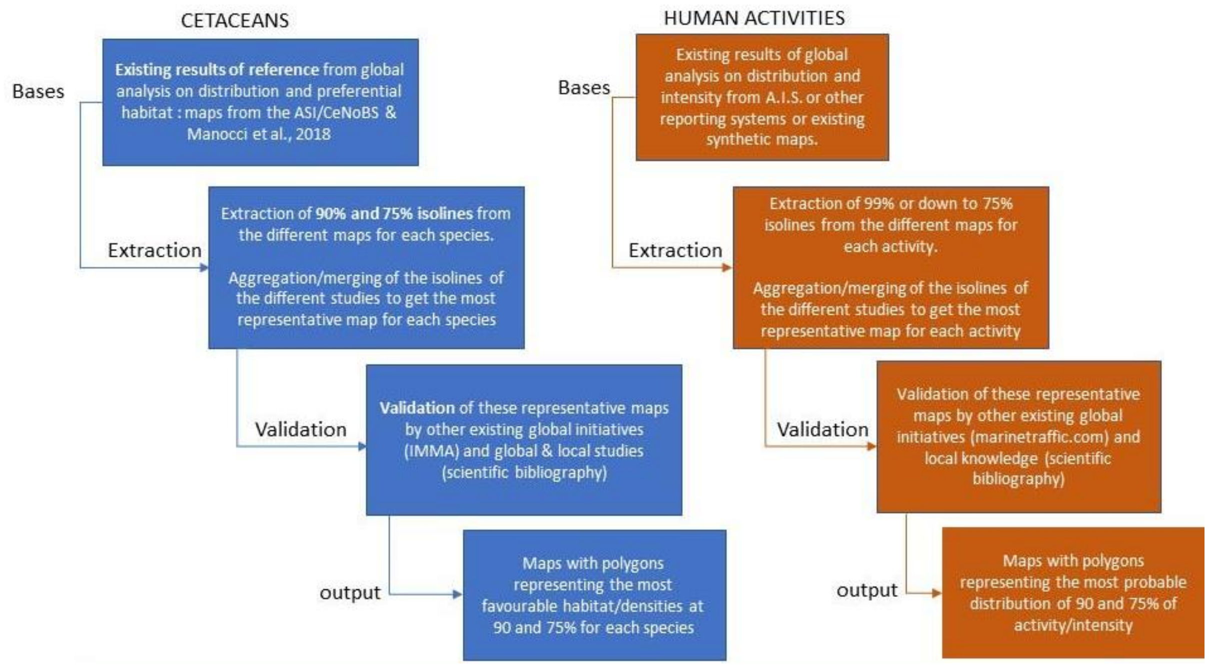
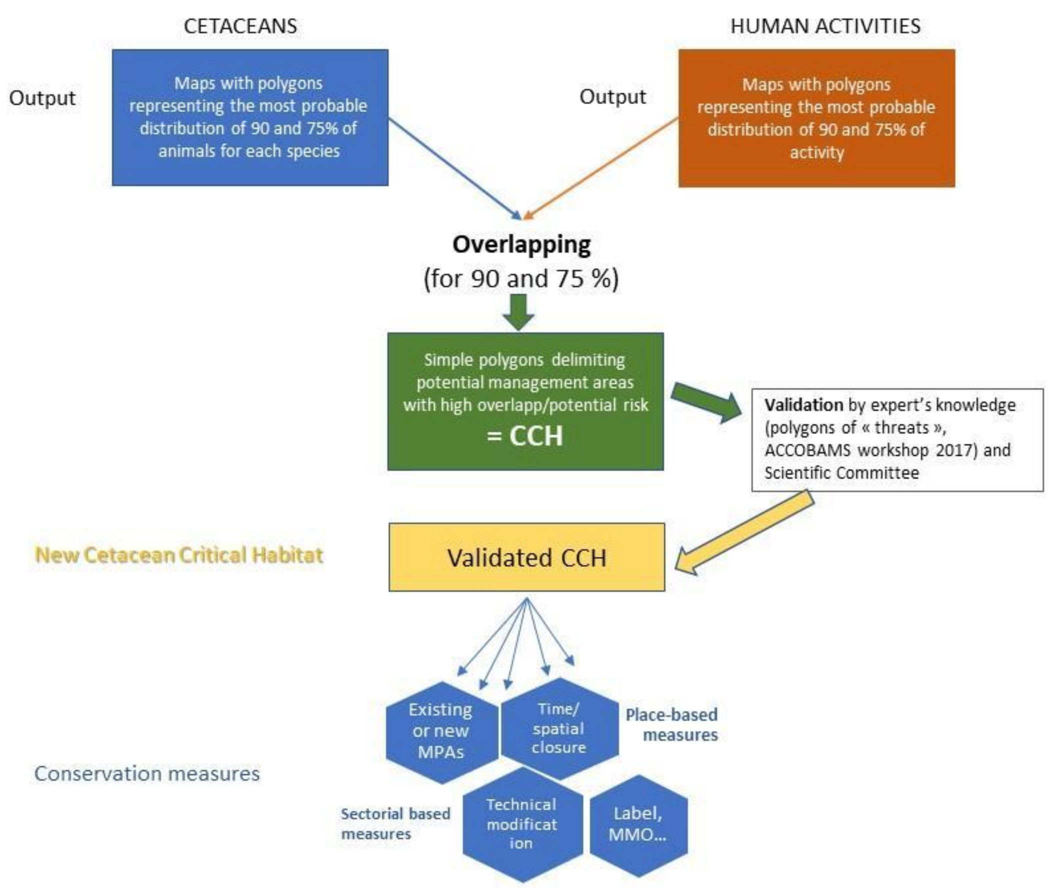
Introduction

Improvements in the Cetacean Critical Habitat process and method is described schematically in these figures and is explained in more details in this report.

First step:



Second step:



Cetacean data and process

Cetacean input data

The bases are the existing “synthetic” studies/**analyses** that used a lot of existing data, for a large temporal and spatial coverage: the ACCOBAMS Survey Initiative or ASI and the Gap Analysis launched by the Duke Marine Lab. The results of these studies were merely distributional maps or favourable habitat maps for species and distributional or intensity of human activities. Both works are presented below.

ACCOBAMS Survey Initiative (ASI)

The results come from the ACCOBAMS Survey Initiative undertaken in the Mediterranean Sea (ACCOBAMS (a), 2021) and from the ASI/CENOBS/EMBLAS carried out in the Black Sea (ACCOBAMS (b), 2021). Target species are the fin whale, the striped dolphin, the Risso’s dolphin, the common dolphin, the bottlenose dolphin, and the harbour porpoise. There is no existing habitat modelling for the sperm whale, the long-finned pilot whale nor the Cuvier’s beaked whale.

Model-based abundances are expressed as the number of individuals per cell of 100 km². Data have been collected during summer 2018 within the Mediterranean Sea and during summer 2019 for the Black Sea. Modelling has been realized only on data from aerial surveys. The maps of the predicted abundances of each species from the ACCOBAMS Survey Initiative are presented on Appendices

.

Gap Analysis and spatial models of marine species

A global Gap Analysis study was run by Mannocci and colleagues, based on gathered data, boat- or aerial based, from almost all teams working on cetaceans within the Mediterranean Sea from 1999 to 2016 (Mannocci *et al.,* 2018). Following this, the team developed marine species density models. Target species with enough data were the sperm whale, the fin whale, the Cuvier’s beaked whale, the bottlenose dolphin, the striped dolphin, the long-finned pilot whale, the Risso’s dolphin and the common dolphin.

Abundances are expressed as the annual mean of individuals per 25km². The selected covariates for the final model and the associated maps of mean annual predicted densities for each species are presented on Appendices

.

Creation of the “species” polygons of reference

When the information was available in files with format as .tiff or raster or .shp, they were included in the Geographic Information System or GIS (QGis, version 3.16.6) project directly. For raster files, an extraction by contour has been realised, to get the delineated areas excluding the very low values, and a polygon including 90% of the distribution or habitat and another with 75% have been extracted and used.

Figure 1 details the different steps under QGis for the creation of the “species” polygons for the CCH process, an illustrated example of the procedure is visible in the **Appendix 2**.

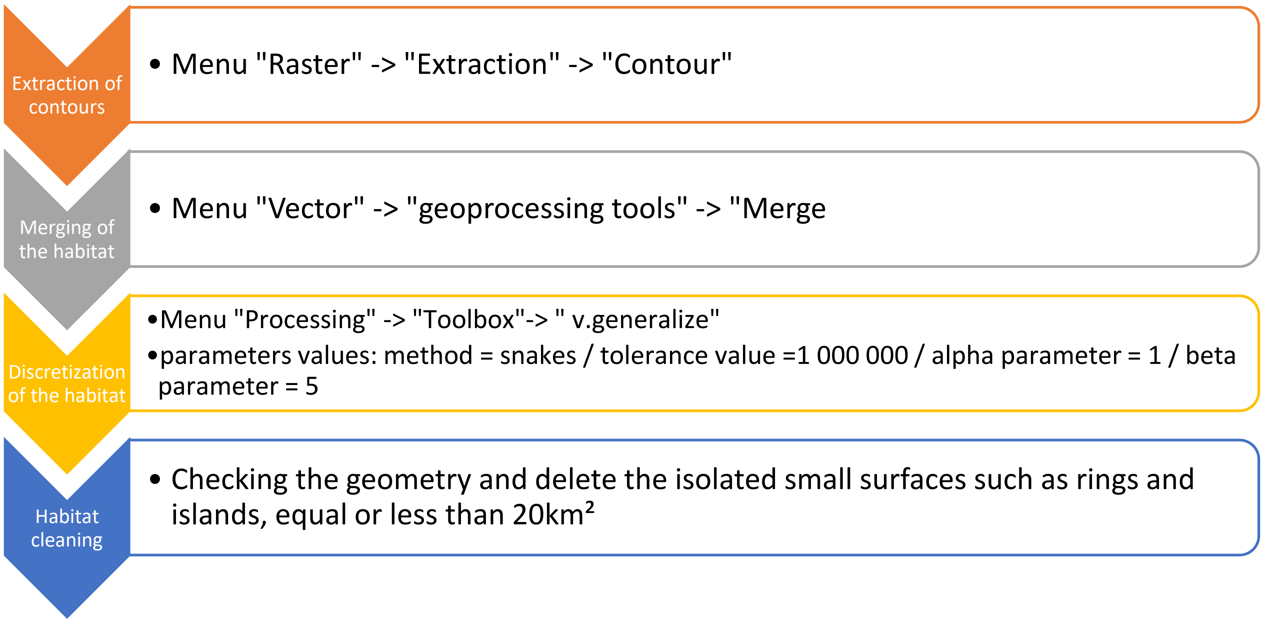


Figure 1: Procedure under QGis

Validation process

As the data used by Mannocci and colleagues and data coming from the ASI&CeNoBS may have some temporal or spatial gaps, the polygons resulting from the CCH process explained before were then for each species compared to other maps resulting from other studies led at the sub-regional or regional scale. If maps were coherent, highlighting the same important areas for the species, then it "validates" the map of species for the following steps in the CCH process to be used. If it was not coherent in some areas (missing areas mainly), a more review process begins in order to know if the area has to be added or not, and if yes, then the results of the other study were used to fill the gap in the CCH species map. Scientific results as well as expert's knowledge were considered for this step.

Table 1 shows the list of publications consulted for the different species.

Table 1: Publications of reference used according to species

	Fin whale	Sperm whale	Bottlenose dolphin	Common dolphin	Striped dolphin	Risso's dolphin	Long-finned pilot whale	Cuvier's Beaked whale	Harbour porpoise
IMMAs	x	x	x	x	x	x	x	x	x
Arcangeli et al. 2019						x	x	x	
Bearzi et al. 2003				x					
Birkun et al. 2014			x	x					x
Cañadas et al. 2016								x	
Druon et al. 2012	x								
Lewis et al. 2018		x							
Notarbartolo di Sciara et al. 2016	x	x					x		x
Sánchez-Cabanes et al. 2017			x	x					x
Vella et al. 2021				x					

Resulting from the CCH process, the maps obtained for the sperm whale (*Figure 2*), the fin whale (*Figure 3*), the striped dolphin (*Figure 4*), the bottlenose dolphin (*Figure 5*) and the Risso's dolphin (*Figure 6*) are in accordance with those from the literature.

However, for the common dolphin and the harbour porpoise, the obtained results do not reflect all the known suitable habitats. To overcome this lack, it was chosen to add the IMMAs regarding each species (**Appendix 3**). Indeed, the IMMAs represent important areas for cetaceans and have been validated according to specific criteria based on scientific results (IUCN MMPATF, 2016). The final maps obtained for the common dolphin and the harbor porpoise are respectively *Figure 7* and *Figure 8*.

For the long-finned pilot whale and the Cuvier's Beaked whale, the validation process is still ongoing.

