



Accord Pelagos relatif à la création en Méditerranée
d'un Sanctuaire pour les mammifères marins

Accordo Pelagos relativo alla creazione nel Mediterraneo
di un Santuario per i mammiferi marini

Final Report of the Pelagos Agreement-funded project

ASSESSMENT OF FISHING-RELATED IMPACTS ON CETACEAN SPECIES AND THEIR HABITAT IN THE PELAGOS SANCTUARY: STATE OF THE ART.

March 2025

2023 Call for Technical and Scientific Consultancy of the Pelagos Agreement

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2023 CALL FOR TECHNICAL AND SCIENTIFIC CONSULTANCY OF THE PELAGOS AGREEMENT

Final Report
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Consultant(s)	Cecilia Pinto, Luca Lanteri, Federico Vignati, Giovanni Roppo Valente, David Gamba, Fulvio Garibaldi
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Introduction

The way fishing activities can exert a pressure on cetaceans' populations can be direct or indirect. Direct impacts are generally related to accidental catches of cetaceans by fishing gears, while indirect impacts are related to multiple factors, such as: the impact of abandoned, lost and discarded fishing gear (ALDFG) left at sea which can interact with cetacean populations; the impact of gear depredation by cetacean which can eventually affect their survival; and the impact of overfishing resources which are part of the diet of cetacean species.

Therefore, to assess the state of the art of the impact of fisheries on cetaceans populations in the Pelagos Sanctuary, four main aspects were explored:

- 1) The impact of ALDFG on cetacean populations;
- 2) The level of fishing pressure for commercial and recreational fisheries from the most updated spatial and temporal data;
- 3) The stock state of western Mediterranean commercial species which are part of the diet of Mediterranean cetaceans;
- 4) The specific impact of interactions between fishing activities and *Tursiops truncatus*.

The impact of ALDFG

The main issue in the management of ALDFG is the lack of an updated estimate of the proportion of volume of ALDFG within the total volume of marine litter at global level, as the latest estimate dates 1975 and has intrinsic uncertainties due to the estimation process (Gilman et al., 2021). More recent estimates are generally reported in weight, which can bias the calculation, and are often not global estimates (Lebreton et al., 2018). According to a WWF report from 2020 (WWF, 2020), ALDFG accounts for 10% of marine litter present in the oceans worldwide, amounting to between 500,000 and 1 million tons of waste lost in the sea each year. Rankings of risks of fishing gears of becoming ALDFG have found that the highest risk are (in order) for set and drift gillnets, tuna purse seine drifting FADs and bottom trawls (Gilman et al., 2021). More in general large mesh size and small twine diameter have a higher potential catchability being ALDFG (Wilcox et al., 2014). Rankings are based on rate of production, fishing effort and adverse ecological and socioeconomic impacts of ALDFG but it should be noted that uncertainties are introduced by a lack of linear relationship between fishing effort units and total catches (Gilman et al., 2021).

In the scientific literature, currently, there are no studies regarding the entanglement and death of cetaceans specifically caused by ALDFG due to the difficulty in determining whether the animal was trapped in active fishing gear or in abandoned nets, as in many cases, especially large cetaceans, are capable of breaking through fishing nets and carrying parts of them away. There are, however, studies that highlight deaths due to entanglement in fishing gear without specifying whether it was active or abandoned gear. Cassof et al. (2011) reports the case of 21 cetaceans (belonging to 4 species) found stranded on the eastern coasts of North America between 1995 and 2009. For 12 individuals, it was determined that the cause of death was related to the entanglement in fishing gear. In the Mediterranean, Pace et al. (2008) analyzed the entrapment of five sperm whales (*Physeter macrocephalus*) in an illegal driftnet near Capo Palinuro (Italy). Fortunately, in this case, the specimens were successfully freed. Another case of entrapment in fishing gear occurred in the Aeolian Islands (Italy) in 2017, where a sperm whale, nicknamed SISO, became trapped in an illegal driftnet. It later died as a result of the net and washed ashore at Capo Milazzo (Siso Project, 2024). What these cases have in common is the inability to determine with certainty whether the fishing gear was actively being used or was an ALDFG. Additionally, the case presented by Manfrini et al. (2023) reports the first documented case of entanglement and death of a striped dolphin (*Stenella coeruleoalba*) in a FAD (Fish Aggregating Device). In this case as well, it is too difficult to determine whether the structure was illegal or an ALDFG.



What adds further confusion in determining whether the fishing gear was active or not is the ability of some species, such as sperm whales, to free themselves from portions of nets entangled around them. However, this often leaves visible scars that help identify the interaction with the fishing gear (Cassof et al., 2011). Another limitation concerning the entanglement of cetaceans is the difficulty in aging the time a dead individual will take to be released by the net once dead (Wilcox et al., 2014).

With the banning of driftnets in 1997 Council regulation 894/97EC the entanglement of cetaceans in fishing nets within the sanctuary should have been strongly reduced. Currently, monitoring ALDFG can help maintain this trend.

Distribution and temporal trends of commercial and recreational fishing effort

Fishing effort of commercial fishery can be expressed in a number of units, of which the most common used one is the number of fishing days implemented by each fleet segment (identified by the size of vessels). Additionally fishing effort can be defined by the number of vessels, the mean gross tonnage and the engine power within each fleet segment. Nowadays, the spatial distribution of these variables is available next to the time series, thanks to the data coming from the remote monitoring systems such as AIS and VMS. Such information can allow to estimate hotspots of fishing activity depending on the gear observed, which will depend mainly by the main target species caught during the year, or during a specific season, depending on the temporal resolution available.

Marine recreational fisheries can be considered a common practice throughout the Mediterranean Sea and the Black Sea; however, still now, despite its ubiquity all over the coastline, it can be considered a data-poor sector and a realistic estimation of socio-economic impact catches and effort on fishery resources is very difficult to define and it can be variable depending on countries (Grati et al., 2021).

Stock status of commercial species encountered in the diet of cetacean populations

Within the Mediterranean Sea commercial species, specifically when managed through national or international management plans, are evaluated regularly by regional or scientific bodies such as GFCM and STECF. Such evaluations can give an indication of the state of health of a population and therefore could be potentially used to interpret some aspects of the state of the population of their predators. When official evaluations combining commercial and scientific data are not available, biomass indices coming from scientific surveys (such as the MEDIT survey in the Mediterranean Sea) can be used to have an indication of the state of the observed population.

*The impact of interactions between fishing gears and cetaceans: the case study of *Tursiops truncatus**

The bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821), is an odontocete cetacean belonging to the family Delphinidae. It has a relatively robust body, a stubby but prominent rostrum, and a pearly grey coloration, darker on the back and almost white on the belly. Its morphology and coloration vary depending on the geographical area of distribution. It inhabits all the world's seas, except for polar and subpolar waters. The male is slightly larger than the female; at birth, calves are about 1 metre long and weigh around 12 kg. Adult individuals can reach up to 4 metres in length and weigh up to 350 kg. It is a highly social species, and solitary

individuals are only occasionally spotted. It is a piscivorous species, feeding on various species of fish and cephalopods (Arpal, 2021).

The common bottlenose dolphin (*Tursiops truncatus*) is listed in Annex II of the EU Habitats directive (92/43/CEE), in Appendix II of Convention on the Conservation of Migratory Species of Wild Animals (CMS), in Appendix II of the Bern Convention, in Appendix II of CITES, and in Annex 2 of the Protocol on Specially Protected Areas and the Biological Diversity in the Mediterranean of the Barcelona Convention (ACCOBAMS, 2023). The Mediterranean subpopulation is least concern according to the IUCN Red List Criteria (Natoli et al., 2021) and has been protected at national and international level since the 1980s. *T. truncatus* is considered

a common species in the Mediterranean basin (Pilleri and Gahr, 1969; Cagnolaro et al., 1983; Notarbartolo Di Sciara and Demma, 1994) and can be observed along most coastal waters (Bearzi and Fortuna, 2006). It inhabits coastal and continental shelf environments where they find their optimal habitat, not venturing beyond the 200 m depth isobaths (Gnone et al., 2023). The bottlenose dolphin is regularly observed in the waters of the Ligurian Sea and the Pelagos Sanctuary (the SPAMI located in the northwestern portion of the basin, between Italian and French waters, including the Principality of Monaco), representing one of the two dominant cetacean species of the area (Gnone et al., 2011; Gnone et al., 2023), with



Figure 1 *Tursiops truncatus*

an estimated abundance of about 7300 (2900-18,500) individuals in the winter, which are reduced to 2900 (600-13,400) in the summer (Laran et al., 2017; a higher estimate compared to the one of Lauriano et al. (2014); a similar seasonal trend was observed by Pace et al. (2022) in the waters off Tuscany. The preference of the bottlenose dolphin for the relatively shallow waters of the Mediterranean shelf, appears to be correlated with the species' feeding habits, as it predominantly feeds on benthic and demersal fish (Voliani and Volpi, 1990; Orsi Relini et al., 1994; Miokovic' et al., 1999; Blanco et al., 2001). Recently, though, within the Pelagos Sanctuary, two behavioural types were identified, characterised by their preference for either shallow waters on gently sloping seabed or for rocky, steep coasts where great depth is reached in proximity of the coast (Vassallo et al., 2020; Gnone et al., 2022), confirming the influence of geo-morphological and ecological characteristics of the landscape on the population structure and distribution described by Carnabuci et al. (2016).

Human presence in the preferred habitat of *T. truncatus* (the continental shelf) has significantly increased over the last decades. This phenomenon often leads, especially during the summer months, to a reduction and fragmentation of the available habitat for this species, contributing to an increase in harmful interactions with humans and a reduction of its vital activities (David, 2002; Papale et al., 2011; La Manna et al., 2013). The greatest impact has been estimated to come from noise pollution produced by engines, as well as the direct disturbance from boats (particularly fast boats) which forces temporal displacement of individuals (Pennino et al. 2014; ACCOBAMS, 2023). This habitat fragmentation and the increase in fishing effort during the summer months (as the weather improves) push dolphins to prey more on fishing gears, increasing the number of dangerous interactions.



Materials and methods

The impact of ALDFG

A literature review was implemented to collect existing information in the scientific literature on the impact of ALDFG on cetaceans, specifically in the Pelagos Sanctuary. Additionally the review was integrated with information from current and past projects on ALDFG held in the Pelagos Sanctuary and collecting information on the existing legislation that can be applied to the case of ALDFG monitoring and management.

Distribution and temporal trends of commercial and recreational fishing effort

Commercial fishery

The main data source of the fishing fleets present along the coast of the Pelagos Sanctuary is the EU Fleet Register database available at: https://webgate.ec.europa.eu/fleet-europa/search_en

The main data provided by the Fleet Register refers to the technical characteristics of the boats (Length - LOA, tonnage - GT, power - kW), useful to define the fishing capacity indices, the main and the subsidiary fishing gears and the year of construction (Age) of the vessels.

The Classification of Fishing Gear reported from now on is derived from the new revision reported in Lucchetti et al. (2023).

The spatial distribution of commercial fishing vessels grouped by gear was analyzed first using data downloaded from the Global Fishing Watch (2024) website. The most updated data, for the year 2020, were downloaded and plotted summing the daily fishing hours across the whole year. Data were filtered including only recordings between 1 and 100 hours in this first extraction, to remove single records reporting unique high amount of hours in a single cell, as these should be verified.

As Global Fishing Watch data have a number of limitations when used at small scale resolution (such as gear classification), we report the available information from the publicly available DCF FDI dataset (https://stecf.ec.europa.eu/data-dissemination/fdi_en) that reports spatial distribution in 2022, by gear and fleet segment. It should be noted that this dataset is available only at GSA and country resolution.

In order to have a higher resolution of the fishing effort within the Pelagos Sanctuary, data by region were requested for the Italian regions of Liguria, Tuscany and Sardinia.

Recreational fishery

The main data source reported refers to technical reports and pilot studies (EU Data Collection Framework - DFC) based on qualitative interviews and questionnaires (Guillot et al., 2018, Grati et al., 2021b). Additionally data were requested to the MASAF to explore which data are available at national level for recreational fishery.

Stock status of commercial species encountered in the diet of cetacean populations

Stock status of commercial stocks within the Pelagos Sanctuary was derived by the assessment carried out in three GSAs (7, 8, 9) by the STECF and GFCM Committee and summarized within the CFP report (STECF, 2024).

Trends of biomass indices were estimated from the MEDIT survey data (European Commission, JRC, 2025).

*The impact of interactions between fishing gears and cetaceans: the case study of *Tursiops truncatus**

A literature review was implemented to collect existing information in both, scientific and grey literature, on the interactions of *T. truncatus* and fishing activities and the potential effect of these interactions on the survival of *T. truncatus* populations in the Pelagos Sanctuary.

Results

The impact of ALDFG

Monitoring and removal of ALDFG

Monitoring ALDFG is not easy due to their nature as discarded fishing gear, which often means their location once lost is unknown. Some projects, such as the Life GHOST project (Da Ros et al., 2016), which aims at identifying and remove ALDFG, have carried out local mapping of discarded nets before proceeding with their removal. However, at the moment there is no universal protocol for monitoring ALDFG. The main limitation in monitoring nets or fishing gear lost on the seabed, lies in their vast dispersal potential. Where mapping has been conducted, it was developed through targeted surveys in areas of high natural value (Da Ros et al., 2016) or in marine protected areas (MPAs) (although this is dependent on the extension of the MPA) where it was known that fishers lost their nets.

Monitoring in the Sanctuary could be conducted within MPAs or in areas of high natural interest where it is known there is significant fishing pressure from both commercial and recreational fishers, as in the Ulisse and Penelope seamounts, which, as Bo et al. (2021) reported, are subject to fishing pressure. Potential monitoring guidelines could be drafted following the methodology promoted by the Life GHOST project and Life Strong Sea Life project (July 2023) which are the only available references at the moment. Those involve:

- an initial survey conducted using acoustic instruments such as side-scan sonar and multibeam to identify the fishing gear;
- once the fishing gear is identified, a second assessment is necessary using a ROV or a scuba diver to determine whether the removal operation is feasible and to ensure there is no significant damage to the benthic communities;
- the removal of ALDFG can be either total or partial in situations where total removal would cause greater harm to benthic communities than leaving it in the water.

This assessment must be conducted by a marine biologist both during the monitoring phase and the fishing gear removal phase. The removal operations must be carried out by the Coast Guard through the action of OTSs (Underwater Technical Operator) and a marine biologist diver to coordinate the removal activities (Da Ros et al., 2016).

From 2015 to 2020, the GHOST MED project (Fig. 2) worked in the French Mediterranean waters to gather reports of ALDFG (Abandoned, Lost, and Discarded Fishing Gear) through an approach combining the analysis of scientific studies and the use of a citizen science service. This led to 1,256 ALDFG reports, which were analyzed in detail, considering various characteristics. Through these reports, it was possible to calculate two main indices: the environmental impact index and the landscape impact index. The combined analysis of these indices led to the creation of a removal index, a tool to facilitate the decision of whether to remove the ALDFG from the seafloor. Additionally, thanks to the collected reports, a map of the presence of lost fishing gear was produced (Ruitton et al., 2019).

Overview of ALDFG in the Pelagos Sanctuary

Some studies document the presence of ALDFG within the sanctuary. BO et al. (2021) analyzed a total of 700 images obtained through an ROV. For the Ulisse Seamount, marine sea floor litter was present in 34% (242 items) of the analyzed frames, with 88% attributed to ALDFG. The same trend was observed for the Penelope Seamount, where marine litter was present in 61% of the frames, and ALDFG represented 94% of the identified items. In this study, ALDFG was found to originate from artisanal or recreational fishing activities in the area. The main ALDFG items included fragments or entire longlines, ropes, trolling lines, and sinkers.

Giusti et. al. (2019) analyzed five canyon systems from west to east of the Ligurian Sea: Dramont (France), Monaco (Principality of Monaco), Bordighera, Arma di Taggia, and Bergeggi (Italy), at depths ranging from 20 to 445 meters. The ROV dives surveyed the sea bottom over a total distance of 19,304 meters. A total of 146 items were found in the study areas, accounting

for 85% of DFGs (divided into fishing nets (57%), lines (12%), and ropes (16%)). The remaining 15% was related to general urban litter. Bergeggi was the area with the highest density of litter, followed by Monaco and Bordighera. DFGs were more prevalent in the sites of Bergeggi and Bordighera, while urban litter was more abundant in the Monaco area.

In another study nine stations along the entire Ligurian Arc were examined with ROV linear video transects between 30 and 200 meters deep, covering a total length of 51 km. A total of 3,546 litter items were reported from the images recorded on the Ligurian deep continental shelf and shelf break. Of these, 83% (2,944 items) were ALDFG, while the remaining 17% (602 items) were urban litter. Fishing lines were the most abundant, with nylon lines accounting for 67.7% of the total ALDFG, while an additional 11.8% was represented by ropes. The 2,944 ALDFG items were categorized into fishing lines, including ropes (2,340 observations), fishing nets (523 observations), which consisted of 102 gillnets (GTR), 4 gillnets (GNS), 412 unidentified artisanal nets, and 18 observations of trawling and purse seine nets, as well as 63 observations of other fishing gear, such as fishing pots and mooring gear (Enrichetti et. al., 2020). In the north of Sardinia, Costa et al. (2024), during 3 ROV operations and two diving operations, found 2 octopus traps, 2 trammel nets (700m and 150m), and a gillnet (100m).

It should be noted that almost all ALDFG present in the sanctuary are gillnets or recreational fishing lines, which are found on the seabed. According to the existing literature, these do not appear to pose a risk to cetaceans as they are not observed still fishing in the water column and no cetaceans have been observed feeding on ALDFG on the seabed.

Legislation about ALDFG

Within the Pelagos Sanctuary, the legislation regarding ALDFG management is quite complex. In Italian waters, it is still unclear how this type of waste should be disposed of. The EU Directive 2019/883 of April 17, 2019, known as "MARPOL," stipulates that waste accidentally caught, including ALDFG, must be disposed of as special waste in designated areas at port facilities, without imposing any additional costs on those unloading the material. France follows the European directive, while in Italy the "Salvamare" law (D.l. 60/2022), aligns with the European directive by classifying waste accidentally caught or voluntarily collected (including ALDFG) as ship-generated waste. Once at the landing port, individuals can dispose of the waste in designated collection areas free of charge. The same option is available at small non-commercial ports with reduced marine traffic, where waste collection is managed by the local municipality.

The EU member states must also follow the EU Regulation 1224/2009 that requires fishing vessels to recover lost gear as soon as possible, also obliging them to have the necessary tools on board. If recovery is not possible, the skipper must report to the competent authorities:

- the identification number of the fishing vessel;
- the type of lost gear;
- the time and location of the loss;
- the measures taken to recover the gear.

As for the Principality of Monaco, there are no well-documented specifics, but through collaboration with the Pelagos Sanctuary and international partners, there is an effort to comply with the MARPOL directive. However, it should be noted that the fishing effort along the coast of the principality is particularly limited.

Active projects in the Pelagos Sanctuary

In 2022 and 2023, dedicated days were held in the Portofino Marine Protected Area for the removal of ALDFG from the seabed. These events were organized as part of the EcoeFISHent project (2023), in collaboration with WWF. During these initiatives, several kilograms of lost fishing materials were removed from the seabed. The EcoeFISHent project aims to promote circular activities and the reuse of fishing materials. The recycling of ALDFG is also promoted by other projects such as PRISMAMED ("Piano RIfiuti e Scarti in Mare di pesca, acquacoltura e di

porto nel Mediterraneo 2018-21"; <https://interreg-maritime.eu/web/prismamed>), which aims to recycle ALDFG and other waste of marine-origin.

Another project that promotes the monitoring and removal of ALDFG within the sanctuary is Strong Sea Life (2021-2026), which operates in the MPA of Asinara Island. Within the report potential guidelines to implement the monitoring and removal of ALDFG are described.

As for the French portion of the sanctuary, there are several projects promoting the monitoring, removal, and recycling of ALDFG. DéFi-Méd (Naturdive, 2024) is a project that aims at identifying and removing ALDFG in the Var, Alpes-Maritimes, and Corsica, mainly in Marine Protected Areas. In addition, the French Office for Biodiversity (OFB) launched projects in 2021 such as "RECUPMED 2", aimed at the removal and valorization of lost fishing gear, with a dedicated funding of €150,000. These efforts aim at minimizing environmental impacts by involving local communities.

The Principality of Monaco, not having active projects of its own, actively collaborates with private companies such as PRODIVE, which voluntarily carry out ALDFG removal operations.

