Interactions Between Cetaceans and Small-scale Fisheries in the Mediterranean

STUDY AREA 1

The Case of Central Mediterranean

Sicily, Italy

LOW IMPACT FISHERS OF EUROPE

MAVA FONDATION POUR LA NATURE

MARE CAMP

Interaction Between Cetaceans and Small-Scale Fisheries in the Mediterranean

Study Area 1: The Case of Central Mediterranean, Sicily, Italy.

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The present report is part of a Collection of Reports where interaction between cetaceans and small-scale fisheries in the Mediterranean has been analysed. This report shows the results in one out of three areas of study, concretely in Sicily, Italy. They all proceeded with a coordinated approach with common methodology and database. Please see the other two case study reports and Conclusive Report for further information.

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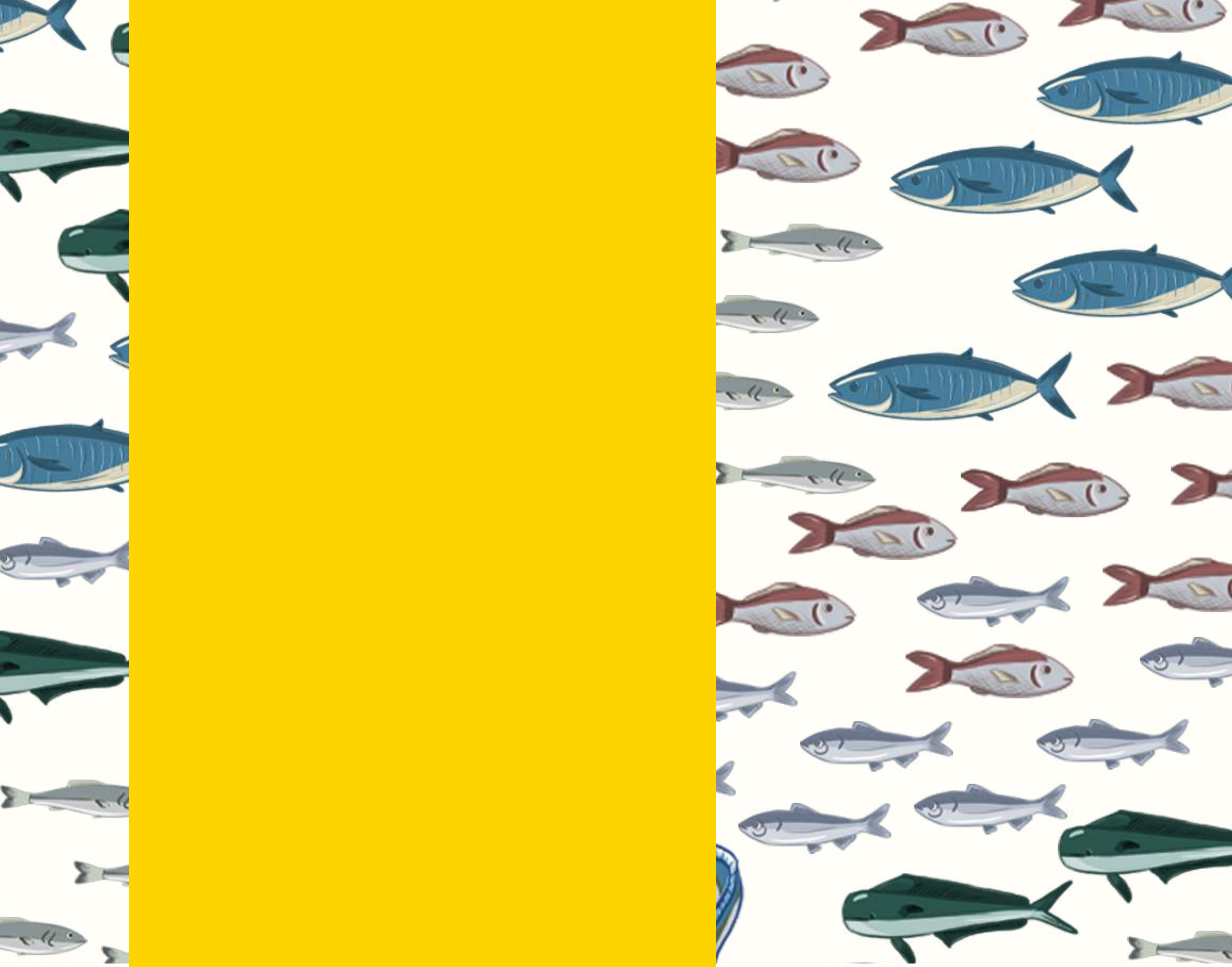


Background

With the ratification of the Regional plan of action for small-scale fisheries in the Mediterranean and the Black Sea signed in Malta on September 26, 2018, the General Fisheries Commission for the Mediterranean (GFCM) and 18 Mediterranean and Black Sea countries have committed themselves to **take actions aimed at ensuring the long-term environmental, economic and social sustainability of small-scale fisheries.**

Three months later, experts and scientists from 45 countries met up at the first Fish Forum at FAO headquarters, in Rome, to discuss the state of the art of fisheries, aware that human activities with an impact on marine living resources, such as fishing, require a concerted approach by riparian countries. In that occasion, beside fisheries effects, other **interactions of vulnerable species with human activities**, including pollution and depredation effects, were identified as **emerging issues requiring further studied**. In particular, despite various trials, the scientific community has unanimously declared that no permanent solution has been found to solve the problem of the depredation of catches on the fishing gears made by cetaceans (FAO, 2018).

Today, we count about **135 000 small-scale fishers operating in the Mediterranean**, which is a semi-enclosed basin that plays an intrinsic role in the development of the different countries bordering its shores, but that just **in the last four years has lost 5 000 small-scale fishing vessels of its fleet.** Seafood products have traditionally been among the most important supplies traded in this region, as well as fish consumption has always been a basic part of coastal communities' diet. Unfortunately, the overexploitation of marine living resources implemented in the last decades by industrial fleets has made the entire ecosystem more fragile, with consequences on the catches of the small-scale fisheries already affected by an anthropogenic pressure which can be able to jeopardize the livelihoods of the coastal communities of the region relying on these resources for a long time (FAO, 2016; FAO, 2018).

Conscious of the environmental challenges, **the Mediterranean countries are oriented to reduce the impacts of the interactions between fishing activities and threatened species**, limiting over-fishing and incidental catches in fishing gears (by-catch). Also, in the framework of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), these countries are facing the existing conflicts between fishers and cetaceans that feed on commercially important marine species during fishing operations, causing damages to fishers' gears and exacerbating hostilities.

In order to assess the socio-economic and ecological impacts linked to the phenomenon of cetacean-fishery interaction in Mediterranean and to lay the foundations for suggesting new techniques capable of mitigating this problem, an **international research project coordinated by the Low Impact Fishers of Europe platform (LIFE)** was set up in 2019 in collaboration with the Asociación Herpetológica Española (AHE) in Andalusia, Spain; the Malta College of Arts, Science and Technology (MCAST) in Malta; and the MareCamp Onlus Association in Sicily, Italy, where also the "**Floating Laboratories programme**" was activated. The project, entitled "**Interaction between cetaceans and small-scale fisheries in the Mediterranean**" and from here named "The project", is supported by the MAVA Foundation which has a keen interest in protecting threatened, Endangered, and Sensitive Species (TES), and is seeking solutions through engaging with small-scale fishers and promoting exchanges on best practices between them.

This report firstly describes interaction cases between cetaceans and fisheries from the Mediterranean and every ocean in the world, and existing strategies to mitigate this issue. An overview of the status of small-scale fisheries and of the presence of cetaceans in the Mediterranean follows. Bioacoustics basics are also mentioned. After an introduction on the study area, an accurate description of the Italian and the Sicilian fishing fleets will precede an in-depth on the *métiers* prevailing in the small-scale fisheries fleet of North-Eastern Sicily. Survey data collected during summer-autumn 2019 are analyzed with a multidisciplinary approach in order to show results at environmental and socio-economic level, with reference to depredation and by-catch events involving cetaceans and others vulnerable species, fishing effort of small-scale fisheries in the Gulf of Catania, and incidence factors and consequences of depredation. A specific ethogram referred to the "feeding in net" behavior applied by the bottlenose dolphin is also presented. Finally, the report ends with suggestions and conclusions linked to a follow up of the project.

A focus on the Project related to the Sicilian area

The entire project aims to tap into the rich local and experiential knowledge of the fishers to document the extent and severity of interactions with cetaceans, to understand the intensity of the problem, and to propose solutions. Indeed, the study intends to shed light on the problem of the cetacean – fishery interaction and encourage better management of the dispute between conservation of wildlife and maintenance of fishing practices, suggesting the development of new mitigation strategies aimed at reducing the cost of the impact of dolphins on fishing, due to their opportunistic feeding behavior near fishing gears. To do this, an assessment of the level of attack by dolphins on fishing gears was made, identifying the repercussions of the losses on the financial and economic level.

A time extension of the project points to achieve the specific goals to enhance the conservation of vulnerable species by mitigating their interactions with fisheries, including both incidental catches and depredation matters; to reduce losses suffered by fishers due to depredation; and to increase the awareness of national authorities, fishers and civil society on the issue.

Research activities here described refers to the studies conducted in Sicily in the framework of the "Floating Laboratories" initiative. In particular, the research was aimed at: demonstrating the existence of conflicts recognized as cetacean-fisheries interaction in a sample area of eastern Sicily; understand the dynamics of depredation on fishing gears through direct observation and documentation of the different ways of interacting; estimate the incidence of interaction events and the consequent economic damage for the fleet that practices small-scale coastal fishing, as well as the social and market repercussions; assess the status of the operational fleet in eastern Sicily and its fishing effort in a sample area; deepen the problem at the level of species for dolphins and of fishing gear for fishery; explore the occurrence of by-catches of vulnerable species.

The initiative follows LIFE's core objectives based on collaboration between fishers and scientists in order to combine the local and experiential knowledge and data generated by the fishers with the data gathered by the scientists providing joint solutions to take into account also in decision-making processes.

The main questions that drive the research are

1. What is the effort of the small-scale fishing fleet and what does it fish in North-Eastern Sicily?
2. Is the Catania fleet subjected to interaction with cetaceans? If yes, what kind?

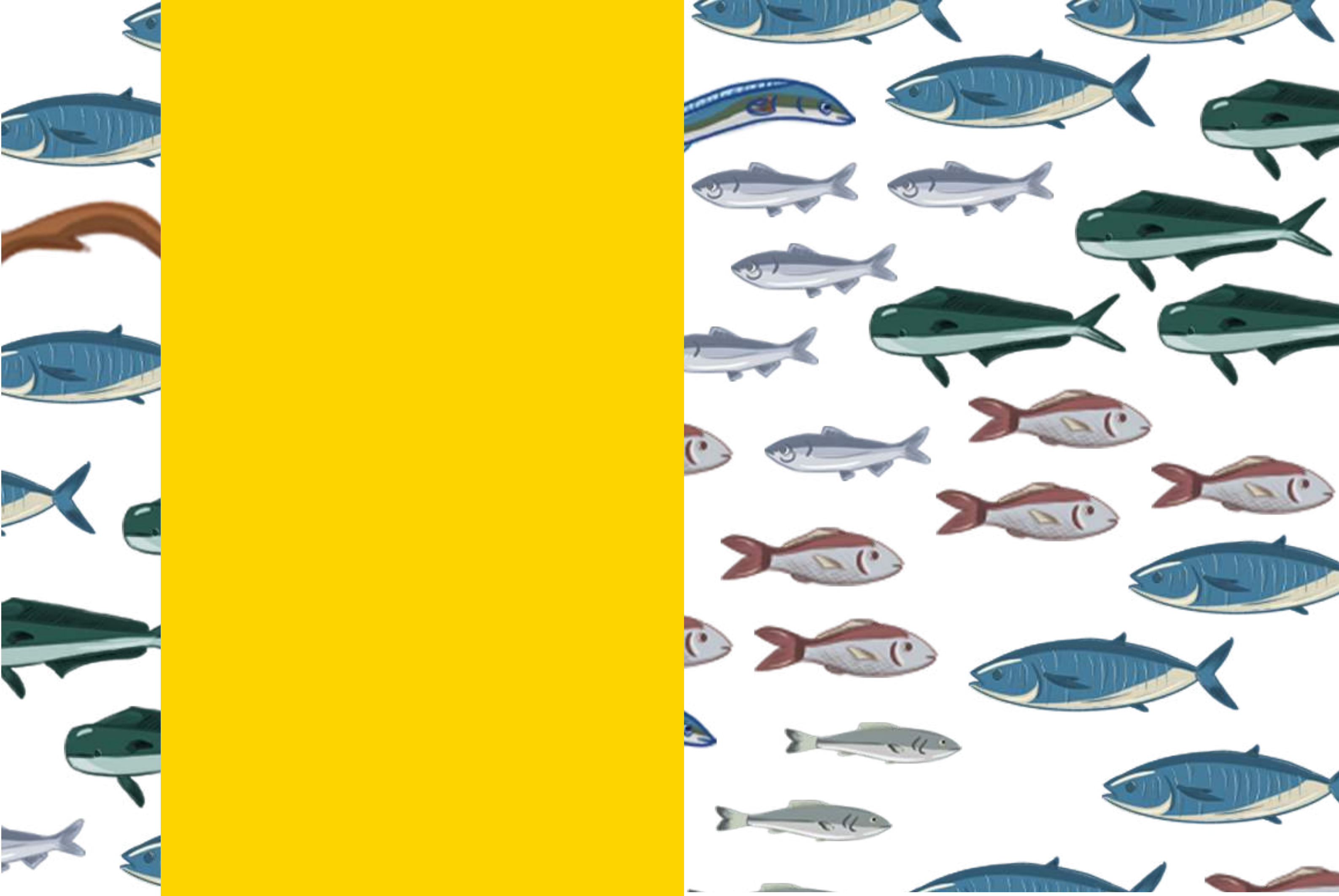
   If so

   1. Which species interact?
   2. On what factors does the interaction depend (fishing gear, time or moon phase, weather conditions, Douglas sea state, type of bottom, depth of gear, target species, length or mesh size of the net, proximity of other fishing boats, quantity of catches, degree of residence of the dolphins in the area, herd composition, fishing area, distance from the coast, duration of the fishing set or of the gear retrieval)?
   3. What are the damages and what is the economic loss?

The hypotheses that we will try to verify are:

1) There is a species of delphinid more inclined than others to interact with fishing gear in order to depredate on them, which prefers certain areas and species, and acts at specific times according to identifiable and repeated behavioral patterns.

2) The selectivity of some artisanal fishing gears favors a reduced by-catch rate, in favor of the conservation of vulnerable marine species.



Introduction

Interaction between cetaceans and fisheries: reports and experimentations

The hunting methods and the nutrition choices of wild species respond to specific economic optimization models that define the relationships between energy expenditure for foraging and payoff deriving from the consumption of the preys. **Top-predators tend to minimize the search interval between preys and maximize the intake rate while eating**, preferring decisions that maximize energy per unit time providing the highest gain (Danchin et al., 2008; Hughes and Roger, 1989).