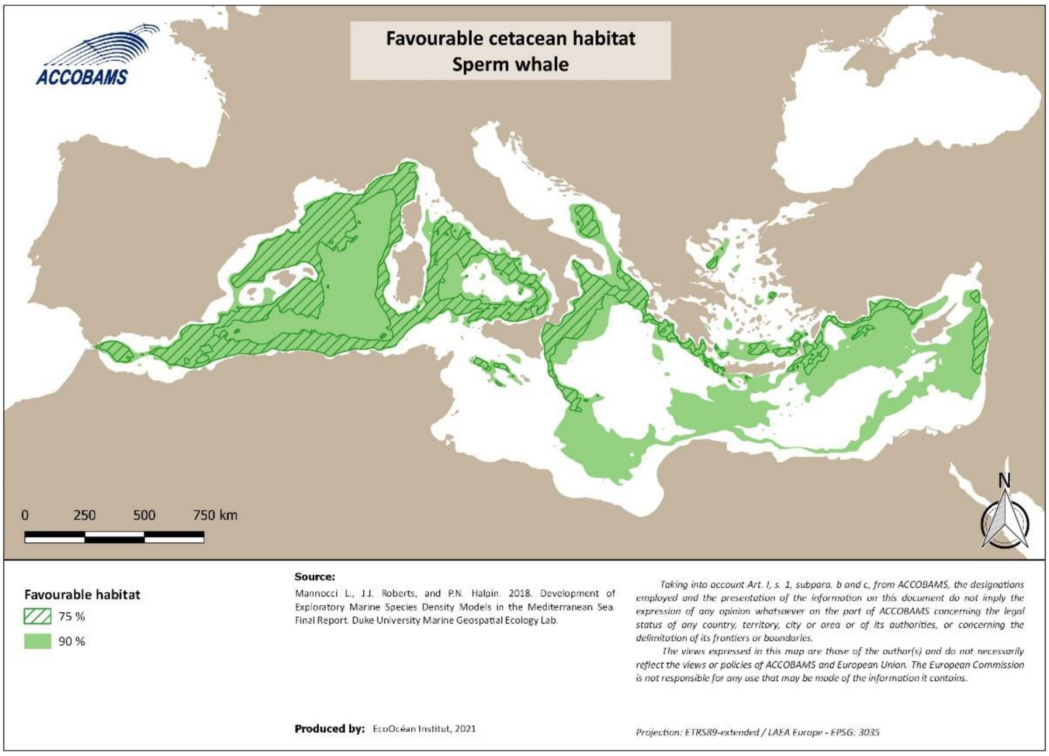


Figure 2: Favourable habitat for the sperm whale

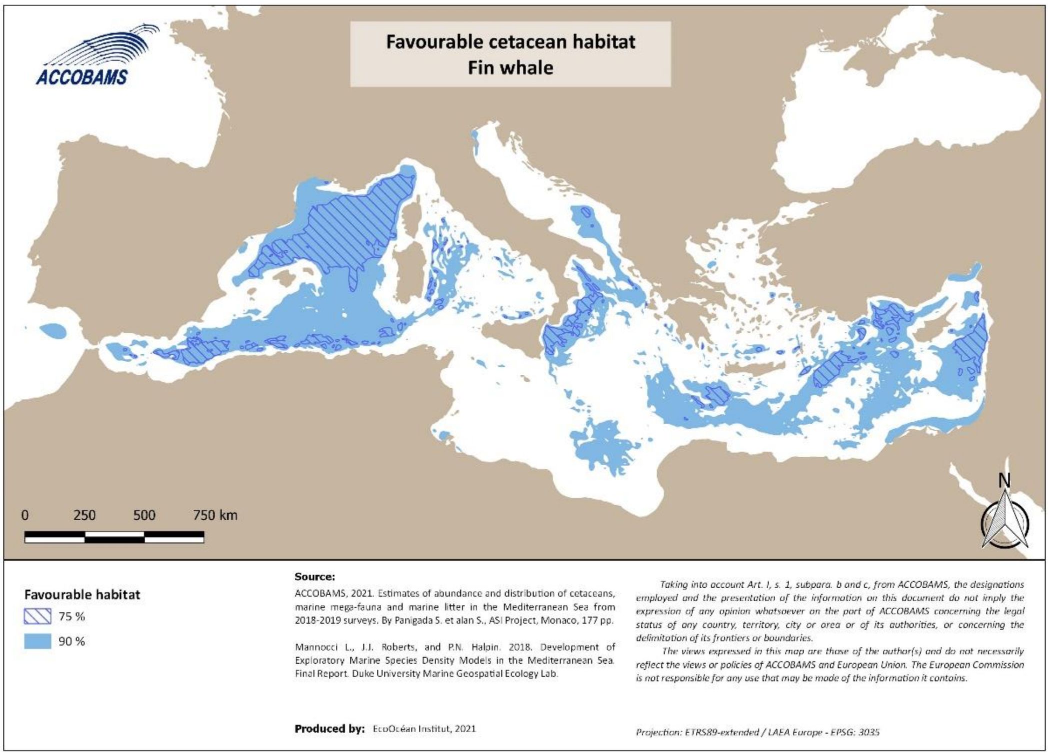


Figure 3: Favourable habitat for the fin whale

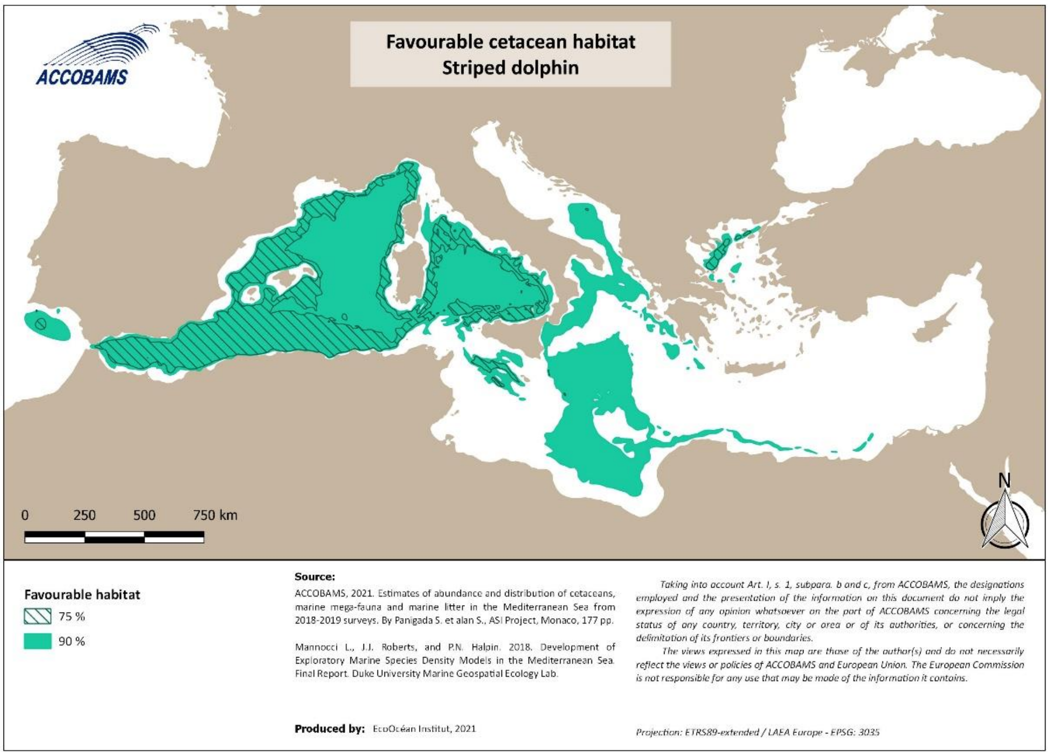


Figure 4: Favourable habitat for the striped dolphin

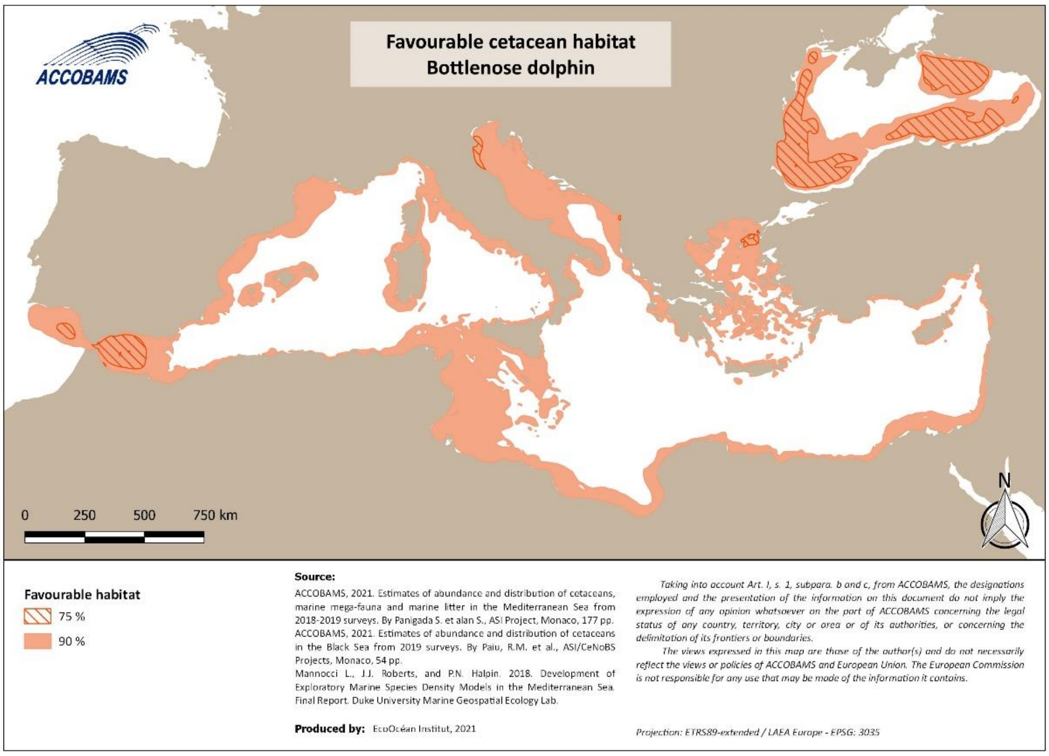


Figure 5: Favourable habitat for the bottlenose dolphin

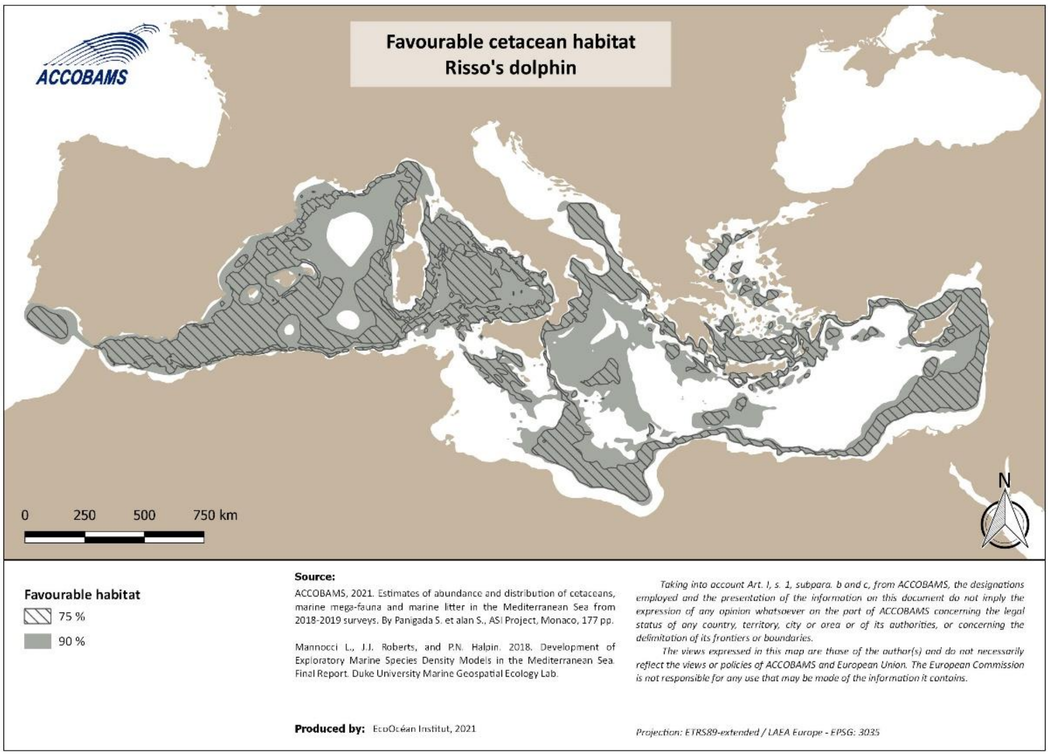


Figure 6: Favourable habitat for the Risso’s dolphin

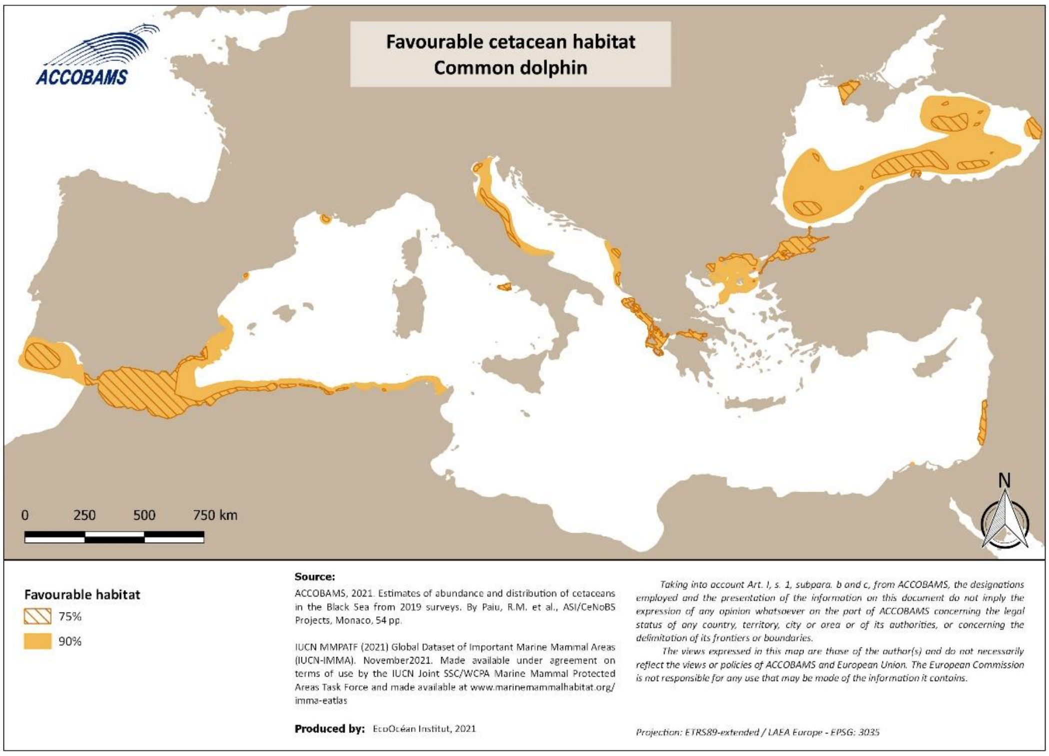


Figure 7: Favourable habitat for the common dolphin

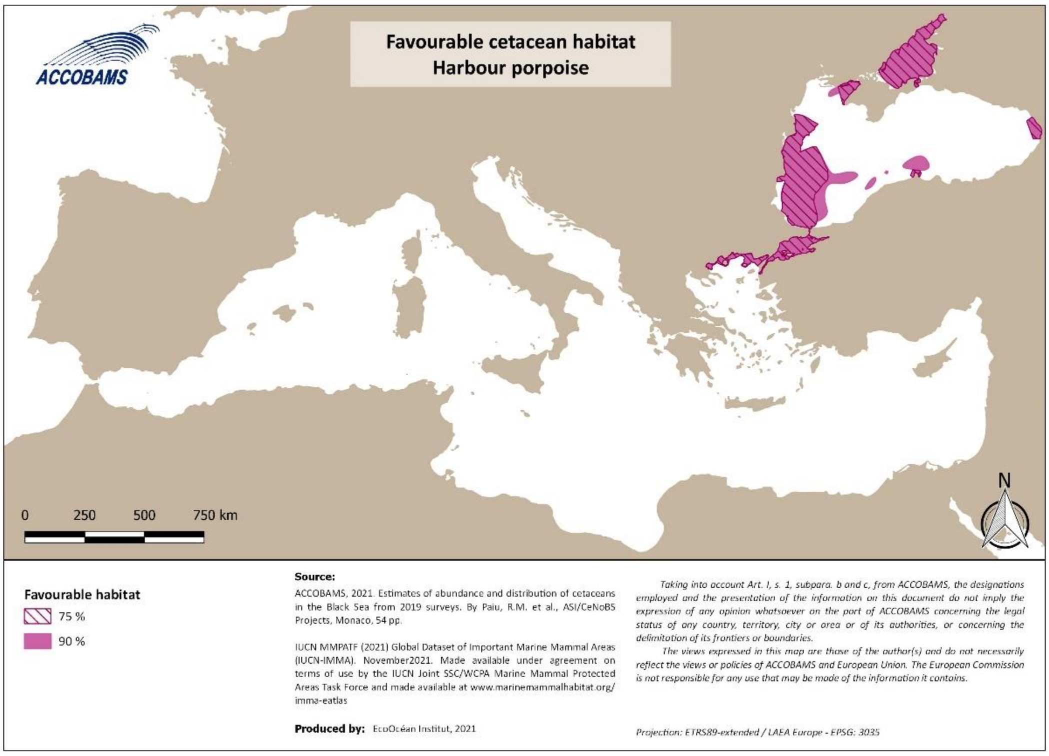


Figure 8: Favourable habitat for the harbour porpoise

Data on human activities

Marine Traffic (large commercial vessel)

Marine traffic input data

The marine traffic of large commercial vessels is monitored at sea with a mandatory tool, the Automatic Information System (AIS) and each vessel of that type around the world is equipped with AIS. Maps were built based on AIS data from the whole 2018 year.

The grid resolution is 0.1x0.1; and the unit corresponds to the number of AIS message emitted over the grid surface during the study period. Analysis and compilation of AIS data have been realized by SINAY. The category of large commercial vessels includes cargos, tankers, container ships, ferries, cruise vessels...

Marine traffic polygons

The same method as for the cetacean polygon process has been apply: contour extraction / discretization / cleaning. At the end, isopleth 75% and isopleth 90 % of the annual traffic in the Mediterranean Sea are displayed respectively on *Figure 9* and *Figure 10*.

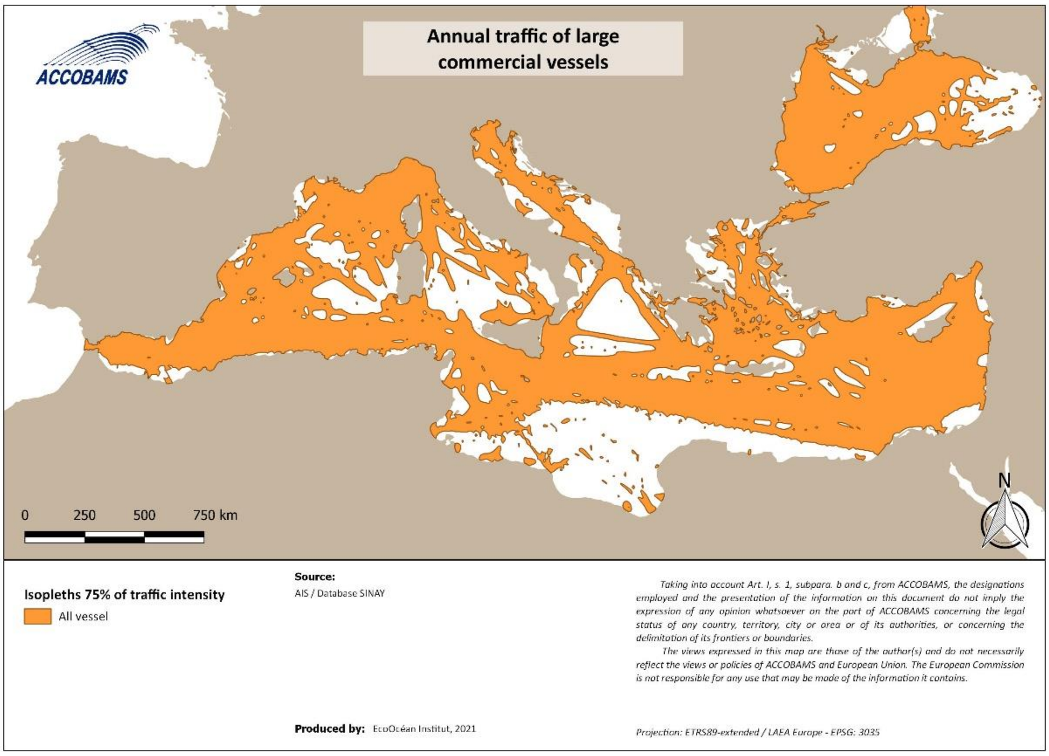


Figure 9: Marine traffic polygon (Isopleth 75%)

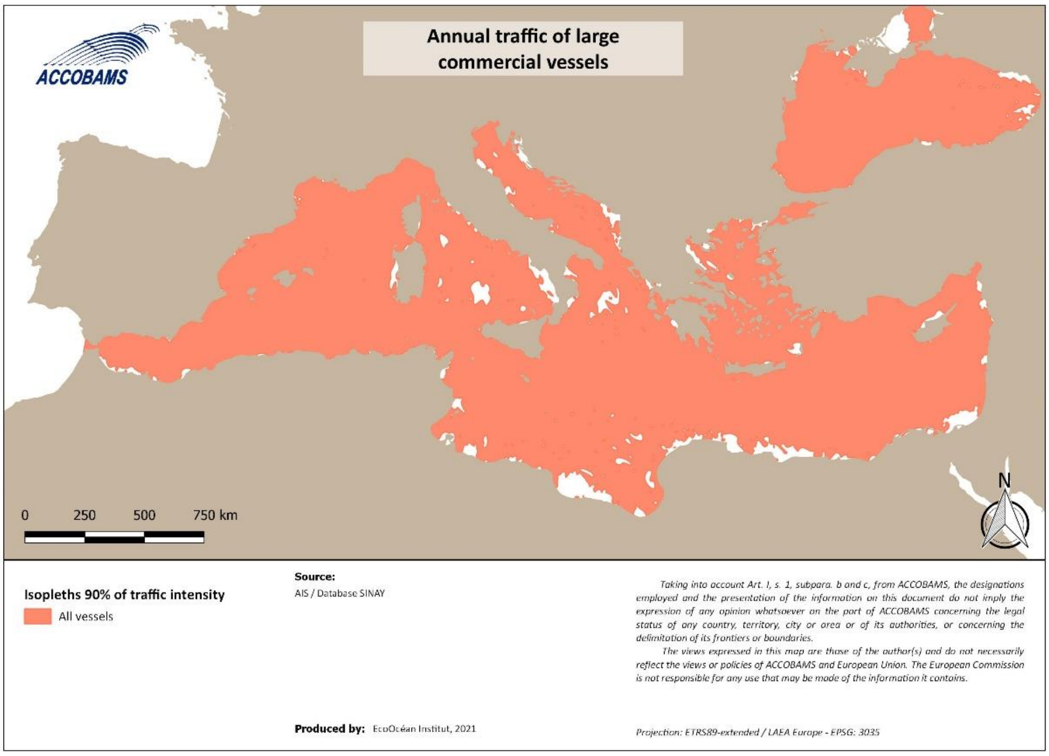


Figure 10: Marine traffic polygon (Isopleth 90%)

Validation

The annual density map of marine traffic displayed on the web site https://www.marinetraffic.com/ has been used to validate or complete the information regarding the maritime traffic, as well as the Medtrends work (Piante and Ody, 2015).

Fishery

The fishery activity at sea is not easy to map. Indeed, some tools to follow each vessel at sea exist, as the AIS, but this tool is mandatory for European vessels only, and for vessels larger than 12 m only. Therefore, as the fishery fleet in the Mediterranean Sea consists of 83% of small-scale vessels (*Figure 11*, FAO, 2020), without AIS, those ones are not monitored at sea. Large vessels from non-European countries are not traceable at sea neither. Another way to manage fishery vessels at sea mostly in European countries is the VMS tool. But those data are not easily available and do not bring much more than the easily accessible AIS.

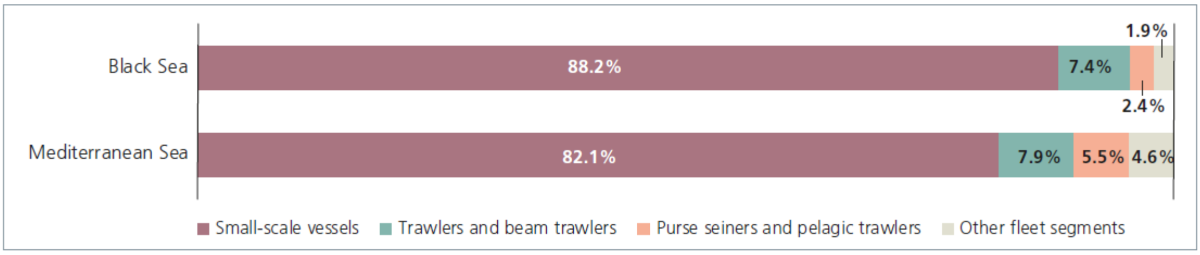


Figure 11 : Fleet segment composition in the Mediterranean and Black Sea, FAO 2020

Fishery input data

Data on fishery activities come from the AIS results from the Global Fishing Watch website[1], free of access, and consists of a compilation of daily hours of fishing during the year 2018 in a grid of 0.1x0.1° cells.