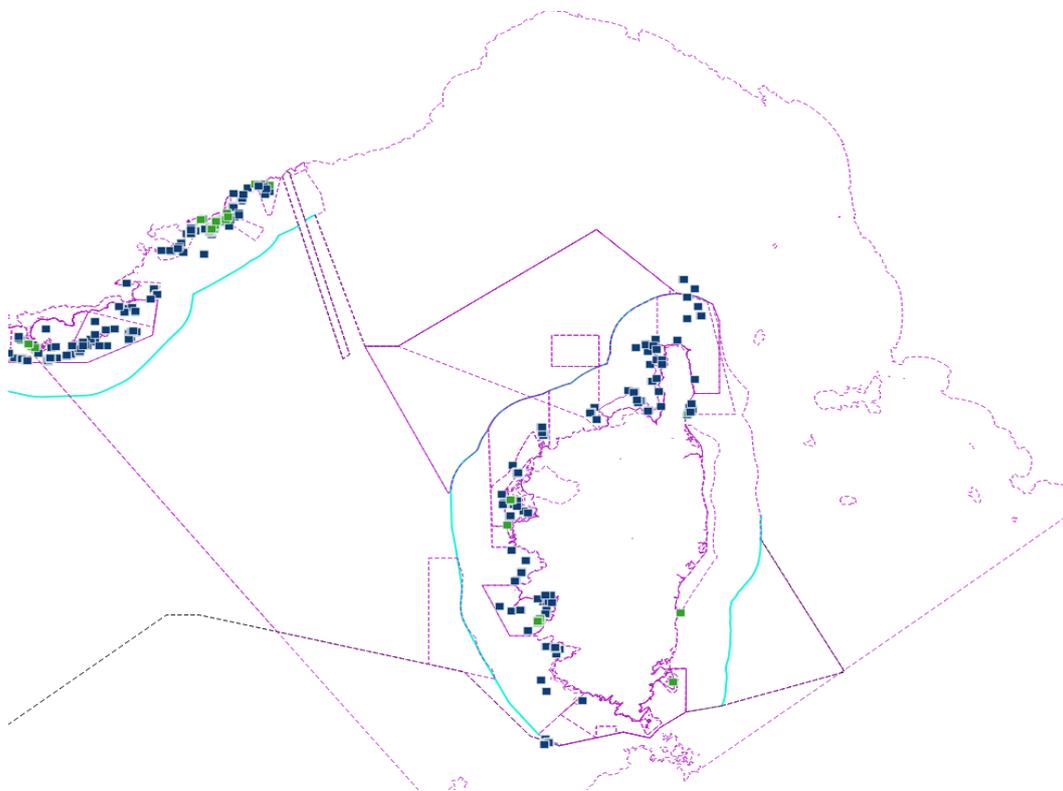


Figure 2 Map of abandoned fishing nets identified by the GHOST MED project (2022)

Distribution and temporal trends of commercial and recreational fishing effort

Commercial fishery

In general the professional fishing fleets registered in the study area are characterized by a total amount of 1,704 vessels, for a total of 10,528 GT (tonnage) and 124,427 kW (power). They are composed by small-sized vessels (mean LOA 8.6 m), ranging from 0.2 to 153 tonnage (mean value 6.2 GT) and between 0 and 612 power engine (mean value 73 kW).

In the study area the main fleet segment is represented by boats belonging to the small scale fishery, up to 12 m LOA; more in details, boats ranging between 6-12 m LOA are 1,133 (66%), while between 0-6 m LOA are 338 (20%).

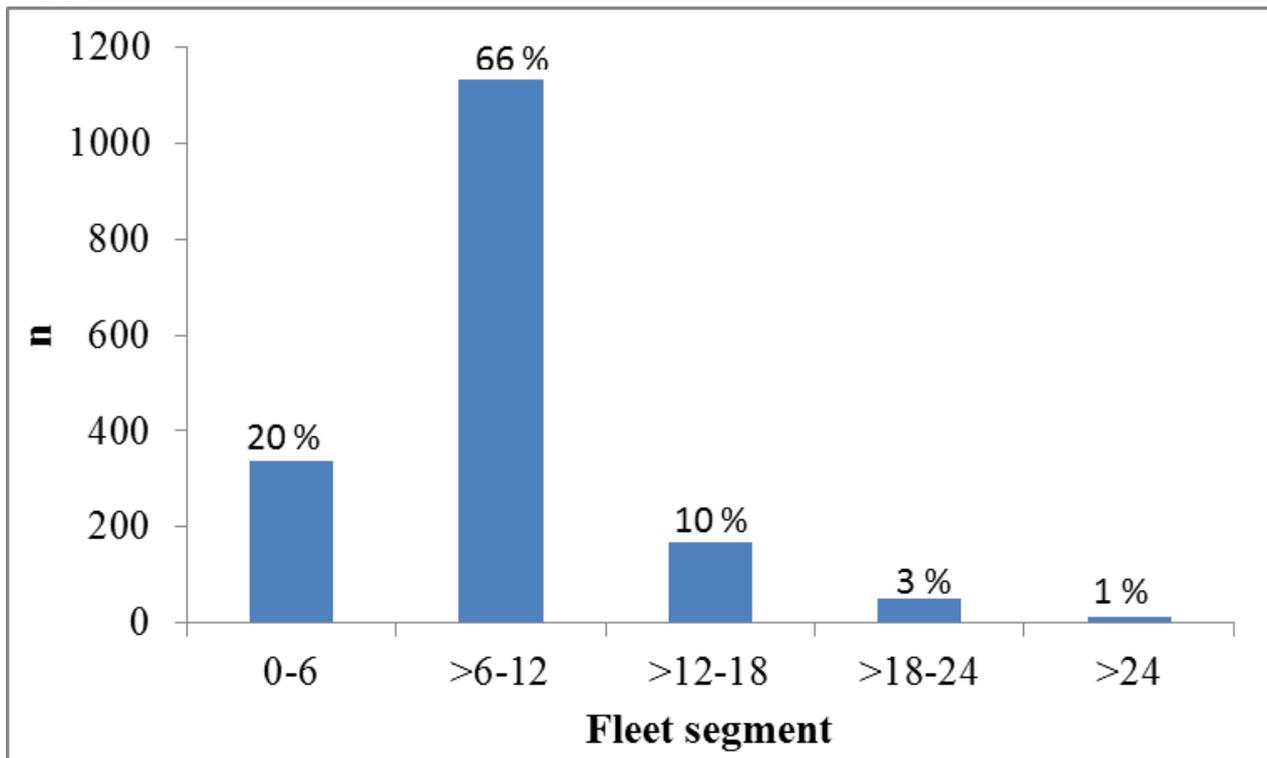


Figure 3. Fishing fleet segments of the Pelagic Sanctuary.

More in details the professional fishing fleets distributed along the Pelagos area were divided in 14 maritime districts (Table 1) respectively:

- 10 in Italy: 4 in the Liguria region (Imperia – IM, Savona –SV, Genoa – GE, La Spezia – SP), 4 in Tuscany (Marina di Carrara, Viareggio, Leghorn, Porto Ferraio) and 2 in Sardinia (Porto Torres, La Maddalena)
- 4 in France: 2 in Corse (Bastia and Ajaccio) and 2 along the south French coast (Toulon and Nice);
- no data are reported in the Fleet Register about fishing vessels in Monaco, given that it is not a EU country, but from local knowledge there are two boats (<12 m LOA), belonging only to one fisherman.

Leghorn fleet (n= 343) represents the main district in terms of number of vessels, followed by Genoa (n=180) and Toulon (n=161). The district with the largest fishing vessels is Porto Ferraio (mean value 10.6 m LOA) followed by Imperia (mean value 9.9 m LOA) and La Spezia (mean value 9.7 m LOA) (Table 1; Figure 3). The fishing capacity indexes ratio (GT vs kW) is characterized by small vessels with high engine power in Corse and confirm the presence of the largest vessels in Porto Ferraio and La Spezia. Instead, Marina di Carrara, Nice and Savona represent the marine district with the lowest fishing capacity.

Table 1. Mean and absolute values, by maritime district, of the main fishing capacity indicators of the professional fishing fleet by maritime district: length overall (LOA), gross tonnage (GT), engine power (kW).

Nation	Number of vessels	LOA mean value	GT total	GT mean value	kW total	kW mean value
Region						
Marine district						
FRANCE	422	7.8	1,588.4	3.8	38,009.0	90.1
Corse	173	8.2	859.7	5.0	20,229.0	116.9
Ajaccio	113	8.0	582.2	5.2	13,044.0	115.4
Bastia	60	8.5	277.5	4.6	7,185.0	119.8
French coast	249	7.5	728.7	2.9	17,780.0	71.4
Toulon	161	7.7	517.6	3.2	12,061.0	74.9
Nice	88	7.1	211.1	2.4	5,719.0	65.0
ITALY	1,282	8.9	8,939.4	7.0	86,418.4	67.4
Liguria	497	8.7	3,034.4	6.1	31,950.6	64.3
Genoa	180	8.7	1,089.4	6.1	11,377.0	63.2
Savona	139	7.3	508.0	3.7	6,513.0	46.9
Imperia	110	9.9	780.0	7.1	8,461.9	76.9
La Spezia	68	9.7	657.0	9.7	5,598.7	82.3
Sardinia	202	9.2	1,265.0	6.3	16,822.0	83.3
Porto Torres	140	9.5	1000.0	7.1	12,626.8	90.2
La Maddalena	62	8.5	265.0	4.3	4,195.3	67.7
Tuscany	583	8.9	4,640.0	8.0	37,645.8	64.6
Leghorn	343	8.9	2,724.0	7.9	22,487.8	65.6
Viareggio	130	9.2	1,111.0	8.5	8,126.3	62.5
Porto Ferraiolo	64	10.6	723.0	11.3	6,146.9	96.0
Marina di Carrara	46	6.7	82.0	1.8	884.8	19.2
Total	1,704	8.6	10,527.8	6.2	12,4427.4	73.0

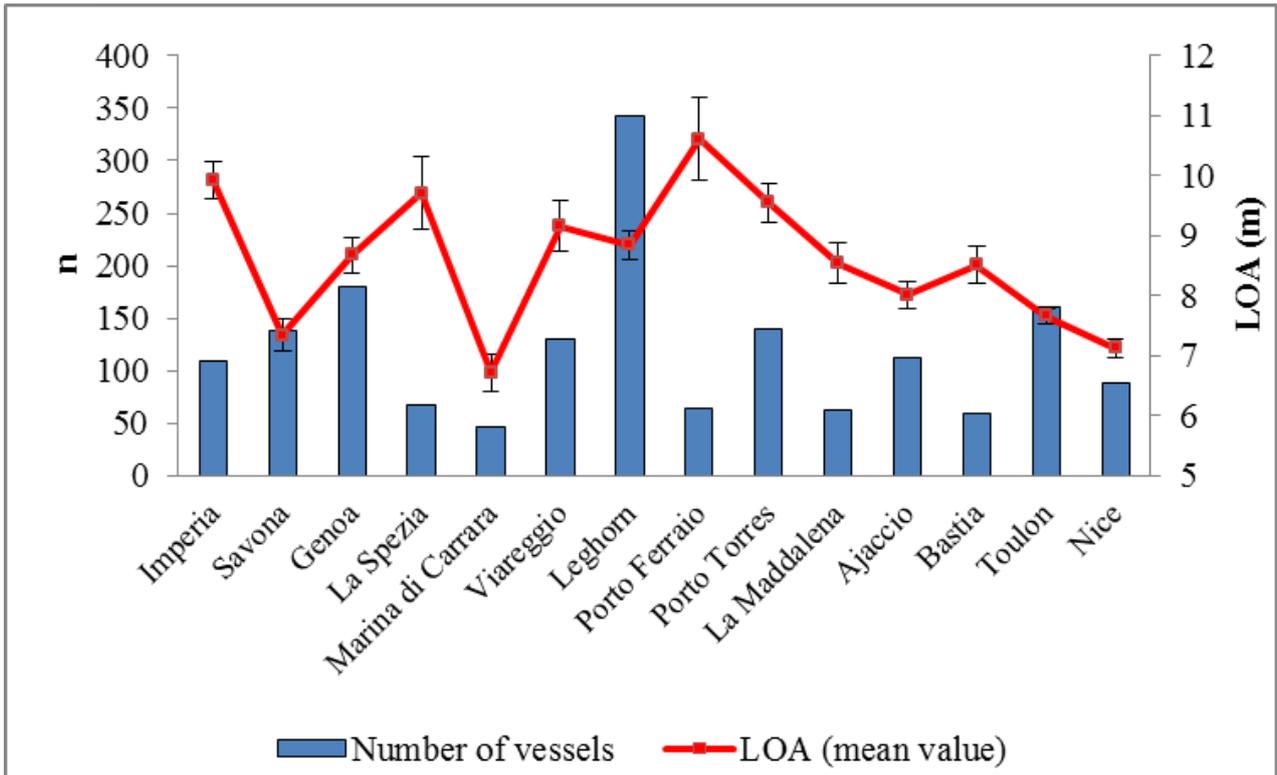


Figure 4. Number of vessels and mean length (LOA) of the professional fishing fleet by maritime district.

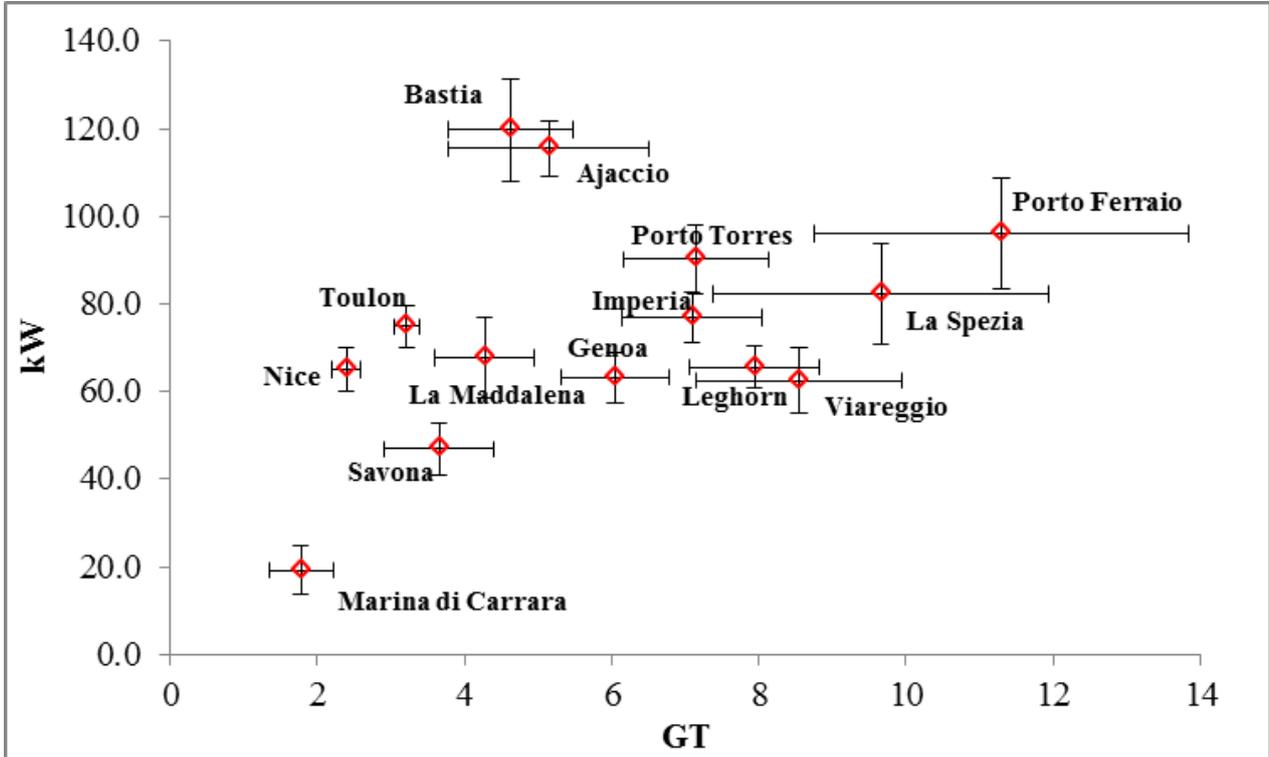


Figure 5. Mean gross tonnage (GT) and engine power (kW) (mean values) of the professional fishing fleet by maritime district in the Pelagos Sanctuary (bars indicate Standard Error).



The main fishing gear reported in the dataset is the set longline (LLS), followed by the purse seine (PS) and gillnets (GNS) (Table 2; Figure 6). Italy is the country with the largest numbers of LLS (n=698), PS (n=298) and OTB (n=208) declared, while in France the main gears resulted the nets: GNS (n=187) and GTR (n=158) (Table 2; Figure 6). It is important to emphasize that the data extrapolation was based on the primary gear declared in the Fleet register, likely derived from vessel owner communication. The high number of LLS reported for Italy (54% of the total) does not necessarily represent only fishing boats using LLS, instead it should be taken into account to assess the size of the small-scale fishery (SSF), where LLS are just one of the gears used onboard of a single fishing vessel, together with GNS and GTR. Those three gears are in fact grouped together under the fishing technique PGP (indicating vessels using polyvalent passive gears).

Table 2. Main fishing gears per vessel reported in the EC fleet register.

Gear name	Gear code	Italy (Liguria, Tuscany, Sardinia)	France (French Coast-Corse)
Towed dredges	DRB	-	9
Pots	FPO	-	2
Gillnets	GN	-	1
Encircling gillnets	GNC	-	1
Drift gillnets	GND	2	-
Fixed gillnets	GNF	-	1
Gillnets	GNS	73	187
Combined gillnets-trammel nets	GTN	-	9
Trammel nets	GTR	-	158
Handlines	LHP	1	1
Longlines	LL	-	6
Drifting longlines	LLD	-	5
Set longlines	LLS	698	29
Boat operated lift nets	LNB	-	2
Diving	MDV	-	5
Gear not know	NO	1	-
Bottom Otter Trawl	OTB	208	4
Midwater otter trawl	OTM	-	1
Purse seine	PS	298	1
Midwater Pair Trawls	PTM	1	-
Total		1,282	422

In terms of fishing capacity four of the main gears belong to the SSF (LLS, GTR, GNS, PS) while the OTB segment is characterized by the highest values of the fishing fleet performing in the Pelagos Sanctuary (Figure 6-7).

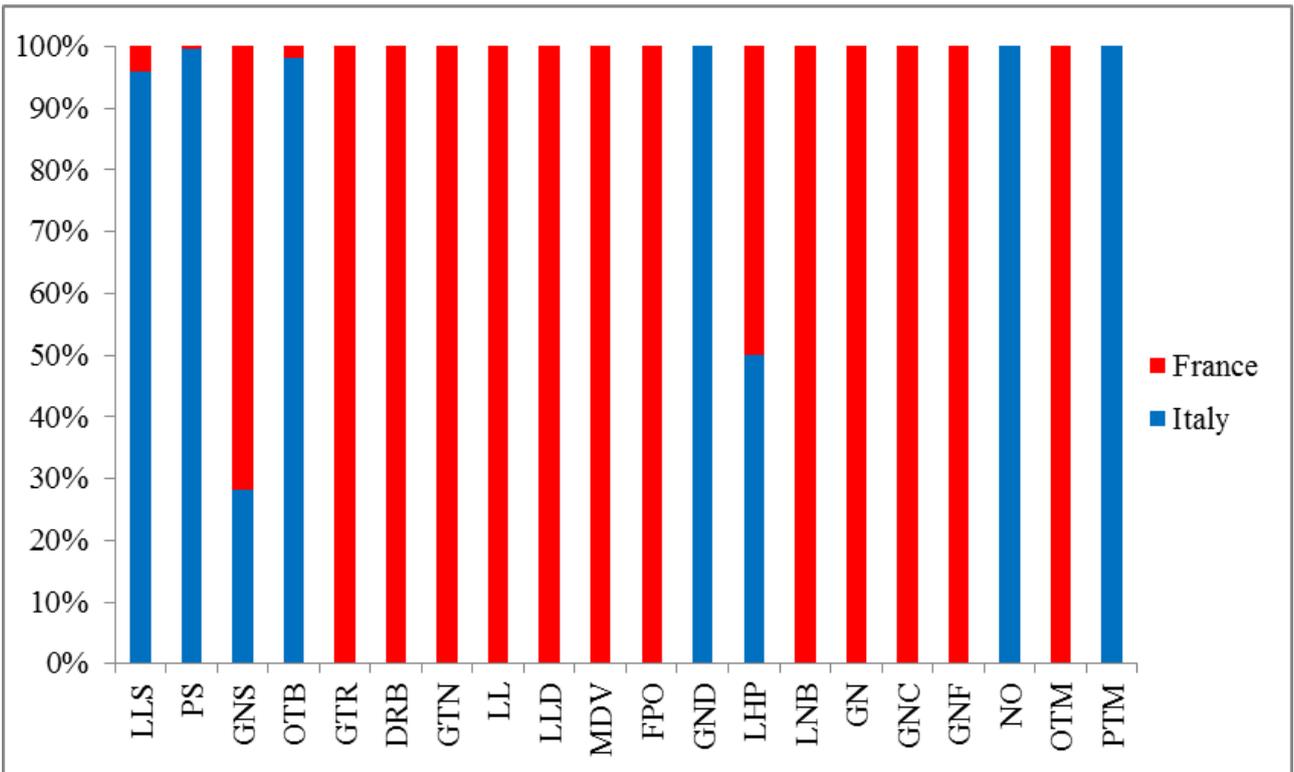
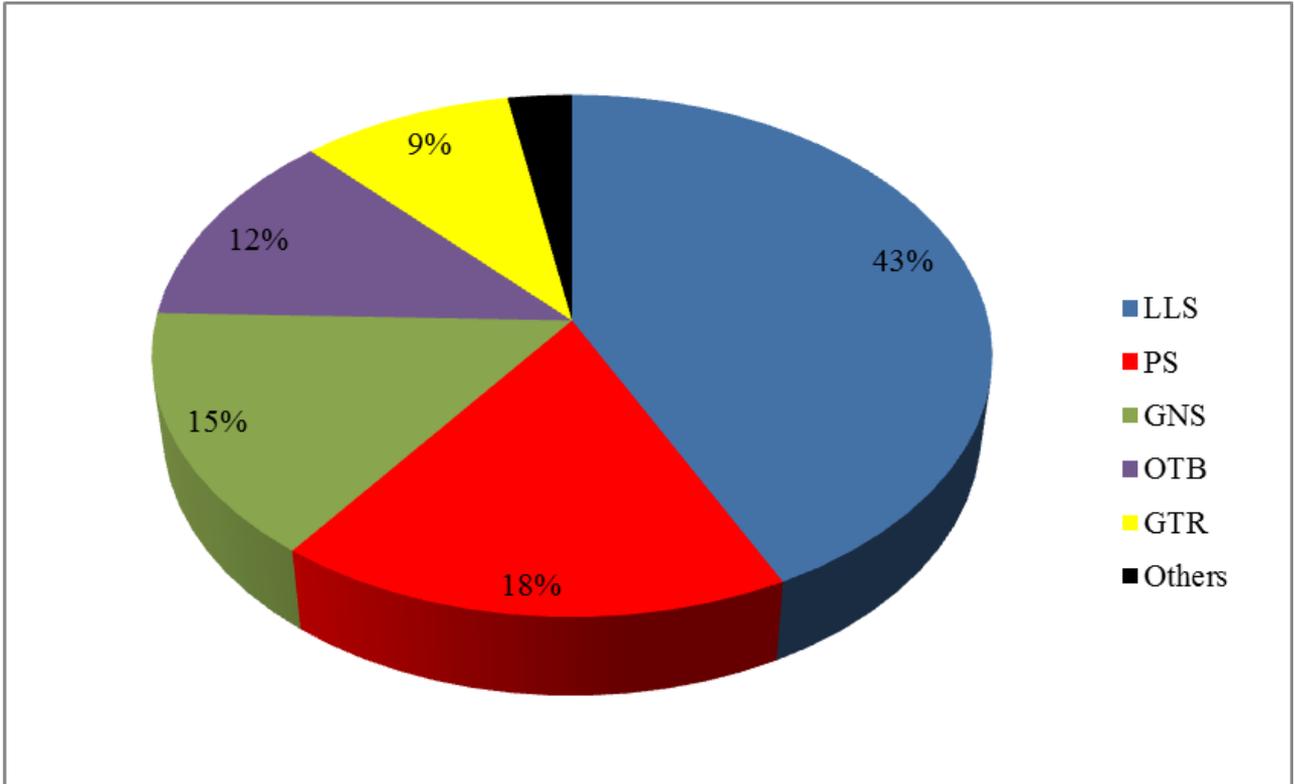


Figure 6. Main fishing gears reported in the Pelagos Sanctuary (up) and percentage of different gears in Italy and France (down) (source: EC fleet register).