Feeding strategies that lead marine mammals like cetaceans to carry out attacks and depredations on fishing gear, constitute a special case to which these optimization models are applied. **Odontocetes,** specifically dolphins, species protected by national and international conventions, **are the main responsible for conflicts with fishing**, which can generate environmental, social and economic problems, with serious consequences especially for fishermen who practice the small-scale coastal fishing (Snape et al., 2018). Dolphins can cause scattering or move away entire fish schools from the fishing gears, also leading to a complete loss of the catch or a destruction of the nets. The damage caused by these small-sized cetaceans to small-scale fishing involves the removal of the prey or their damage when trapped in the gears, the tearing of portions of the net with the generation of holes of various sizes, the loss of baits, the time wasted to make unsuccessful fishing trips, interruption of fishing activities, repair or repurchase of damaged fishing gears (Reeves et al., 2001; Bearzi et al., 2011).

A potential solution to the problem is represented by the **use of acoustic signal generators** (ADD or Pinger, AHD, DDD and the Dolphin Interactive Dissuasor of new generation - DiD), to be attached to fishing gear, which emit medium to high frequency sounds underwater. However, **the long-term effectiveness of these devices is still controversial**, since they have been designed to move away marine mammals from fishing gears, but often, due to the phenomenon of habituation, after a few months of use they turn out to be ignored or even become a bell indicating the availability of food with a very low search energy cost (Northridge et al., 2006; Hamilton and Baker,2019).

Conflicts between wild fauna and fishers may be as old as fishing itself. However, today such interactions are the cause of critical economic losses to the fishers and they are documented everywhere in the world (Monaco et al., 2019).

There are several studies in the Mediterranean that report the occurrence of depredation events put in place by *delfinidae*. From the Adriatic Sea by bottlenose dolphins on gillnets and trawlers, to the Tyrrhenian Sea with bottlenose dolphins on nets or exploiting the concentration of wild preys near fish farms (Figure 1) (Díaz López, 2006; Bearzi and Bonizzoni, 2018); and from the central-eastern Ionian Sea where striped dolphins wait for fishermen that throw overboard the bait fish into the water (Figure 2), to the Western basin with still bottlenose dolphins in action on nets and trawlers (INRH, 2015; Bouhadja et al., 2017; Benmessaoud et al . 2018). The interactions of common bottlenose dolphins, short-beaked common dolphins and Risso's dolphins are reported from all over the Europe and from different areas of the Mediterranean (di Sciara, 2002; Monaco et al., 2019; Geraci et al., 2019; Snape, 2019) and beyond, such as cases of depredation on longlines by killer whales near the Strait of Gibraltar (Camiñas et al., 2018) (Figure 3), and on various tools by bottlenose dolphins in the Black Sea (Birkun et al., 2014).

Figure 1. Group of bottlenose dolphins searching for prey between the floating cages of a marine fin fish farm. Source D. López, 2006.

Figure 2. Screenshots of the underwater video available on https://www.youtube.com/watch?v=i9xdiC79eJA, showing killer whales depredating a longline.

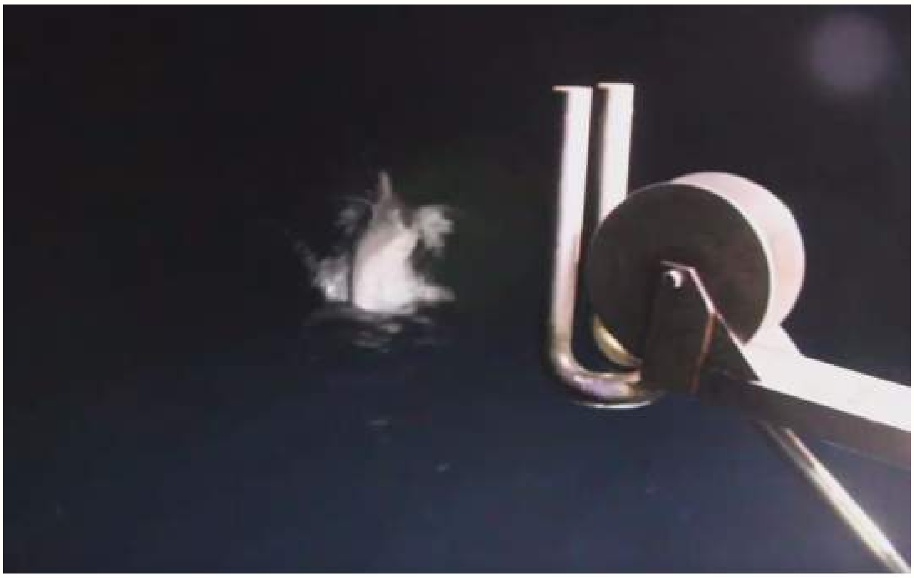


Figure 3. Screenshot of the video available on https://www.facebook.com/iSea.org/videos/225222735234098/UzpfSTU2OTI5MTcxNjU3ODAzNjpWSzozMDY2NT-c3MzUwMDI4NjYz/, showing a striped dolphin eating the sardines used as lure by a Greek fishing vessel.

It is the attitude of these cetaceans to obtain food by taking advantage of the presence of fishing gears, that causes the risk they become themselves caught. Such incidental mortality has been recognized as responsible of depletion of cetacean populations, recently increasing due to the proliferation of synthetic gillnets throughout the world, causing the by-catch also of other marine mammals and vulnerable species like seabirds, turtles, fish, and other non-target organisms (Reeves & Leatherwood, 1994; Read et al., 2006; Snape 2019). The main cetacean species documented as victims from the Mediterranean and the Black Sea are common bottlenose dolphin, short-beaked common dolphin, striped dolphin, Risso's dolphin, sperm whale, and harbor porpoise (Reeves & Leatherwood, 1994; Di Sciara 2002; Birkun et al., 2014; Bearzi and Bonizzoni, 2018).

The most frequent signs visible both in living and stranded individuals that have been involved in interactions with fishing gears are the presence of nets (Figure 4) or lines with hooks (Figure 5; Figure 6; Figure 7) which, if they do not lead the animals to a death by drowning because they are hold underwater, they can cause infections or injuries as much fatal (Hamer et al., 2010).

Figure 4. A Minke whale (*Balaenoptera acutorostrata*) sighted in the Tyrrhenian Sea entrapped in a fishing net. It is an occasional species for the Mediterranean, that is why this event was even more serious. Source MareTerra.

Figure 5. A hooked sperm whale. The yellow circle indicates a hook stuck between the teeth which was later removed by a diver. Screenshot of the video available on https://www.facebook.com/undervisionpro/videos/772166356534357/.

Figure 6. A false killer whale caught on a pelagic longline hook. Source National Marine Fisheries Service, United States Federal Government.

Figure 7. A bottlenose dolphin with an embedded hook and trailing line, with the hook encrusted with stalked barnacles (Gill et al., 2019).

Animals survived to by-catch events usually show also the presence of markings on the head, dorsal fin leading edge, and peduncle, where injuries can occur when they struggle against a fishing gear (Figure 8) (Gill et al., 2019). Therefore, given the difficulty of direct observation of hooked and entangled cetaceans, scars and wounds of anthropogenic origin noted on their body (Figure 9) are useful signs for estimating the fishing gear impact upon cetaceans, among which there are dorsal fin damage, V-shaped wounds, sawed edges and deformities in the caudal region (Félix et al., 2017).

Figure 8. Dolphin with injuries consistent with a line wrap around the peduncle (Gill et al., 2019).

Figure 9. Individual with mouthline notch and scarring consistent with a fishery interaction (Gill et al., 2019).

To mitigate the effects of this type of interactions, research groups from all over the world have designed various types of devices. The majority of solutions tested to mitigate catch depredation typically focus on four strategies, which are harassment, deterrence and echolocation disruption, and avoidance (Hamer et al., 2012).

A work made by Birkun et al. (2014) summarizes all the examples of mitigation known, coming from different countries and involving fishing fleets active in the Mediterranean Sea, the Atlantic and the Pacific Oceans. **Actions based on effort limitations** include the institution of fishery bans in order to avoid by-catch events, usually defining a combination of gear characteristics and geographical area. In specific cases, a limit on the amount of fishing allowed is imposed, considering the length of the gears or the number of fishing days. Zones with a known high by-catch rate can be also closed off for a specified period of time. **Interventions for design and use of gears** concern mitigation of both by-catch and depredation events and consist in switching to alternative gear or to modify particular aspects of gear design or use, such as mesh size. These can be further detailed in **additional measures** considering the use of devices, specific to the gear they are addressed, such as reflective or stiff nets equipped with met-al filler compounds to nylon twine to increase their acoustic reflectivity (Bordino et al., 2013); escape hatches in trawl nets; and acoustic deterrents (ADDs) like pingers to generate aversive noises that may deter cetaceans from approaching fishing gear or the noisiest acoustic harassment devices (Birkun et al., 2014; Bearzi, 2018).

However, most studies are focused precisely on the use of acoustic pingers, even if habituation cause a decrease of their effectiveness and many practical constraints exist, including the size and cost (Dawson et al., 1998). Even at the World Marine Mammal Conference that took place in December 2019 in Barcelona, no tool capable of definitively solving the problem of the cetacean-fishing interaction was presented. Only a few specialized works on particular species or tools involved in by-catch events have been successful, such as the fishing rope strength on the severity of large whale entanglements (Knowlton et l., 2015), or the case of small multi spheres attached to the nets that zeroed the entanglement of Harbour porpoises (*Phocoena phocoena*).

Figure 10. Depredation mitigation prototype closed. Source Paraped project.

Much work remains to be done, to be discovered and tested in order to arrive at a solution that can bring together the Mediterranean fleets. Among the most innovative ideas we can find in literature there are illuminated bottom set nets and illuminated surface driftnets for saving small cetaceans as dusky dolphins and Burmeister's porpoises (Bielli, 2020), even if other works on light-emitting devices into fishing gear have been shown they are more addressed to reduce non-target capture of crustaceans and fish (SafetyNet, 2020); and electrical pulses from the gear activated when cetacean approaches (Hamer et al., 2010). Nevertheless, the latter may be difficult to maintain and has potential ethical issues for cetaceans and safety issues for crew therefore it has not been further developed.

Instead, **several mechanical approaches have been implemented, even if they are in the test phase yet.** Par example, the "Paraped" project is creating masking nets to protect longlines catches, however, its depredation mitigation prototypes (Figure 10; Figure 11) need still the improvement of the triggering system and the identification of materials which can be used to design effective protection (Rabearisoa et al., 2019).

Figure 11. Depredation mitigation prototype activated.
Screenshots of the videos available on https://paradep.com/en/actualites/non-classe-en/.

Its operation follows that of Physical Depredation Mitigation Devices (PDMD) previously adapted to longlines to reduce interactions of toothed whales, designed to provide a physical barrier of various shapes and materials that remains clear of the hooks during the soak period and then slides down the branch line over the caught fish when this is caught (Figure 12; Figure 13) or during the haul (Figure 14) (Hamer et al., 2010; Goetz et al., 2011).

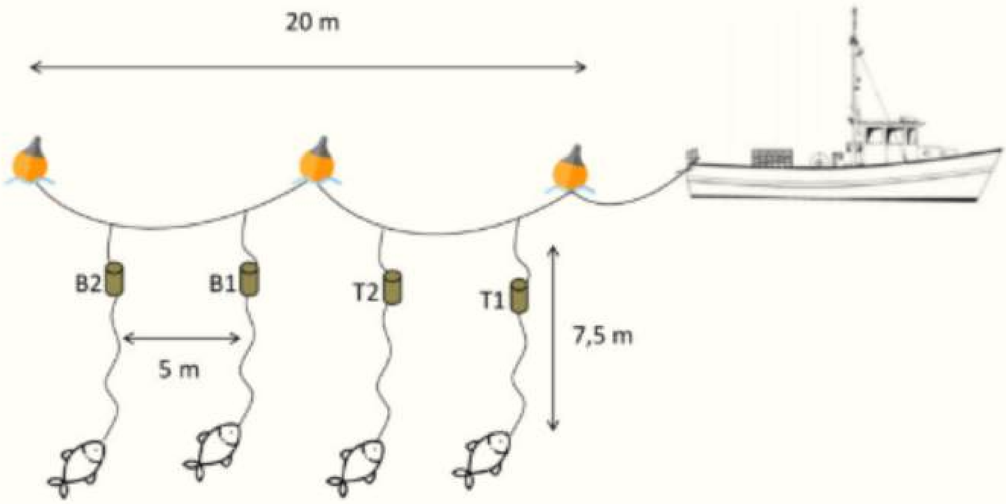


Figure 12. Arrangement of the PDMDs along a longline. Source Goetz et al., 2011.

Other variants of the umbrella-and-stones system, like the DEPRED device, consider a double physical action put into practice by many streamers of which the upper ones freely move around the fish (deterrent effect) and the lower ones are weighted, covering the fish (protective effect) (Figure 15; Figure 16). However, despite the umbrella systems were quite effective in preventing the accidental by-catch of seabirds and toothed whales, as well as depredation events, it causes a significant reduction of the catches, so their negative effects undermine the benefits (Hamer et al., 2010; Rabearisoa et al., 2015).

Since cetaceans are protected by numerous national and international agreements and many species are present on the Red List of the International Union for Conservation of Nature (IUCN), not all methods and devices to avoid fishing-cetacean interaction are allowed. Among the **prohibited practices and devices towards marine mammals** there are explosives, firearms, live ammunition, taste/smell deterrents, chemical irritants, poisons and toxins, and anti-predator netting (Long et al. 2015).

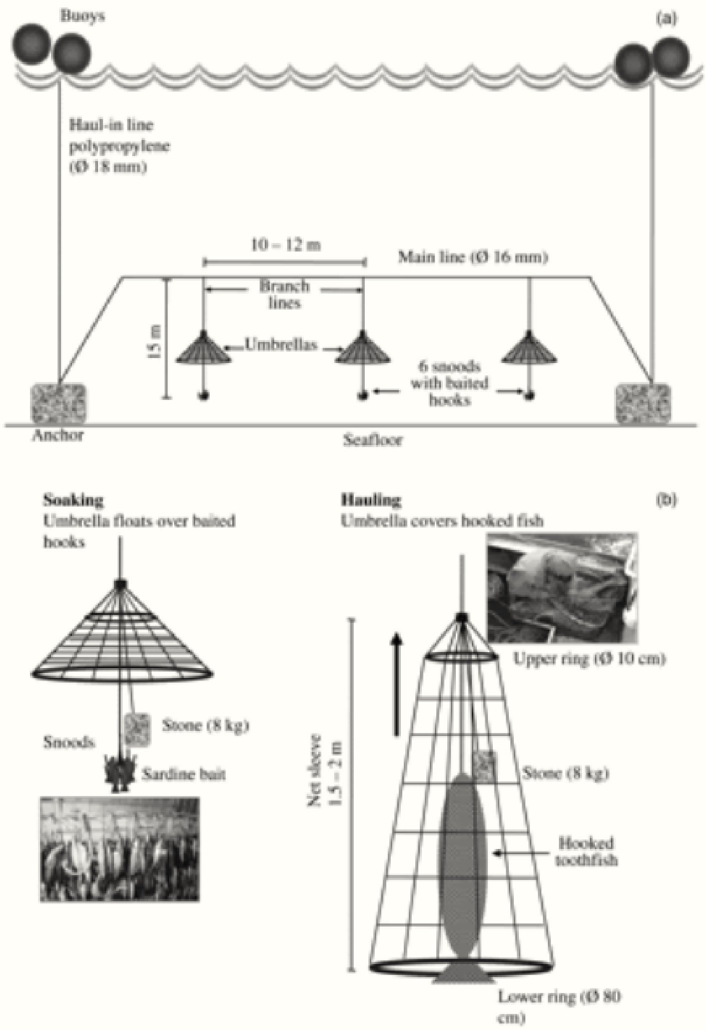


Figure 13. Experimental longline setting (a), and the “Umbrella-and--stones” design and mechanism (b). The pressure of the caught fish fighting against the hook causes the cap of the pod to open and release the streamers, and the pod to descend the snood toward the hook. Source International Council for the Exploration of the Sea.