Global Fishing Watch analyzes AIS data collected from vessels identified as known or possible commercial fishing vessels, and applies a fishing detection algorithm to determine "apparent fishing activity" based on changes in vessel speed and direction. The algorithm classifies each AIS broadcast data point for these vessels as either apparently fishing or not fishing and shows the former on the Global Fishing Watch fishing activity heat map.

Vessels are divided into 5 categories:

- drifting longlines
- seiners: vessels using seine nets, including potential purse seine vessels, targeting tuna and other species, as well as danish and other seines
- trawlers: all types
- fixed gear: a category that includes potential set longlines, set gillnets, and pots and traps
- all fishing

Fishery Polygons

The same method as for the cetacean data process has been applied to obtain the polygon of this activity: contour extraction / discretization / cleaning. However, because the activity exploits the sea in a dynamic way, not going each time exactly in the same place, it appears that the intensity expressed in those small cells seemed not the best parameter to represent this activity spatially. Indeed, the 75% of effort highlighted really very small areas, and mapping outcomes appear really not representative of this activity at sea. (**Appendix 4**). So, it was decided to keep almost the 99% effort.

Validation

Several works about spatialisation of fishery activities exist based on AIS e.g.:

- Piante & Ody, 2015.
- Vespe et al., 2016

Their comparison shows that the maps obtained are all almost the same.

Nevertheless, in order to take into account also the artisanal fleet, the layer produced through modelisation by Halpern et al. (2008) of this activity in the Mediterranean Sea and Black Sea, was downloaded and added to the map of this pressure. And considering the data collected during the ACCOBAMS Survey Initiative on fishery vessels and the results obtained from those data by David & Roul (2021), it appears important to use those results (kernel analysis) to fill some gaps in the pressure map too. Then, the final map merges the polygons of the three sources (*Figure 12*).

[1] *https://globalfishingwatch.org/map/*

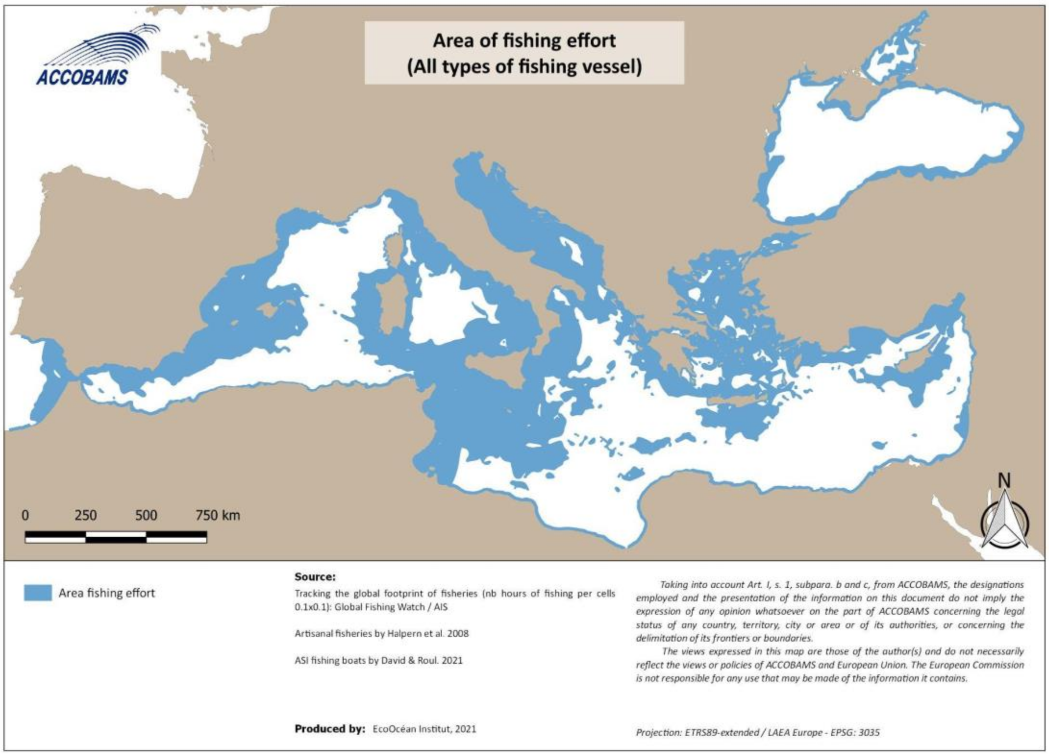


Figure 12: Area of annual fishing effort in the Mediterranean Sea and the Black Sea

Whale watching

Existing maps of the whale-watching pressure at sea exist, but locally in France (Mayol *et al.*, 2012) or in Italy (Sicomar project). The project of mapping this activity at the ACCOBAMS scale is ongoing, in link with the ACCOBAMS working group on Whale-watching.

Whale watching input data

Either data recorded directly from observers onboard or owners of the Whale-watching vessels during their trips can be used, or a modelisation could be applied at the ACCOBAMS area scale.

Recreational vessel

No precise map of this activity exists within the ACCOBAMS area.

What is planned is to use or redo the exercise of modelisation leading to the map of this activity in Piante & Ody (2015) or Halpern et al. (2008).

For the validation process, the data on human activity from direct observation at sea, like the one collected by the Medtrix aerial surveys along the French Mediterranean coasts (https://medtrix.fr/), will be used.

Fix and punctual activities: fish farms, oil&gas platforms and seismic exploration

Maps of some fix activities, as fish farms and oil&gas platforms may be drawn, based on existing knowledge and official listing and charts as future steps.

Considering more punctual activities, as seismic exploration or coastal building, it is difficult to map those in the CCH process as they are mot permanent. The base of this activities will be taken from Maglio et al., 2016 when it will be updated.

Overlap of species and human activities maps, creation of new CCH polygons

Overlap and intersect

The "species" polygons will be overlapped with the "human activity" polygon through GIS. The resulting overlapping part will define the potential "interaction" areas. Within those interactions are the threats to the species. As first examples, the CCH exercise has been ran on known threats as:

- Marine traffic and large species of cetaceans (fin whale and sperm whale) for ship strike and continuous noise
- Fishery and delphinids (bottlenose dolphin, common dolphin, striped dolphin and harbour porpoise) for depredation and bycatch

But any overlap can be realised, as sperm whale and Risso's dolphin versus fishery, all species versus recreational vessels and whale-watching, and coastal species versus coastal building. Globally the exercise should be done at least at the two levels of 90% (conservational approach) and 75%, and at other levels if needed.

QGis procedure: use the species layer (favourable cetacean habitat) as the first layer, then the pressure layer (human activity) as the overlay layer through the tool "Vector" -> "Geoprocessing Tools" -> "Intersect".

The overlap maps with both types of layers still visible, favourable cetacean habitat and annual traffic of human activities as example, are presented on **Appendix 5**. **The intersect part of this overlap constitute the CCH polygon.**

The final maps of the CCH are below and represent the potential "interaction" areas between the species and human activity (from *Figure 13* to *Figure 17*).

Common dolphin and fishery

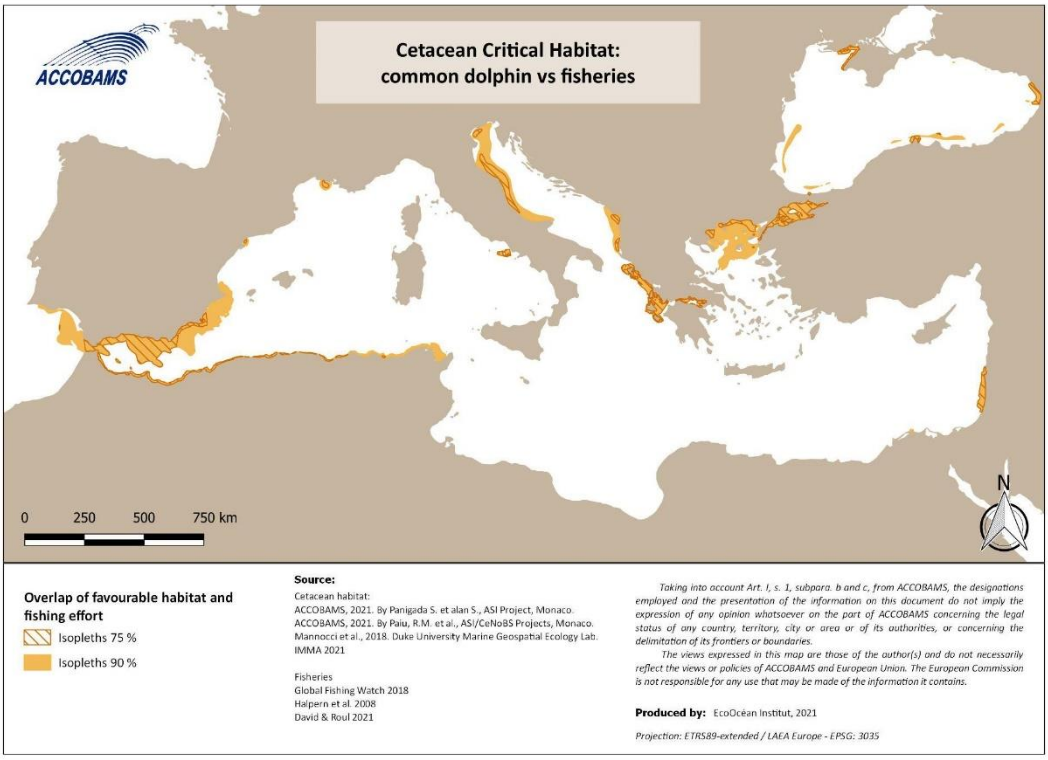


Figure 13: Cetacean Critical Habitat of the common dolphin versus fishery activities in the Mediterranean Sea and the Black Sea

Bottlenose dolphin and fishery

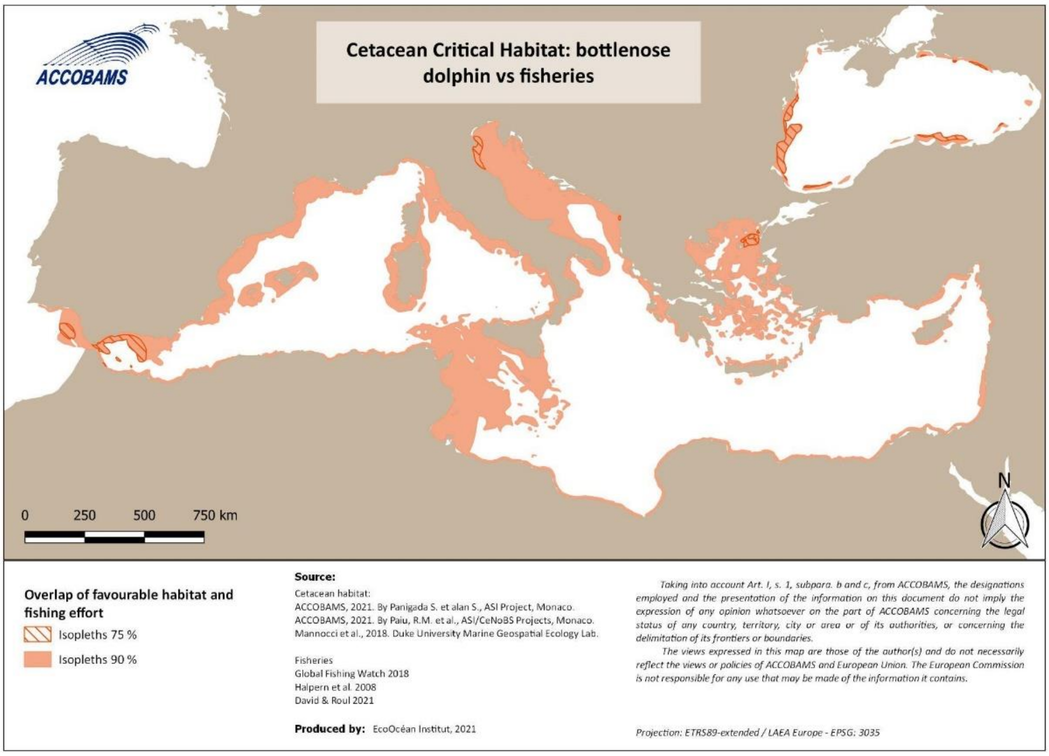


Figure 14: Cetacean Critical Habitat of the bottlenose dolphin versus fishery activities in the Mediterranean Sea and the Black Sea

Harbour porpoise and fishery

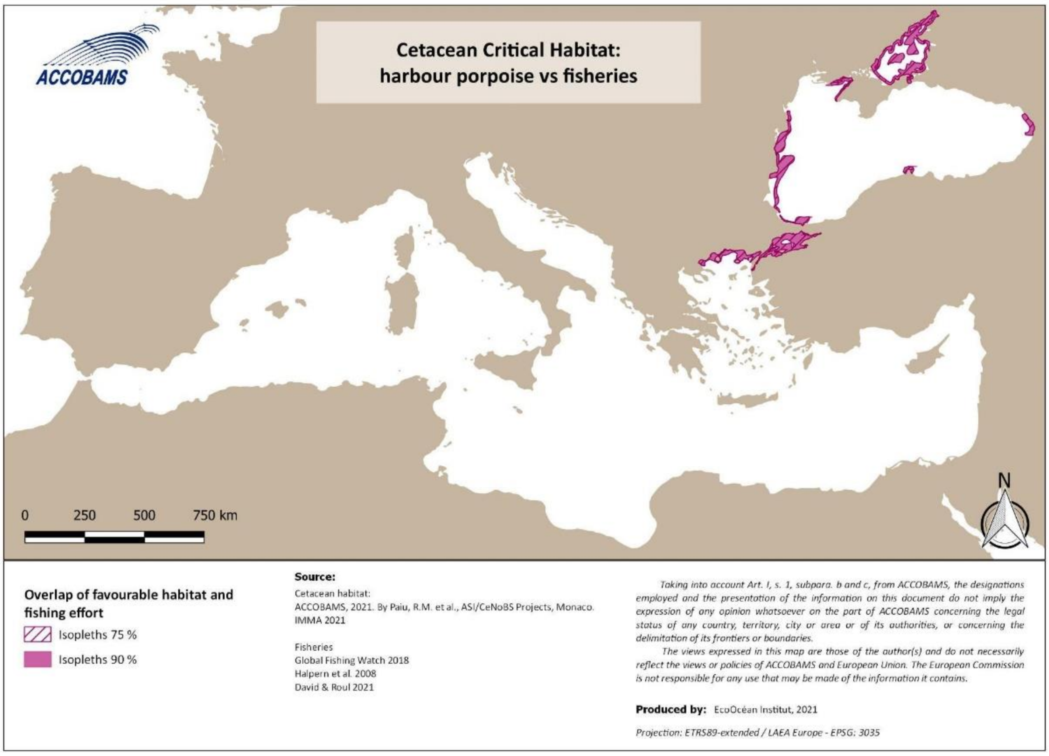


Figure 15: Cetacean Critical Habitat of the harbour porpoise versus fishery activities in the Mediterranean Sea and the Black Sea

Fin whale and marine traffic

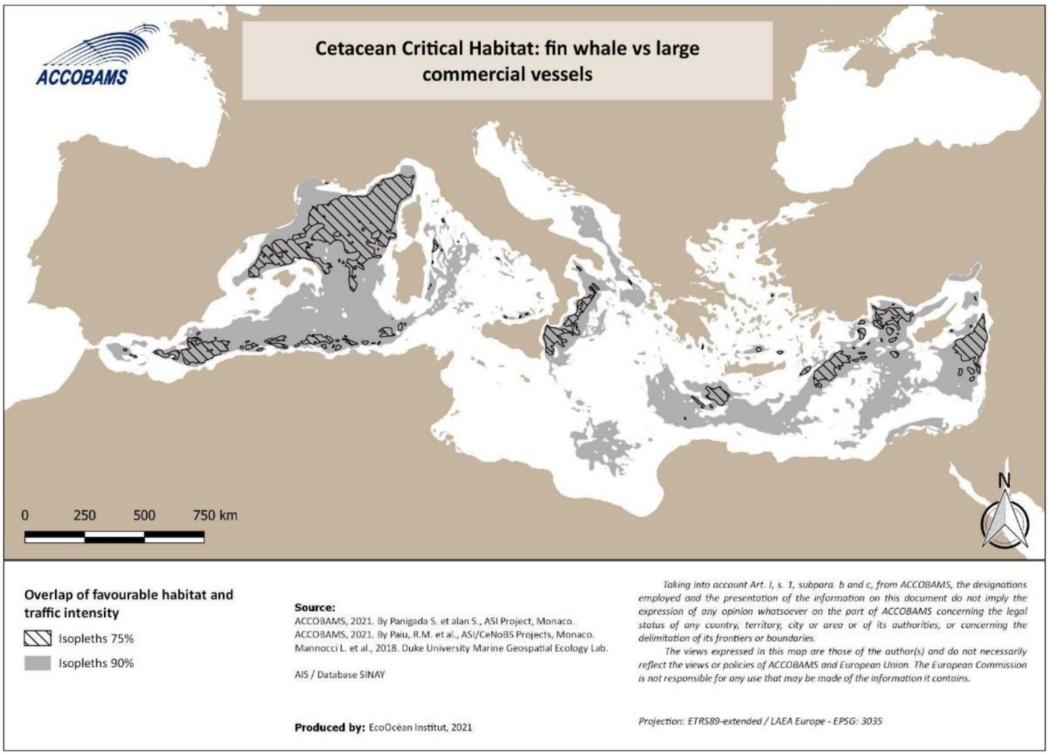


Figure 16: Cetacean Critical Habitat of the fin whale versus marine traffic in the Mediterranean Sea

Sperm whale and marine traffic

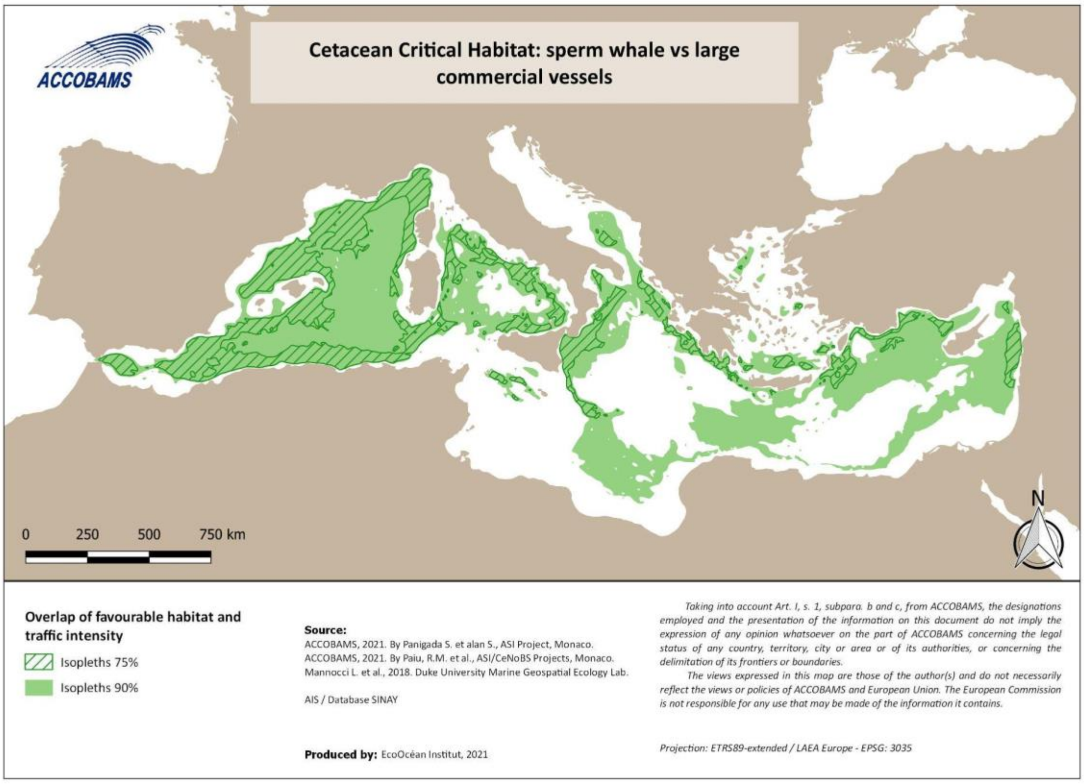


Figure 17: Cetacean Critical Habitat of the sperm whale versus marine traffic in the Mediterranean Sea

Validation of the proposed new CCH

The resulting new CCH proposed maps will be compared and **validated with the polygons issued from the ACCOBAMS workshop on expert's knowledge** (ACCOBAMS, 2017). Other experts have been consulted since then and it is an ongoing process for each sub-region and each threat.