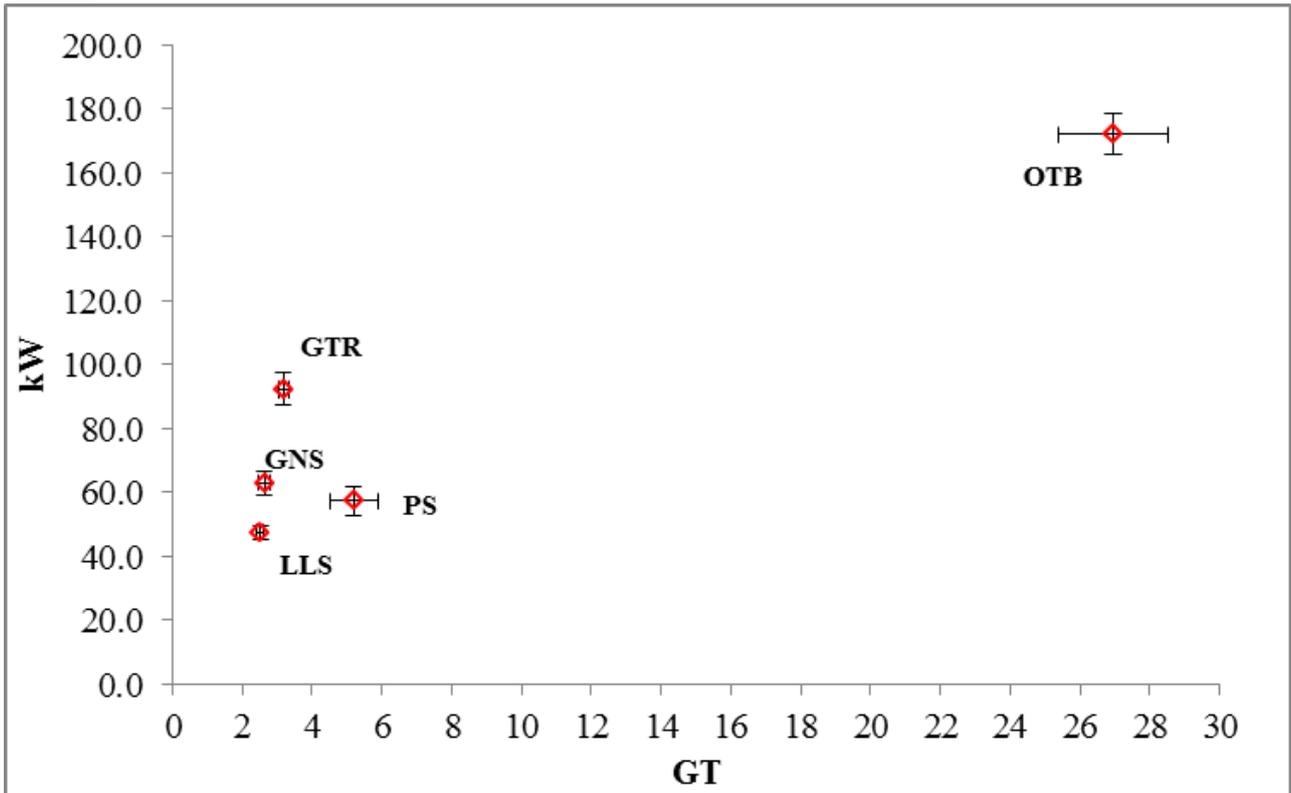


Figure 7. Mean gross tonnage (GT) and engine power (kW) (mean values) of the professional fishing fleet by main gear types reported in the Pelagos Sanctuary (bars indicate Standard Error).



Figure 8. Different fishing vessels belonging to otter trawl (left) and small scale (right) fisheries.

The only available data in the Pelagos Sanctuary from the Global Fishing Watch are for trawling gear (Fig. 9). Thanks to our local knowledge of the distribution of the fleets, it was highlighted that under “trawling” gear, were reported also records in areas which are generally fishing spots of drifting longlines, where depths are higher than 1000m and trawlers are not allowed. In Figure 10 the tracks of longliners that are known to be fishing in the western Ligurian Sea are reported to show that the GFW data need to be verified when working at small scale.

In order to properly map the effort of gears other than trawls, accessibility to remote sensing data should be eased by the Italian national administration, to allow comparison of large publicly available data (such as the GFW dataset) elaborated through the license system with national level data, to correct potential errors and improve the quality of publicly available data which are fundamental for research purposes. Additionally this would allow to map the distribution of all gears also at small scale and by fleet segment.

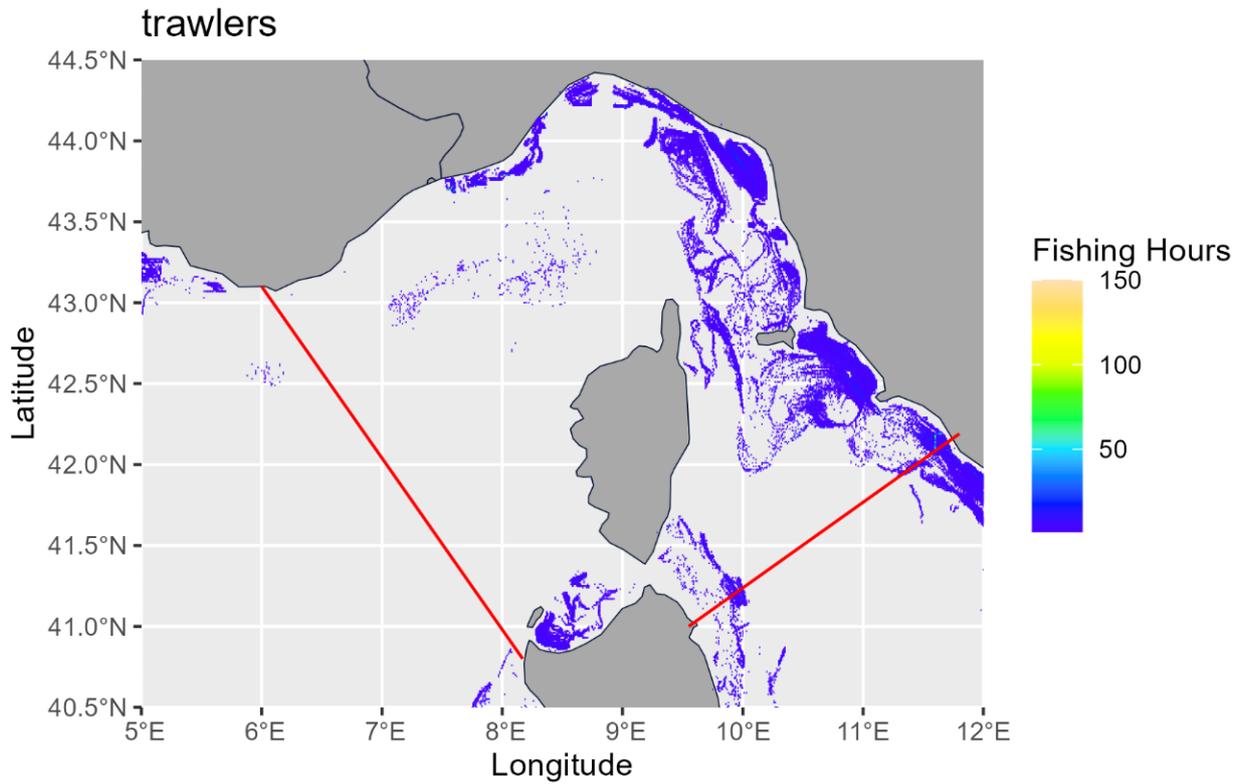


Figure 9 Distribution of trawlers effort (in fishing hours) in the Pelagos Sanctuary in 2020. Red lines identify the indicative borders of the Pelagos Sanctuary.

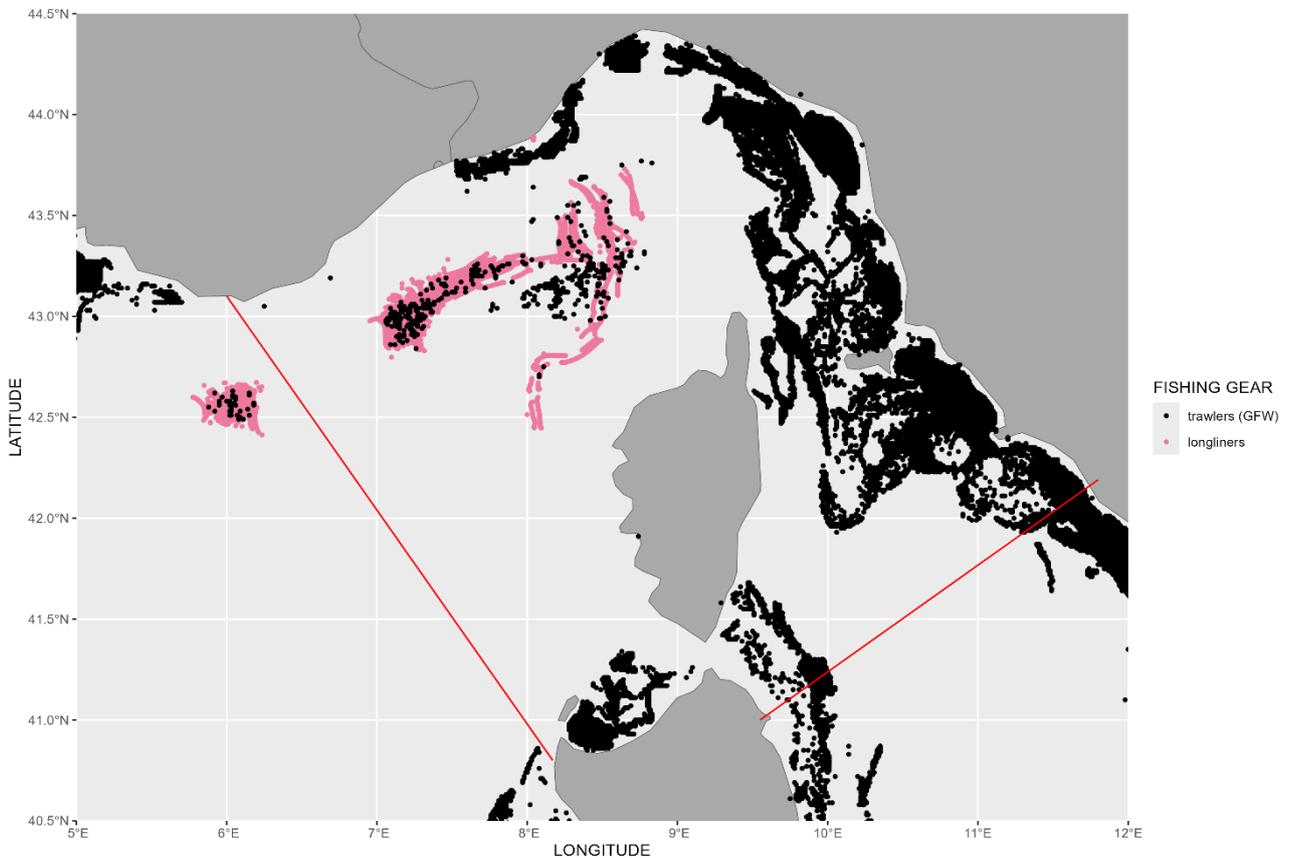


Figure 10 Comparison of the trawlers effort (in fishing hours) from the GFW dataset (black) and of longliners fishing tracks in the Pelagos Sanctuary in 2020. Red lines identify the indicative borders of the Pelagos Sanctuary.

From the DCF dataset longliners and set nets are mainly represented by artisanal fisheries (<12m) where spatial information are only available for the French GSA (7-8) (Figure 11-13).

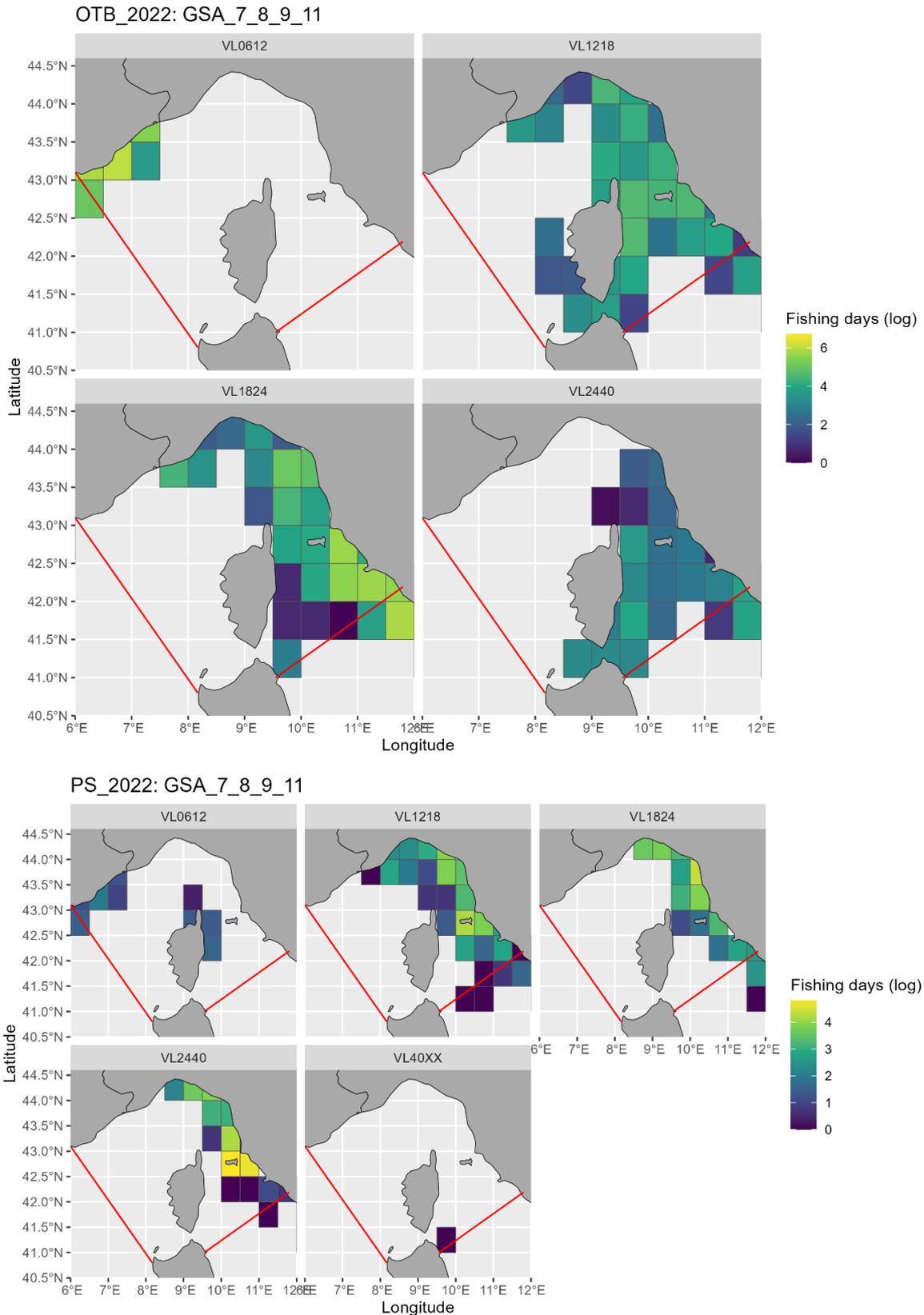


Figure 11 Distribution of fishing effort of bottom trawls (OTB) and purse seines (PS) in fishing days (logged values) at C-square resolution for 2022, by fleet segment. Red lines identify the indicative borders of the Pelagos Sanctuary.

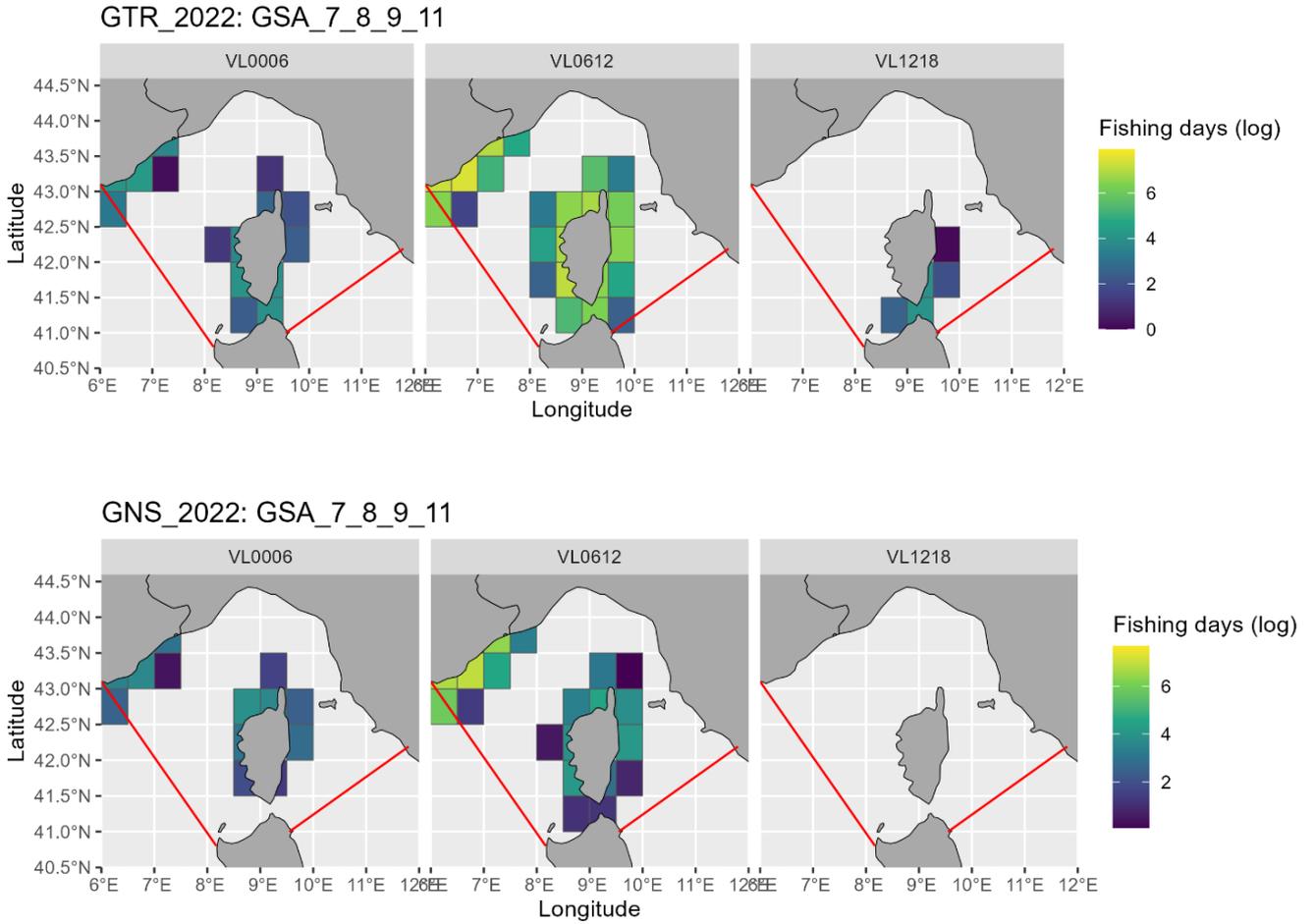


Figure 12 Distribution of fishing effort set nets (GNS and GTR) in fishing days (logged values) at C-square resolution for 2022, by fleet segment. Red lines identify the indicative borders of the Pelagos Sanctuary.