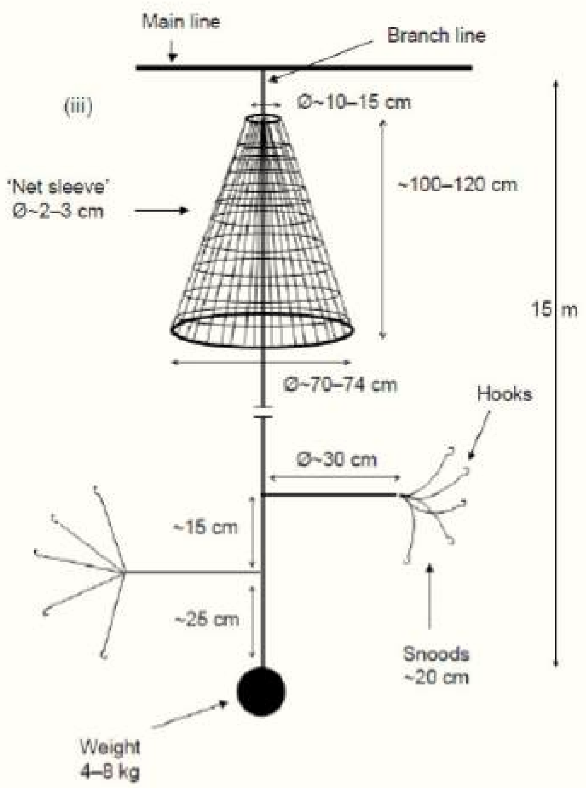


Figure 14. Schematic diagram of a robustly constructed PDMD "Net sleeve" fitted to a demersal longline. Source Hamer et al., 2010.

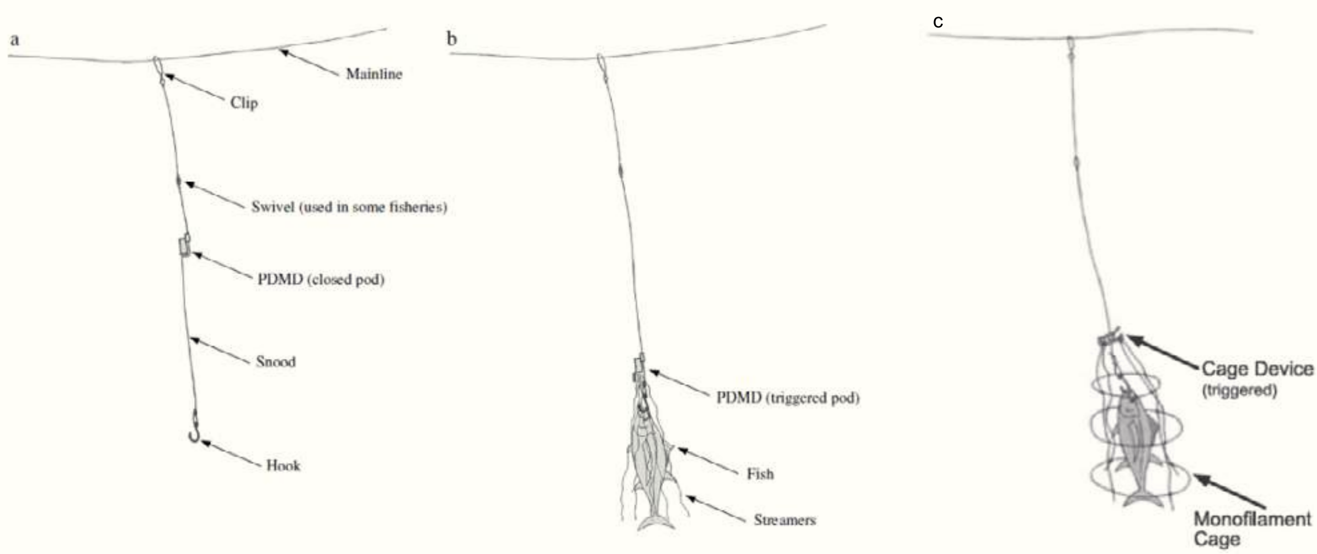


Figure 15. According to this PDMD, depredating whales are deterred by the streamers, because they flap around next to the caught fish and mimic tangles in the fishing gear. Source Goetz et al., 2011.

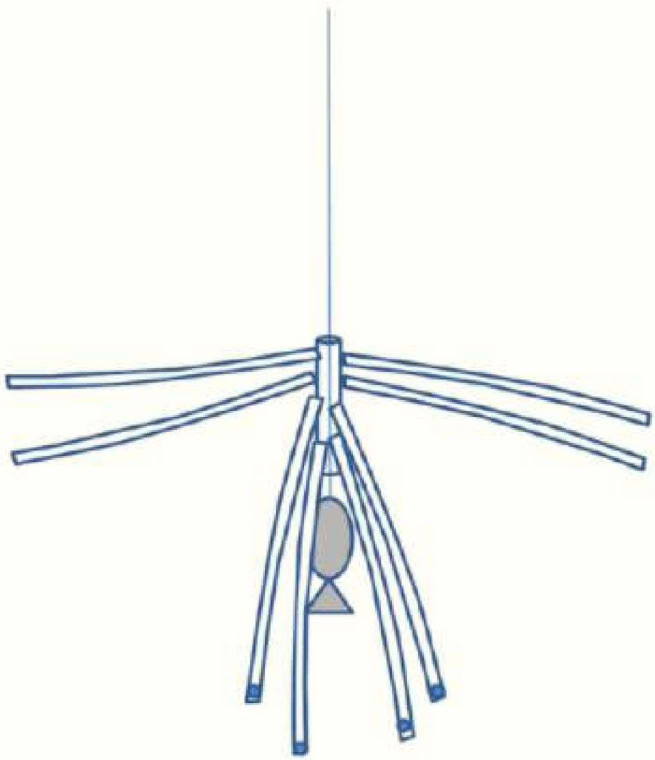


Figure 16. The DEPREDation mitigation device for preventing predator attacks and protecting captures. Source Rabearisoa et al., 2015.

At European level, the fisheries and aquaculture sectors are supported by the European Commission (EC) with the regulation on the European Maritime and Fisheries Fund (EMFF), established for 2014-2020, that covers investments in equipment for defending gear and catches from protected marine mammals and seabirds, and operations such as schemes for compensation for damage to catches caused by protected wildlife. However, the measures are transposed late at regional level and financial support has not yet been activated in various areas of the Mediterranean (Monaco et al., 2019).

The study described in this report could contribute to define new appropriate management approaches for small-scale fisheries (SSFs) and vulnerable species in the Mediterranean area, by providing baseline information to build a sound management plan and concrete mitigation solutions. **Actions carried out in the Sicilian region** for this purpose are:

a) Identification of the sample fleet and drafting of a protocol for monitoring at sea with **standardized surveys** adapted to investigations on cetacean-fishery interaction.

b) Territorial survey on the local fleets that practice small-scale fishing and accuse negative interactions with cetaceans (research on statistical and bibliographic sources, data collection in the field, interviews and focus groups).

c) Construction and **activation of the fishermen network** to be involved in the data collection, and use of the fishers' register.

d) Visual monitoring of the presence of cetaceans and of the fishing activities made by the small-scale fleet in a sample area of eastern Sicily, through the **use of scientific boats and of fishing vessels with observers onboard** (observation, sighting and interaction survey).

e) **Check of the integrity of the fishing gears** *ex ante* and *ex post* the fishing trips, with measurement of any damage suffered.

f) **Bioacoustic monitoring** by means of hydrophones placed in an underwater environment near the fishing gear, with recording of the sounds emitted by dolphins during depredation and non-depredation events.

g) Analysis of the data collected with an **interdisciplinary and systemic approach** by means of statistical software, bioacoustics and geomodelling.

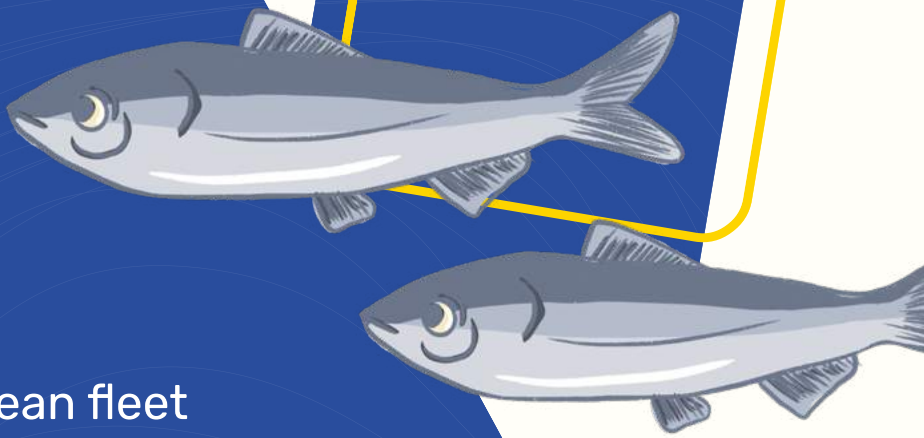
h) Preparation of **reports** and scientific papers.

i) **Dissemination** through conferences, videos and online material.

CHAPTER 01

Small-Scale Fisheries

Status of the Mediterranean fleet



INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN

Study Area 1:
The Case of Central Mediterranean
Sicily, Italy

The term “Small-scale fisheries” (SSFs)” is often used interchangeably with “Coastal fisheries” and “Artisanal fisheries. **In the EU, “small-scale coastal fishing” refers to fishing vessels under 12 meters of length using non-towed gears** according to the regulation for the European Maritime and Fisheries Fund (EMFF - Regulation (EU) No 508/2014). But this is far from universal. Although these terms may be synonymous, the way they are defined in different countries may be quite different. These different local and national contexts need to be taken into account where these broad categories can also be divided in more subclasses (Table 1).

For the purposes of this study, we define small scale fisheries as vessels under 12 metres using non-towed gears.

Vessel groups			Length classes (LOA)			
			< 6 m	6 - 12 m	12-24 m	> 24 m
Polyvalent	P	Small-scale vessels without engine using passive gears	P-01	P-02	P-03	P-04
			P-13			
		Small-scale vessels with engine using passive gears	P-05	P-06	P-07	P-08
		Polyvalent vessels	P-09	P-10	P-11	P-12
					P-14	
Seiners	S	Purse seiners	S-01	S-02	S-03	S-04
					S-09	
		Tuna seiners	S-05	S-06	S-07	S-08
					S-10	
Dredgers	D	Dredgers	D-01	D-02	D-03	D-04
				D-05		
Trawlers	T	Beam trawlers	T-01	T-02	T-03	T-04
		Pelagic trawlers	T-05	T-06	T-07	T-08
				T-13		
		Trawlers	T-09	T-10	T-11	T-12
Longliners	L	Longliners	L-01	L-02	L-03	L-04
				L-05		

Table 01. Fleet segmentation made by the General Fisheries Commission for the Mediterranean (GFCM) as defined by Recommendation GFCM/41/2017/6. In orange, some potential combinations are proposed (FAO, 2018). Source http://www.fao.org/gfcm/activities/fisheries/fleet/segmentation/en/.

An important omission in the way these terms are defined is the important socio-economic dimensions of small-scale, coastal and artisanal fisheries. Small scale fishing activities tend to be small family businesses, with the owner working on board, with close family members working as crew and helping to run the business and rooted in cultural traditions. Catches are relatively small, so value addition is very important. In this regard, any damage to the catches can have devastating economic consequences.

Considering the total capture fisheries production **in the Mediterranean, landings are stable at about 850 000 tonnes per year in the last triennium**, with catches dominated by small pelagics (herrings, sardines, anchovies) that represent nearly 49% of the total catches. The most productive region is the western Mediterranean with 265 100 tonnes, followed by the Adriatic Sea and the central and eastern Mediterranean (FAO, 2016; FAO, 2018).

The estimated annual revenue related to marine capture fisheries in the Mediterranean and Black Sea is of **USD 2.8 billion and directly employ about 248 000 people** onboard fishing vessels. Even if the **polyvalent vessel group represents only 26% of total revenue, it provides employment to 59% of all fishers in the region, counting about 135 000 small-scale fishers** operating just in the Mediterranean. However, the sector is in decline and today counts **5000 fewer small-scale fishing vessels** from its fleet rather than the last four years (FAO, 2016; FAO, 2018).

This damages a segment already vulnerable and with a limited capacity to adapt or cope to shocks, with less and less availability of workers with the necessary skills to provide support services. Indeed, since associated with working at sea, the employment of small-scale fishers is highly seasonal, unpredictable and dangerous, so low attractive for new generations. Moreover, its contingency on weather conditions, as well as its dependency by climate change and reductions in fish stocks (Annex 1), may affect the income of small-scale fishers that is already seasonal, irregular and unpredictable.

The increasing overexploitation of marine resources, environmental damage, climate change, pollution and competition with other fishing sectors merely is intensifying the pressure from the elements of risk mentioned before that threaten the viability and sustainability of the livelihoods of the coastal fishers, as well as the maintaining of local traditions and cultural heritage of the Mediterranean region (FAO, 2019).

CHAPTER 02

Safeguard of Cetaceans in the Mediterranean Sea

INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN

Study Area 1:
The Case of Central Mediterranean
Sicily, Italy

Marine mammals are species of concern in the world, this is why a **Marine Mammal Protected Areas Task Force** (MMPATF) was created in 2013 by the **International Committee on Marine Mammal Protected Areas** (ICMMPA), the **International Union for the Conservation of Nature's** (IUCN), the **World Commission on Protected Areas** (WCPA), and members of the IUCN's Species Survival Commission (SSC). The Task Force supervises the definition of **Important Marine Mammal Areas** (IMMAs) that may merit place-based protection and/or monitoring to improve the conservation status of specific species or populations, and support existing national and international conservation tools with respect to **Marine Protected Areas** (MPAs), including Ecologically or Biologically Significant Areas (EBSAs) under the Convention on Biological Diversity (CBD), and Key Biodiversity Areas (KBAs) identified through the IUCN Standard (IUCN, 2016).

Countries are also Contracting Parties of other international agreements that comprise the safeguard of the cetaceans like the **Convention for the Protection of the Mediterranean Sea Against Pollution** (Barcelona Convention, 1978) which include the protection and management of **Specially Protected Areas** (SPAs), and the establishment of a list of Specially Protected Areas of Mediterranean Importance (SPAMIs) for protecting conservation of species; and the Council Directive 92/43/EEC on the **Conservation of natural habitats and of wild fauna and flora** (Habitats Directive, 1992) which comprised the establishment of the Natura 2000 network to protect species and habitats. Under this Directive all cetaceans are strictly protected in European waters and their deliberately capture, kill or disturb, as well as to cause deterioration or destruction to their breeding or resting places are punished. Also, requires that Member States establish a monitoring system for incidental capture and killing of cetaceans, and to take measures to ensure that these do not have a significant negative impact on the species.