This mapping comparison between CCH and expert's knowledge regarding the human threats is show by species from Figure 21 to 25.

Comparison of CCH of common dolphin versus fishery activities and the expert's knowledge

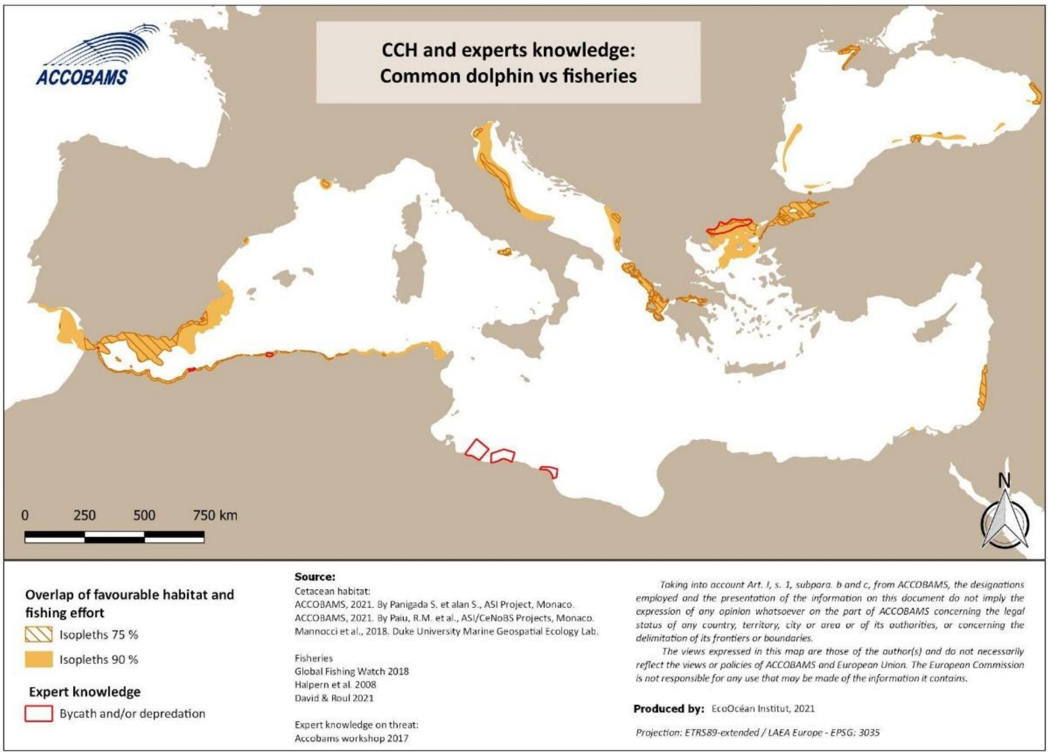


Figure 18: Map of comparison between the Cetacean Critical Habitat of the common dolphin vs fishery and the expert's knowledge in the Mediterranean Sea and the Black Sea

Comparison between the CCH of bottlenose dolphin versus fishery activities and the expert's knowledge

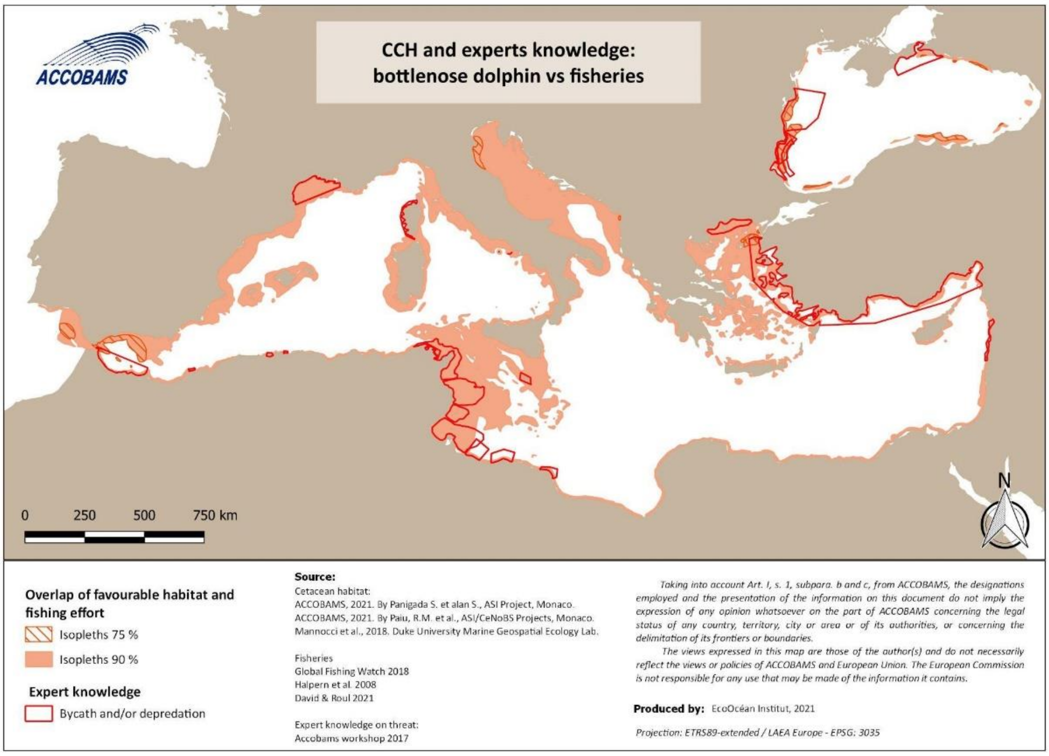


Figure 19: Map of comparison between the Cetacean Critical Habitat of the bottlenose dolphin vs fishery and the expert's knowledge in the Mediterranean Sea and the Black Sea

Comparison between the CCH of harbour porpoise versus fishery activities and the expert's knowledge

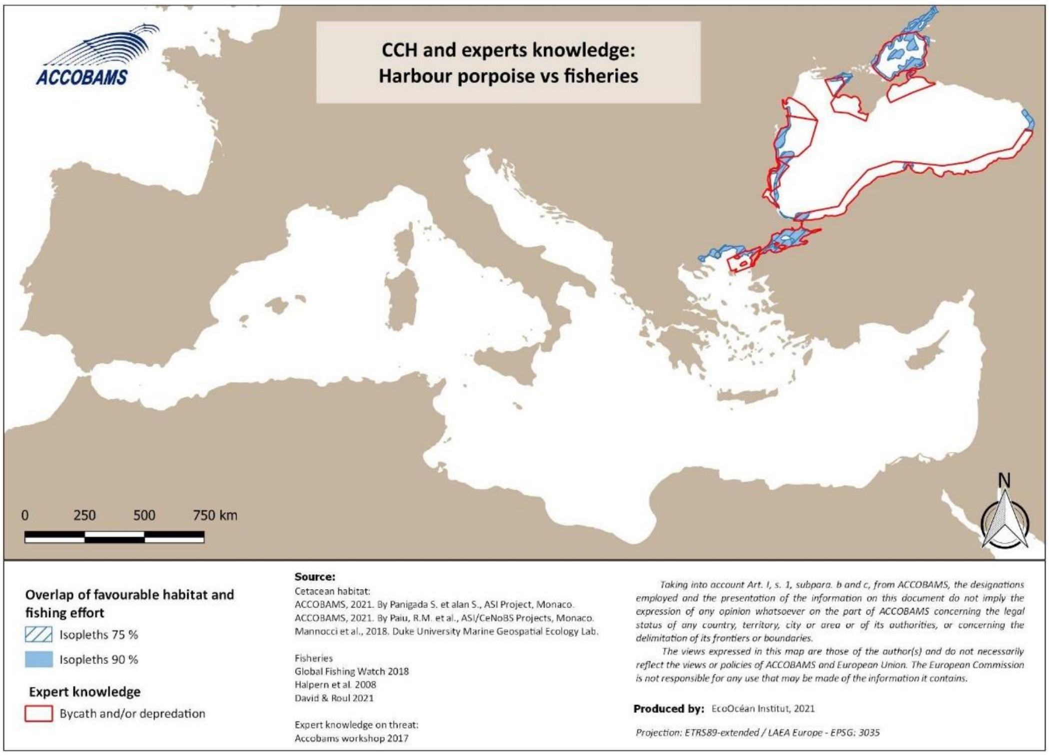


Figure 20: Map of comparison between the Cetacean Critical Habitat of the harbour porpoise vs fishery and the expert's knowledge in the Mediterranean Sea and the Black Sea

Comparison between the CCH of fin whale versus marine traffic and the expert's knowledge

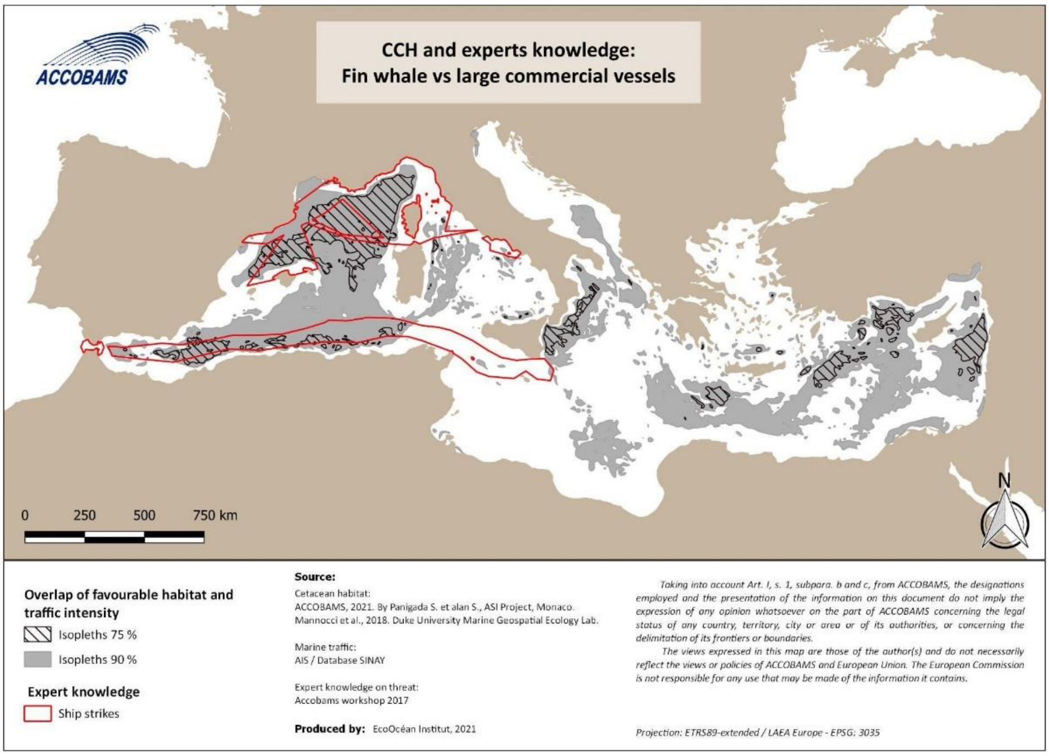


Figure 21: Map of comparison between the Cetacean Critical Habitat of the fin whale vs marine traffic and the expert's knowledge in the Mediterranean Sea

Comparison between the CCH of sperm whale versus marine traffic and the expert's knowledge

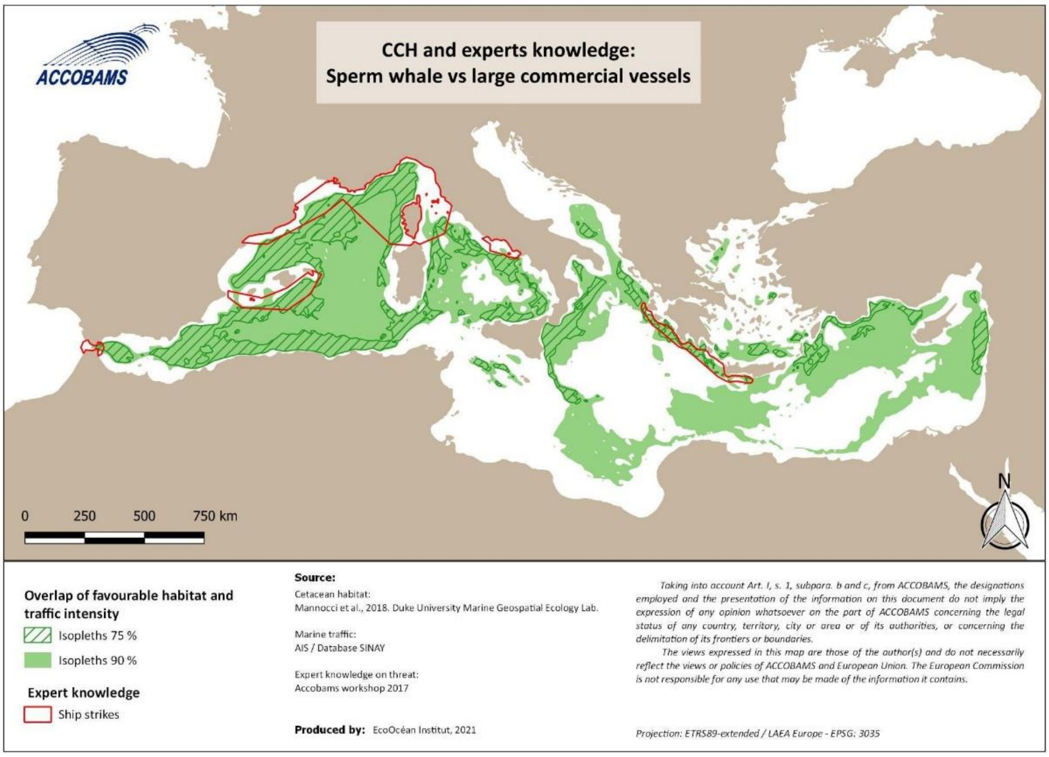


Figure 22: Map of comparison between the Cetacean Critical Habitat of the sperm whale vs marine traffic and the expert's knowledge in the Mediterranean Sea

Identification of the type of interaction and/or threat within the CCH

CCH have been built with human activities maps and species maps. But one pressure may impact in different ways the same species, as for example, marine traffic may impact fin whale through ship strike and also through continuous low frequency noise. So, the CCH “marine traffic” for fin whale will represent both those threats. If potential of ship strikes and potential impact of continuous noise have been analysed and mapped separately, then within the CCH “marine traffic and fin whale” it will be possible to find the different threats maps.

For fishery, at this stage, only a global CCH of potential interactions can be drawn. Those interactions can be, at a further step, defined per gear or métier. Such a layer per gear can be done as some data exist per gear, but not sure if data exists or are available to spatialise at the Mediterranean level or ACCOBAMS level the different types of fishing or métier.

Perspectives for management and/or conservation measures

As a first next step, the obtained CCH should be discussed among experts with updated knowledge.

Then, identification of relevant measures for adequate management in each CCH will have to be discussed, in collaboration with all stakeholders including other Organizations, such as UNEP-MAP/RAC-SPA, BSC, IMO, IWC, and GFCM, in particular through the Strategic Alliance.

For management purposes there will probably appear the need to lead further more in-deep analysis, either on a case-by-case CCH basis, or for some, at the regional scale. For example, for marine traffic and ship strikes, as lethality rises with speed of the vessels, it may be useful to define the parts of the CCH which include the paths of the vessels with the highest speed. In the example below, vessels were split into 3 categories, with threshold coming from a review of the literature on ship strike for cetaceans:

- ships with speeds ≤ 14 knots
- ships with speed ranging between 14 and 30 knots
- ships with speed > 30 knots

Example of marine traffic in the northwestern Mediterranean Sea (NWMS)

Figure 30 and 31 show the overlap of respectively 75% and 90% of the favourable habitat of large cetaceans and the annual marine traffic of large commercial vessels split by categories of speed, focused on the NWMS.