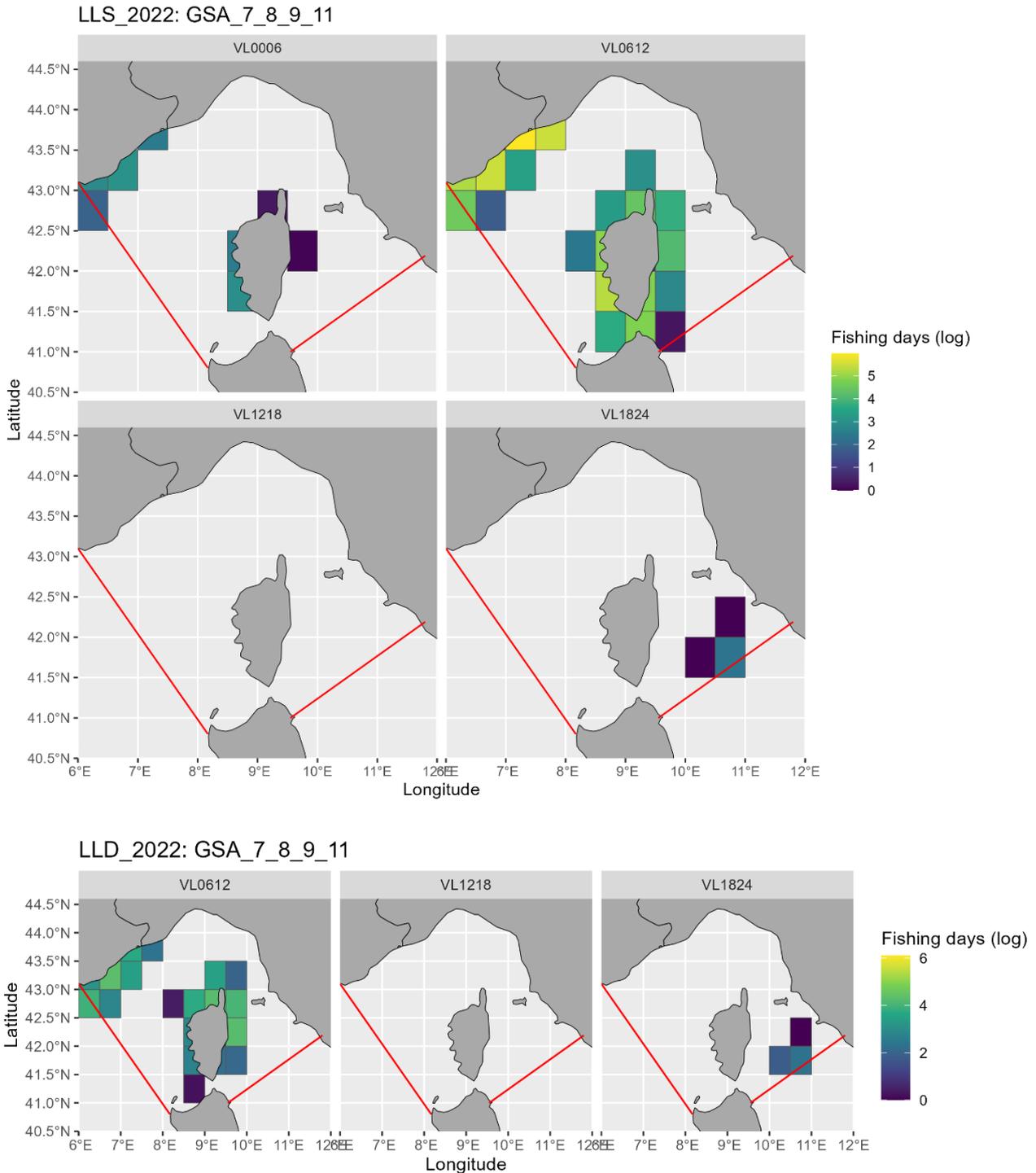


Figure 13 Distribution of fishing effort set (LLS) and drifting (LLD) longlines in fishing days (logged values) at C-square resolution for 2022, by fleet segment. Red lines identify the indicative borders of the Pelagos Sanctuary.

In Fig. 14 are shown the historical time series, from 2013 to 2022, of fishing effort (expressed in total fishing days) declared per gear and by GSA. It can be observed that bottom trawlers (OTB) effort has been decreasing consistently across areas, specifically in GSA 9. It should be noted that the increase of OTT in GSA 7 is due to a shift in the area from OTM to OTT. In Fig. 15 vessel numbers by GSA and gear are reported. It can be noted that inactive vessels have been increasing in all GSAs since 2019, specifically in GSA 9.

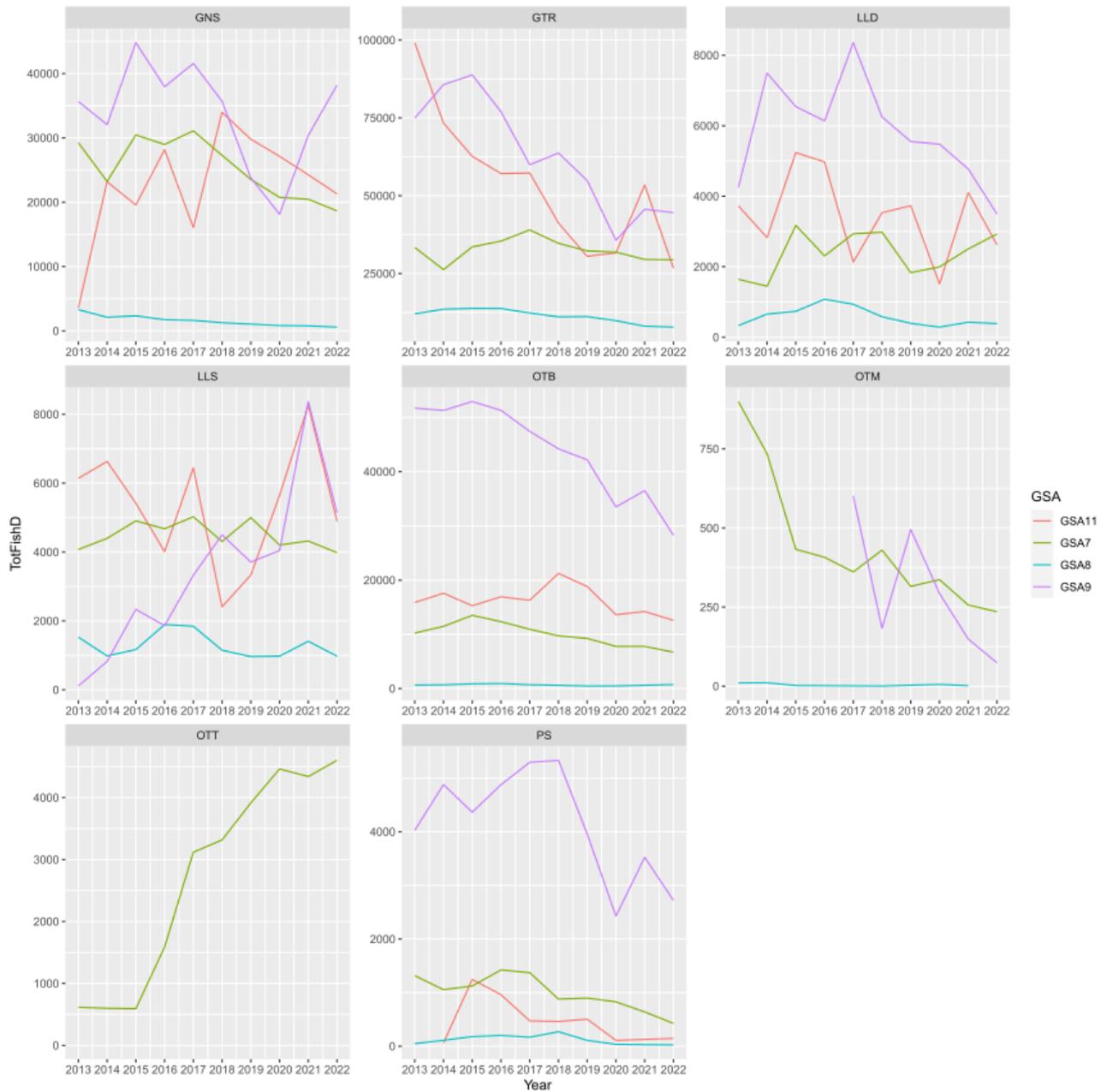


Figure 14 Time series of total fishing days per gear and GSA.

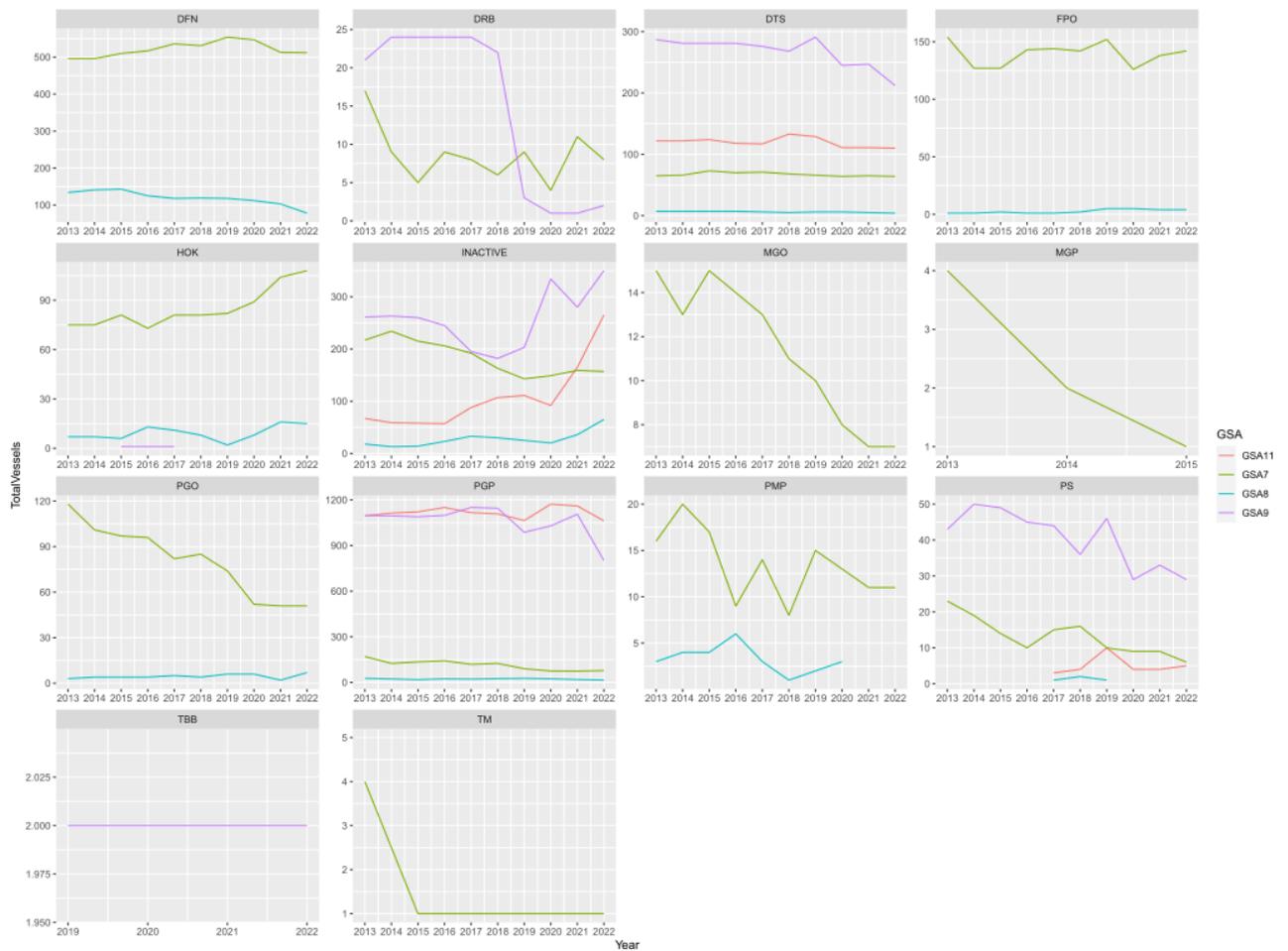


Figure 15 Time series of total vessel number per gear and GSA.

Figure 16 shows the available time series (2015-2023) of fishing effort (expressed in total fishing days) per region (Liguria, Toscana and Sardinia) and fleet segment for the fishing techniques DTS (demersal techniques) and PGP (passive gears). In all regions it can be observed the strong decrease of DTS, specifically for fleet segments >12m, while passive gears (PGP) show a general decrease across all fleet segments. It is interesting to observe that while total fishing days are decreasing, the total number of vessels (fig. 15) are not necessarily decreasing for all fleet segments for DTS (except for the 12-18m segment) and are stable for PGP in Tuscany and Liguria, while they are increasing for Sardinia in fleet segments <12 m.

Average vessel age, instead, is strongly increasing across all regions and fleet segments suggesting the fleet is mainly represented by obsolete vessels (fig. 18).

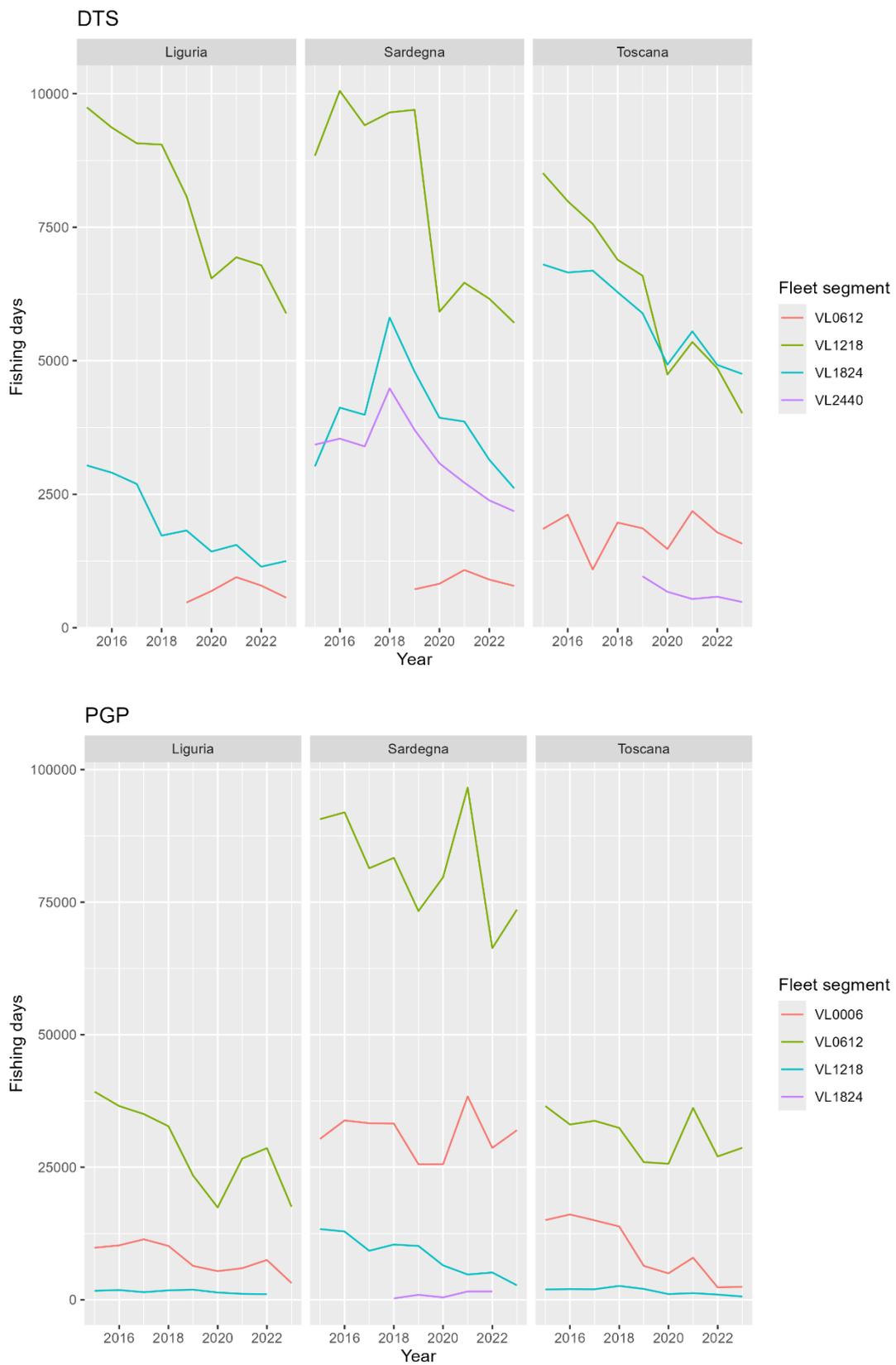


Figure 16 Time series of fishing days for DTS (demersal trawlers) and PGP (passive gears) by Italian region and fleet segment.

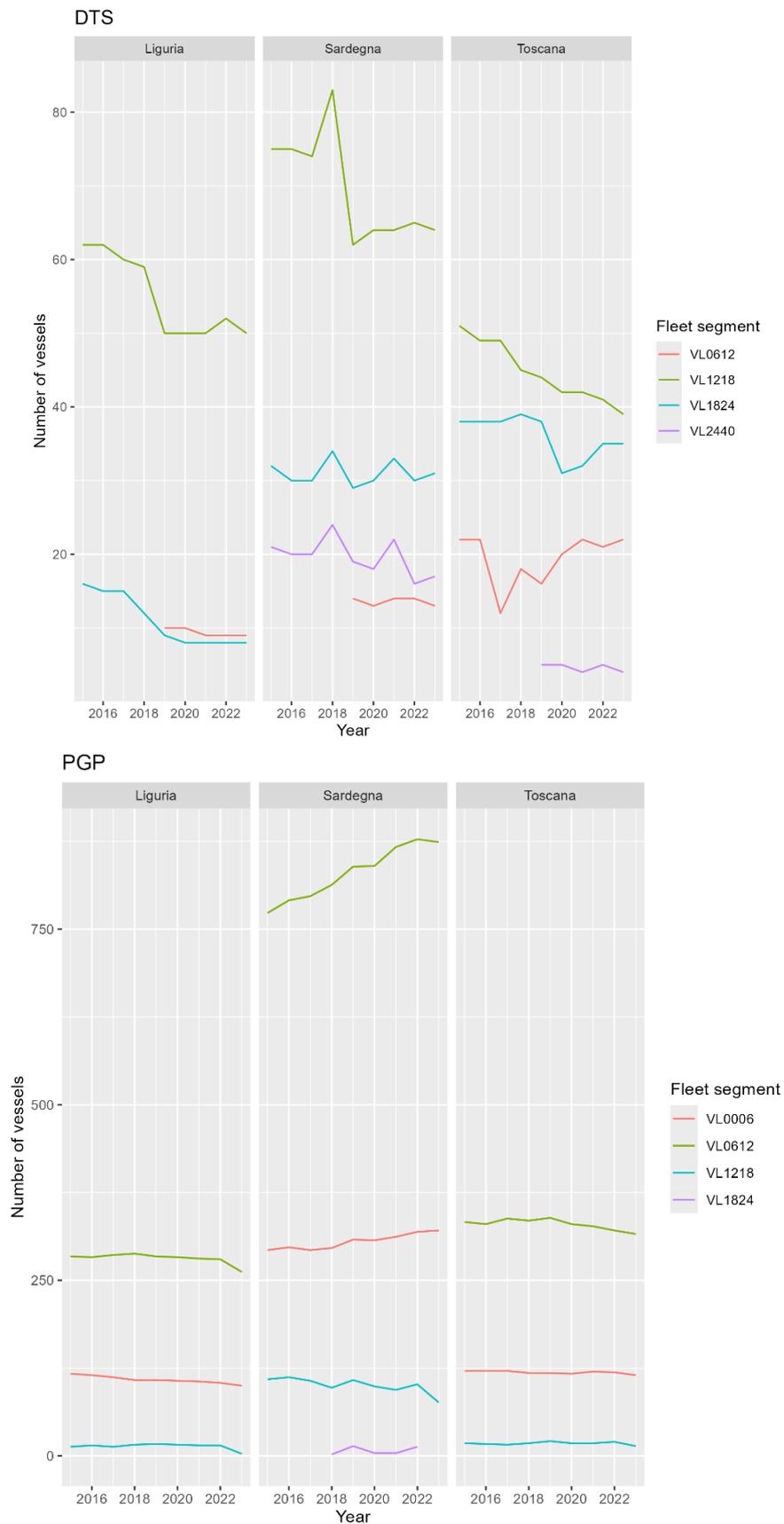


Figure 17 Time series of number of vessels for DTS (demersal trawlers) and PGP (passive gears) by Italian region and fleet segment.