Additional obligations of European Member States include the conservation of cetacean populations and the monitoring and mitigation of by-catch and other anthropogenic impacts under the **Marine Strategy Framework Directive** (MSFD), and the Council Regulation (EC) No. 812/2004, as well as regional treaties such as the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) and the **Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area** (ACCOBAMS).

Moreover, under the **United Nations Environment Programme** (UNEP) was developed the **Mediterranean Action Plan** (MAP, 1975) approved by the Mediterranean countries and the EC as institutional framework for cooperation in addressing common challenges of marine environmental degradation. The Programme was then updated as **Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean** (MAP Phase II, 1995), until the implementation of the Ecosystem Approach of the MAP system (2008, 2012) to support regional and national efforts towards achieving **Good Environmental Status** (GES) in the Mediterranean.

	Species	Common name	Visibility	IUCN status
Toothed whales	*Delphinus delphis*	Short-beaked common dolphin	**Regular**	EN*
	Tursiops truncatus	Common bottlenose dolphin	**Regular**	VU*
	Stenella coeruleoalba	Striped dolphin	**Regular**	VU*
	Grampus griseus	Risso's dolphin	**Regular**	DD*
	Ziphius cavirostris	Cuvier's beaked whale	**Regular**	DD*
	Physeter microcephalus	Sperm whale	**Regular**	EN*
	Globicephala melas	Long-finned pilot whale	**Regular**	DD*
	Steno bredanensis	Rough-toothed dolphin	Incidental	NA**
	Pseudorca crassidens	False killer whale	Incidental	DD
	Orcinus orca	Killer whale	Incidental	DD
Baleen whales	*Balaenoptera physalus*	Fin whale	**Regular**	VU*
	Balaenoptera acutorostrata	Minke whale	Incidental	LC
	Megaptera novaengliae	Humpback whale	Incidental	LC

Table 02. Species of cetaceans of the Mediterranean Sea with their occurrence in the basin and IUCN status. EN: Endangered; VU: Vulnerable; LC: Least Concern; DD: Data Deficient; NA: Not Applicable. Source https://www.iucnredlist.org/. Our elaboration. *Mediterranean subpopulation; **Europe.

As showed in Table 2, seven species of toothed whale (Odontocetes) (*Delphinus delphis, Tursiops truncatus, Stenella coeruleoalba, Grampus griseus, Ziphius cavirostris, Physeter microcephalus, Globicephala melas*) and one of baleen whale (Mysticetes) (*Balaenoptera physalus*) are regularly present in the Mediterranean waters. Some of these, although being cosmopolitan species, constitute isolated subpopulations that are at risk of extinction in the Mediterranean and therefore are catalogued as Vulnerable or Endangered in the IUCN red list.

2.1. In-depth on bioacoustics

Cetaceans use sound in many contexts, such as in social interactions, as well as to forage and to react in dangerous situations (Monaco et al, 2016). Since the environment in which they live has determined the selection of the acoustic system as the privileged sense for underwater communication and orientation, they communicate in a wide variety of ways.

Here we explore the sound production and use in the two families of Odontocetes sighted during this study: *Delphinidae* and *Physeteridae*.

The ***Delphinidae*** family includes mammalian species in which acoustic communication is particularly developed and complex, playing a fundamental role in environmental exploration, predation and in mediating social interactions. Dolphins produce a wide variety of sounds for both echolocation and intraspecies communication purposes which can be classified into two main categories: impulsive and tonal sounds.

Impulsive sounds include echolocation clicks and burst-pulsed sounds. Clicks are short duration, highly directional and broadband sounds. These signals are used for echolocation, a sensory capacity that odontocetes share with a few other animals. The echolocation consists in the active emission of sounds and in the following one processing of return echoes to locate objects and receive detailed information on the surrounding environment (Jefferson et al., 1993). In particular, the animal manages to rebuild an "auditory image" through the interpretation of the different echo intensities, produced by a series of clicks that return to the dolphin after hitting an object. This complex system allows the elaboration of information concerning size, shape, speed, distance, direction and some of the internal structures of the objects detected underwater. Particularly, the bottlenose dolphin (*Tursiops truncatus*) emits clicks within a frequency going from 50 kHz to more than 130 kHz (Au, 1993; Parsons and Dolman, 2003) each of which lasts generally between 50 and 128 microseconds (Au, 1993). The burst pulsed sounds are series of clicks (click trains) emitted at a very high repetition rate and used with different communication purposes. They originate highly variable vocalizations usually summarized in the term "barks" which seem to be present in all dolphin species. These sounds have been associated with underwater feeding behavior. Díaz López & Shirai (2009) hypothesized that bottlenose dolphins use these sounds in intraspecies interaction during depredatory behavior on fishing nets and on aquaculture gears. As suggested in several studies, these sounds may play an important role in avoiding or in solving intraspecies competition for the resource (Defran and Pryor, 1980; Overstrom, 1983; Blomqvist et al., 2004; Díaz López & Shirai 2009). As recently pointed out by Papale et al. (2019) evidence on *Tursiops truncatus* and *Grampus griseus* strongly support the hypothesis that burst pulses have a key role during both foraging/feeding activities and in intraspecific communication (Arranz et al., 2016; Luis et al., 2016).

The second category includes **tonal sounds** that can be distinguished into “whistles” and “moans”, both considered important in intraspecies communication. Whistles are narrow-band, frequency modulated, tonal sounds. These sounds have usually most of the energy comprised between 4 e 23 kHz and a duration higher than 200 ms (Díaz López & Shirai, 2009). Based on observed spectral features, and considering the variety of sounds emitted by the different *Delphinidae* species, we defined tonal sound as “moans” when they had frequency range included approximately between 4 and 10 kHz, lasting from 200 milliseconds to about 1 second, and they were composed by several discontinuous - frequency descending tones.

Regarding the ***Physeteridae***, the sperm whale (*Physeter macrocephalus*) is the unique representative of this family in the Mediterranean. The sperm whale continuously emits impulsive sounds underwater to acoustically map the surrounding environment, to search for food and to communicate with conspecifics. Emitted clicks have duration up to 100 ms, source levels up to 236 dB re 1µPa (RMS), frequency range to more than 30 kHz with a centroid frequency of 15 kHz (Møhl et al. 2003). Sperm whale sounds used for echolocation and predatory activity can be distinguished into three main categories: regular clicks, click trains and creaks.

Regular clicks are sounds associated with the sperm whale’s orientation and predatory activity, emitted regularly during deep dives. This category includes long click sequences, which develop in a frequency range of about 100 Hz to 20 kHz (Zimmer et al. 2005). The single signal generally lasts within 10-20 ms (Goold and Jones, 1995).

Sperm whale clicks can be easily classified by the analysis of the interval between one click and the next, the so-called Inter Click Interval (ICI). The ICI represents the time taken by the sound impulse to travel twice the distance between the sperm whale and the prey or between the sperm whale and the bottom surface. According to this scheme, after issuing the click the animal waits for the echo to return from the affected object before emitting the other click. As in other Odontocetes species, the ICI variates progressively as the sperm whale approaches the prey or the object of interest, demonstrating the close analogy with the echolocation signals of the dolphins suitable for predation. The acceleration in regular click sequences (progressive reduction in ICI value) is defined here as "**Click train**". With the term "**Creak**" we indicate the extreme acceleration of the click emission rate at the end of a click train, reaching up to 200 clicks/sec (Gordon 1987). Creaks are commonly produced by sperm whales during feeding deep dives, however they are often quite challenging to record due to their high directionality and to the fact that the animal may actively change the direction of its body as aiming to prey capture (Miller et al., 2004) and the signal may therefore be lost by a stationary hydrophone close to the surface.

CHAPTER 03

Study area

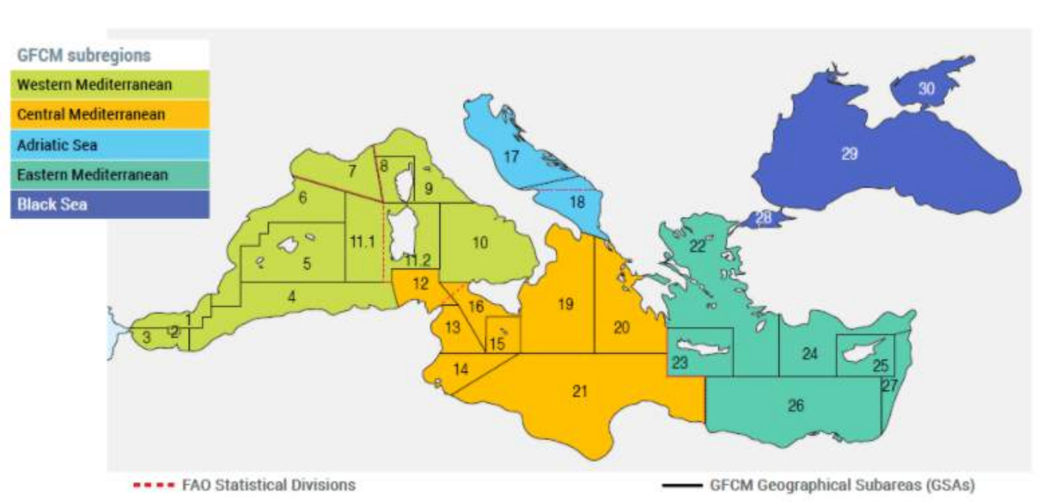
Characteristics of North-Eastern Sicily

INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN

Study Area 1:
The Case of Central Mediterranean
Sicily, Italy

Investigations of this report were located in the **Western and Central Mediterranean Sea**, in correspondence of the geographical sub-areas (GSAs) number 10 and number 19, Italy (Figure 17).

The Italian capture fisheries production was of 185 300 tonnes in 2014–2016 triennium that is 16% of total landings across the GFCM area. In economic terms, **in 2017 it generates a revenue of € 912 523 000**, of which 21% **(€ 187 716 000)** deriving from small-scale fishing activities (FAO, 2018; DG MARE, 2018).



GFCM GSAs

01 - Northern Alboran Sea	07 - Gulf of Lion	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus
02 - Alboran Island	08 - Corsica	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant
03 - Southern Alboran Sea	09 - Ligurian Sea and Northern Tyrrhenian Sea	15 - Malta	21 - Southern Ionian Sea	27 - Eastern Levant Sea
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - South of Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Islands	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic Sea	23 - Crete	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant Sea	30 - Azov Sea

Figure 17. GFCM subregions and geographical sub-areas (GSAs). Source GFCM, 2018.

Considering that **Sicily is the most representative region of the Italian small-scale fisheries fleet** and also that literature reports many cases of cetaceans-fisheries interaction in its waters (Tringali et al., 2001; Vindigni et al, 2016; Monaco et al., 2019), it has been chosen as pilot study area.

In particular, **the project investigates interaction cases of dolphins and whales with small-scale fisheries activities carried out in the Ionian Sea, closeness to the eastern coast of Sicily** (red line), **and in the southern Tyrrhenian Sea, paying attention to the Aeolian Islands area** (yellow line) (Figure 18). These zones have a high level of primary and secondary productivity despite they are subjected to a strong anthropogenic impact, among which an intense commercial and touristic marine traffic, and they include many nature reserves (e.g. the MPA "Capo Milazzo" in the North; the MPA "Isole Ciclopi" and the ONR "Foce del fiume Simeto" in the center; the AMP "Plemmirio" and the ONR "Oasi Faunistica di Vendicari" in the South), sites of community interest (e.g. "Fondali di Brucoli e Agnone" in the center) and marine areas to be enlarged or established (e.g. "Grotte di Aci Castello" in the center, and the MPA "Aeolian Islands" in the North).

The area hosts a rich marine flora and fauna, including several resident or migratory marine reptiles, sharks and seabirds. Regular species of cetaceans in these waters are common bottlenose dolphins, striped dolphin, Risso's dolphin, short-beaked common dolphin, pilot whale, Cuvier's beaked whale, sperm whale and fin whale (Monaco et al., 2016).

Seven focal zones for data collection have been selected based on peculiar characteristics such as the morphology of the coast, depth and type of seabed, composition of the local fleet, existing influences, and degree of isolation from other fleets (Table 3). From zone 4 to zone 6 is included the heterogeneous area of the **Gulf of Catania in which fall the 300 km2 range of action of the floating laboratories' fleet of the project** (white rectangle in Figure 18).

Figure 18. The study area: North (yellow) – Eastern (red) Sicily. Our elaboration.

Focal zones	Characteristics
1) Salina – Lipari	Aeolian islands, pelagic fauna, touristic impact
2) Patti – Ganzirri	Strait of Messina, ancient small fishing villages
3) Giardini Naxos – Riposto	Fishing fleet drastically reduced
4) Capo Mulini – Aci Castello	Marine Protected Area, volcanic origin, deep waters (Gulf of Catania)
5) Ognina – Catania	Sandy bottom, shallow waters, intense marine traffic (Gulf of Catania)
6) Brucoli, Siracusa	Calcareous and muddy bottom, deep waters (Gulf of Catania)
7) Portopalo di Capo Passero	Far South, strong interference of trawlers

Table 3. Focal zones of the study area. Our elaboration.

The **Sicilian fishing fleet, strongly characterized by traditional and multipurpose *métiers***, it is dangerously exposed to the phenomena of climate change and overfishing because of which fish resources and so catches are decreasing. Fluctuations in the abundance and distribution of fish stocks are the first factors to induce cetacean populations to vary their home range in relation to the availability of resources. This could cause an increasing of the cases of interference with fishing activities, especially with the small-scale one which is already threatened by a high rate of cetacean-fisheries interaction in Sicily, and that requires the use of new urgent mitigation actions, as well as the implementation of strategies aimed at reducing losses due to this type of conflicts (Tringali et al., 2001; Tringali et al., 2005; Tringali et al., 2009; Lapiccirella et al., 2018; Monaco et al., 2019).

Previous studies demonstrated the persistence of conflicts between cetaceans and fisheries in the island and tested the feasibility and efficacy of using pingers to reduce dolphin depredation, especially made by bottlenose dolphin, on trammels and gillnets from the Archipelago of Egadi Islands (ICRAM, 2001; Buscaino et al., 2009; Maccarrone et al., 2014; Gönener and Özsandıkçı, 2017) to that of the Aeolian Islands (Blasi et al., 2015). Interaction with trawlers and acquaculture cages was documented in Lampedusa (Pace et al., 1999; Pulcini et al., 2004; Celoni et al., 2006). Pinger were tested also in South-Western Sicily and in the Gulf of Catania (ICRAM, 2001; Bellante et al., 2007) where moreover also conflicts with striped dolphins and Risso's dolphins are mentioned (Tringali et al., 2001; Lapiccirella et al., 2018; Monaco et al., 2019).

Since **these studies have not led to a mitigation of the problem**, occasionally, fishers take retaliatory measures against dolphins like using blackpowder fireworks or homemade bombs to scare dolphins away from their nets, or feeding them with fish containing needles, nails or poison, especially in periods characterized by a high concentration of conflicts (Tringali et al., 2001; di Sciara, 2002).