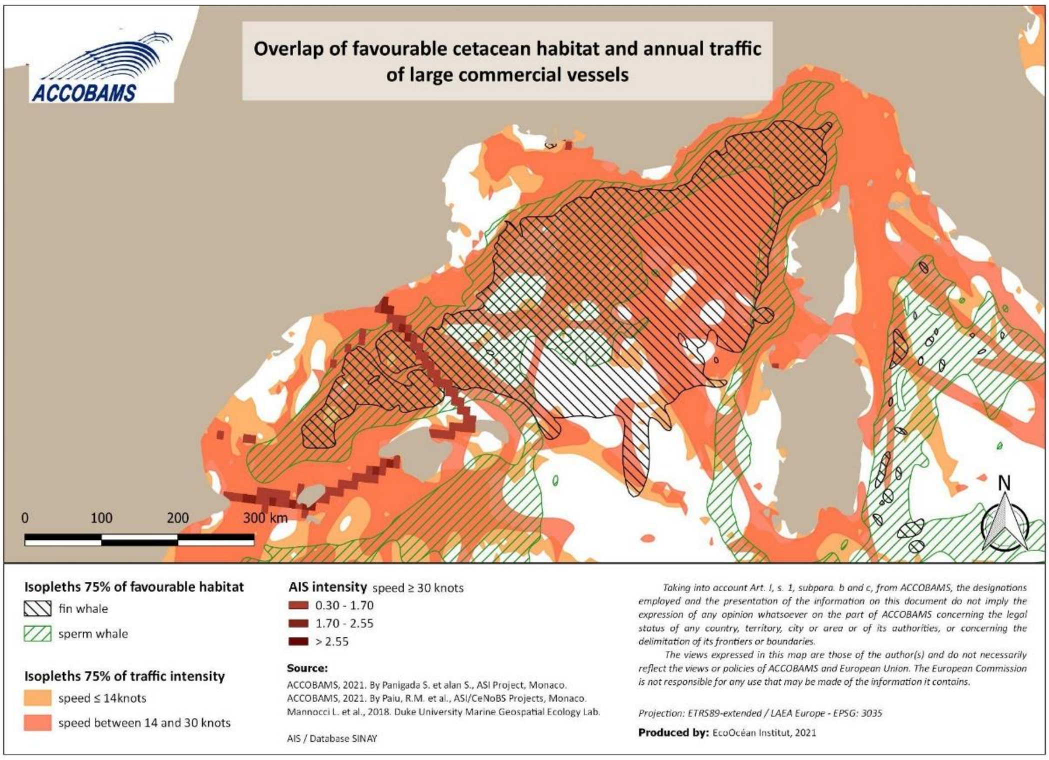


Figure 23: Overlap of 75% of the favourable habitat of large cetaceans and 75% of the annual marine traffic with vessel speeds ≤ 14 knots, between 14 and 30 knots and > 30 knots, in the NWMS

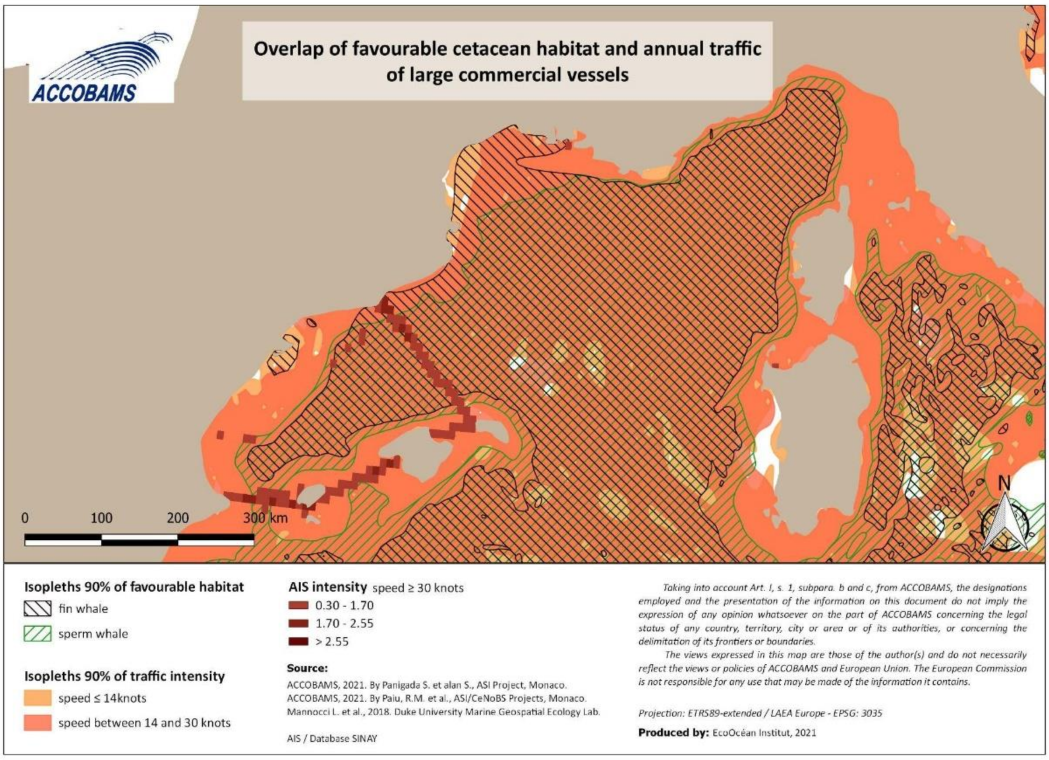


Figure 24: Overlap of 75% of the favourable habitat of large cetaceans and 75% of the annual marine traffic with vessel speeds ≤ 14 knots, between 14 and 30 knots and > 30 knots, in the NWMS

Another example is the need to go further in precision as for the fishery activities that need to be mapped by gear or metier, at the ACCOBAMS scale or at some CCH scale.

Also, the need for simpler polygons defining areas to be managed will arise. A rule for smoothing the CCH shapes, resulting as a raw result of the overlap/intersect exercise needs to be discussed.

Globally, it seems that the exercise is a useful tool and there is a need to pursue the exercise with all type of pressures and species. It highlights areas where cetaceans may be at risk, and where this is already known and the work toward identifying the adequate managements measures should begin. But it shows also where a cetacean may be at risk in areas unknown or less known yet by the scientific community, needing therefore research to confirm their status of CCH. The example in *Figure 25* shows how CCH maps can be used.

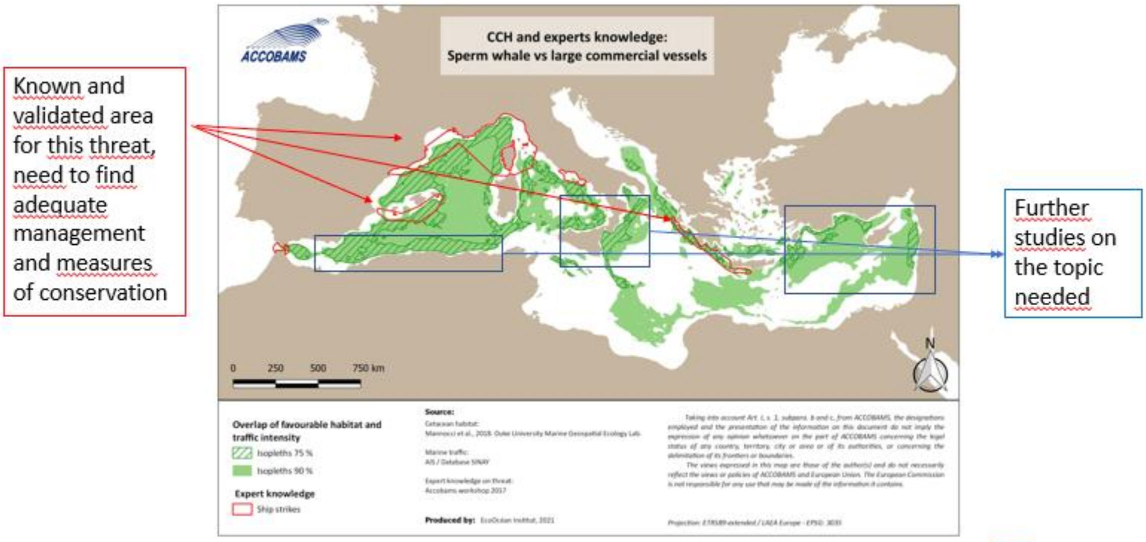


Figure 25: Perspectives of work from CCH maps

Moreover, for punctual/temporal human activities generating impulsive noise, such as oil&gas prospection, naval exercises, explosion, coastal building, etc, it is not possible to define CCH related to them due to their punctual occurrence. Nevertheless, those activities are impacting cetaceans and should therefore be considered within the process. Therefore, a simple rule can be agreed on: none of those activities should occur within the IMMA or within the cetacean's species reference maps or within an existing Marine Protected Area (see the web-site mapamed). If it may occur, each time a human activity generating impulsive noise is located within an IMMA or within the cetaceans species reference maps or within a MPA, it should be considered as a punctual/temporal CCH and mitigation measures (impact assessment study, sectorial measures, operational measures…) should automatically be requested.

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Appendices

Appendix 1: Cetacean input data

ACCOBAMS Survey Initiative

The table below shows the parameters and selected covariates for the model for a group of species in the Mediterranean Sea.

Table: Parameters and selected covariates (edf = estimated degrees of freedom; p = significance of the covariate) for the fin whales, Risso's dolphins, striped dolphins and bottlenose dolphins in the Mediterranean Sea (ACCOBAMS (a), 2021)

		Groups/Individuals				Group size			
Species	**Resp. Variables**	**Covariates**	**edf**	**p**	**Deviance explained (%)**	**Covariates**	**edf**	**p**	**Deviance explained (%)**
Fin whales	Indviduals	Lat	1.15	<0.001	45.2				
		Lon	1.16	<0.001					
		mlt_0608	0.89	0.0038					
		distshelf	1.06	<0.001					
Risso´s dolphins	Groups + Grsize	distcanes	0.86	<0.001	19.6	Lat	0.64	0.1	38.9
		Lon	1.04	<0.001		mlt_0608	0.75	0.047	
		mlt_month	0.89	<0.001		ssh_0608	1.81	<0.001	
		CI	1.50	<0.001					
Striped dolphins	Groups + Grsize				26.9	Aspect	1.28	0.106	13.2
		Lat-Lon	13.67	<0.001		Lat	0.62	0.126	
		depthmax	4.18	<0.001		Lon	0.82	0.019	
						SD_sst_month	5.74	<0.001	
Bottlenose dolphins	Groups + Grsize				15.3	depthmax	2.5	0.004	18.6
		Lat-Lon	20.06	<0.001		distcany	0.66	0.079	
		CI	2.39	<0.001		mlt_0608	0.72	0.069	
						sst_0608	0.92	<0.001	

The following maps illustrate the predicted abundance of the fin whales, the Risso's dolphins, the bottlenose dolphin and the striped dolphin in the Mediterranean Sea.

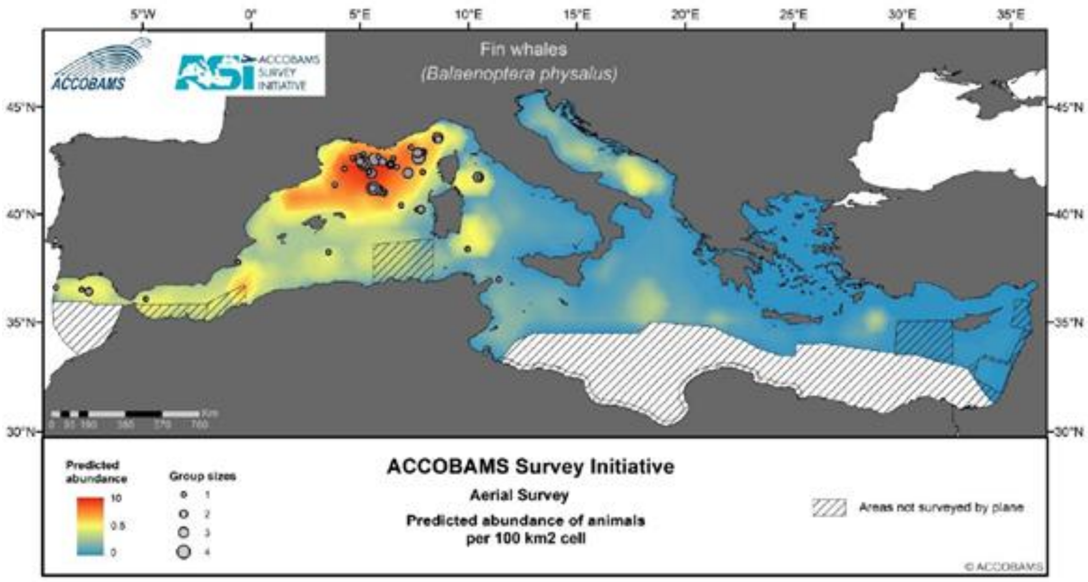


Figure: Predicted abundance of the fin whale species in the Mediterranean Sea (ACCOBAMS (a), 2021)

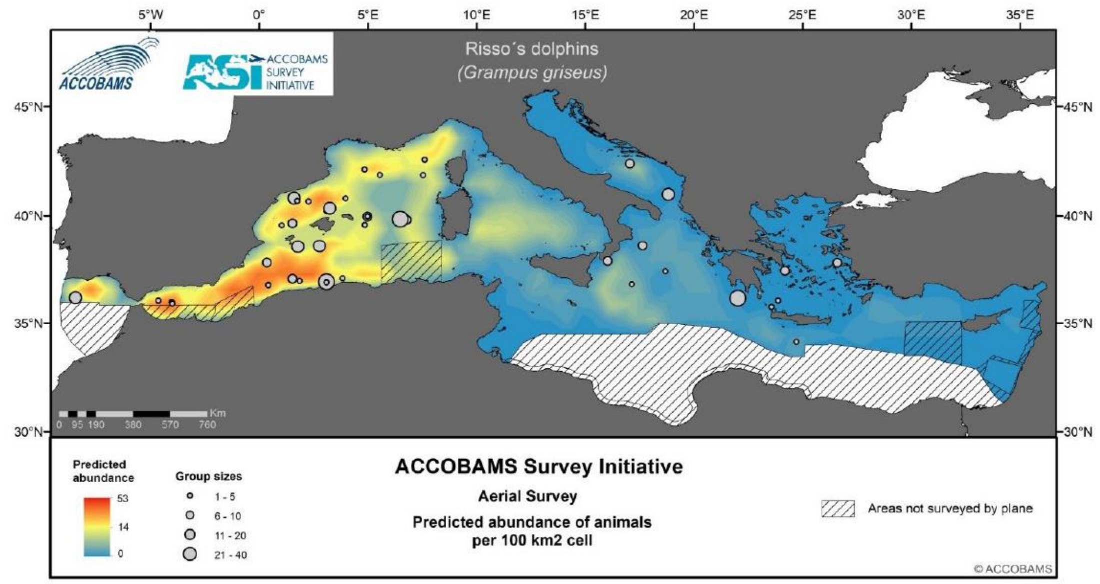


Figure: Predicted abundance of the Risso's dolphin species in the Mediterranean Sea (ACCOBAMS (a), 2021)

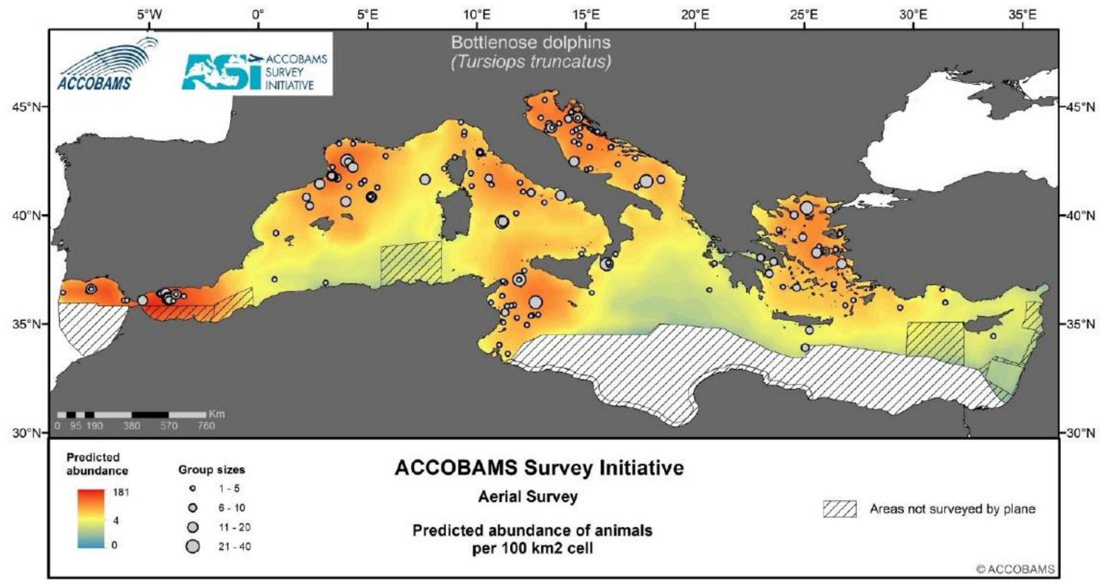


Figure: Predicted abundance of the bottlenose dolphin species in the Mediterranean (ACCOBAMS (a), 2021)

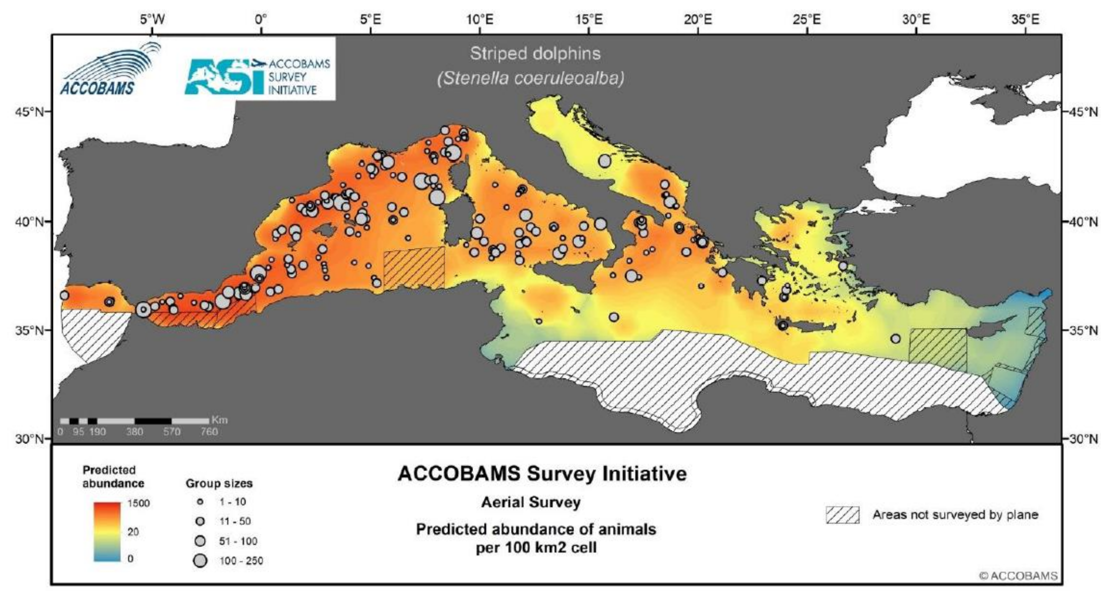


Figure: Predicted abundance of the striped dolphin species in the Mediterranean Sea (ACCOBAMS (a), 2021)

The table below shows the parameters and selected covariates for the model for a group of species in the Black Sea.