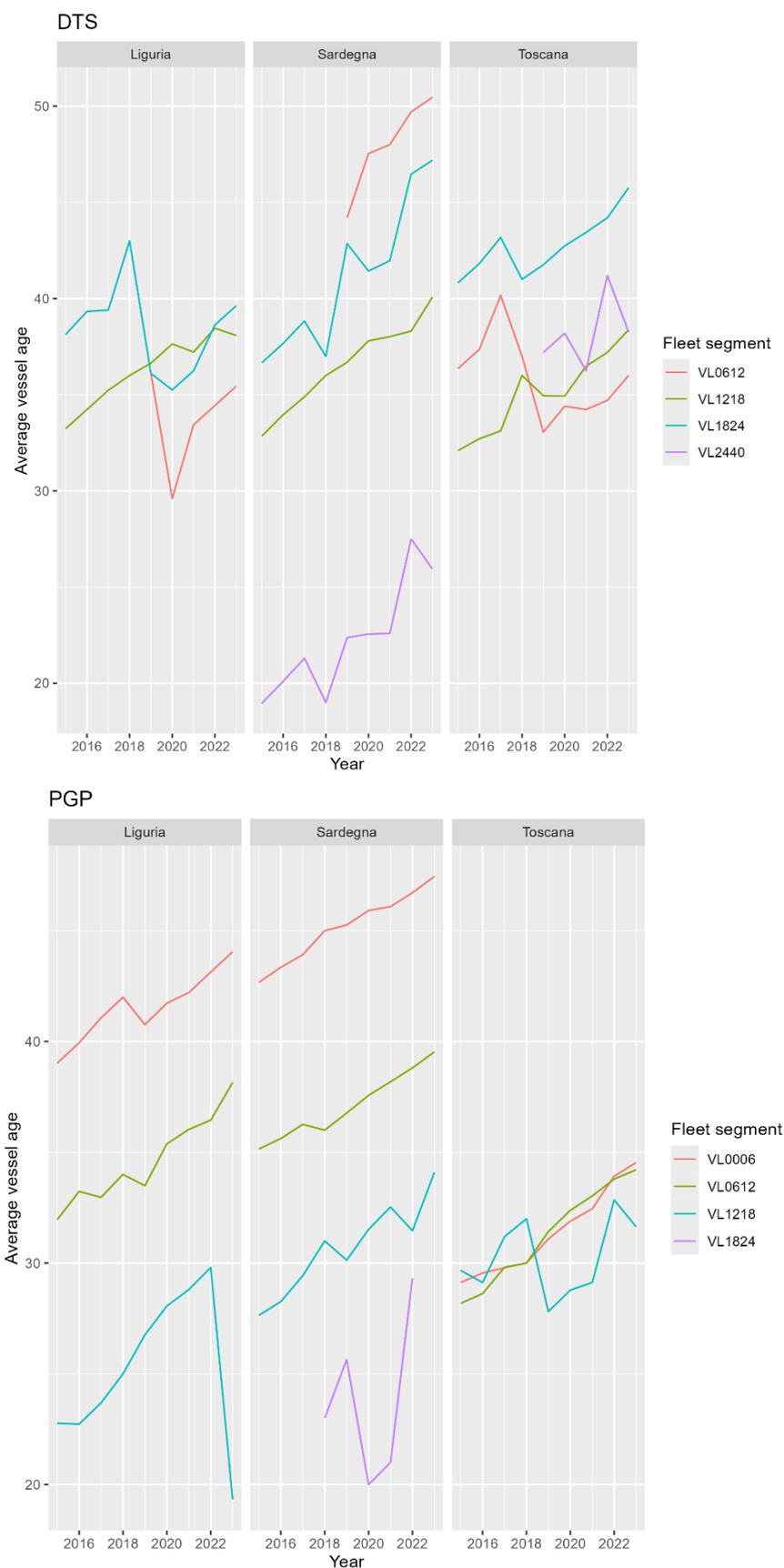


Figure 18 Time series of average vessel age for DTS (demersal trawlers) and PGP (passive gears) by Italian region and fleet segment.

Recreational fisheries

In France were estimated 2,750,000 recreational fishers (Guillot et al., 2018; Grati et al., 2021b); data derived by the report do not allow to estimate the percentage of fishers on the Mediterranean French coast (Provence-Alpes-Côte d'Azur). Generally fishing on shore appears to be the most practiced method (¾ of the total numbers), the most common fishing gear is the fishing pole used by the 39% of fishers. The recreational fishing onboard (19% of total fishers) corresponds to an activity marked by the seasons starting in the spring with peaks during summer months. Regarding the catches there are three target species (fishes): the mackerel (*Scombrus spp.*), the sea bass (*Dicentrarchus labrax*) and the gilthead seabream (*Sparus aurata*). The last one represents the main species caught in the Mediterranean French coast area (Provence-Alpes-Côte d'Azur) while, in the Mediterranean Sea in general, gilthead bream, cuttlefish and common Pandora are the three most important species caught by recreational fishers. The average fishing effort is 10.5 trips/year, 36% of the total number of "occasional fishers" reported to have only one to three fishing trips/year (Grati et al., 2021b).

According to Hyder et al. (2018), the number of recreational fishers in France is lower, about 1,319,000 with a large part of these operating in the Atlantic area (Fig. 19a-b) with an average yearly effort of 6.8 fishing days per fisher.

In Monaco, recreational fishers are found mainly on the harbour's dike (Francour and Gagnè, 2016), practicing shore-fishing throughout the year, with one or multiple fishing poles, with an average of nearly two days per week. The fishers reported an average catch of 941.3 g per outing, with a range from 250 to 3000 g. Most of the catches were fish (92%; 23 species), with fewer cephalopods (8%; mainly squids at 91% and octopuses at 9%). Among the fish, the majority were Sparidae (gilthead bream, sea breams, bogue, saupe, and others) at 40%, followed by Scombridae (bonito, mackerel, tuna) at 13%, Sphyraenidae (barracudas) at 9%, and Clupeidae (sardines, anchovies) at 8%. Other families such as Congridae, Labridae, Moronidae, Mugilidae, Muraenidae, Pomacentridae, Scorpaenidae and Serranidae, each represented less than 4% of the reported catches. The most frequently mentioned species were: *Diplodus spp.* (12.8%), *Sphyraena spp.* (9.4%), *Sparus aurata* (10.1%), *Sardina pilchardus* (7.4%), *Sarda sarda* (6.7%), and squids (6.7%). The recreational fishing in Monaco is significant, with a considerable impact on the coastal fish population. While it is hard to directly compare it to professional fishing, the number of recreational fishers in Monaco can exert similar pressure on the ecosystem. It is estimated that 12-13 recreational fishers catch as much fish in a day as one exert the same pressure, in terms of yield, as a artisanal one (Francour and Gagnè, 2016). We highlight that on the 28/03/2025 the Monaco Government, in consultation with the Fédération Monégasque de Pêches Sportives, has implemented a mandatory activity declaration for shore fishers. This declaration, which must be renewed annually, will help disseminate national regulations and establish the number of recreational fishers in the Principality of Monaco (<https://monservicpublic.gouv.mc/thematiques/temps-libre/sports-et-loisirs/autorisations-et-certificats/pratiquer-la-peche-a-la-ligne-a-partir-du-rivage>).

In 2010, the Italian Ministry of Agriculture and Forestry Policies (currently Masaf) implemented the national census, which was the first-ever attempt to quantify the marine recreational sport fishery (Ministerial Decree 06/12/2010). According with Romanelli and Fiori (2013), based on data published by Masaf (updated to february 2012), about 800.000 recreational fishers were recorded. The same number reported by Hyder et al. (2018), who defines Italy as the European country with the highest number of recreational fishers in the Mediterranean area with an average yearly effort of 6 fishing days per fisher (Fig. 19a-b). In more recent data published by Masaf (updated to 2013), an increase of the total number of fishers, about 900,000, was recorded. Since the registration form allowed multiple choices regarding the Italian region of activity and the gears used, about 2.2



million communications were analyzed; it was evident though that a large part of recreational fishers declared operating into 2-3 regions and with multiple gears. A total of 644,323 fishers declared they operated into the three regions of the Pelagos Sanctuary (Liguria, Toscana, Sardinia), representing approximately 29% of the total number (Fig. 20). Fishing on shore is the most practiced activity (44%), followed by fishing onboard (36%) and diving (20%). The first gear used was the fishing pole (30%) followed by handline (19%), speargun/harpoons (12%) and longlines (10%).

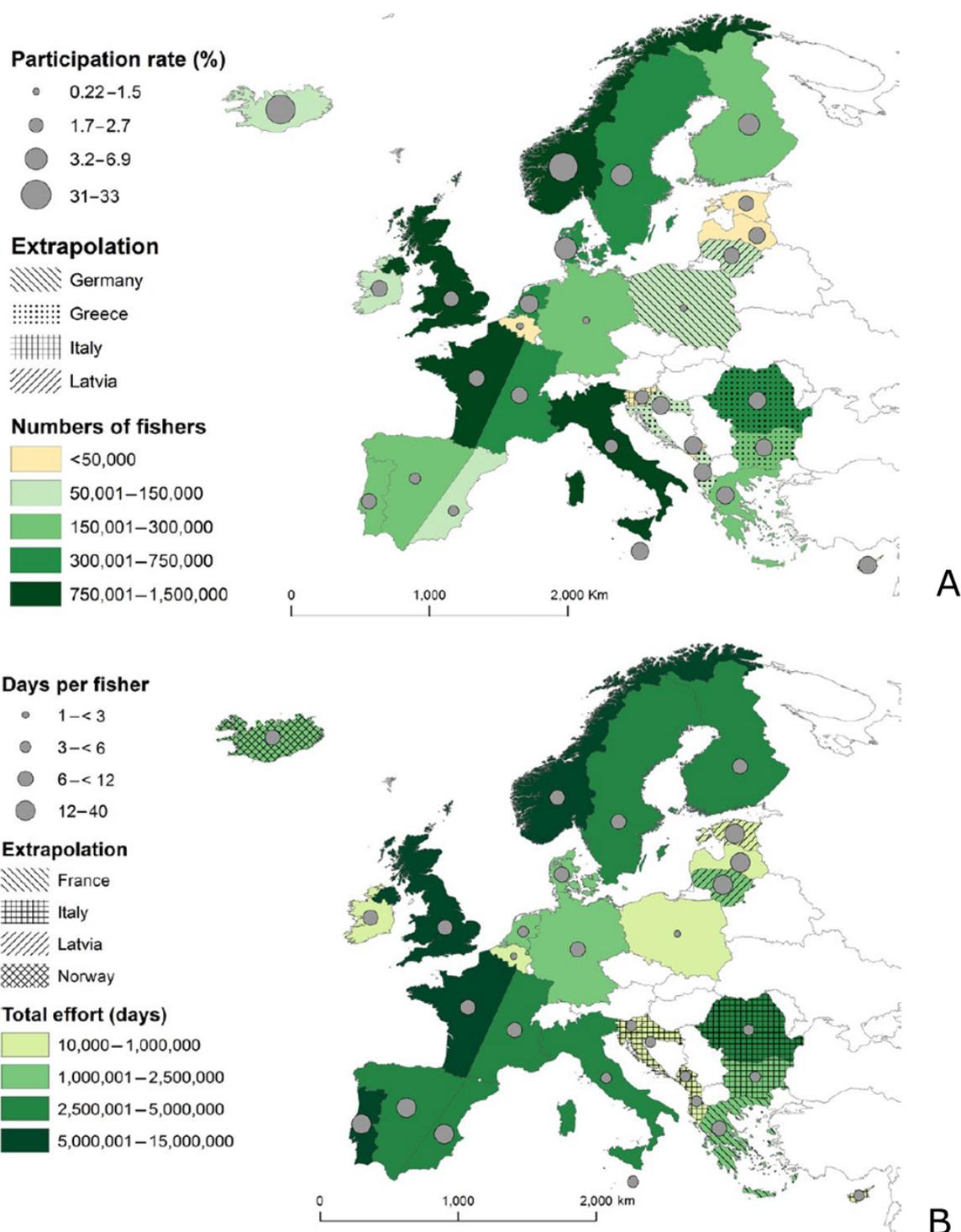


Figure 19 a) Estimated number of recreational sea fishers and the proportion of population that had been sea fishing in the last 12 months; b) Estimated annual effort of recreational sea fishers (average days fished per fisher and total effort). France and Spain were divided between the Atlantic and the Mediterranean region (Hyder et al., 2018).

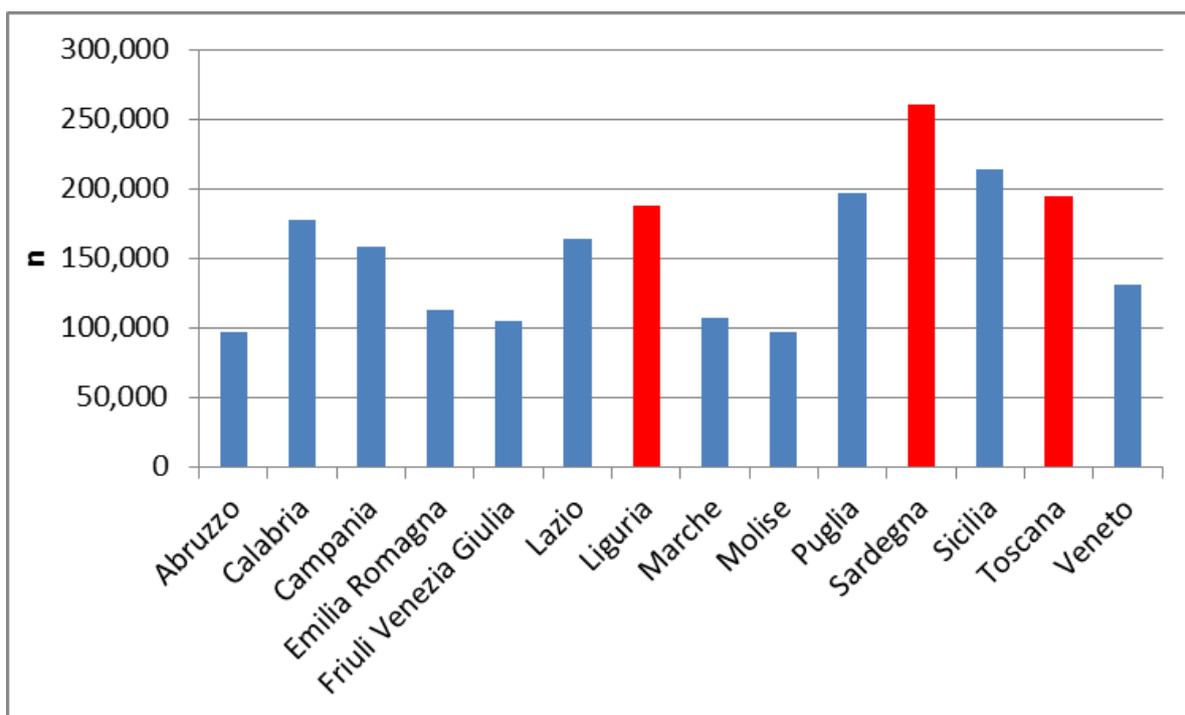


Figure 20 Number of recreational fishers per region in Italy (Source: Masaf, 2013).

Finally, Grati et al. (2021b), reported information on pilot studies carried out between 2018 and 2021, based on the evidence of the weaknesses of the Masaf database. Starting from a validation of the database, with over 1 million records, these data confirm, in part, the previous one including information about species caught (in weight) by recreational fishers:

- fishing from shore (42%) is the most practiced activity, followed by fishing from boat (38%) and diving (20%);
- the most used gears are fishing pole (37%) and handline (23%);
- the primary target species, estimated in catch volumes, were *S. aurata* (151,545 kg), *Loligo vulgaris* (150,207 kg) and *Octopus vulgaris* (133,469 kg), *S. officinalis* (77,391 kg) and *P. erythrinus* (44,311 kg). The species with the greatest impact on commercial fishing was *Pagellus bogaraveo*, with an estimated 14.2% of the total catch volume coming from recreational fishing, followed by *D. labrax* (13.4%), *S. aurata* (12.6%), *L. vulgaris* (7.1%), and *O. vulgaris* (5.3%).

Although data on the extent of the phenomenon are currently unavailable, official data seem to indicate an underestimation of the total number of recreational fishers in Italy (Silvestri et al., 2016). In fact, other estimations suggested a range between 1 and 2-3 millions of marine recreational fishers (Anagnopoulos et al., 1998, Livi et al., 2002; Silvestri et al., 2016; MEDACC, 2016; Silvestri, 2019; FIPSAS, 2024).

Following a request to the Italian administration, currently the only available data for recreational fishers are the number of vessels registered for the bluefin tuna (*Thunnus thynnus*) fisheries (Fig. 21), which are available at regional and at fleet segment level. Other recreational fisheries data are not available at the moment as in Italy an individual license based registration is not implemented, while recreational fishers are only requested to register voluntarily on-line, therefore it is not possible to track the amount of recreational fishers at national or regional level, specifically by gear.

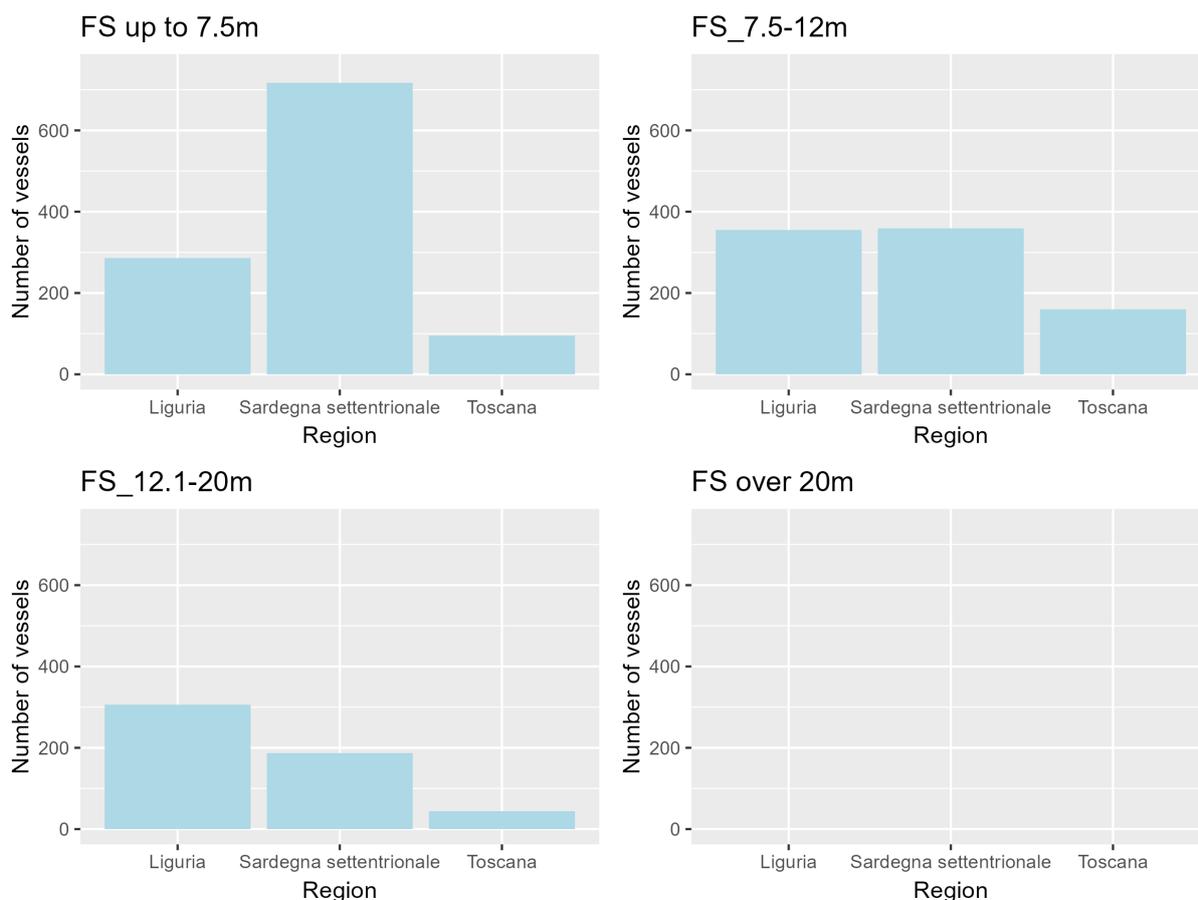


Figure 21 Recreational tuna fishers expressed in number of vessels per region and fleet segment.