Consulting the GeoCetus database of the Cetacean Studies Center (https://geocetus.spaziogis.it/), and the Stranding Data Bank of the Italian Ministry of the Environment, about **200 strandings are officially reported along the Italian coast each year, of which about 46% happen in Sicily**. The bottlenose dolphin and the striped dolphin are the most involved species (39% each). Furthermore, in **29% of total cases, the hypothesized cause of death was that of anthropogenic origin**, above all the interaction with activities linked to fishing. However, in some cases, the specimens may have pre-existing pathologies that can predispose them to come into contact with humans and their gears (di Sciara, 2002; Di Lorenzo et al., 2013; Casalone et al., 2016; Pavan and Podestà, 2019). In case of interaction, the cause of death could be due to by-catch events, bullet wounds or attacks made with harpoons (Figure 19).

Figure 19. Striped dolphin stranded in Brucoli, East Sicily, in January 2020. The lesion is compatible with an object with the cutting end similar to the harpoon type. Source MareCamp.

3.1. The Sicilian Fishing Fleet

Analyzing the available regional data, the Italian annual report provided in accordance with Article 22 of Regulation (EU) No 1380/2013, and the European Fleet Register, the entire **National fishing fleet is composed by 12 060 vessels of which 23% belongs to Sicily**. Considering only the boats from 0 to 12 meters of length, we count 8 658 units in Italy, of which 1 922 are registered in the Sicilian region. Further restricting the scope to vessels with non-towed gears, **the Italian small-scale fishing fleet amount to 8 086 vessels of which 23% registered in the Sicilian Maritime Departments** (Figure 20; Figure 21).

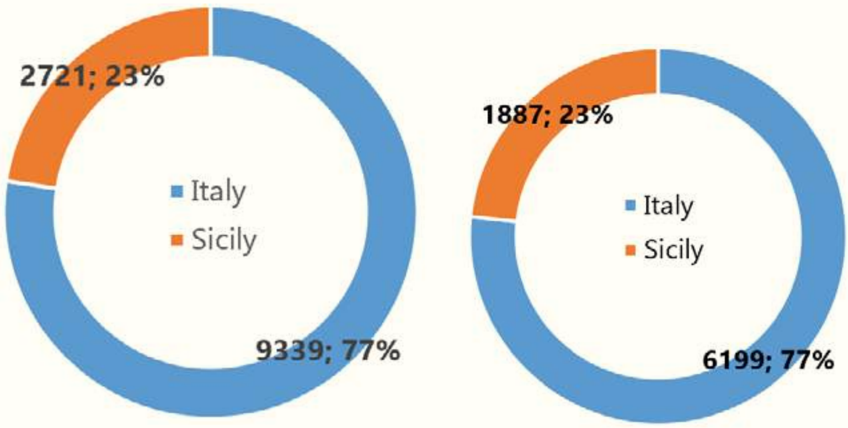


Figure 20. Number of vessels and percentages of the Italian and the Sicilian total fleets (A) and small-scale fleets (B) entered in the Fisheries License Register 2017-2018 of the EC, updated to 31 December 2018. Our elaboration of data available on https://webgate.ec.europa.eu/fleet-europa/index_en.

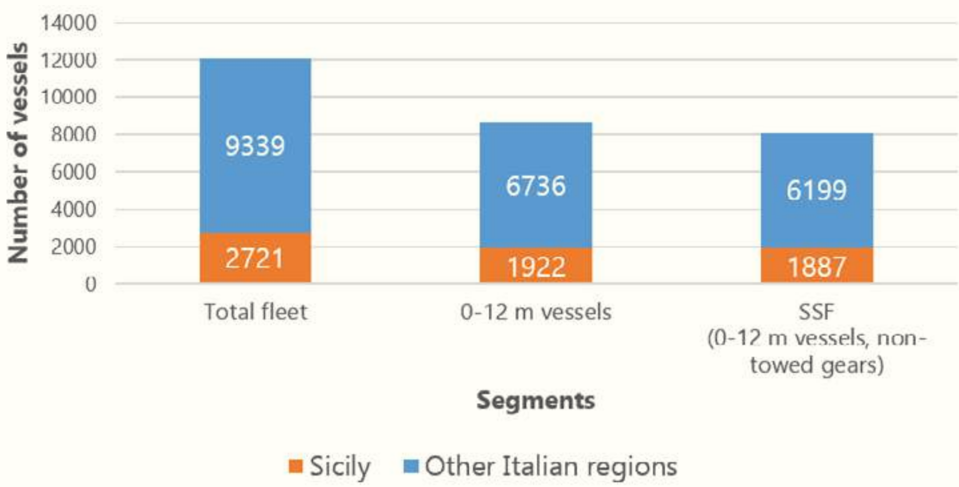


Figure 21. Italian and Sicilian fishing fleets grouped per segments and number of vessels entered in the Fisheries License Register 2017-2018 of the EC, updated to 31 December 2018. Our elaboration of data available on https://webgate.ec.europa.eu/fleet-europa/index_en.

Due to the crisis of the sector and to the European cessation plan, **a fleet capacity decrease was recorded in the last decade, both in terms of GT and engine power**. Compared with 2008, it emerges that the number of vessels decreased by 12.07% (-1 651), GT fell by 25.56% (-50 179) while engine power declined by 19.04% (-218 846 kW) (Figure 22).

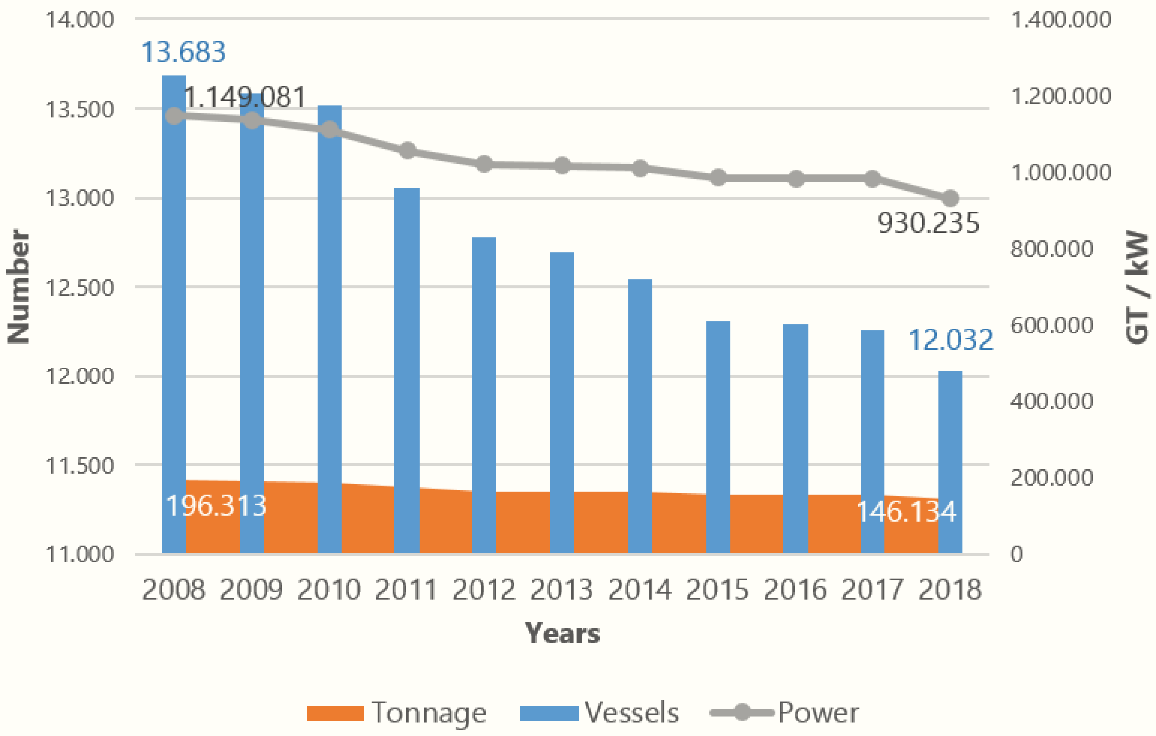


Figure 22. Trend of the Italian fishing fleet in the decade 2008-2018 per number of vessels, tonnage (GT) and power (kW). Our elaboration of data of the Italian annual reports and the EU Fleet Register 2017-2018.

The same negative trend can be observed in the Sicilian fleet where, from 2008 to 2018, the number of vessels decreased by 15.90% (-513), GT fell by 28.94% (-18 295) while engine power declined by 19.66% (-54 897 kW) (Figure 23).

Today's average values of the entire Sicilian fishing fleet indicate the predominance of vessels of 10.54 meters of Length Overall (LOA) (Min 3.50; Max 44.15), with 16.54 Gross Tonnage (GT) (Min 1; Max 665), and 82.74 kW of power of the main engine (Min 0; Max 1 472) (Figure 24). Looking at the Sicilian small-scale fishing segment, the average of the values decreases respectively to 7.18 LOA (Min 3.50; Max 12), 1.96 GT (Min 1; Max 13), and 23.21 kW (Min 0; Max 368) (figure 23), for a total of 3 702 GT and 43 791 kW as compared to the overall fleet which counts 45 013 GT and 225 135 kW (Figure 25).

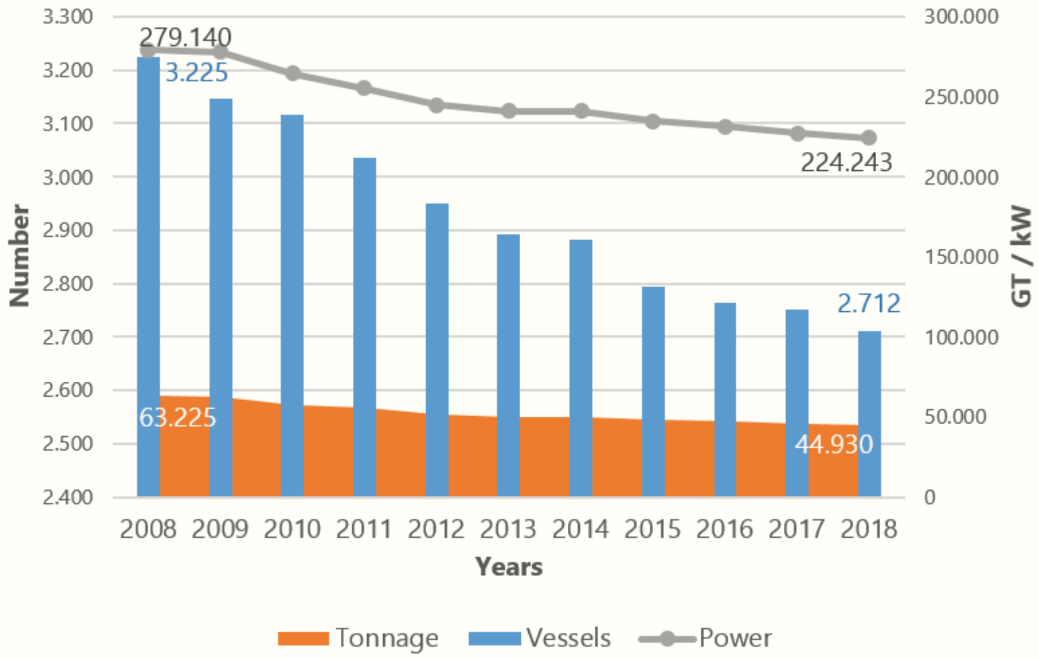


Figure 23. Trend of the Sicilian fishing fleet in the decade 2008-2018 per number of vessels, tonnage (GT) and power (kW). Our elaboration of data of the Italian annual reports and the EU Fleet Register 2017-2018.

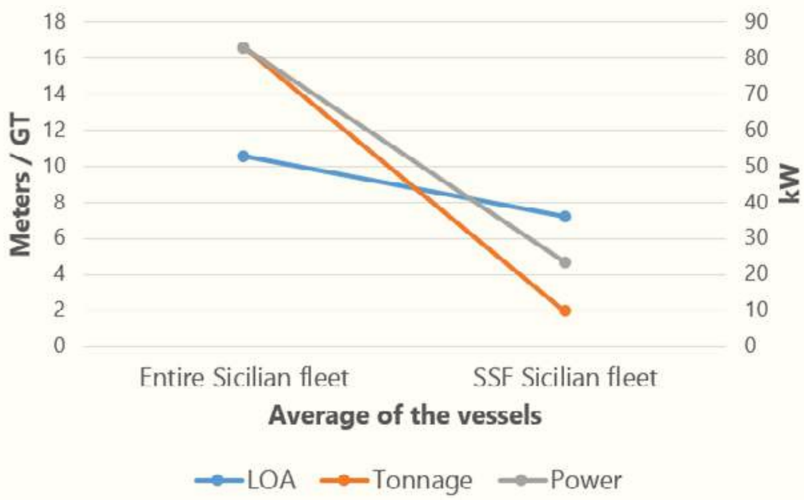


Figure 24. Average value of the Sicilian fishing fleet in terms of Length Overall (LOA), Gross Tonnage (GT) and power of the main engine (kW). Our elaboration of data of the EU Fleet Register 2017-2018, updated to 31 December 2018.

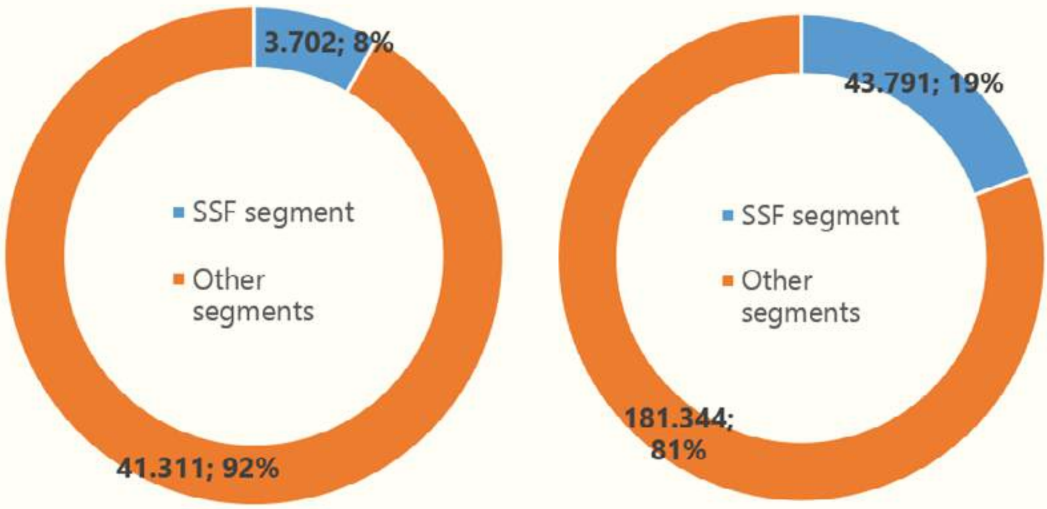


Figure 25. Overall tonnage (GT) (A) and power (kW) (B) of the Sicilian fleet grouped per small--scale fishing segment and other fishing segments. Our elaboration of data of the EU Fleet Register 2017-2018, updated to 31 December 2018.

The reconstruction of the marketing circuit of the fresh caught product coming from the practice of small-scale fishing in Sicily, shows that the **smaller fleets are oriented towards a local market, through direct sales or to the restaurants.** Instead, fishers belonging to more conspicuous fleets use more complex distribution circuits, where there is a consistent presence of wholesalers and intermediaries.

The species caught in the sea during fishing trips are almost all marketed as fresh product. Only a small percentage (anchovies and bluefin tuna) is used in the processing activity.