Table: Parameters and selected covariates (edf = estimated degrees of freedom; p = significance of the covariate) for the common dolphins, bottlenose dolphins and harbour porpoise in the Black Sea (ACCOBAMS (b), 2021)

		Groups				Group size			
Species	**Blocks**	**Covariates**	**edf**	**p**	**Deviance explained (%)**	**Covariates**	**edf**	**p**	**Deviance explained (%)**
Common dolphins	All blocks	Lat,Lon	17.04	0.00000	33.72	Lon	5.57	0.00000	27.40
		Slope	3.41	0.00023		ssc_mean_season	0.96	0.00095	
		ssc_spsd	4.52	0.00000		ssc_spsd_season	5.96	0.00000	
		ssh_mean	5.46	0.00000		ssh_mean_season	5.35	0.00000	
						sst_spsd	0.89	0.00346	
Bottlenose dolphins	All blocks	DistCanEsc	0.89	0.00559	22.59	Dist100	0.91	0.00400	13.60
		DistPorts	0.98	0.00022		DistSlope	4.77	0.00018	
		ssc_spsd_season	2.58	0.00001					
		sst_mean	5.15	0.00000					
Harbour porpoise	All blocks	Lat,Lon	21.30	0.00000	50.75	Lat,Lon	13.13	0.00000	26.79
		DepthMean	0.87	0.00831		Dist2000	7.57	0.00000	
		ssh_mean_season	3.13	0.00002		ssc_mean_season	8.21	0.00000	

The following maps illustrate the predicted abundance of the common dolphins, the bottlenose dolphins and the harbour porpoises.

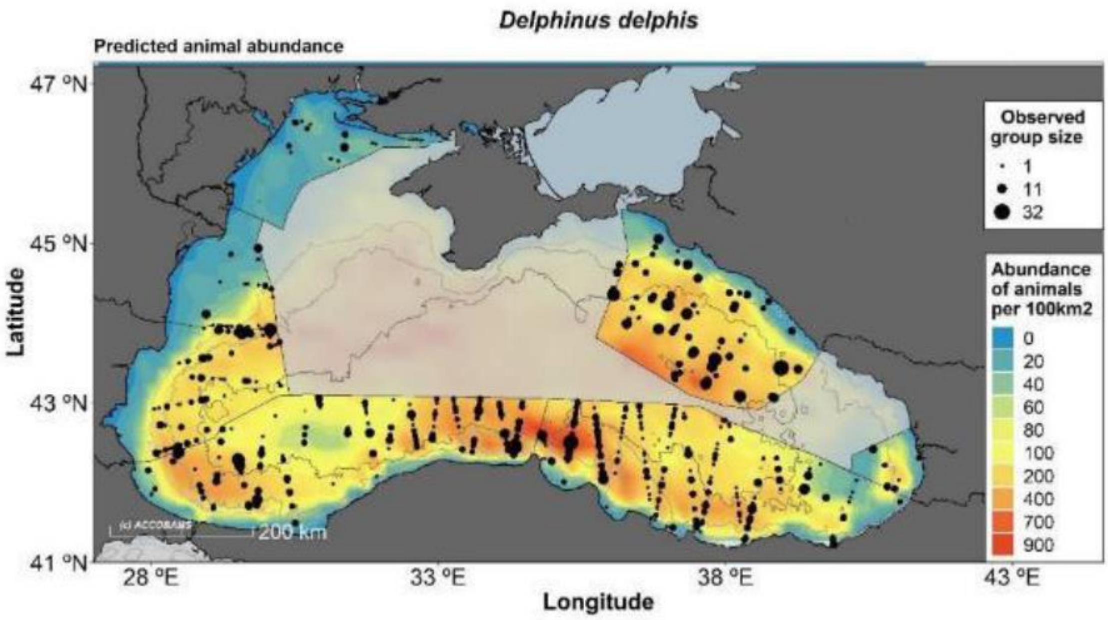


Figure: Predicted abundance of the common dolphin species in the Mediterranean Sea (ACCOBAMS (b), 2021)

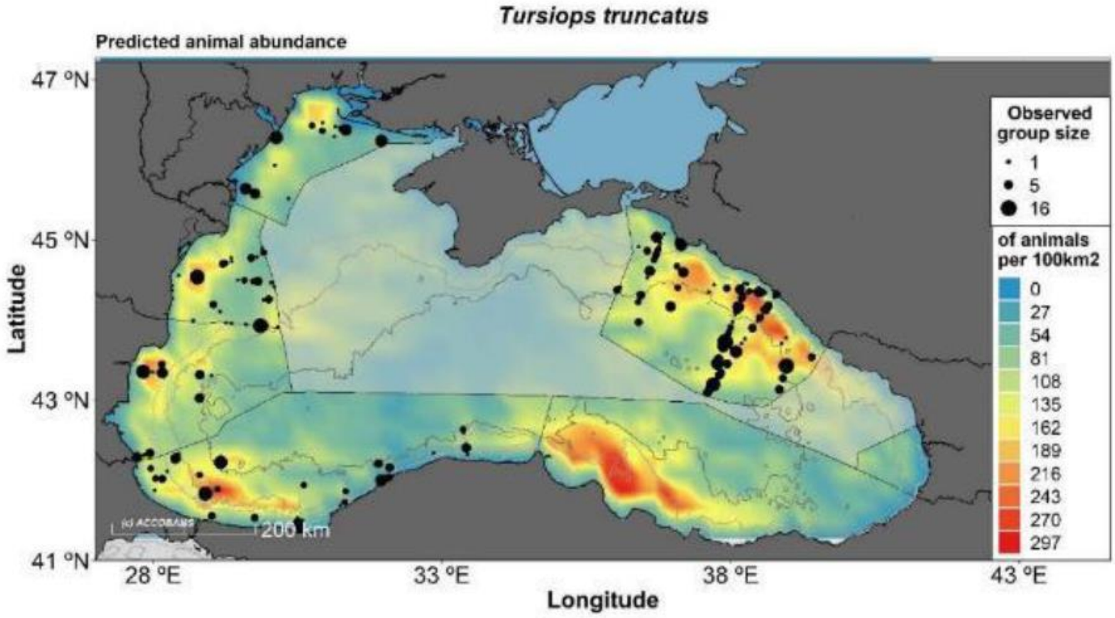


Figure: Predicted abundance of the bottlenose dolphin species in the Mediterranean Sea (ACCOBAMS (b), 2021)

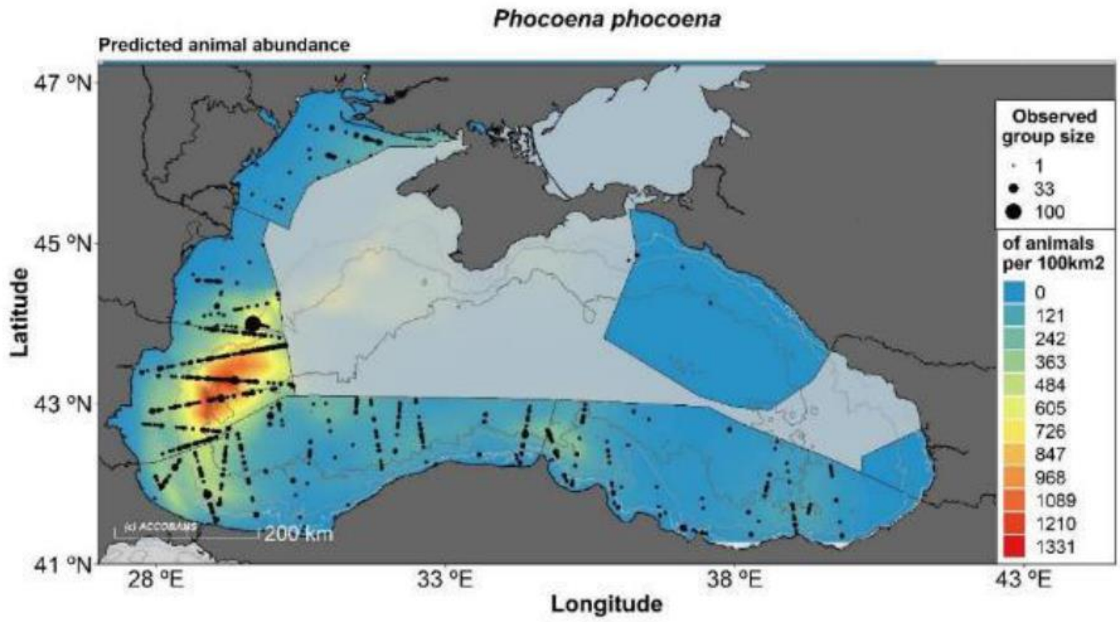


Figure: Predicted abundance of the harbour porpoise species in the Mediterranean Sea (ACCOBAMS (b), 2021)

Gap Analysis and spatial models of marine species

The following table shows the selected covariates used in the final model and its explained deviance.

Table: Selected GAMs based on lowest AIC for each species (Mannocci et al., 2018)

Species	Selected covariates (ordered with in decreased order of importance following F-scores)	Explained deviance (%)
Striped dolphin	Depth NemoSSTMonthly VGPMMonthly SalinityMonthly	17.9
Common bottlenose dolphin	Depth Slope SalinityMonthly	17.3
Short-beaked common dolphin	SalinityMonthly SSTMonthly OPFishMonthly5 Depth	48.3
Risso's dolphin	Depth	11.5
Long-finned pilot whale	Depth SalinityMonthly VGPMMonthly SSTMonthly	44.5
Fin whale	Depth OPFishMonthly5 Slope SalinityMonthly	23.8
Sperm whale	Depth OPFishMonthly3 NPPMonthly	22.0
Cuvier's beaked whale	Depth Slope	36.2

The following maps illustrate the predicted abundance of the sperm whale, the fin whale, the Cuvier's beaked whale, the bottlenose dolphin, the striped dolphin, the long-finned pilot whale, the Risso's dolphin and the common dolphin in the Mediterranean Sea.

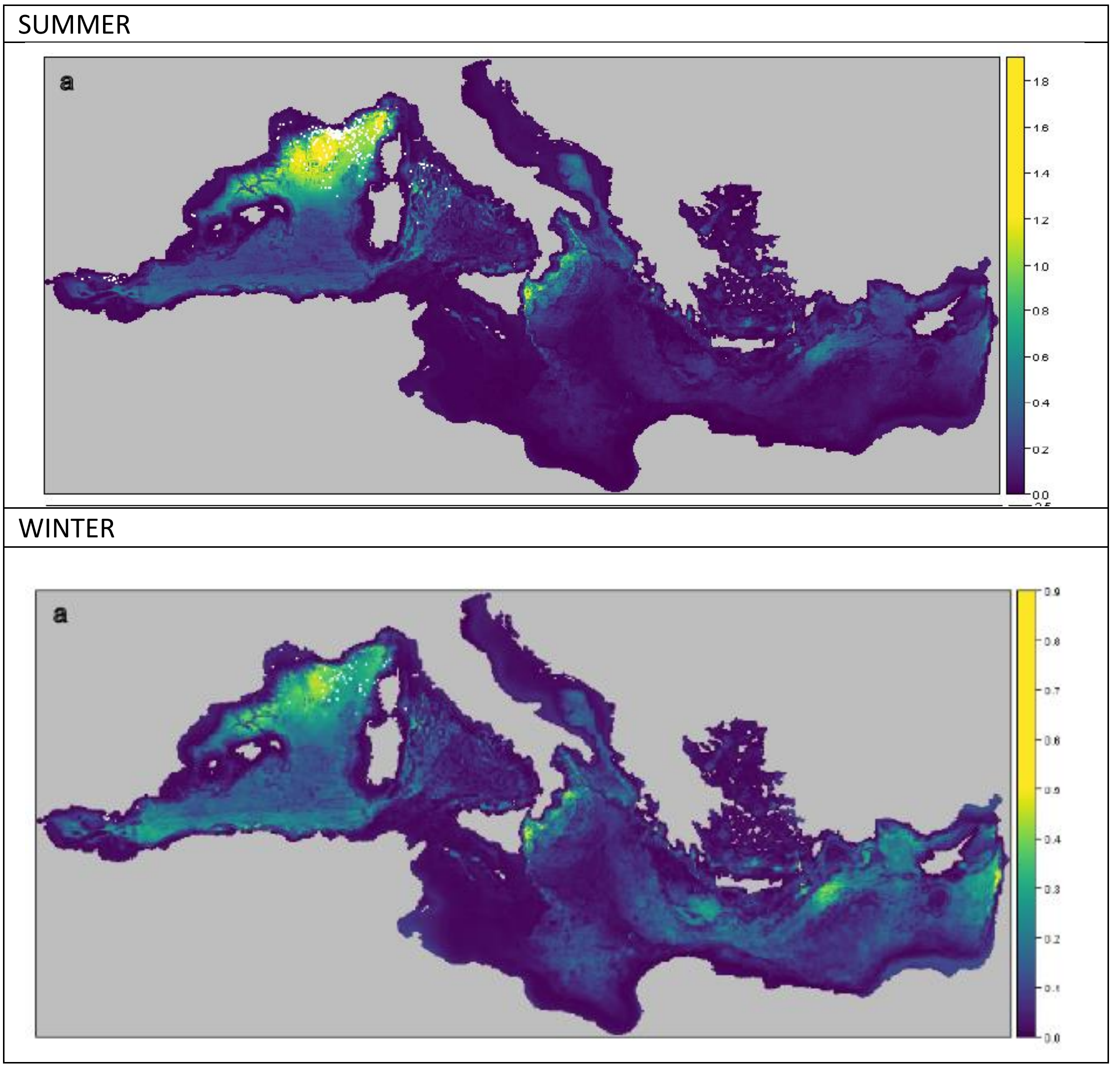


Figure: Maps of mean summer (top) and winter (bottom) predicted densities of the fin whale (individuals per 25 km2). The summer season was defined from March to August and the winter season was defined from September to February. Sightings are overlaid in white on maps (Mannocci et al., 2018)

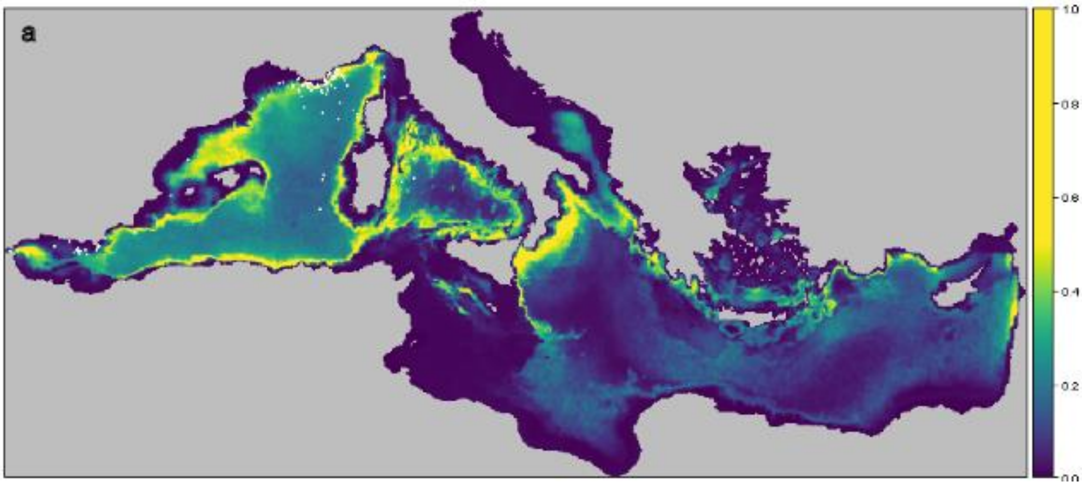


Figure: Map of mean annual predicted densities of the sperm whale (individuals per 25 km2). Sightings are overlaid in white on the map (Mannocci et al., 2018)

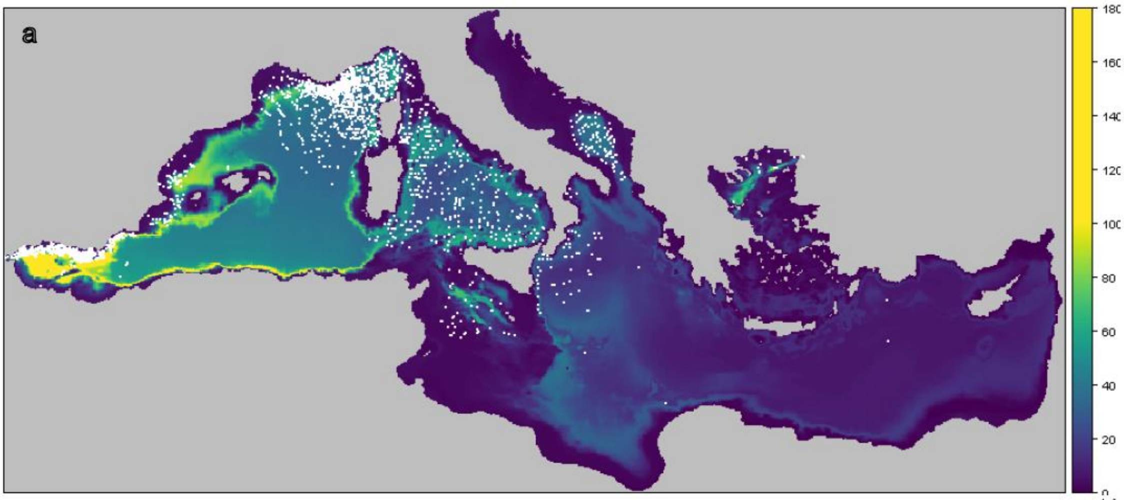


Figure: Map of mean annual predicted densities of the striped dolphin (individuals per 25 km2). Sightings are overlaid in white on the map (Mannocci et al., 2018)

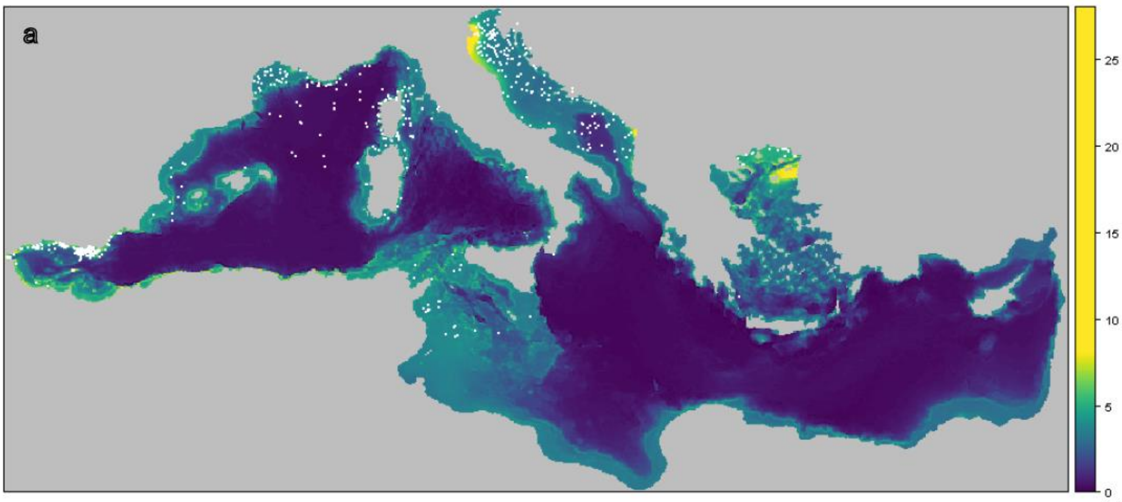


Figure: Map of mean annual predicted densities of common bottlenose dolphin (individuals per 25 km2). Sightings are overlaid in white on the map (Mannocci et al., 2018)