Stock status of commercial species encountered in the diet of cetacean populations

Data summarized in Table 3 show the most updated assessment for every target species with an indication of the safe biological limit; if the stock has F (Fishing mortality) below the values of F-MSY (Maximum Sustainable Yield) it is not in overfishing.

Table 3. Stock status for all stocks in the Pelagos Sanctuary: F ind is the value for F/FMSY ratio; F Status indicate if F is lower than F MSY (Y=Yes; N=No).

Region	EcoRegion	Year	Stock	Common name (Species)	F ind	F status
FAO37	Western Med.	2023	COL_8	Red Coral (<i>Corallium rubrum</i>)	-	*
FAO37	Western Med.	2022	ARA_6_7	Blue and red shrimp (<i>Aristeus antennatus</i>)	3.81	N
FAO37	Western Med.	2020	ARA_9_10_11.1_11.2	Blue and red shrimp (<i>Aristeus antennatus</i>)	4.60	N
FAO37	Western Med.	2022	ARS_8_9_10_11	Giant red shrimp (<i>Aristaeomorpha foliacea</i>)	1.63	N
FAO37	Western Med.	2022	DPS_5_6_7	Deep-water rose shrimp (<i>Parapenaeus longirostris</i>)	0.55	Y
FAO37	Western Med.	2022	DPS_8_9_10_11	Deep-water rose shrimp (<i>Parapenaeus longirostris</i>)	1.29	N
FAO37	Western Med.	2022	HKE_8_9_10_11	European hake (<i>Merluccius merluccius</i>)	2.00	N
FAO37	Western Med.	2022	MUT_7	Red mullet (<i>Mullus barbatus</i>)	0.91	Y
FAO37	Western Med.	2022	MUT_7	Red mullet (<i>Mullus barbatus</i>)	0.91	Y
FAO37	Western Med.	2022	MUT_9	Red mullet (<i>Mullus barbatus</i>)	0.82	Y
FAO37	Western Med.	2022	NEP_9	Norway lobster (<i>Nephrops norvegicus</i>)	1.13	N
FAO37	Western Med.	2022	PIL_7	Sardine (<i>Sardina pilchardus</i>)	0.00	Y
FAO37	Western Med.	2021	ANE_7	European anchovy (<i>Engraulis encrasicolus</i>)	0.02	Y
FAO37	Western Med.	2021	ANE_9	European anchovy (<i>Engraulis encrasicolus</i>)	0.40	Y
FAO37	Western Med.	2021	PIL_9	Sardine (<i>Sardina pilchardus</i>)	0.13	Y

* Overexploited

Here we report the biomass indices estimated from MEDITS data for the demersal and pelagic species (fig.22-30) which are part of the diet of cetacean species present within the sanctuary: *Mullus barbatus*, *Mullus surmuletus*, *Merluccius merluccius*, *Engraulis encrasicolus* and *Sardina pilchardus* in the areas covered by GSA 7, 8, 9 and 11. The level of aggregation reported is the one defined within the evaluation process (for species where an analytical assessment is available). Both in GSA 7 and 9 the indices have lower values for *M. surmuletus* than for *M. barbatus*. While *M. barbatus* shows increasing trends in both

GSA 7 (specifically for GSA 7 since 2013), *M. surmuletus* has decreased in the last three years in GSA 9. *M. merluccius* shows a slightly decreasing index across the time series. Both small pelagics in GSA 7 and 9, sardine and anchovy, have a stable time series despite the historical decrease of sardine in GSA 9. Data for GSA 8 are not sufficient to observe the complete time series from the MEDIT survey. The time series from the MEDIAS survey in Italy have a short time series and do not cover the whole of GSA 9, therefore we report only biomass indices from the MEDIT survey, despite this being a demersal survey so not specifically designed to sample pelagic species.

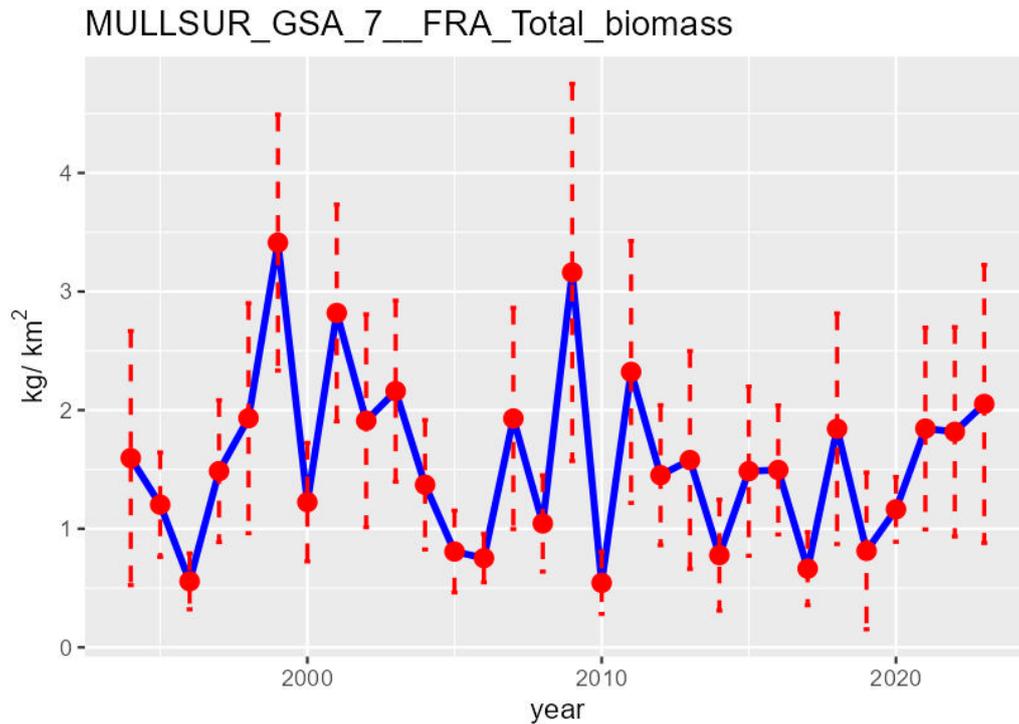


Figure 22 Biomass index of *M. surmuletus* in GSA 7.

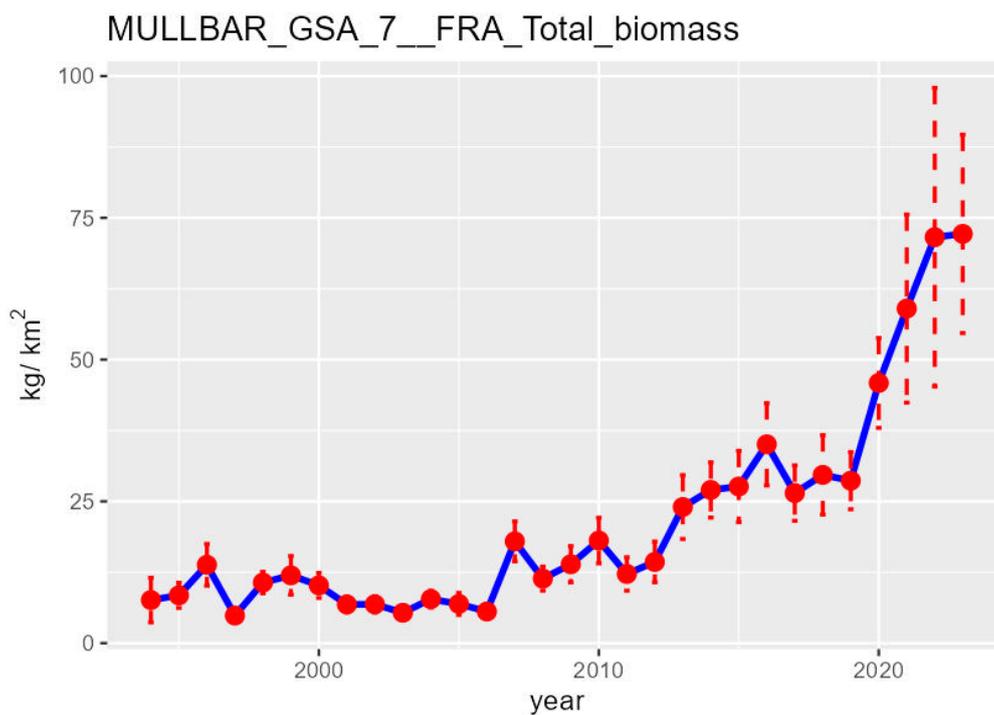


Figure 23 Biomass index of *M. barbatus* in GSA 7.

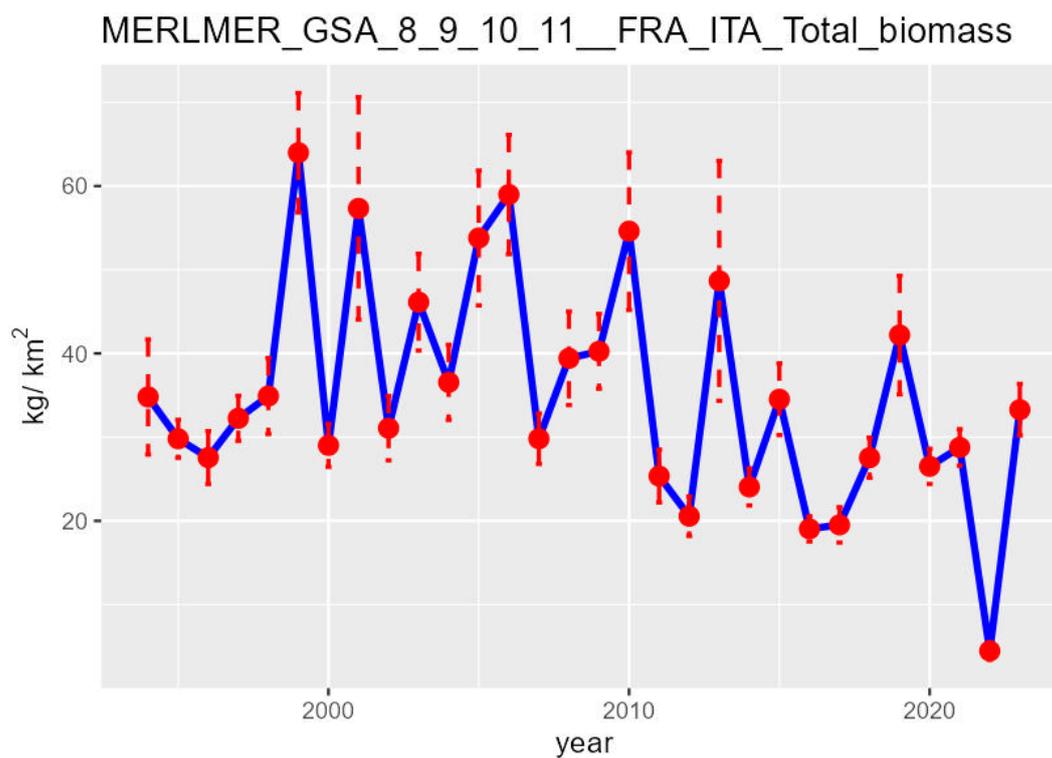


Figure 24 Biomass index of *M. merluccius* in GSA 8-9-10-11. The index in 2022 should not be considered as the MEDIT survey was not held in Italy.

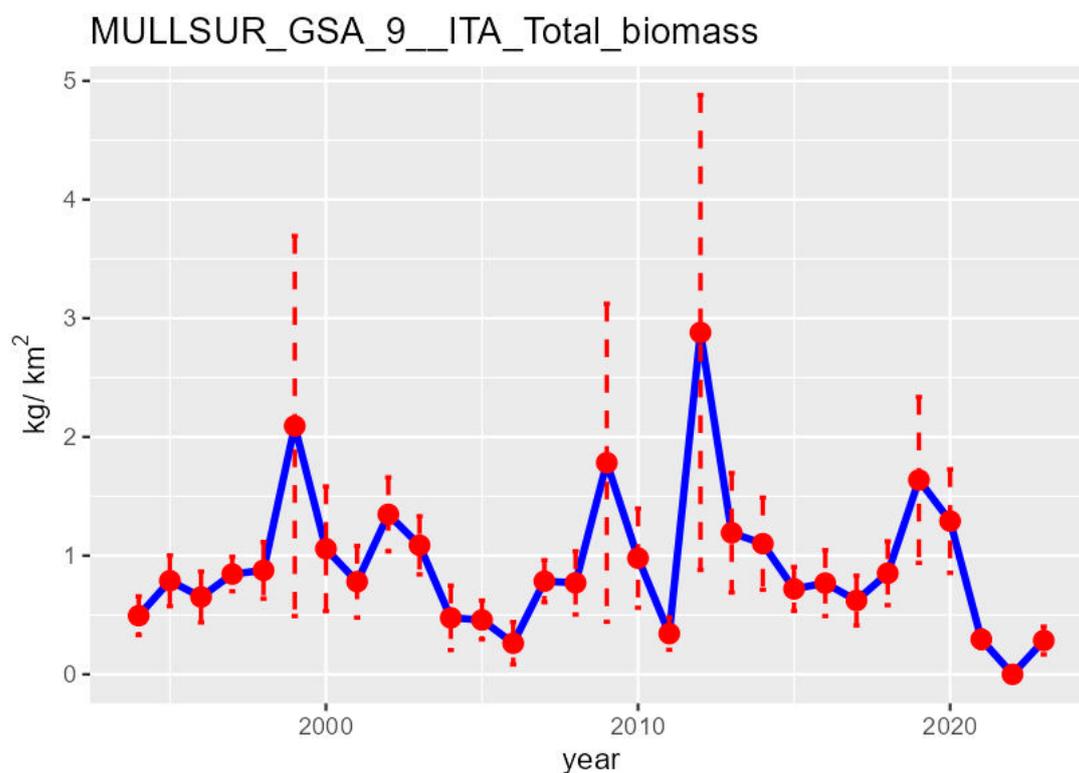


Figure 25 Biomass index of *M. surmuletus* in GSA 9. The index in 2022 should not be considered as the MEDIT survey was not held in Italy.

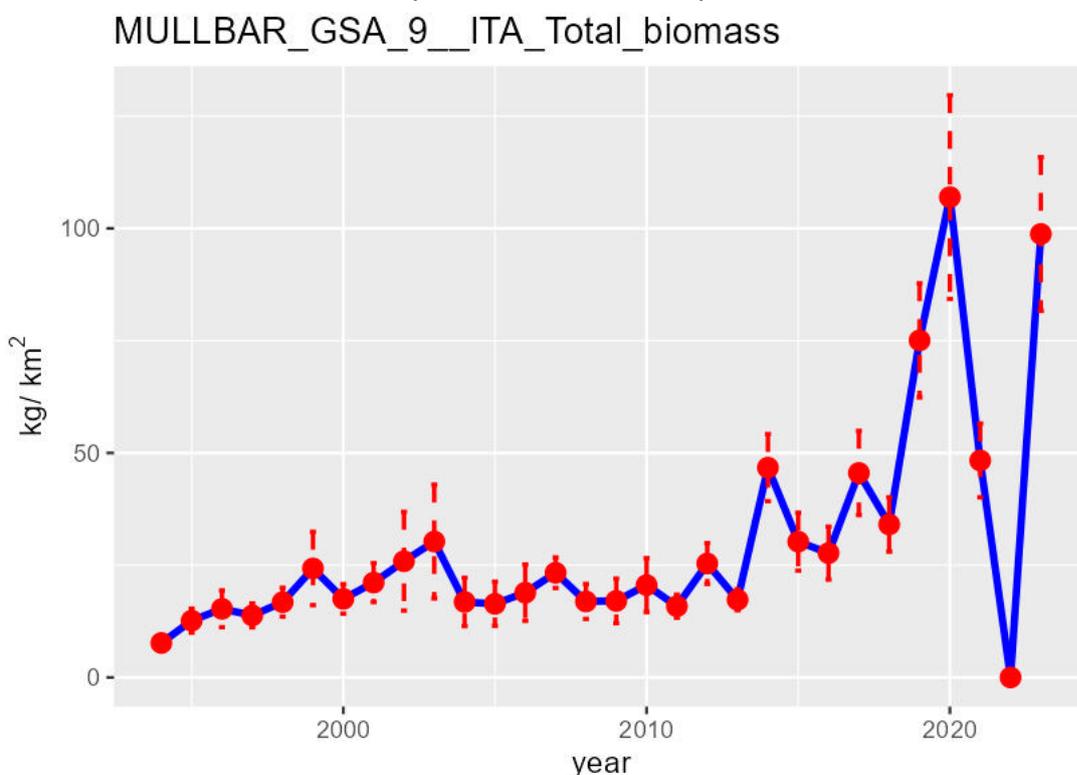


Figure 26 Biomass index of *M. barbatus* in GSA 9. The index in 2022 should not be considered as the MEDIT survey was not held in Italy.

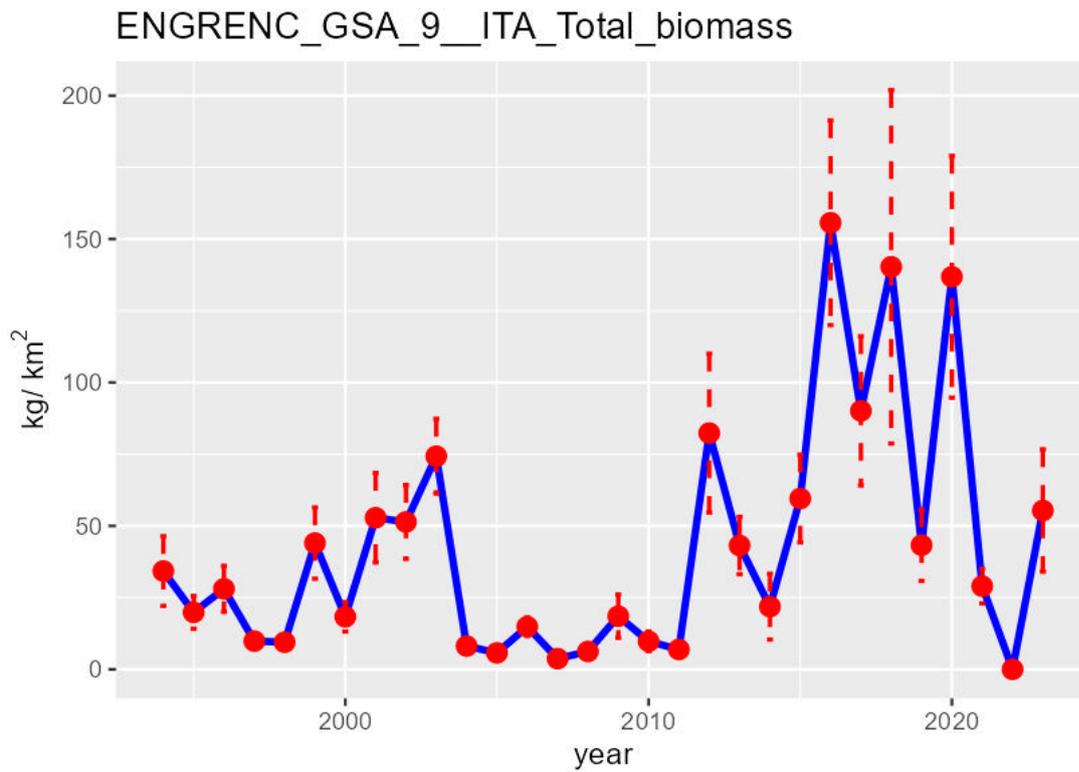


Figure 27 Biomass index of *E. encrasicolus* in GSA 9. The index in 2022 should not be considered as the MEDIT survey was not held in Italy.