The shortest path of the fresh seafood from the SSF follows a short distribution circuit, in which the product is sold directly on the quay, establishing a direct relationship between fisherman and consumer or, in the same way, at open-air fish markets where the fisherman has a sale banquet (Figure 26). The sale on the quay is however little practiced due to the lack of suitable port infrastructures.

Looking at the discontinuous line mark of the schema in the Annex 2, the same fisher can process the catch (e.g. preparations in oil or in salt) and then resell this through direct selling, without intermediaries.

According to the same schema, following a longer path, the fisherman can also sell the catch to the restaurateurs, while a more intertwined one includes the presence of figures such as wholesalers and retailers. Important is also the function of the fish markets, where the product arrives through wholesalers and then is resold to other intermediaries, in this case seafood sale price changes based on the different types of market. In Annex 3 and Annex 4 the minimum and maximum sales prices €/kg are reported for two markets ("Pescheria") in the city of Catania, respectively in Catania center and in Aci Trezza.

Figure 26. Fishers of the Gulf of Catania during selling onboard their vessels, at the dock, or at the near open-air historical fish market. Source LIFE.

Considering previous Table 1, **the Sicilian SSF fleet include the P-05, P-06, P-09, P-10, L-01 segments, with a prevalence of the "Small-scale vessels with engine using passive gears"** vessel group that uses a lot of different fishing gears of artisanal nature.

Below we describe the most recurring fishing gears and *métiers* in our investigation. More specifics of these gears are summarized in the Annex 13.

1) Trammel net. Its Italian name is **"Tramaglio" or "Tremaglio"**, it is a **gillnet that can have different mesh sizes** which are chosen by the fisher according to season and target species, consisting of **three layers of netting** with a small slack mesh inner netting between two layers of large mesh netting within which fish entangle (Figure 27). The net is kept vertical by floats on the headrope and by weights on the ground rope. It is typically employed as **stationary gear at, or near to, the sea bottom**, and fishermen haul it back by hand with the use of a hauler. Depending on the species to be caught, the mesh size varies from 6 to 12 cm and the net is left fixed in the sea for a few minutes (e.g. for mullet), or from sunset to sunrise (for most of the species), or even 2 days (in the case for targeting lobster). Among the main target species there are scorpion fishes, striped red mullets, cuttlefish, and common spiny lobster (Battaglia et al., 2010; Monaco et al., 2019).

2) Artisanal longline (hooks and lines). Named also **"Palangaro" or "Palamito" or "Conzo"**, it is composed by **connected lines, either set at the bottom or drifting, bearing hundreds baited hooks** which remain underwater from 2 hours to 2 days (Figure 28). The hooks can be of different sizes, depending on the target species of the season, generally with a diameter from 1 to 3 cm, a thickness of 1.5-2.5 mm, and various lengths of the stem. Lures (natural or artificial baits) placed on the hooks fixed to the end of a line, attract the fish which get caught and held by the mouth until they are hauled aboard the vessel by hand with the help of a hauler. Its main target species are porgies, European hake, blackspot seabream, common dolphinfish, little tunny (Battaglia et al., 2010; Monaco et al., 2019).

Figure 27. A trammel net in which are visible its three layers of different mesh size. Source LIFE.

Figure 28. An artisanal Palangaro (longline) ready to be baited. Source LIFE.

3) "Menaida" or "Menaide". It is a **traditional gillnet used in the Gulf of Catania** which has a centuries-long history and still survives in very small niche. Its mesh size is adapted to **capture exclusively the European anchovy or the sardine** depending on the season (0.5 – 1.4 cm). **It is deployed vertically in the water, near the surface or in midwater, like a wall of about 10 meters** made by a string of single nylon netting in which fish will gill, **drifting at the depth where the fishers identifies well enough dense anchovies schools** (detection that occurs by experience, with depth sounder, visually, etc.). It is held by a series of floats on the upper line (headrope), and corks (5 for each meter) and weights on the ground-line (footrope) that are regulated each time basing on the depth at which thee is the fish school. Fishes, trying to pass through the net, are caught by their gills operculum in the net webbing and, trying to escape, loose a lot of blood, resulting a product more sweet and dainty. After about 1 hour underwater, the net is brought on board by hand with a net hauler while other **fishers free anchovies one by one, widening the mesh by means of a runner** at the stern of the vessel (Figure 29) (Monaco et al., 2019). These specific operations mean that fishing with menaida requires the presence of several fishermen on board (4-6) who coordinate themselves in the various phases of the fishing set.

Despite the small size of its mesh, the method in which this net is used makes it a highly selective gear capable of capturing a single target species, otherwise it remains empty.

Figure 29. Anchovies fishing with the "Menaida" in the Gulf of Catania. Source LIFE.

4) Single wall. It is a **single-layered gill net made of monofilament fibers** to keep the visibility of the gear low. There are several variations with **different mesh sizes depending on the fishing target. This net is employed as stationary gear at, or near to, the sea bottom**, and fishermen haul it back by hand with the use of a hauler. Fish that do not apparently see the gear, remain trapped under their gill cover (or operculum) or appendages. Main target species are bogue, cod, saddled, seabream, picarels (Battaglia et al., 2010). A common single wall used is the **"Monofilo" net** (Figure 30), but different variants exist such as the **"Palermitana", the "Paurara" or the "Peloseta".**

Figure 30. Hake fishing with the "Monofilo" (a single wall net) in the Gulf of Catania. Source LIFE.

5) "Totanara". It is a **gear for squids included among the *métiers* that require the use of lines and gillnets**, being composed of a line at the end of which there is a bait with several hooked arms that can be baited (Figure 31). The gear is set and haul from the vessel with an electric winch to reach the greatest depths where a light source is activated to attract the flying squid which is its unique target species (figure 30).

No more than 3 lines are used simultaneously, each one with a single totanara (IT Dec. No. 22759 of 24 November 2017). The gear can catch only one squid at a time, which is why the **fisherman repeats the set several times during the night**, that is the typical preferred moment, even if recently some-one has started to use it during the daylight too.

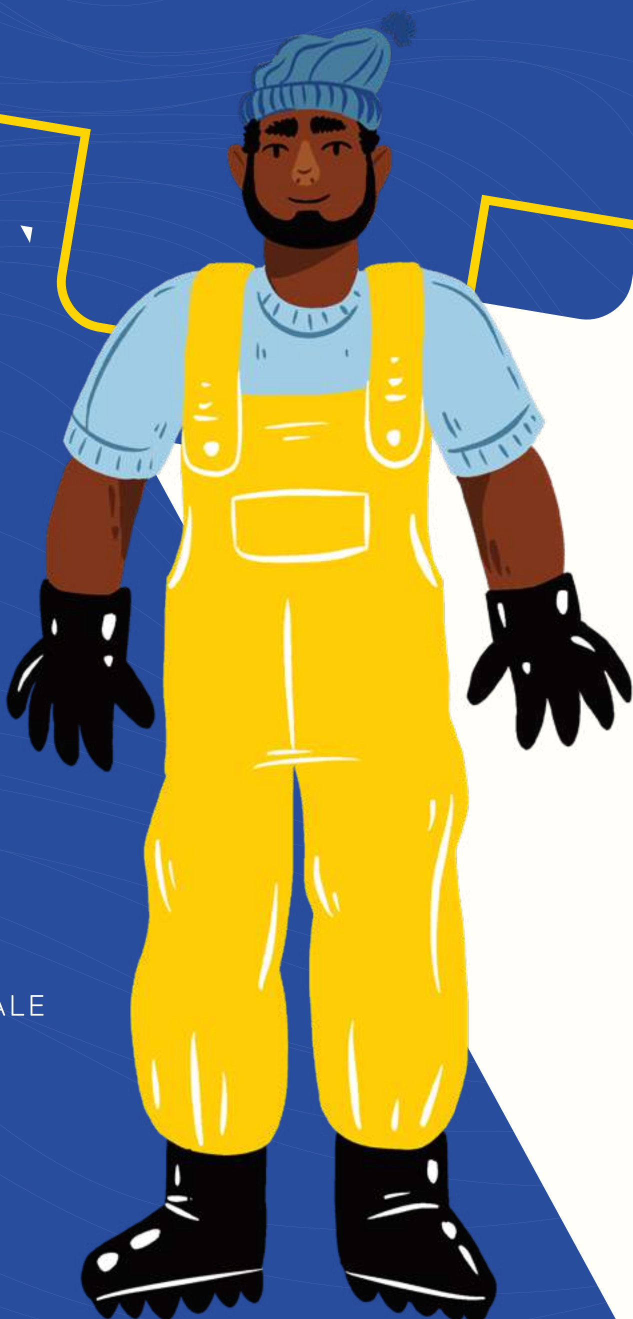
Figure 31. The totanara used in the Gulf of Catania for the flying squid fishing (A), and a fisherman using an electric winch to haul the gear (B). Source LIFE.

6) "Sciabichedda". Named also "**Sciabicheddu**", it is a **boat seine of about 50 m of length and 4 m of height, used like an encircling net**. It is composed by nylon and ropes and it is very poorly ballasted to avoid the collection of mate-rial from the bottom. Used at the sunrise or sunset in areas within 1.5 NM from the coast in correspondence of canyons that go beyond 300 m of depth. The **mesh size of the central bag is about 2.5 cm with the aim to capture shrimps**. Re-duced meshes of 2-4 mm could be used for fishing the Med-iterranean sand eel (*Gymnammodytes cicerelus*). The fisher hauls the net back with the use of a hauler.

7) Pot. It is a kind of s**mall cage made in wicker, wire netting, or plastic, having only one opening**. It is usually **set on the bottom, single or in strings connected to a line, with or without bait** composed by pieces of fish, depending on the target species which can be crustaceans (i.e. lobster, crabs, shrimps) or cephalopods as octopus. The pots are hauled either by hand or with a hauler when fishing in deep waters. The soaking time may last from a few hours to more days. Its Italian name is **“Nassa”**.

CHAPTER 04

Methodologies



INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN

Study Area 1:
The Case of Central Mediterranean
Sicily, Italy

Since cooperation is a synonym of transparency and communication which can lead to more effective management and therefore create indirect benefits (Johnson & van Densen, 2007), **this pilot project was based on a cooperative and participative approach** (Delville et al., 2000), where fishers were actors in their own right in step with scientists in order to make a statement on the situation of depredation and by-catch in North-Eastern Sicily.

Given the complexity of the subject, **a multidisciplinary and systemic approach was also applied** in order to better understand the single and composite incidence of different elements that can influence the occurrence of these events. In this framework, data collection and analysis were carried out considering three main components: a) **ecological** for all that concerns the environment, the species of dolphins involved in interactions with fishing, and the target species of the fishing gears; b) **socio-economic** oriented to know the feelings of fishers and real losses in relation to the interference with the wild fauna; c) and **technical** for exploring the fishing effort and the peculiarities of the local fleet.

Investigations involved fishers and crews of vessels that comply with the criteria of fishing within 12 NM from the coast, be under 12 meters in length and use non-towed gear, and were based on specific survey sheets created to in-depth each component above. **While interviews on the ground were made at the fleet of the entire study area, sailing activities were restricted to the Gulf of Catania.**

Surveys at sea were conducted using the following equipment:

- A 7.20 m inflatable boat with a 150 cv Honda engine. In a few cases, a 12 m inflatable boat with three 250 cv engines.
- GPS Garmin eTrex 10.
- 8x40 and 7x50 binoculars.
- Photo-camera Nikon Bridge P1000.
- Video-camera Sony FDR-AX53.
- Mini Rov – PowerRay Wizard.
- Transceiver radio.
- Meterstick.
- Smartphones with the Boating HD Navionics and WhatsApp Applications.
- Compact camera.
- Action camera.

Sessions for **underwater passive acoustic** monitoring required also the following instrumentation:

- AS-1 Aquarian Scientific Hydrophone with 30 m cable, sampling frequency 192 kHz.
- PA-4 low-noise and broadband Hydrophone Preamplifier with P48 phantom power assembly.
- A/D conversion board and recorder. Behringer UMC204HD audio interface 2x4 / TASCAM DR-100MK3, with a 32 GB SD storage card.
- MIDI/USB a 24bit/192khz pre-amplifier MIDAS/phantom +48v.

Data collected during the various step of the research were after analyzed with a computer using different software depending on the information nature: Office and SPSS (Excel database, calculation and graphs); ArcGis 10.2.2 (mapping distribution and statistics); Audacity (Bioacoustics); DARWIN and FinFindR (Photo-IDentification).

Among the methodologies for population study, the **photographic identification and mark-recapture principles** were followed using the visual method of Würsig & Würsig and the computer-assisted software packages (Stanley, 1995; Thompson et al., 2019).

The Photo-ID is a non-invasive method used to identify individuals over time and space based on natural signs. It is widely recognized to be applied on **cetaceans** whose easier features to identify are notches, scares and depigmentations accumulated in the dorsal fins. To be comparable, photos of the dolphins must have a high quality and be taken as perpendicularly as possible to their body axis. Natural signs are also used to apply the mark-recapture method in order to assess population size and structure, as well as distribution and particular patterns, taking advantage of the various photographic sessions in the time as recapture events of the individuals (Hammond, 2009).

In order to find out the most affecting parameters for depredation events, the **Multiple Correspondence Analysis (MCA)** method has been applied, which allows studying the association between two or more qualitative variables (Desbois, 2008; Le Roux and Rouanet, 2010). Accordingly, a list of quantitative variables and classes has been structured and crossed examining the different sightings of cetaceans recorded during depredation (Table 4).

Fishing effort was calculated as **Catch Per Unit Effort (CPUE)** expressed in weight of the catch and time of the fishing gear deployed underwater (Hinton and Maunder, 2004), and also by multiplying the tonnage by the average fishing days according to indications on the Reg. EC 2091/1998, and compared with values on the basis of the gear length or number of hooks and the time spent in fishing, following charts provided by the FAO and adapted to SSF (Table 5; Table 6).

The online surveys on interaction cases, addressed to all the fishers belonging also to other areas and fleets in addition to those of this study, were created using Google Forms.

The field research was divided in many phases, some of which with a temporal overlap. For a better understanding, we distinguish the following main activities.

1. Face to face interviews to small-scale fishermen made by experienced samplers in the North-Eastern area of Sicily. *July-October 2019*.
2. Monitoring made by experienced observers during normal fishing activities onboard three Floating Laboratories that are small-scale fishing vessels operating in the Gulf of Catania. *August-September 2019*.
3. Monitoring carried out by scientists with the sentry boat in the Gulf of Catania. *July-October 2019*.
4. Monitoring fulfilled by the network of the Floating Laboratories composed by the sentry boat and 10 small-scale fishing vessels operating in the Gulf of Catania. *July-October 2019*.