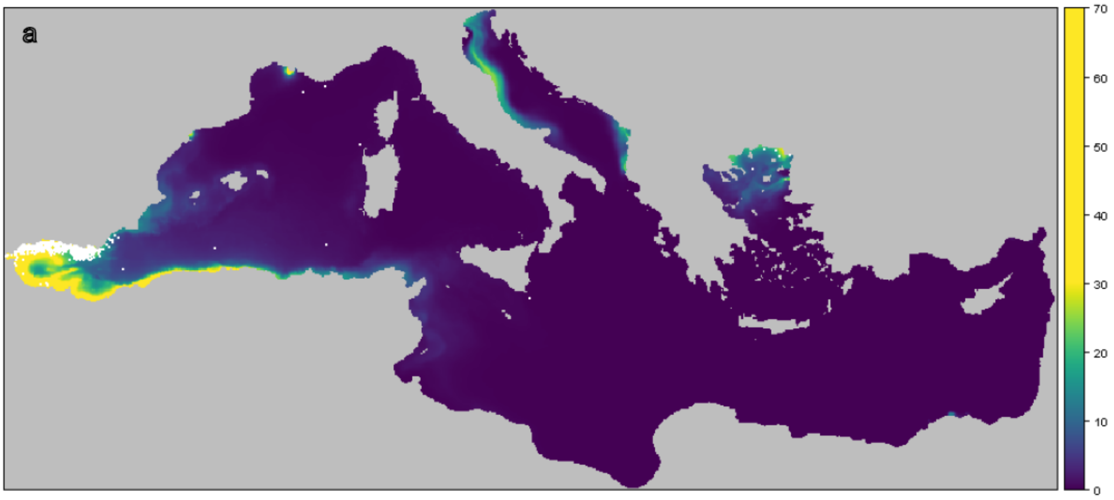


Figure: Map of mean annual predicted densities of the short-beaked common dolphin (individuals per 25 km2). Sightings are overlaid in white on the map (Mannocci et al., 2018)

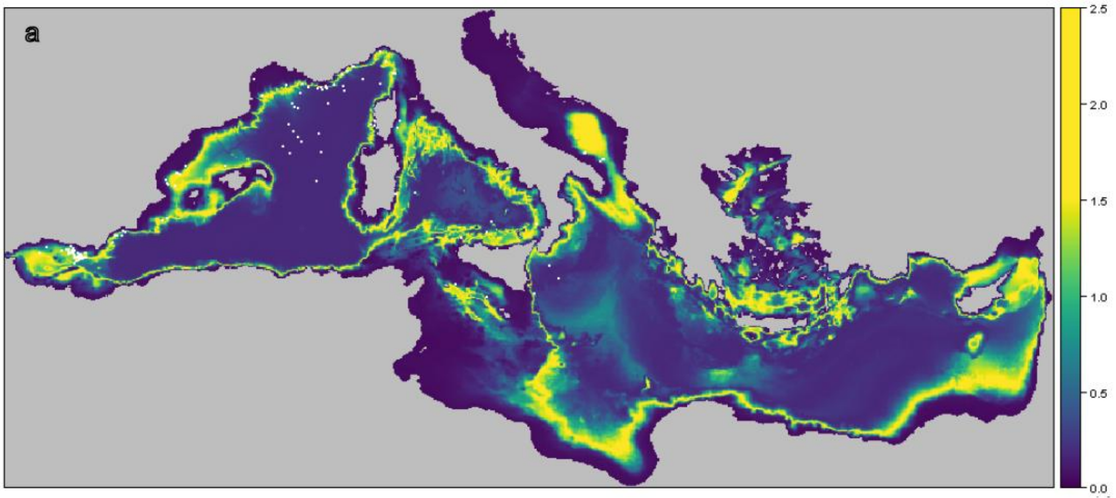


Figure: Map of mean annual predicted densities of the Risso's dolphin (individuals per 25 km2). Sightings are overlaid in white on the map (Mannocci et al., 2018)

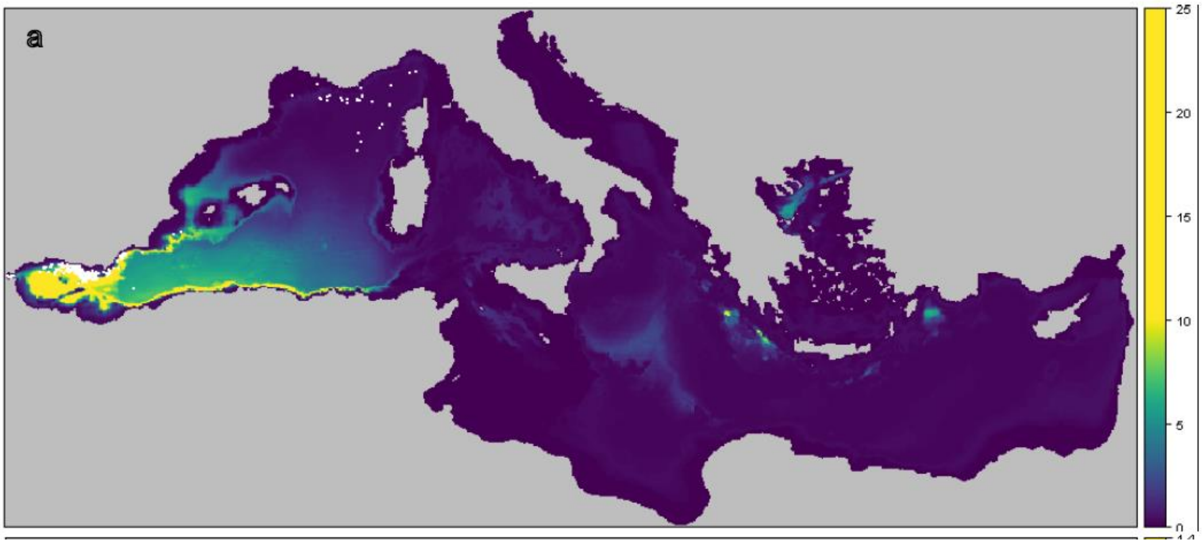


Figure: Map of mean annual predicted densities of the long-finned pilot whale (individuals per 25 km2). Sightings are overlaid in white on the map (Mannocci et al., 2018)

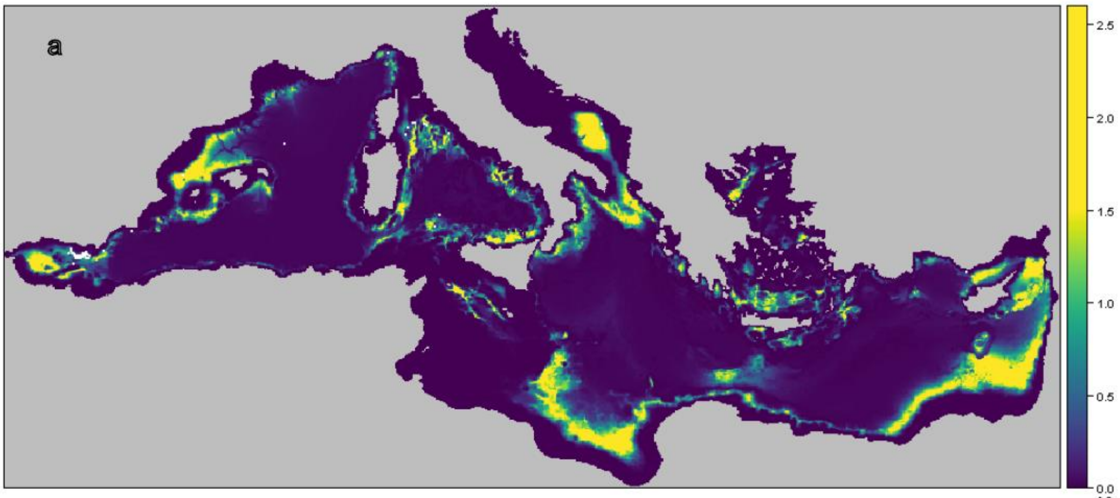


Figure: Map of mean annual predicted densities of the Cuvier's beaked whale(individuals per 25 km2). Sightings are overlaid in white on the map (Mannocci et al., 2018)

Appendix 2: Example with the habitat of fin whale

Step 1: Extraction of contour

Maps below are displaying 75% and 90% of the favourable habitat for the fin whale species from ACCOBAMS Survey Initiative and from Mannocci et al. 2018.

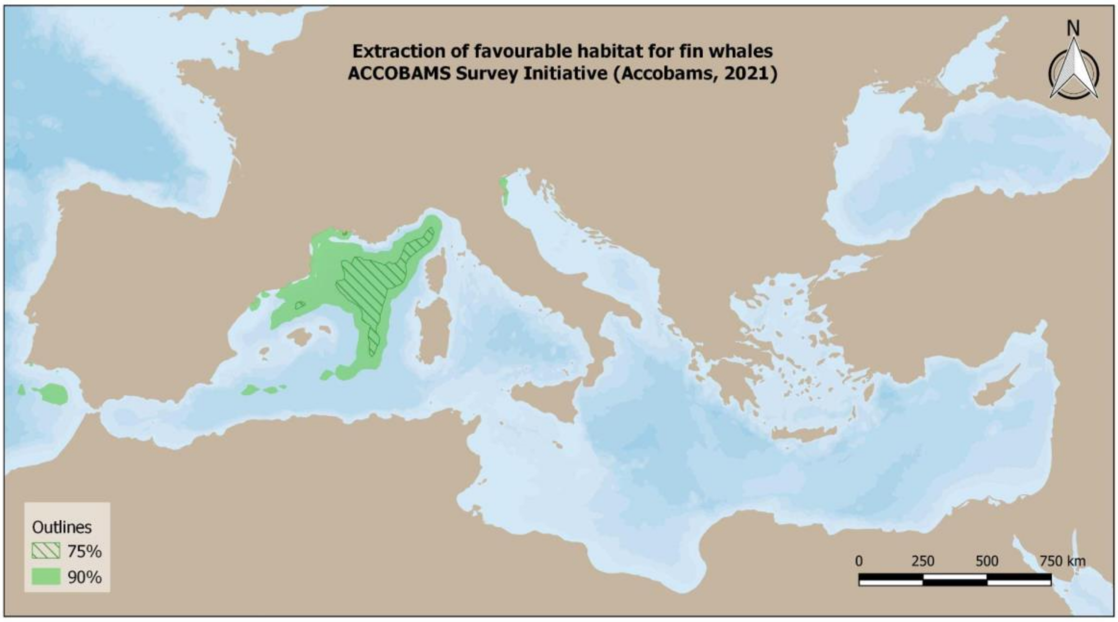


Figure: Extraction of 75% and 90% of the favourable habitat for the Fin whale from ACCOBAMS Survey Initiative data

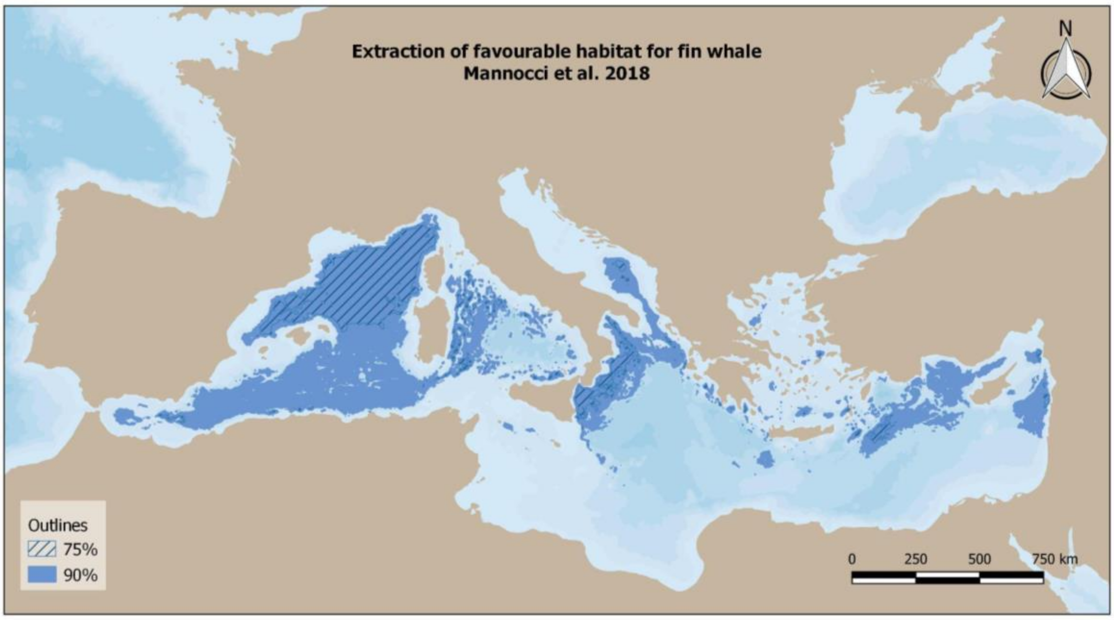
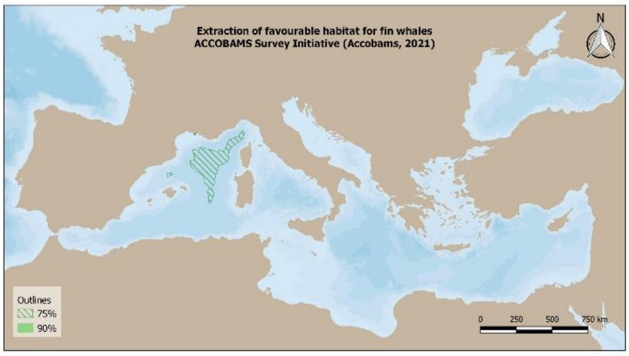


Figure: Extraction of 75% and 90% of the favourable habitat for the Fin whale from Mannocci et al. 2018

Step 2: Merging of the habitats

The maps extracted from ACCOBAMS 2021 and from Mannocci et al. 2018 have been merged according to the % of favourable habitat for the species (75% and 90%).



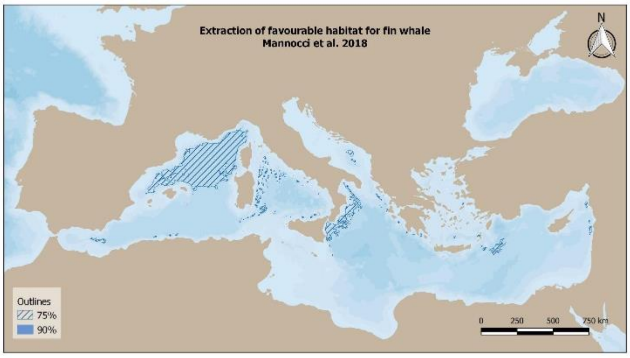


Figure: 75% of the favourable habitat for the fin whale from ACCOBAMS and from Mannocci et al., 2018

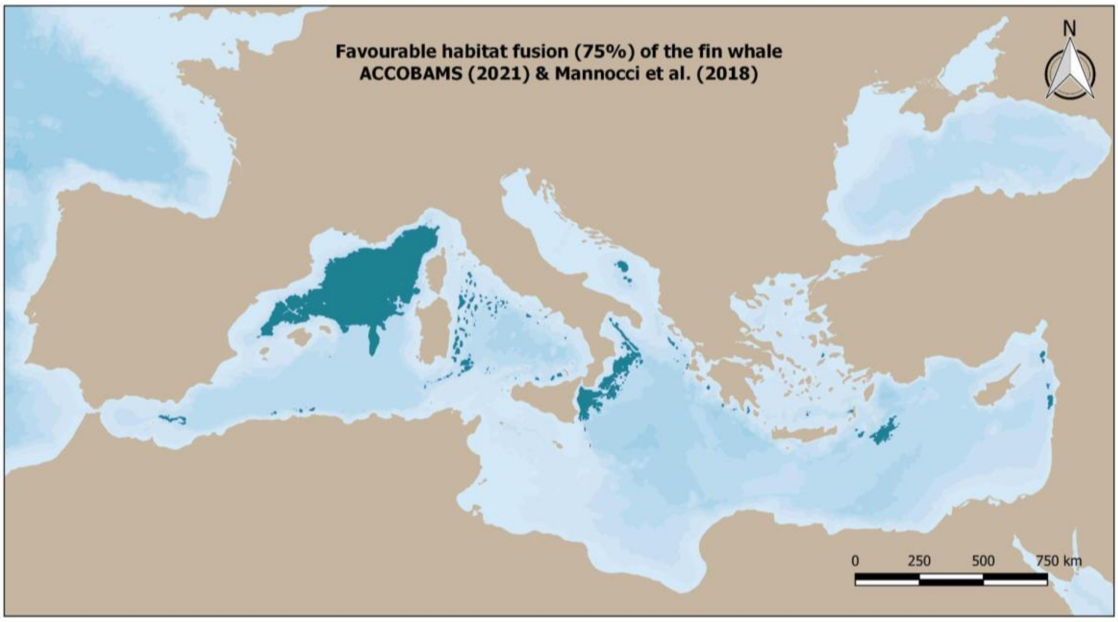


Figure: Merging of the two previous maps corresponding to the 75% of the favourable habitat for the Fin whale

Step 3: Discretization of the "habitats"

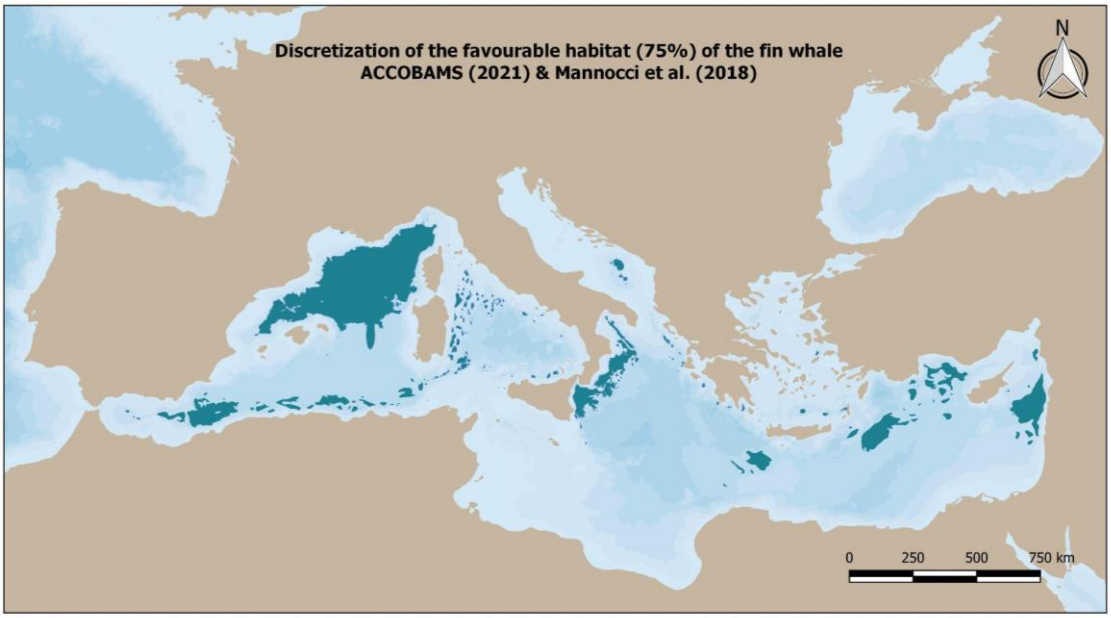


Figure: Discretization of the 75% of the favourable habitat for the Fin whale species in the Mediterranean Sea