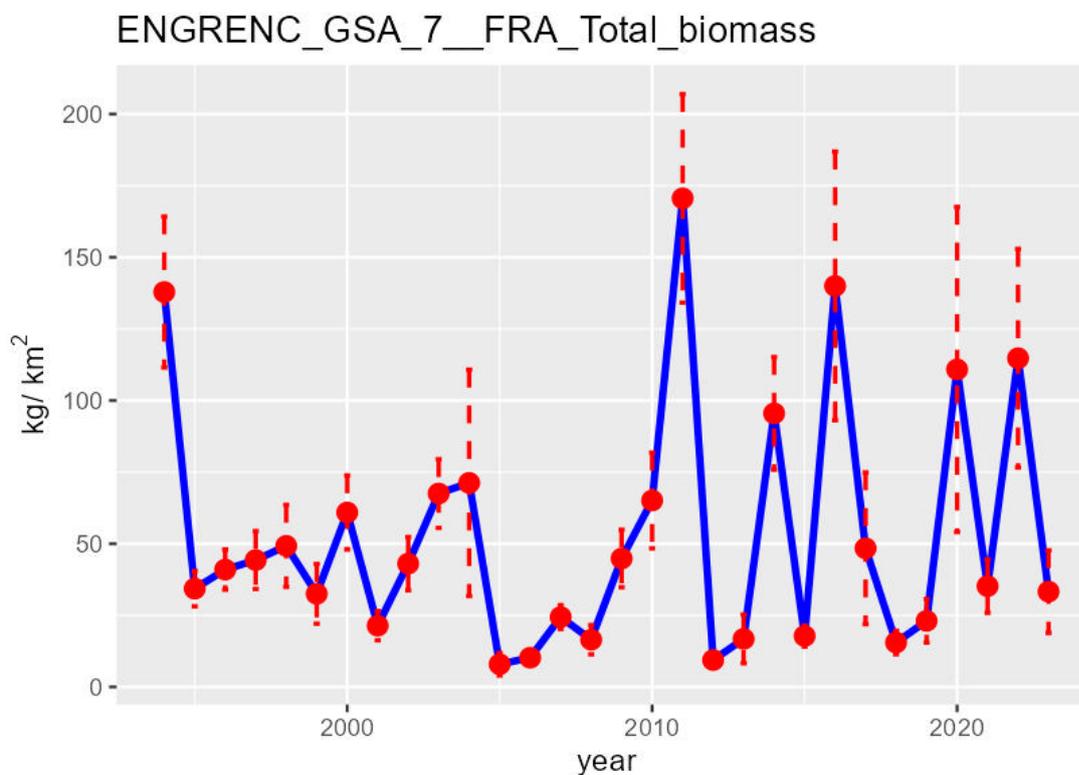


Figure 28 Biomass index of *E. encrasicolus* in GSA 7.

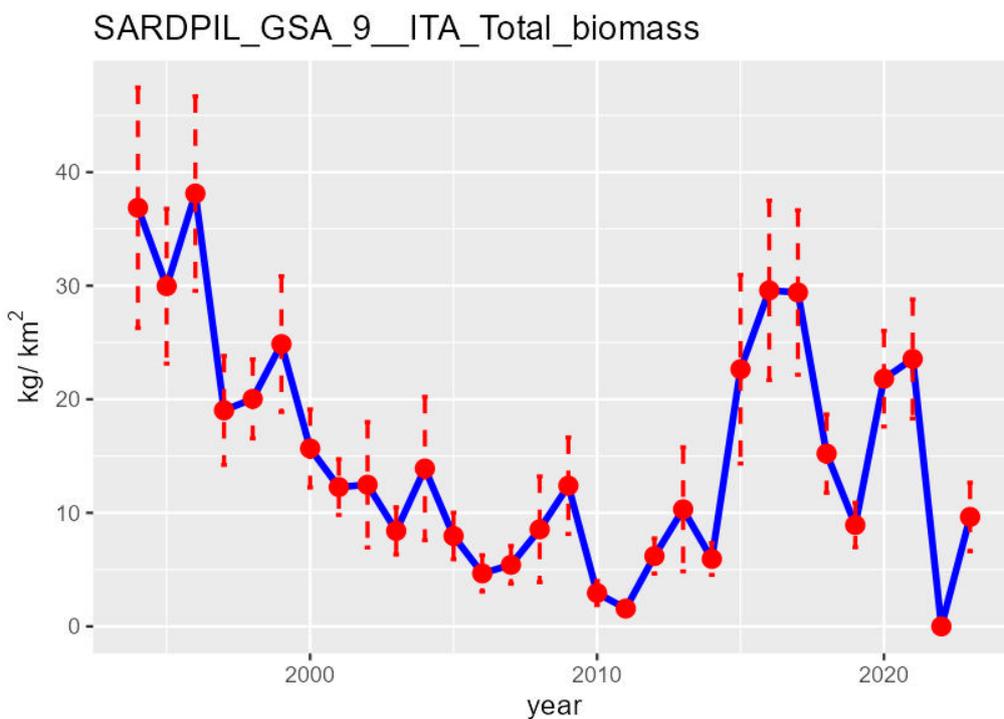


Figure 29 Biomass index of *S. pilchardus* in GSA 9. The index in 2022 should not be considered as the MEDIT survey was not held in Italy.

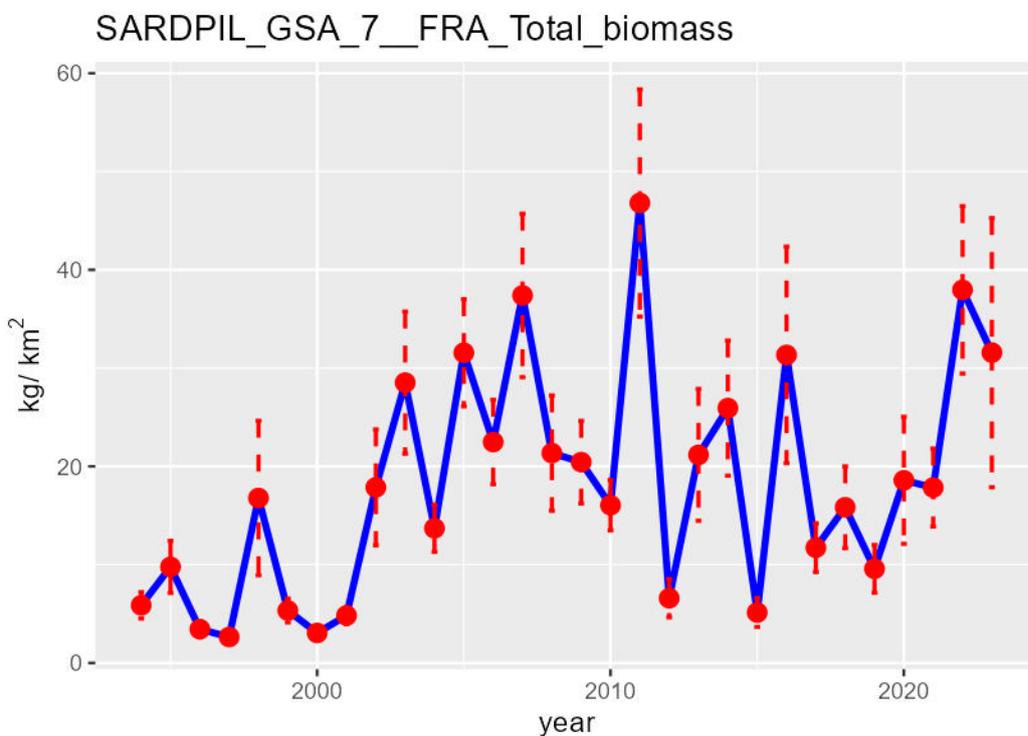


Figure 30 Biomass index of *S. pilchardus* in GSA 7.

*The impact of interactions between fishing gears and cetaceans: the case study of *Tursiops truncatus**

Interaction between bottlenose dolphin (*Tursiops truncatus*) and fisheries

The overlap of human activities with the habitat of *T. truncatus* created the opportunity for this species to develop the ability to use such an overlap for its advantage. An example is how bottlenose dolphins learned to obtain fish during fishing activities, from trawlers, gillnets and aquaculture fish cages, which can become an integral part of their feeding strategies. Such an interaction can cause conflicts with fishers, specifically in the case of small-scale fishers, as it will cause both loss of catches and damages to the fishing gear (Milani et al., 2019; Papale et al., 2020; Buscaino et al., 2021). Such conflicts have become a common problem all across the Mediterranean Sea as observed in the Valencia region (Spain) (Revuelta et. al., 2018), in Greece (Milani et. al. 2007; 2019), Croatia (Li Veli et. al., 2023) and in Italy.

The real extent of this problem (both in space and time) and the economic consequences on the fishing industries are still largely unknown (ACCOBAMS, 2023), therefore monitoring with acoustic devices and mapping of the interactions should be improved to help find solutions to this problem.

This phenomenon, in the Pelagos Sanctuary, has been observed in Italy in the north of Sardinia in the La Maddalena Archipelago (Pennino et.al., 2014), on the island of Asinara (Lauriano et. al., 2004), in the Ligurian Sea at the Lavagna aquaculture "Aqua de Ma" (GE), near the coasts of Loano (SV), Manarola (SP), Arenzano (GE) (monitored by the TursioNet® project), Chiavari (Fossa et al., 2011a) and in Corsica in the Bonifacio strait Natural Reserve (Rocklin et. al., 2007), thanks to the Life DELFI Project activities (LIFE18 NAT/IT/000942) (Figure 31).

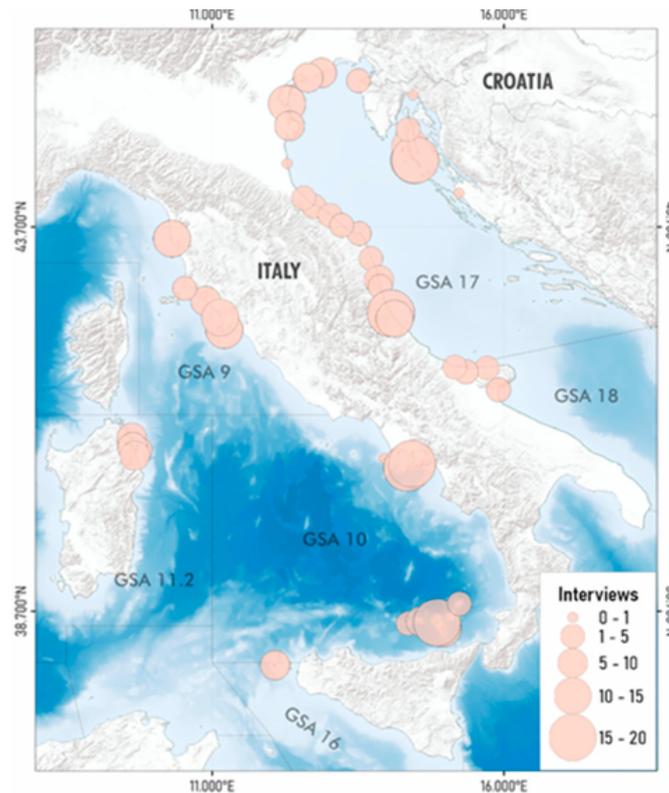


Figure 31 Study Area and interaction observed by Life DELFI project (Li Veli et al., 2023).

During predation actions on nets, that cause damage to the equipment and damage the catch, there can be ingestion of net fragments, which can result in the death of the animal, as seen with two specimens found stranded on the coast of Tuscany (Ceciarini et al., 2023). Another danger sometimes comes from the reactions of fishers, which can escalate into acts of violence, as observed in a study conducted in southern Italy on the cutaneous wounds of bottlenose dolphins by Leone et al. (2019), which analysed a gunshot wound on the back of one specimen.

Interactions between *T. truncatus* and fishery can also involve unintentional takes (by-catch), such as entrapment in bottom gillnets and trammel nets, entrapment in trawl nets, entrapment in purse seines, entrapment in long lines and entrapment in discarded or abandoned nets and illegal driftnets (Reeves et al., 2001; Bearzi, 2002; Bradai et al., 2010).

Purse seines in the Mediterranean Sea recorded interactions with cetaceans that might end up in the nets during fishing operations, but those are generally rare and these do not seem to have led to incidental catches causing death as the net gets either broken or reopened by the fishers (Garibaldi, 2021).

Interactions with trawlers that cause an incidental catch have a higher probability of ending up with the death of the caught individual as it would be held underwater potentially for a too long period. The studies carried on to evaluate the potential catch rate of towed gears on *T. truncatus* showed annual rates between 0.001 - 0.007, depending on the type of towed gear (demersal or pelagic trawlers or twin trawlers) (Morizur et al., 2012; Fortuna et al., 2012; Sala et al., 2018). It should be noted though that uncertainty around these

estimates can be high and it is still unknown to which extent a population of *T. truncatus* could bear such catch rates, therefore conclusions should be done with caution (Fortuna et al., 2012)

The average incidental catch rate of bottom-set nets is estimated to be higher, between 0.5 and 1 per year, as this is also the fishing gear with which the highest number of interactions with *T. truncatus* are recorded for (Garibaldi, 2021). The possibility of entanglement depends on the characteristics of the fishing gear, such as mesh size, yarn strength, depth of deployment and fishing strategies, among other aspects. However, entanglements due to depredation are generally scarce (Brotons et al., 2008).



Figure 32 Gillnet damaged by *T. truncatus* (Fossa, 2010)



Figure 33 Typical bite by *T. truncatus* on *Mullus* spp. (Lauriano et. al. 2004)

Because of their opportunistic behaviour, bottlenose dolphins may be perceived as competitors by the fishers. Furthermore, their opportunistic action on the nets can cause damages to the fishing gear, exacerbating the conflict (Milani et al., 2019; Giménez et al., 2021).

These types of events are encountered in the Pelagos Sanctuary and its surrounding areas; a specific hot-spot is northern Sardinia, where several cases of interaction are observed.

In this area, several studies have been conducted to evaluate and quantify the rate of interaction between bottlenose dolphins and small-scale artisanal fishing. Here, interactions are very frequent and have a substantial impact on the local fishing community; in the period between October 1999 and October 2001, 29 interactions were observed out of 88 observations on surface nets and 7 interactions out of 67 observations on deep nets, leading to a mean economic damage of 1168,4 € per boat (Lauriano et. al., 2004). In Pennino et. al. (2014) 84 interactions were observed out of 354 observations in the period between July 2007 and July 2009.

In 2010, in the coastal waters near Chiavari (Liguria), damage on trammel nets were observed in four cases over 34 fishing operations (Fossa et al., 2011b). The whole Liguria region was monitored (Arpal, 2021), interviewing fishers from the four regional departments. The results showed that the highest levels of interactions with *T. truncatus* are reported on bottom-set nets (70% of interviews) which suffers the biggest and most common damages and therefore economic loss; fishers report that interactions increase during the summer and have also been increasing in the last decade as they suggest an increasing encounter rate (Arpal, 2021). Another study within the Ligurian region, the TursioNet® project, applied acoustic recorders on bottom-set nets, allowing to identify interactions between bottlenose dolphins and passive gears, on a total of 5166 registration events (77490 minutes) 1,8% (1395 minutes) contained evidence of presence (Coppolella, 2023). To understand if there is an interaction in the event analysed with the sonograms, it is necessary to also include the fisherman observation to verify the potential damage to the fishing gear. The sites of greatest interest have been Loano (SV), Manarola (SP), and the aquaculture facility in Lavagna, where a large number of interactions with the farming cages were recorded (Coppolella, 2023).

Between July and November 2020, Life DELFI Project (LIFE18 NAT/IT/000942) collected 209 interviews with fishers in 9 different Italian and Croatian macro-areas (Fig. 31), 88% of the respondents experienced interaction with dolphins in their careers; 58,7 % reported damage to their catch for depredation. (Li Veli et. al. 2023).

Regarding the French and Corsican coasts, there is not much information reported in the literature. Rocklin et al. (2007) report 76 interactions out of 614 fishery events in the southern part of Corsica within the Bonifacio Strait Natural Reserve in the period between 2004 and 2006.

Strandings within the sanctuary

Cetaceans strandings can be due to a number of different causes, such as sickness, loss of direction, injuries. Some injuries can be caused during interactions and depredation of fishing gears. Sometimes, dead and stranded specimens can be found due to the ingestion of small fragments of nets (Đuras Gomerčić et al., 2009). During net depredation, the animal may tear and ingest parts of the net, which can accumulate in the digestive system, causing an obstruction. Another phenomenon that occurs is the entanglement of net fragments in the dolphin's glottis. These fragments can obstruct the glottis and cause it to malfunction, leading to the animal drowning during a dive (Đuras Gomerčić et al., 2009). Over the years, numerous necropsies of stranded bottlenose dolphins have revealed several cases of death due to these causes. One case is the discovery of two specimens on the Tuscan coast, both of which died from ingesting nets (Ceciarini et. al. 2023).

In Figure 34 are reported the percentages of *T. truncatus* strandings recorded within the Pelagos Sanctuary, divided by region in Italy. The data come from the "Monitoring of Cetacean Strandings on Italian Coasts" database (<http://mammiferimarini.unipv.it>). The data reported for Sardinia cover the north part of the region, between Capo Falcone and Capo Ferro.

To date, 365 strandings of bottlenose dolphins have been recorded within the Pelagos Sanctuary; specifically, 66% (n=241) along the Tuscan coast, 18% (n=58) along the Sardinian coast, and 16% (n=66) along the Ligurian coast.

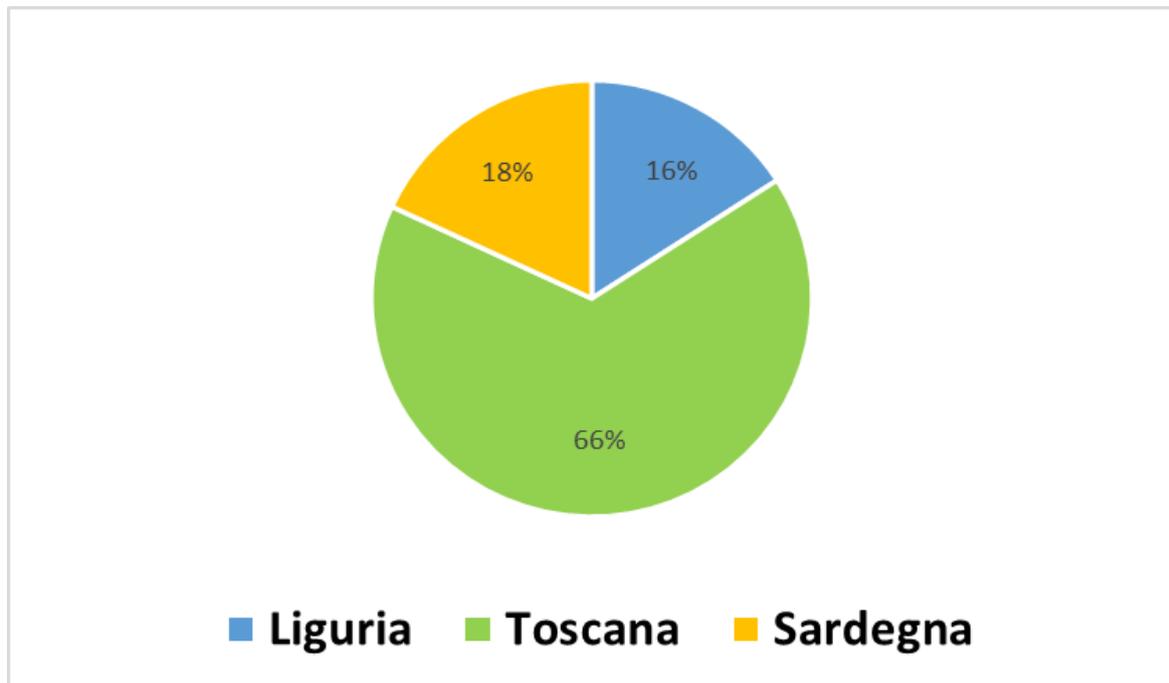


Figure 34 Percentage of strandings by region within the Pelagos Sanctuary.

Results show that 5.7% of *T. truncatus* stranded within the Pelagos Sanctuary had interactions with fishing gears, as indicated by the presence of hooks (n=1), nets (n=14), and/or fishing gear marks on the body. Specifically, as shown in Figure 35, 8.6% (n=5) in Liguria, 5.4% (n=13) in Tuscany, and 4.5% (n=3) in Sardinia.

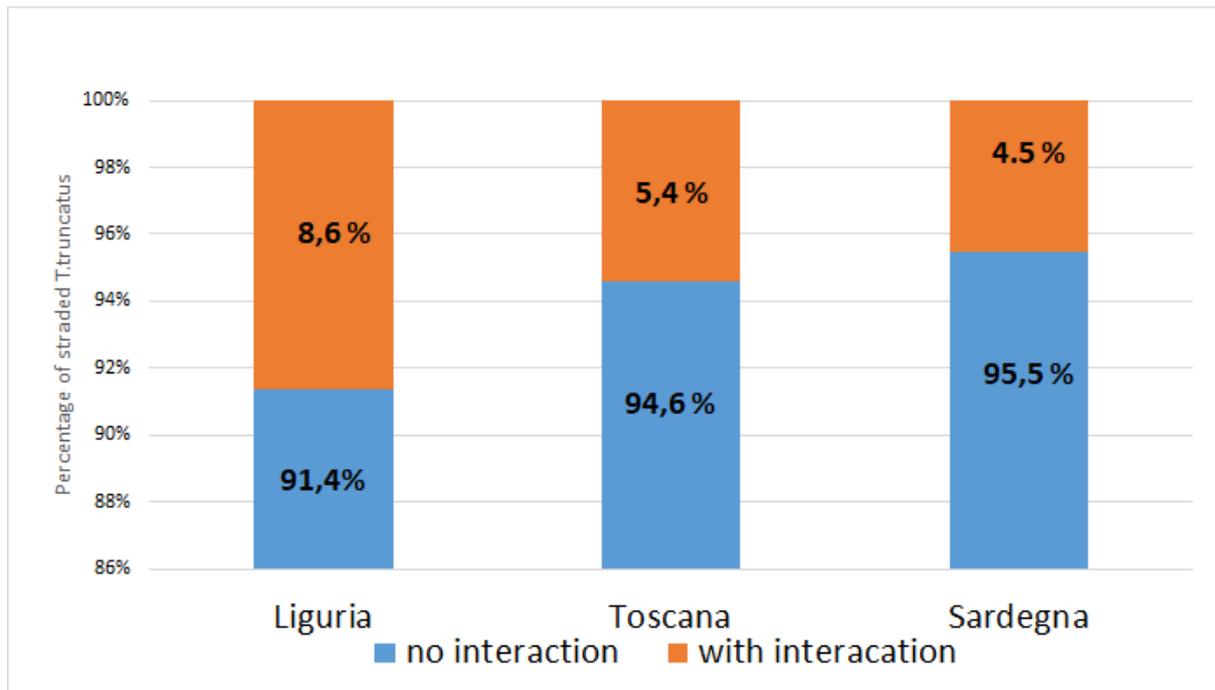


Figure 35 Percentage of stranded *T. truncatus* that interacted with fishing gears in the Pelagos Sanctuary by region.