Classes	Variables	Descriptors and their abbreviations				
		A	B	C	D	E
Environment	Time	Sunrise	Sunset	Night		
		Ss	St	Ni		
	Moon phase	New Moon	First quarter	Full Moon	Third quarter	
		Nm	Fq	Fm	Tq	
	Weather conditions	Moderate	Good	Very good	Excellent	
		Mo	G	V	E	
	Bottom type	Muddy	Mixed 1 (sand and mud)	Mixed 2 (sand and rocks)		
		Mu	Sm	Sr		
	Bottom depth	<-20 m	20-50 m	51-100 m	>-100 m	
		L	M	H	HH	
Fishing gear	Fishing system	Trammel for mullets and groundfish	Menaida fo anchovies	Single wall for codfish and groundfish	Longline for cod and small pelagics	Totanara for flying squid
		Tr	Me	Sw	Lo	To
	Gear depth	<-20 m	20-50 m	51-100 m	>100 m	
		l	m	h	hh	
	Catches quantity	0	1-10 kg	11-25 kg	26-50 kg	
		z	vL	L	g	
	Length of the net	No net	0-200 m	201-500 m	501-1000 m	1001-2000 m
		NN	sh	me	med	ln
	Proximity of other fishing boats	1 within 100 m	>1 within 100 m	1 within 101-500 m	>1 within 101-500 m	1 or more within 500-1000 m
		ff	f	fs	ss	mm
	Fishing set	0-40 minutes	41-60 minutes	120-180 minutes	>180 minutes	
		vf	fa	lt	llt	
	Gear retrieval	0-20 minutes	21-30 minutes	31-40 minutes	41-60 minutes	>60 minutes
		LLT	LT	NT	MT	MMT
	Distance from the coast	0.5-1 NM	1.1-3 NM	3.1-6 NM	>6 NM	
		ld	md	Ld	vld	
	Fishing area	North	Center	South		
		Nor	Cen	Sou		
Cetacean	Degree of residence of the dolphins in the area	Identified	Non identified			
		ID	nID			
	Herd composition	1	2	3	4-5	>6
		1	2	3	>3	>6
	Species	Bottlenose dolphin	Physeter macrocephalus	Not identified		
		Bd	Pm	NI		
Depredation	Entity of the new holes	Hauled up immediately	Many small and big	Many also very big	Destroyed	No net
		ha	ms	mb	de	Nn
	Damaged hooks and lures	Yes	No			
		y	n			
	Damaged catch	Yes	No			
		Y	N			

Table 4 Classification of the variables adapted to the case study for the Multiple Correspondence Analysis (MCA). Our elaboration.

FLEET SEGMENTS			EFFORT MEASUREMENTS		
Vessel groups		Length classes (LOA)	Unit of capacity	Unit of activity	Nominal effort
P	Small-scale vessels without engine using passive gears Small-scale vessels with engine using passive gears Polyvalent vessels	All	Net length[1]	Fishing days	Net length x Fishing days
			Number of traps/pots[1]	Fishing days	Number of traps/pots x Fishing days
			Number of lines[1]	Fishing days	Number of lines x Fishing days
S	Purse seiners Tuna seiners	All	GT	Number of fishing sets[2]	GT x Number of fishing sets
D	Dredgers	All	GT	Fishing days	GT x Fishing days
T	Beam trawlers Pelagic trawlers Trawlers	All	GT	Fishing days	GT x Fishing days
L	Longliners	All	Number of hooks[1]	Fishing days	Number of hooks x Fishing days

Table 5. Fishing effort measurement by fleet segment. Source FAO.

Fishing gear		Gear code	Unit of capacity	Unit of activity	Nominal effort
Surrounding Nets	With purse lines (purse seines)	PS	GT	Number of fishing sets[1]	GT x Number of fishing sets
	One boat operated purse seines	PS1			
	Two boats operated purse seines	PS2			
	Without purse lines (lampara)	LA			
Seine nets	Beach seines	SB	Net length[2]	Fishing days	Net length x Fishing days
	Boat or vessel seines	SV			
	Danish seines	SDN			
	Scottish seines	SSC			
	Pair seines	SPR			
	Seine nets (not specified)	SX			
Trawls	Bottom trawls	TB	GT	Fishing days	GT x Fishing days
	Bottom beam trawls	TBB			
	Bottom otter trawls	OTB			
	Bottom pair trawls	PTB			
	Bottom nephrops trawls	TBN			
	Bottom shrimp trawls	TBS			
	Midwater trawls	TM			
	Midwater otter trawls	OTM			
	Midwater pair trawls	PTM			
	Midwater shrimp trawls	TMS			
	Otter twin trawls	OTT			
	Otter trawls (not specified)	OT			
	Pair trawls (not specified)	PT			
	Other trawls (not specified)	TX			
Dredges	Boat dredges	DRB	GT	Fishing days	GT x Fishing days
	Mechanised dredges	HMD			
	Hand dredges	DRH			
Gillnets and Entangling Nets	Set gillnets (anchored)	GNS	Net length[2]	Fishing days	Net length x Fishing days
	Driftnets	GND			
	Encircling gillnets	GNC			
	Fixed gillnets (on stakes)	GNF			
	Trammel nets	GTR			
	Combined gillnets-trammel nets	GTN			
	Gillnets and entantling nets (not specified)	GEN			
	Gillnets (not specified)	GN			
Traps	Stationary uncovered pound nets	FPN	Number of traps/pots[2]	Fishing days	Number of traps/pots x Fishing days
	Pots	FPO			
	Fyke nets	FYK			
	Stow nets	FSN			
	Barrier, fences, weirs, etc	FWR			
	Aerial traps	FAR			
	Traps (not specified)	FIX			
Hooks and Lines	Handlines and pole-lines (hand operated)	LHP	Number of lines[2]	Fishing days	Number of lines x Fishing days
	Handlines and pole-lines (mechanised)	LHM			
	Trolling lines	LTL			
	Set longlines	LLS	Number of hooks[2]	Fishing days	Number of hooks x Fishing days
	Drifting longlines	LLD			
	Longlines (not specified)	LL			
	Hooks and lines (not specified)	LX			

Table 6. Fishing effort measurement by fishing gear. Source FAO.

Surveys at sea have been preceded by a territorial survey in order to select fishing vessels to be involved in the Floating Laboratories network. The selection followed these steps:

- Consultation of the local Port Authorities registers and the EU Fishing Fleet register to choose a stratified sample of active vessels belonging to small-scale fisheries operating in the coastal waters of the Gulf of Catania.
- Meetings with fishermen to inform them about the project, verify their availability and subscribe an agreement for ensuring the mutual collaboration with the observers and the coordinator.

As summarized in the Table 7, final **Floating Laboratories are homogeneously distributed in the North-Center-South sections of the Gulf of Catania**, respectively having as base port Aci Trezza, Catania and Brucoli. Each Floating Laboratory represents one or more specific fishing gears among the tremaglio (trammel net), the menaida (drifting gillnet), the monofilo (single wall type net), the palangaro (longlines), and the totanara (gear for squids).

Section	Code	Harbour	Main fishing gear
North	1	Aci Trezza	Tremaglio (trammel net), totanara (gear for squids)
	2	Aci Trezza	Palangaro (longlines)
Center	3	Catania	Menaida (drifting single wall gillnet)
	4	Catania	Menaida (drifting single wall gillnet)
	5	Catania	Menaida (drifting single wall gillnet)
	6	Catania	Menaida (drifting single wall gillnet)
South	7	Brucoli	Monofilo (entangling single wall gillnet)
	8	Brucoli	Tremaglio (trammel net), monofilo (single wall net)
	9	Brucoli	Tremaglio (trammel net), monofilo (single wall net), palangaro (longlines)
	10	Brucoli	Tremaglio (trammel net), monofilo (single wall net)

Table 7. Fishing vessels selected as Floating Laboratories in the Gulf of Catania. Numbers in blue indicates vessels having observers onboard.

All the protocols, survey sheets, and databases used for the collection and analysis of data have been reviewed and shared with an international group of experts, belonging to the various partners of the project, in order to facilitate their standardization and replication in other areas.

The main characteristics of the four main investigative activities are summarized below.

Face to face interviews

The study implied interviews with fishermen conducted by experienced samplers, based on a **structured questionnaire including closed-ended and open-ended questions** (Coll, 2014) about interaction cases. Since personal interviewing is thought to create more confidence between interviewer and respondents, and ensure a better quality of recorded data (White et al., 2005), these surveys were conducted face-to-face. Moreover, according to Goetz (2014), timing of interviewing was adjusted to the seasonal and daily routine of the fisheries sampled in order to maximize the number of interviews for each sampling day.

As suggested by Moore et al. (2010), the interviews started explaining the purpose of the project and assuring the confidentiality of the information provided. Question and answer choices were simple, straightforward, worded unambiguously and took between 30-90 minutes depending on the availability and the talkativeness of the fisher.

Data about technical characteristics of the fishing fleet, catches, incidence of interaction with cetaceans, types of damage in case of depredation, losses and costs incurred, mitigation measures employed, etc. were collected on basis of the questionnaire in Annex 5. When the interviewee talked about aspects of his profession not covered in the questionnaire, he was not interrupted and the sampler continued to take notes, so the order of the questions could vary in favor of a more colloquial interview. Interviewed fishers have been informed about the possibility to report the details of future interaction cases also filling in the additional permanent on-line survey.

The protocol used to choose and stratify the sample of fishers to be involved in the face to face interviews is explained in Annex 6.

Observation on the Floating Laboratories

Since the most accepted method to quantify catches and by-catch rates requires the **involvement of independent observers on board fishing vessels** (Moore, 2010), three samplers, each one on-board a small-scale fishing vessel selected as Floating Laboratory , investigate the fishing effort, damages of depredation and by-catch events observing fishing activities, recording the start/end time of gear setting/retrieval, assessing the integrity of the gears before their use and measure eventual following damages with a meterstick. Data on track, fishing area, number and duration of fishing trips, catch characteristics, etc. were also collected filling in a specific survey (Annex 7). The damage estimate was mainly based on the count of the holes in the nets, and on the classification of their size in small (0-30 cm), medium (31-80 cm), big (81-120 cm), and very big (> 120 cm).

Observation on the sentry boat

Monitoring with the **inflatable boat used as sentinel**, sailing in the Gulf of Catania while the ten fishermen of the Floating Laboratories network were doing their normal fishing activities, was addressed to provide documentary evidence of the possible conflicts or by-catch events involving vulnerable species, and in general of the work of the local small-scale fleet with video-photographic material. Observations aimed at understanding the peculiarities, strengths, weaknesses and internal management modalities of the fleet and the different existing *métiers*, and how they are impacted and respond to interaction with cetaceans. Recordings of the depredation cases had the objective to interpret the movements of the dolphins, the reason why they apply an opportunistic behavior and the dynamics that define their actions towards the fishing gears. Environmental and bioacoustical data were also collected in order to find any existing relation between more parameters during sightings.

The importance of the Floating Laboratories network lies in the fact that the **sentry boat benefits from real-time communication with the ten fishing vessels**, ready to alert researchers if they spot dolphins or if these interact with their equipment. In this way, the probability of being able to document the events of depredation increases and therefore also that of understanding how to mitigate them.

Generally, telephone or radio communications started at 4:00 a.m. to give information about the position of the fishing set, and finished by 10:00 a.m. when surveys and fishing trips took end, except for the occasions in which surveys were carried out completely in the evening hours (7:00 p.m. – 00:00 a.m.) to follow the fishing with the totanara (gear for squids).

Observers onboard the sentry boat had to compile different **survey charts** depending on the events to sign:

1. An observation survey during the entire monitoring (Annex 8)
2. A sighting survey in case of presence of cetaceans (Annex 9)
3. An interaction survey in case of cetaceans observed near a fishing gears (Annex 10)

The **monitoring protocol** requires that sea activities have performed always respecting the following conditions.

- Before starting the official research activities, make one or more test surveys at sea.
- Each fisherman is able to communicate with the observers of the sentry boat by at least one method between radio and phone.
- Good sea state (value ≤ 2 of the Douglas scale) and good visibility settings.
- At least two observers and one skipper on-board the sentry boat.
- At least one technician able to perform underwater passive acoustic monitoring on-board the sentry boat when doing bioacoustics sampling.
- At least one technician able to pilot the underwater drone on-board the sentry boat.
- The sentry boat is large enough to accommodate all the samplers and their instrumentation.
- The sentry boat cruising speed going from a fishing vessel to another is low (≤ 6 knots), decreasing when approaching it during catch activity. It can accelerate to a high speed when receiving a real-time warning on interaction by a fishing vessel out of sight in order to reach it as soon as possible.
- The entire route of the sentry boat is automatically recorded through a GPS or a smartphone running the Boating HD App in order to be able to download waypoints and tracks for the next analyses.
- Samplers of the sentry boat collect data on naval traffic, fishing activities, weather changes, sightings of cetaceans and other marine wildlife, and interaction events regularly, completing the specific observation sheets.
- When observing cases of interaction between cetaceans and fisheries, the samplers of the sentry boat activate all their recording devices in proximity of the interaction scene, without disturbing fishing activities. During the observation of the interaction, the motor of the sentry boat is stopped or used only for little movements necessary for recording data and to apply correct maneuvers at sea.

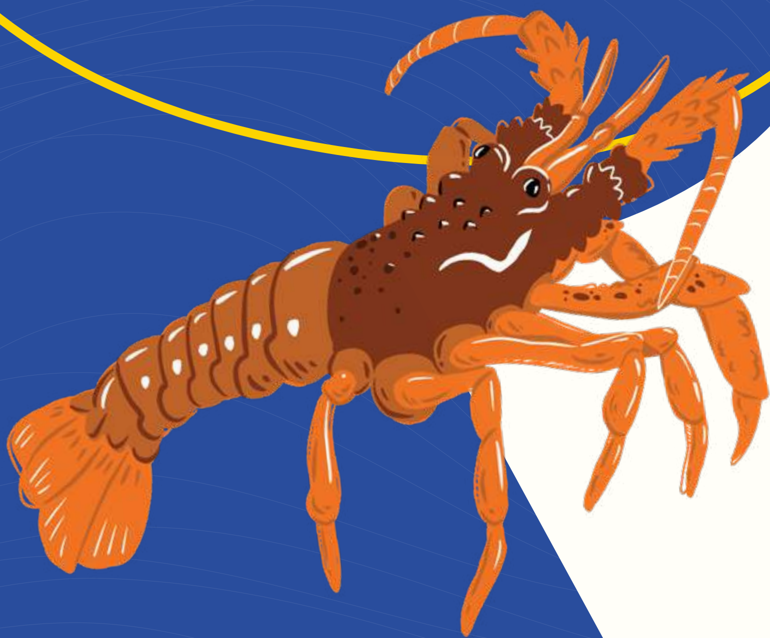
Acoustic monitoring activities were performed by recording sounds from cetacean species engaged in predatory and depredatory behavior on fishing nets. The protocol for acoustic data acquisition consisted in the use of a hydrophone deployed at a depth of about 6 m, and of the related acquisition chain composed by preamplifier – AD/c board – portable recorder in fixed configuration mode. During each sighting, the recording session started shortly after the photo-identification of the animals, in order to initially assess the presence and to visually confirm the species sighted. Acoustic (.wav) files were recorded continuously at sampling frequency of 192 kHz. In order to assess the presence of the animals during fishing operations, recordings were acquired whenever the boat stopped in proximity of the different fishing vessels and the acoustic acquisition continued for the entire duration of the sighting and of the fishing operations. During each event, **recordings were monitored in real time by the operator on board the research sentry boat,** by using headphones connected to the digital recorder. This procedure allowed the instantaneous verification of the animal presence when they were engaged in underwater activities such as predation on fishing nets or they were swimming in proximity to the fishing vessels and gears.

Other information from the Floating Laboratories network

The fishermen had the task of compiling daily a register (Annex 11) in which to write general information about their fishing trip (i.e. date, time, number of operators on board) and, for each fishing set, data on times, type of gear used and its location, species and quantities of catches, presence and number of dolphins, and any damage suffered or by-catch events.