Step 4: Habitats cleaning

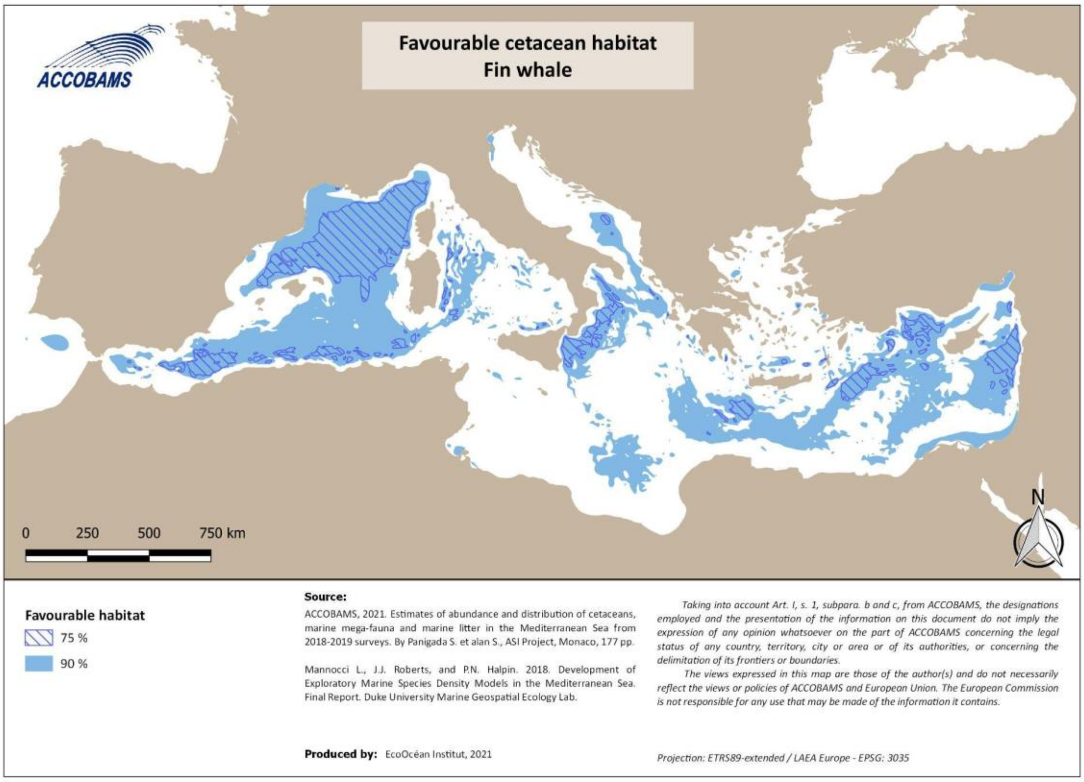
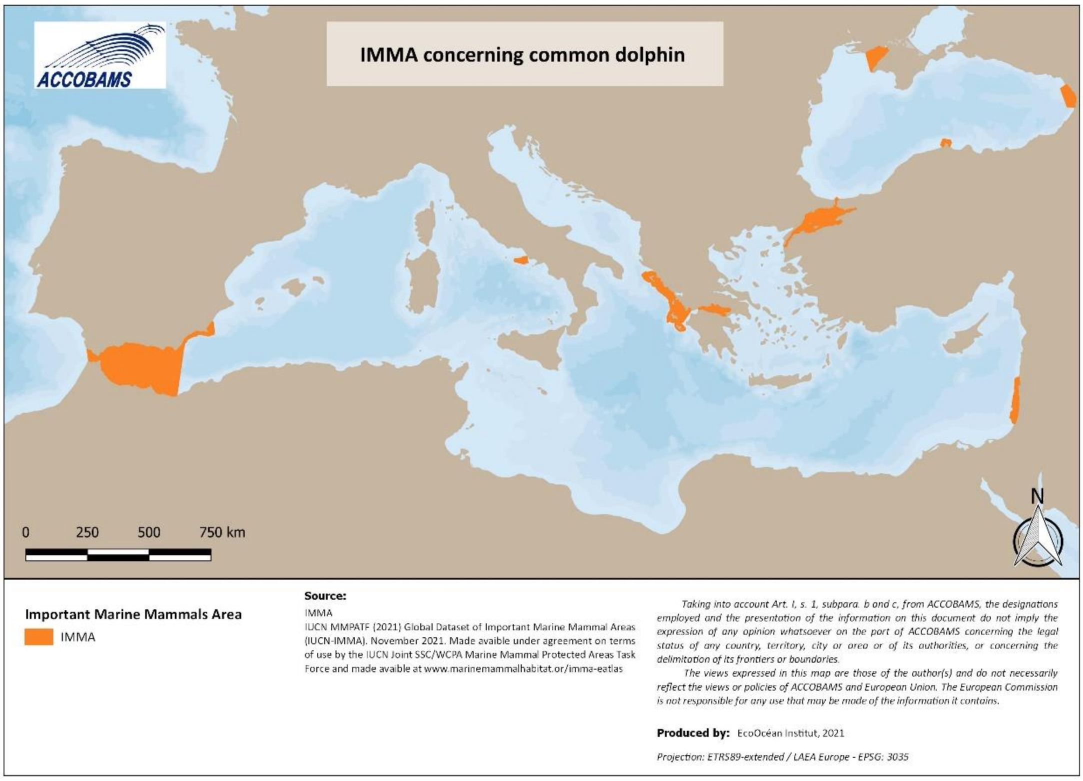
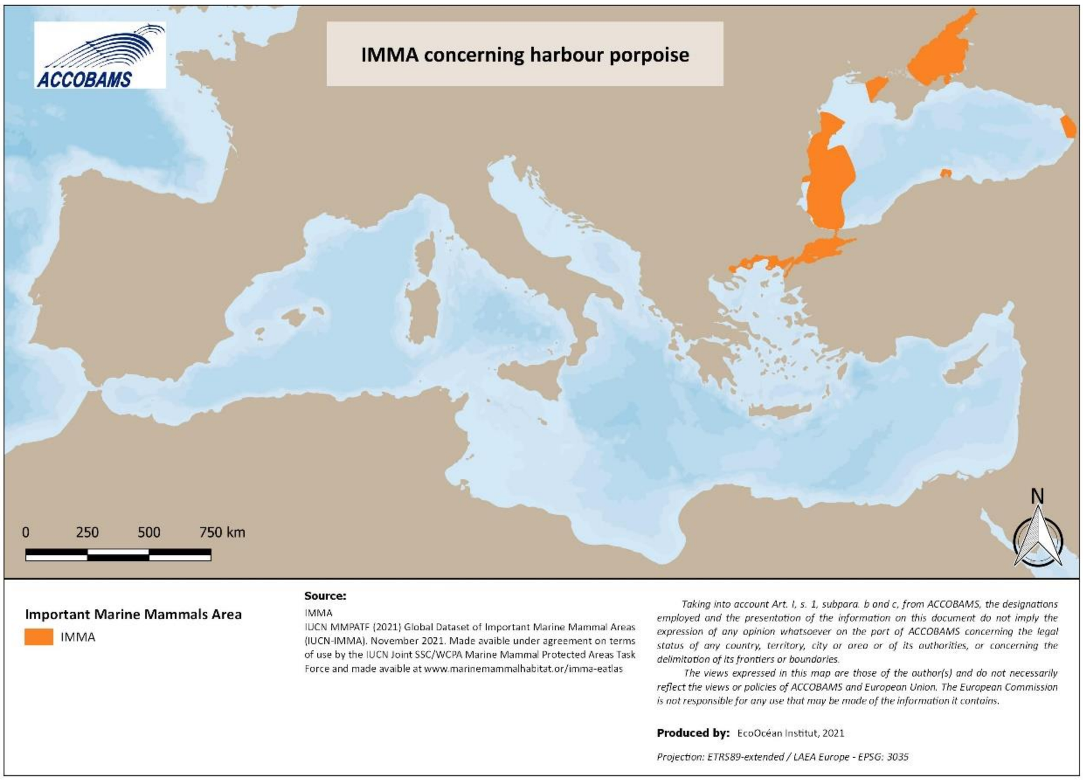


Figure: Favourable habitat for the Fin whale

Appendix 3: Map of IMMA





Appendix 4: Fishery polygons

Figure below shows the annual fishing effort (all types of fishing activity) displaying 75% and 90% of the fishing effort from the Global fishery watch data.

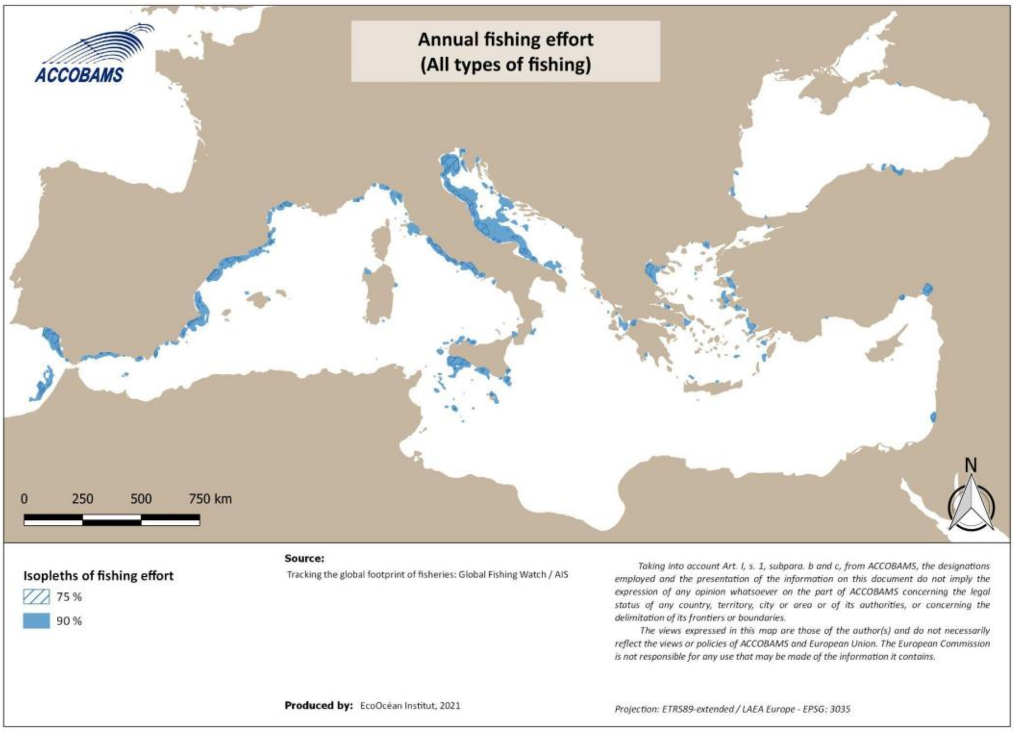


Figure: 75% and 90% of the fishing effort in the Mediterranean Sea

Figure illustrates the annual fishing in the Mediterranean Sea with an effort of fishing ≥ 1 hour, for all types of fishing vessels.

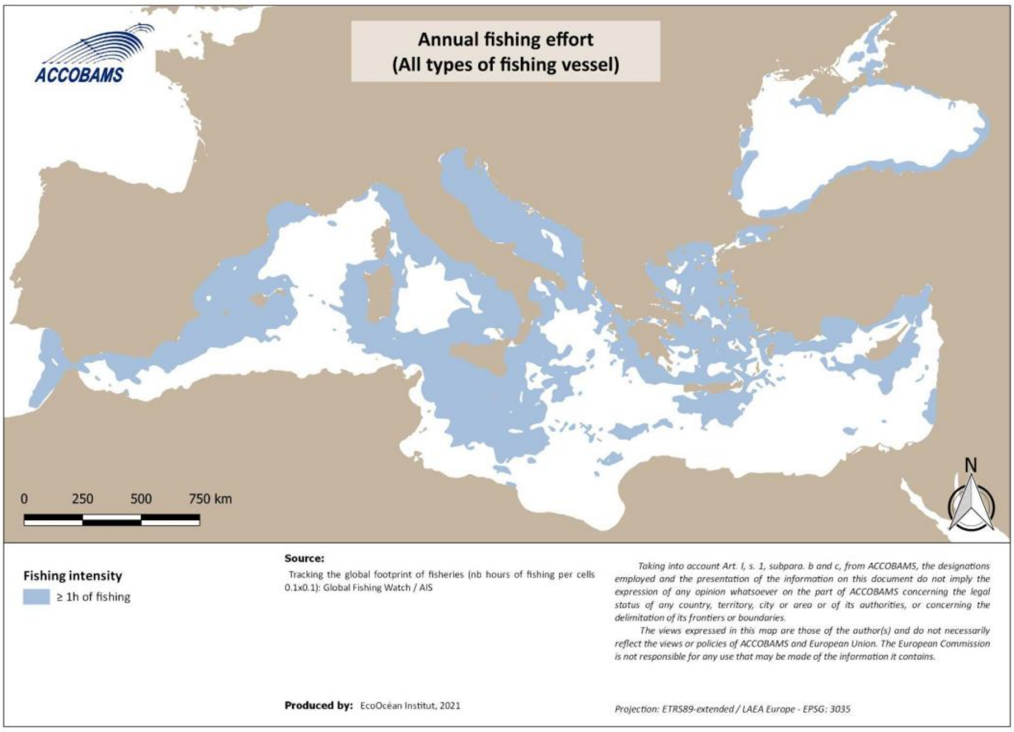


Figure: Annual fishing effort ≥ 1 hour in the Mediterranean Sea

Appendix 5: Overlap and intersect between favourable cetacean habitats and annual traffic of human activities

Since fin whale and sperm whale are the species most affected by the collision risks with large vessels, 75% of the favourable habitats for these two species have been overlapped with 75% of the large commercial vessels traffic intensity (all speeds combined), the overlapping is displayed on the map below.

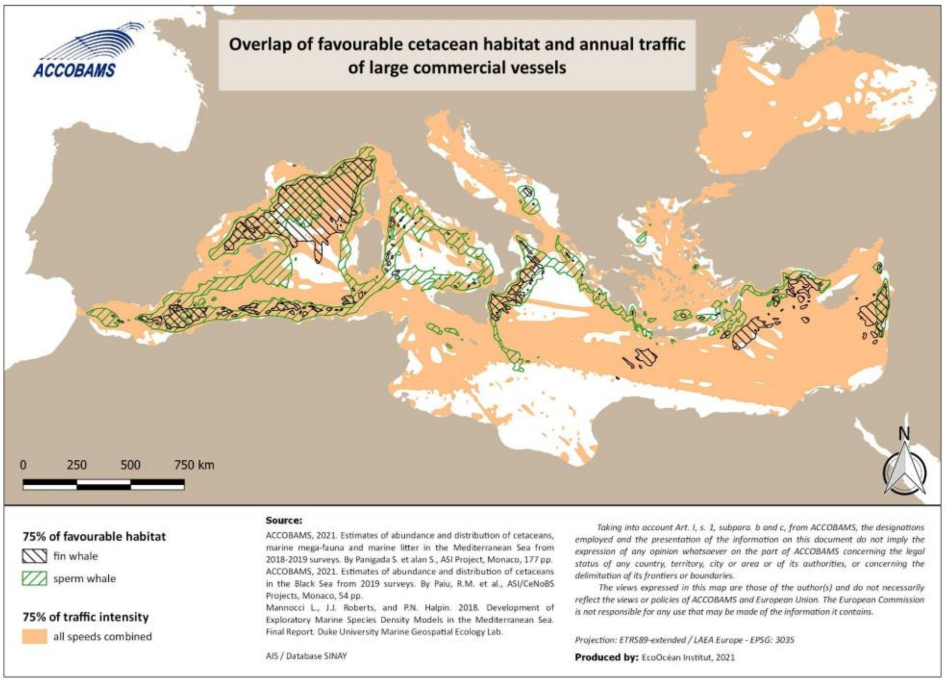


Figure: Overlap between 75% of the favourable habitat of Sperm whale and Fin whale and 75% of the large commercial vessels intensity

The map below shows the overlap between 90% of the favourable cetacean habitat and 90% of the large commercial vessels intensity.

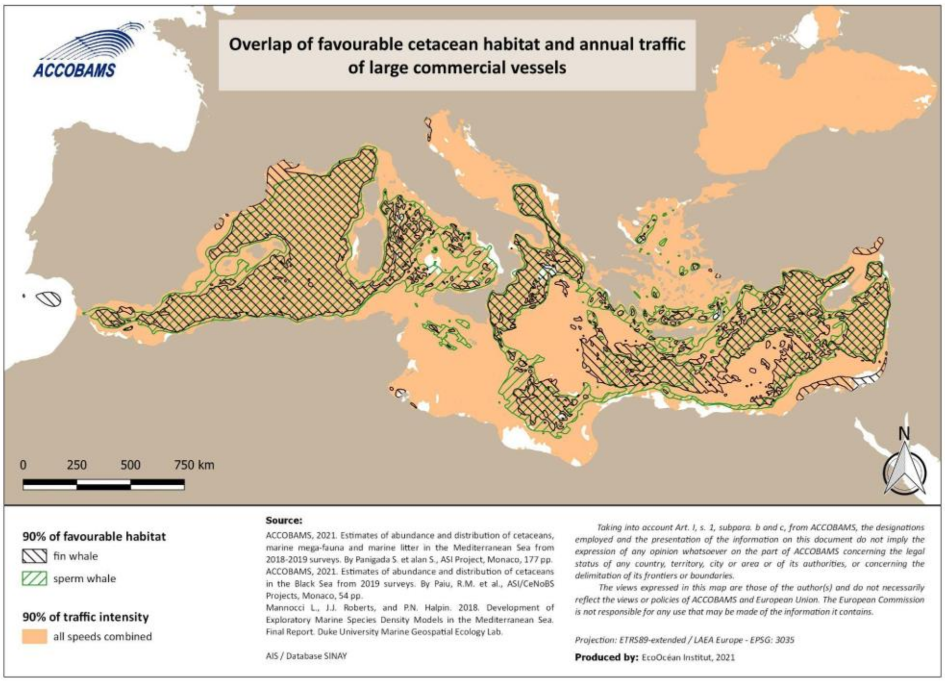


Figure: Overlap between 90% of the favourable habitat of Sperm whale and Fin whale and 90% of the large commercial vessels intensity