Figure 36 shows a map illustrating the recorded strandings of *T. truncatus* along the French Mediterranean coast. The map was created using data collected by the *Centre National de la Recherche Scientifique* (CNRS) (*Stranding monitoring – PELAGIS, s.d.-a*), which has been dedicated to the study and monitoring of marine megafauna for over 50 years.

It is important to note that, despite the extensive data collection, due to technical reasons and database access limitations, it was not possible to extrapolate from the CNRS website the data related exclusively to strandings occurring in the Pelagos area.

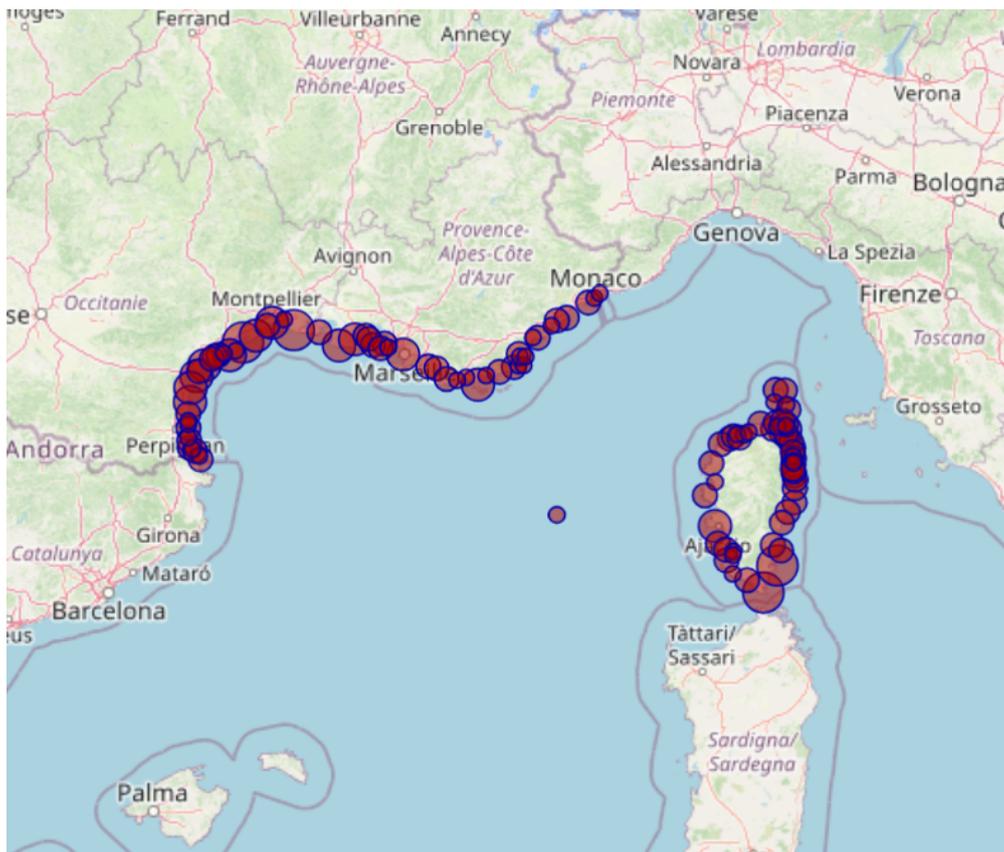


Figure 36 Map of *T. truncatus* strandings along the French Mediterranean Coast (www.observatoire-pelagis.cnrs.fr)

Figure 37 presents the annual number of *T. truncatus* strandings recorded from 1990 to the present. However, due to limitations in the currently available data, it has not been possible to definitively determine the specific causes of these strandings or to establish whether direct interactions with fishing gear may have contributed to these events.

A comparative analysis was also conducted between the number of strandings recorded along the French Mediterranean coast and those reported in the Pelagos area in Italy (Figure 37). The results did not reveal significant similarities in annual trends, suggesting that the underlying dynamics driving strandings in these two regions may differ.

Since 2000, an apparent increase in strandings has been observed in both Italy and France. This rise is most likely linked to the widespread use of mobile phones, which has facilitated the reporting of stranded animals, leading to a higher number of documented cases.

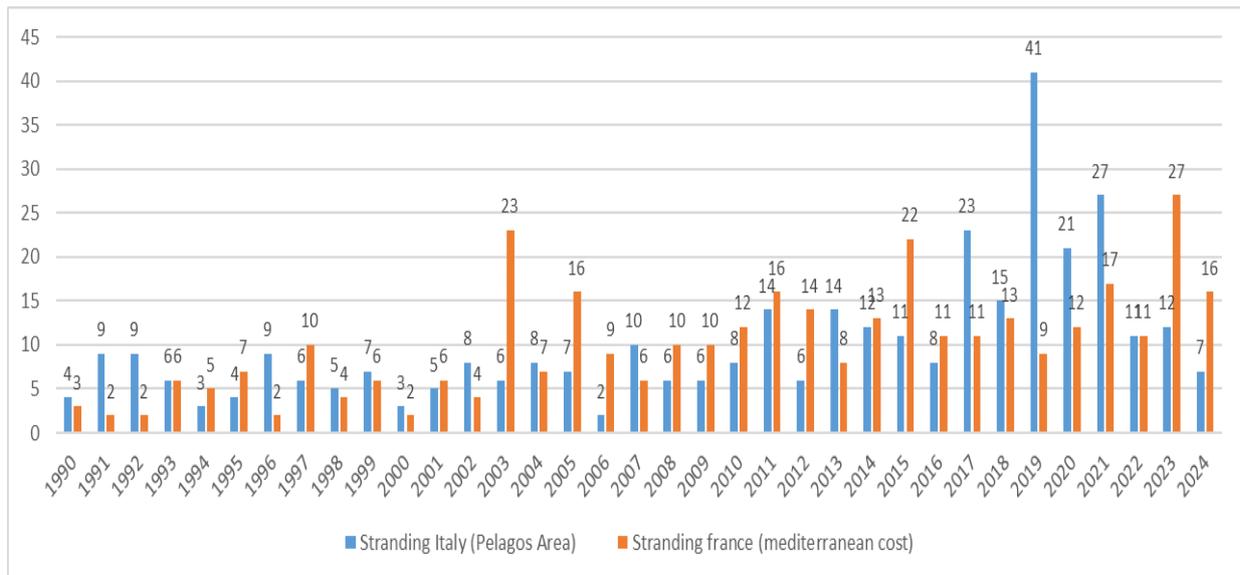


Figure 37 Strandings on Italian and French coast by year

Implemented solutions

Some studies, such as that by Revuelta et al. (2018) and Li Veli et. al. (2023), have attempted to economically quantify the impact of interactions between *T. truncatus* and small-scale fisheries observing that the value can vary significantly from area to area, sometimes reaching values of 2,000-3,000 € per year per boat.

The cost of catch loss and net damage caused by *T. truncatus* in the Balearic Islands between 2001 and 2003 was estimated as 6.5% of the total catch value and the annual loss as 3.4% of the total catch by weight (Brotons et al., 2008). Another study conducted in the Balearic Islands between September and October of 2001 estimated that the total economic damage caused by *T. truncatus* amounted to 1,094 € per trammel boat (Gazo et al., 2008). In Italy a study based on 209 interviews, conducted between July and October 2020, estimated that the annual loss per boat can range between 1,000-10,000 € (Li Veli et. al., 2023).

Within the Pelagos Sanctuary Lauriano et al. (2004) carried out an investigation in northeastern Sardinia and estimated that the catch loss from 1999 to 2001 came to about 1.170 € per trammel boat per fishing season, based on direct observations. In Liguria fishers interviewed during 2020, 18.4% reported no damage by *T. truncatus* dolphins, 6.1% estimated a loss between 50-200€ per year, 24% estimated a loss between 200-1,000 € per year, 40% estimated a loss between 1,000-3,000€, and 10.2% reported damage higher than 3,000 € (Arpal, 2021).

This significant economic loss generates much discontent in the affected fishing communities, making it necessary to implement measures to safeguard both parties. Globally, and in the Mediterranean basin as well, various deterrent methods are being

experimented: acoustic deterrents are the most used to mitigate interactions between cetaceans and fishing gear.

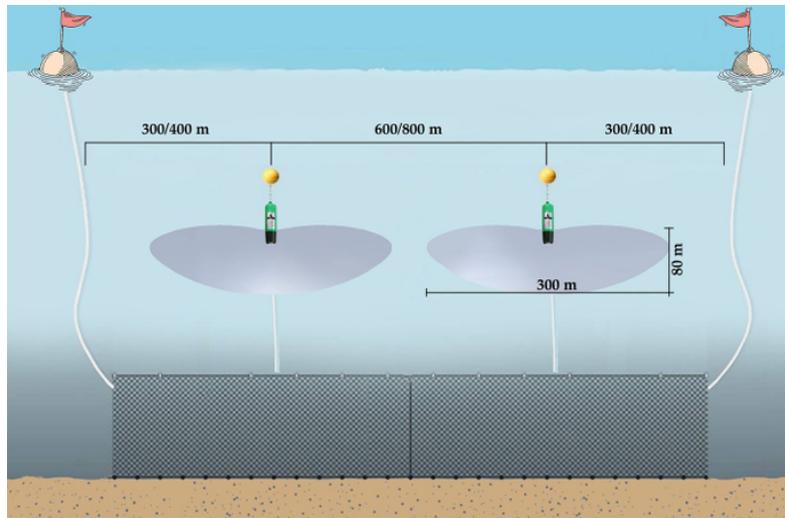


Figure 38 Correct way to install Pinger model DiD-01 (Ceciarini et. al. 2023).



Figure 39 "DiD-01" (Dolphin interactive Deterrent), STM Products S.r.l. (Fiandino, 2023).

Among those the most common are pingers, cylindrical receiver-transmitters that are placed on gillnets or trammel nets (Fig. 38-39) to deter dolphins from preying on the nets. These devices activate and emit high-frequency sounds whenever they are hit by dolphin clicks, serving as a deterrent to dissuade the dolphins. Ceciarini et al. (2023) proved that

the pinger (model DiD01) is effective in reducing dolphin-fishery interactions without negatively affecting target and non-target catches. Other studies conducted in the Atlantic Ocean, with different pinger models, have shown that *T. truncatus* can become accustomed to the transmitters' noise, potentially leading to the "Dinner Bell effect", where the sound of the pinger becomes associated with the presence of food in the net, thereby increasing the number of interactions (Cox et. al. 2000; Bordino et al., 2002; Ceciari et. al. 2023). Studies held in the Adriatic Sea showed positive results in the beginning of the project, but a gradual reduction of the deterrent effect showed habituation through time in this case as well (Sala et al., 2018).

Currently, various types of deterrent tools are being tested to prevent interactions with fishing gears. These can be divided into different categories of deterrents: acoustic, olfactory, visual, and based on echolocation reflection (although these have not been tested yet on commercial fisheries large scale case studies) (Lucas and Berggren, 2023). Some fishers also use different techniques to deter, like shifting the timing of the net deployment and hauling, or producing noise by hitting the boat to scare the dolphins. On demersal trawlers sometimes an additional netting panel covering the codend is added (Li Veli et. al., 2023). However, there is often a risk of eliciting overly acute responses in the animals, causing stress and potentially leading to their death (Shakner and Blumstein, 2013).

In Figure 40, the reaction scale to different stimuli with the corresponding responses is shown. Acoustic distraction causes an anxiety response and a tendency to avoid the tool. However, it is also apparent that habituation to the stimulus is easy, rendering the stimulus ineffective over time.

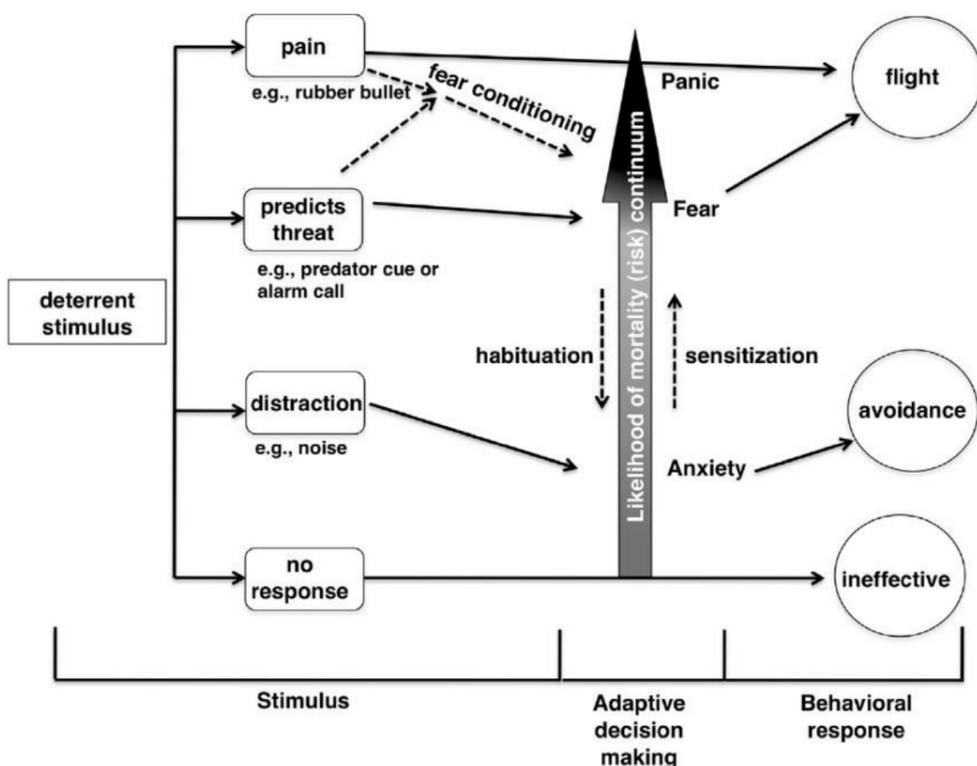


Figure 40 Reaction scale to deterrent stimulus (Shakner and Blumstein, 2013).

Studies implementing illumination of bottom-set nets using LEDs in the green visible spectrum, showed positive results both for sea turtles and for small cetaceans. Bielli et al. (2020) observed a reduction of 66.7% of incidental catches in bottom-set nets for dusky dolphins and Burmeister's porpoises. Griebel and Schmid (2002) report that bottlenose dolphins have visual systems sensitive to green wavelengths, suggesting that illuminations could be effective for this species as well.

In Liguria it was observed that the majority of fishers (>70%), suggested that a solution to the damages due to the interactions with *T. truncatus* would be an annual reimbursement either a state payment or a state reimbursement to buy new fishing gear (Arpal, 2021). Only 10% of fishers supported the use of acoustic deterrents as a solution to the interactions (Arpal, 2021).

Conclusion and recommendations

The impact of ALDFG

ALDFG are a significant form of pollution globally and within the Pelagos Sanctuary. Due to their nature, they are difficult to monitor, especially lost fishing nets. Fortunately, projects like EcoeFISHent, LIFE GHOST, Defi-Med, RECUPMED 2 and others, aim at removing ALDFG from the Pelagos Sanctuary area. Their removal is essential to reducing the impact on marine fauna and flora. It is though necessary to assess, as highlighted in the Life GHOST and Life Strong Sea Life protocols, whether the removal of ALDFG can cause further damage to benthic populations. In cases where removal is risky, it is recommended to deactivate the net while keeping it in situ.

Given the vastness of the Sanctuary, effectively monitoring ALDFG across all the water column is nearly impossible. A possible solution is to focus on monitoring areas of high biological importance or those known to fishers for their higher likelihood of net loss like shoals or seamounts. Another solution is to implement EU Regulation 1224/2009 with a toll-free number linked to the responsible authority for gear recovery, further reducing the obligation for the commercial fishers to attempt gear retrieval, as this practice could cause further damage to the seabed where the fishing gear has been dispersed. As the Sanctuary is constituted by three different countries (France, Monaco and Italy) it would be important to understand and define how the implementation of existing legislation could be homogenized across the Pelagos Sanctuary. The literature shows that almost all ALDFG found in the Sanctuary are gear lost on the seabed and that gillnets and, in general, marine debris lost on the seabed do not pose a significant risk to cetaceans. However, it should be highlighted, that the main risk for cetaceans comes from gear actively in use (as observed in *T. truncatus*), which can cause interactions also bringing to death both indirectly, such as during depredation where death can be caused by the ingestion of fishing gear parts, and directly through accidental catches and entanglements.

Due to the limitations in collecting precise information on quantity of ALDFGs and on their potential impact on cetacean population, it is not currently possible to estimate the effect of ALDFG on the survival of cetaceans populations in the Pelagos Sanctuary.

Distribution and temporal trends of commercial and recreational fishing effort

The fleet within the Pelagos Sanctuary is mainly represented by small scale fisheries (<12m) and passive gears (PGP). In the last 10 years the effort (expressed in total fishing days) in the area has been decreasing, specifically in GSA9, both for DTS and PGP fishing

techniques; number of vessels have been decreasing as well, except for vessels between 0-12m in Sardinia. The reduction of vessel numbers and fishing days started already in 2018, before the implementation of regulation EU 2019/1022 (which acts on the whole western Mediterranean Sea (European waters)), but the effort of trawlers of all fleet segments is now regulated since 2020 by EU 2019/1022, therefore an increase of fishing effort of trawlers is not envisioned in the near future. To the contrary such reductions could potentially bring an increase of fishing effort (in number of vessels and therefore number of fishing days per year) within the PGP sector if there was a shift of investments in the fishing sector. This should be considered if information on the distribution of hotspots of cetaceans species were to be combined with the available information on the spatial distribution of fishing effort. Additionally it is important to highlight that to evaluate the potential effect of fishing effort (by gear) on cetacean species it would be fundamental to be able to estimate the rates of interactions between specific species and specific gears which. These estimates, as shown for *T. truncatus*, are still highly uncertain due to the complexities in the monitoring of the consequences of such interactions and in reconstructing the actual causes of death of individuals observed when already stranded.

Stock status of commercial species encountered in the diet of cetacean populations

Commercial species, which are analytically evaluated and that are part of the diet of cetaceans species, are: *M. barbatus*, *M. surmuletus*, *E. engrasicolus*, *S. pilchardus*, *M. merluccius*. With the exception of *M. merluccius* stocks all other stocks covering GSAs 7-8-9 (within which falls the Pelagos Sanctuary) are not evaluated to be in a state of overfishing and the biomass indices show positive trends. Therefore, the state of these specific preys would not be a potential cause of worry for the state of cetacean populations feeding on them.

*The impact of interactions between fishing gears and cetaceans: the case study of *Tursiops truncatus**

Currently, the most common practice to mitigate the consequences of interactions between *T. truncatus* and the fishing industry is state payment of a sum to cover the economic damages caused by the animals. It should be noted that state aid as a long term solution could risk becoming economically unsustainable on top of being a fragile system that could be highly dependent on the political agenda of the government in charge. Additionally the difficulties and uncertainties in quantifying the economic losses due to depredation of the catch by bottlenose dolphins could also undermine the establishment of such a process. On the other hand it should be considered that acoustic deterrents (and deterrents in general) could potentially become attractive instead of repellent once local populations of cetaceans become accustomed to their presence on the fishing gears. Therefore, it is of high importance that further research keeps on going to be able to find long term solutions to the problem of fishers-cetaceans interactions in order to guarantee both, the long term viability of cetacean populations and the profitability of small scale coastal fisheries. In the Pelagos Sanctuary area this is particularly important as following the study by Arpal (2021), in 2023 a new proposal to define a pSIC to protect *T. truncatus* in the Ligurian Sea has been approved at regional level (n.414 05/05/2023) following the D.P.R. 357/97 following the European Directive 92/43/CEE.

Future work should focus on integrating all the available information reported, together with additional information on demographic parameters, population estimates and habitat suitability maps of cetacean species to attempt evaluating the state of cetaceans populations within the Pelagos Sanctuary. Specifically first attempts could be implemented on *T. truncatus* being the most easily observed and studied species of the Sanctuary and

potentially the one on which are available most information to parameterize an evaluation process.

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