CHAPTER 05

Analysis and results



INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN

Study Area 1:
The Case of Central Mediterranean
Sicily, Italy

Before to process the research data, **about 1 000 paper surveys were manually converted in 12 digital thematic databases containing over 160 000 records**, in order to organize and prepare the datasets for the following analysis. Also, new databases have been created and GPS routes has been converted to be uploaded in a GIS environment as well.

Face to face interviews happened in all the seven focal zones of the study area (Figure 18, chap. 5) involving 10 fishers in the North part and 20 in the Eastern, representing 7% of the total small-scale fisheries active in the area (Table 8), having 6 main recurring fishing licenses from North to South: longlines (27%), single wall nets (27%), trammels (21%), pots (11%); encircling nets (8%), and gears for squids (6%) (Figure 32).

	No. of vessels	Sample %
North-Eastern SSF fleet in the Sicilian registers	780	3,8
Operative SSF fleet in the study area	420	7,14

Table 8. Structure of the sample of interviewed in North-Eastern Sicily per number of vessels rate. Our elaboration.

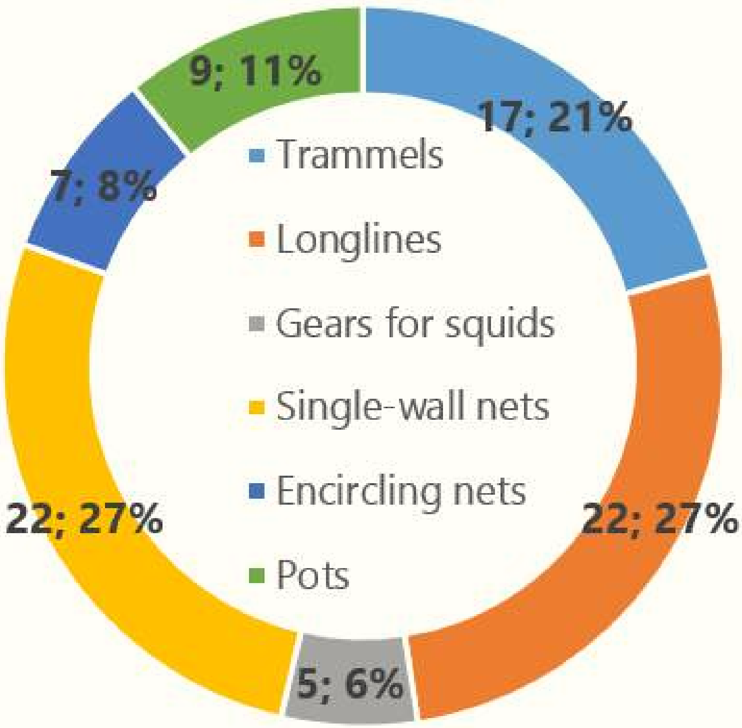


Figure 32. Structure of the sample of interviewed in North-Eastern Sicily per number and type of fishing gear. Our elaboration.

Looking only at the sample of the East zone, each fishing vessel have a minimum of 4 and a maximum of 12 licenses, with an average of 5.5 licenses per boat (Figure 33) where the presence of set longlines and gillnets prevails, followed by driftnets like the menaida gear, trammels and other gears of minoritary use (harpoon, fyke nets, etc.) (Figure 34). However, **a minor use of polyvalence must be considered as each fishing vessel uses less than half of the gears for which it is authorized.**

The total time spent at sea for the project amounts at 1 721 hours, covering over 6 000 Nautical Miles (NM) and 395 fishing sets (Table 9). In particular, observation effort accomplished by samplers on-board the three Floating Laboratories includes 45 surveys for more than 150 sailing hours and 431 NM (Table 10). Incomplete paper forms were not considered for the analysis.

Surveys carried out by the sentry boat while the ten Floating Laboratories were fishing are 37 and covered over 1 000 NM during 182 hours of observation (Figure 35). Interesting is to note that while the fleets in the North and in the South part of the Gulf of Catania exploit nearby areas, fishers of Catania (central zone) act in the whole Gulf, making also long displacements even if remaining close to the coast and so covering distances four times longer (Annex 12).

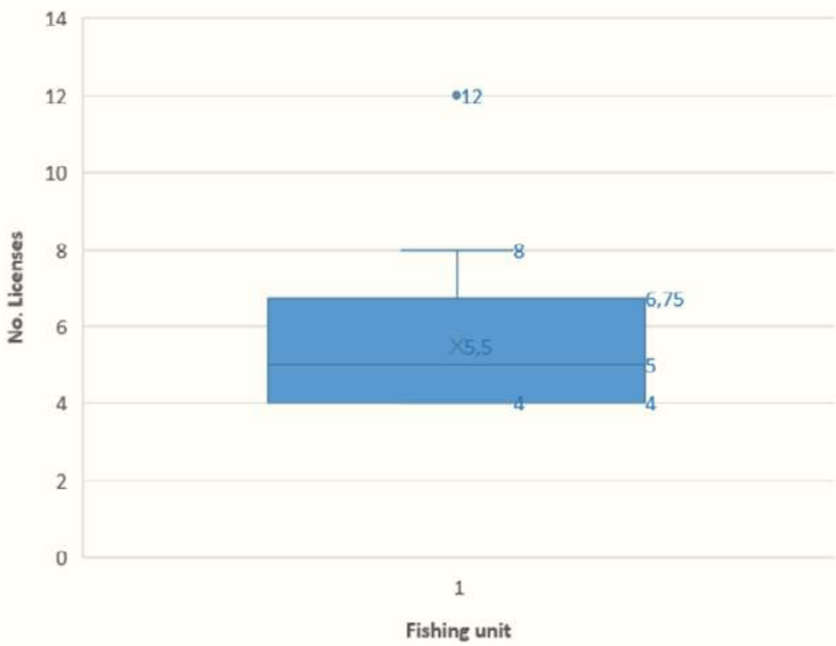


Figure 33. Statistics of the number of licenses owned per fishing vessel of the sample belonging to the SSF fleet in East Sicily. Our elaboration.

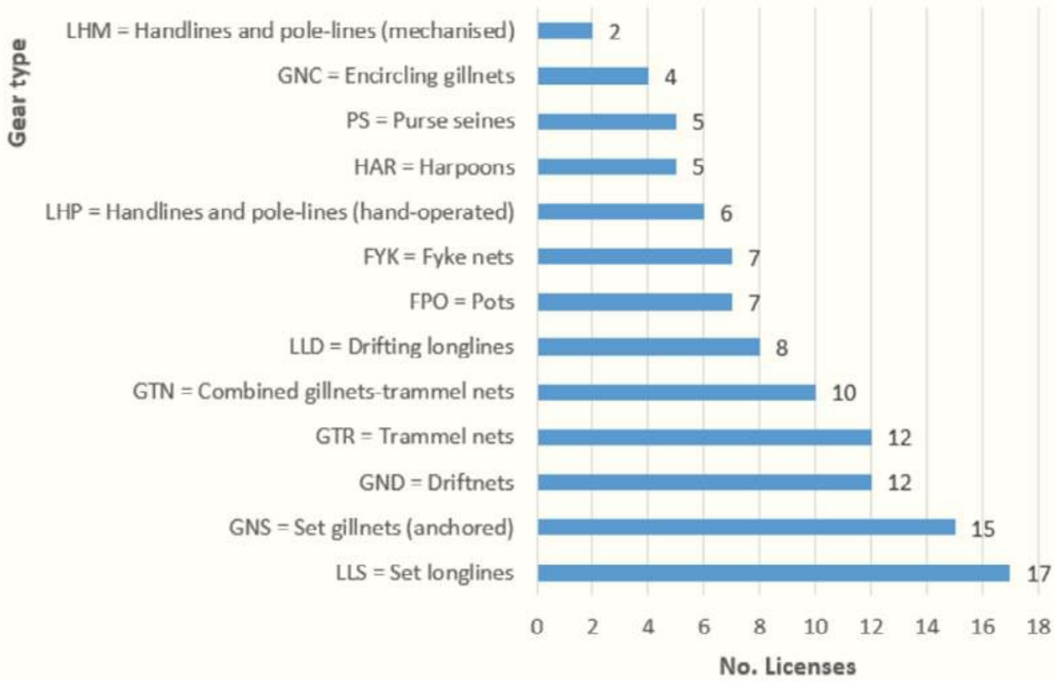


Figure 34. Statistics of the number of licenses per gear type owned by the sample belonging to the SSF fleet in East Sicily. Our elaboration.

	FLs with observers	FLs solo	Sentry boat
Hours	152	1 387	182
Nautical miles	431	4 192	1 400

Table 9. Specifics of the observation effort made by the network of the Floating Laboratories (FLs) programme. Our elaboration.

	FL 1	FL 2	FL 3
Tot.	51.09	228.86	151.27
μ	3.45	15.26	10.09
σ	1.12	7.68	2.95

Table 10. Nautical miles covered by the three observers on-board the three Floating Laboratories (FLs) in the Gulf of Catania. Our elaboration.

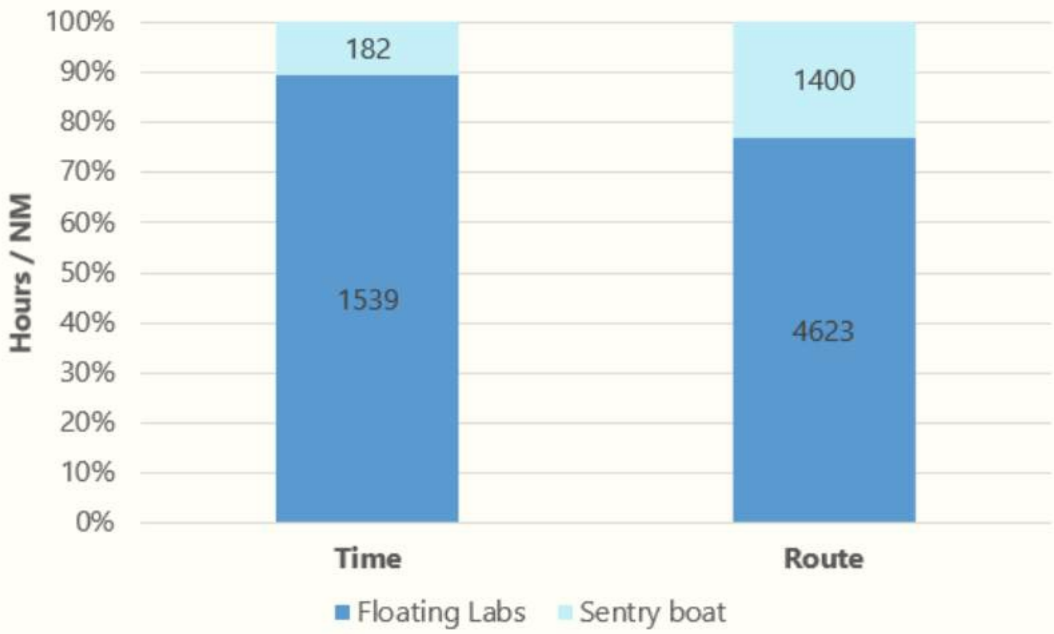


Figure 35. Observation effort made by the network of the Floating Laboratories programme. Our elaboration.

During the surveys over 10 000 high quality shots have been taken (over 100 GB storage) and then sorted by day, boat and other categories such as nets, harbors, and events like by-catch and other interactions with vulnerable species.

Photos and videos on fishing operations were shared via Google photos with the fishers. Shots of dolphins having the right requirements were used for the Photo-ID analysis.

Acoustic data were analyzed by experts in bioacoustics by looking at the spectrograms and simultaneously listening to the acquired recordings by means of the open source software Audacity. The presence of the different sound categories was studied in relation with each performed survey. In particular, the occurrence of impulsive echolocation clicks and tonal sounds, according to each species acoustic repertoire, was investigated and recorded in an ad-hoc work folder by using Microsoft Office Excel program. In addition, the occurrence of sounds specifically related to feeding activities and predation was studied for all recorded species.

5.1. Rising characteristics of the local fleet

Interviews to fishers permitted to have a clearer image of the local fleet. Starting from technical characteristics, the sample of Eastern Sicily counts a total tonnage of 60 GT (μ= 3.25; σ= 2,4468) (Figure 36) with a power of 788.23 kW (μ= 43.79; σ= 29.718) (Figure 37), and it is composed by vessels having an average of 9.3 meters (σ= 1.98868) (Figure 38) and 37.75 years old (σ= 18.719) (Figure 39).

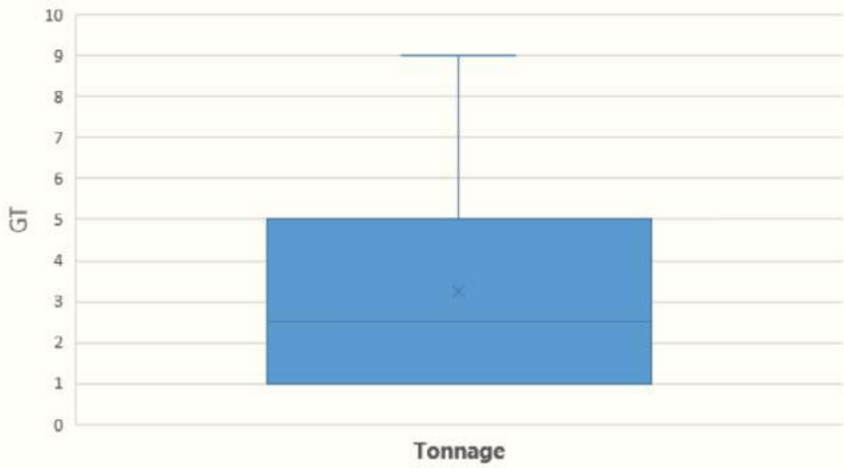


Figure 36. Gross tonnage of the fleet involved in the interviews (Eastern Sicily, 2019). Our elaboration.

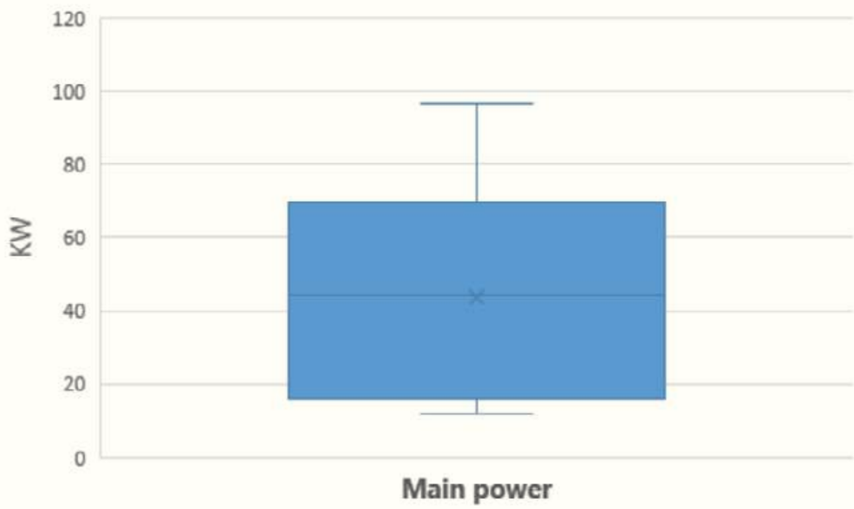


Figure 37. Main power of the fleet involved in the interviews (Eastern Sicily, 2019). Our elaboration.

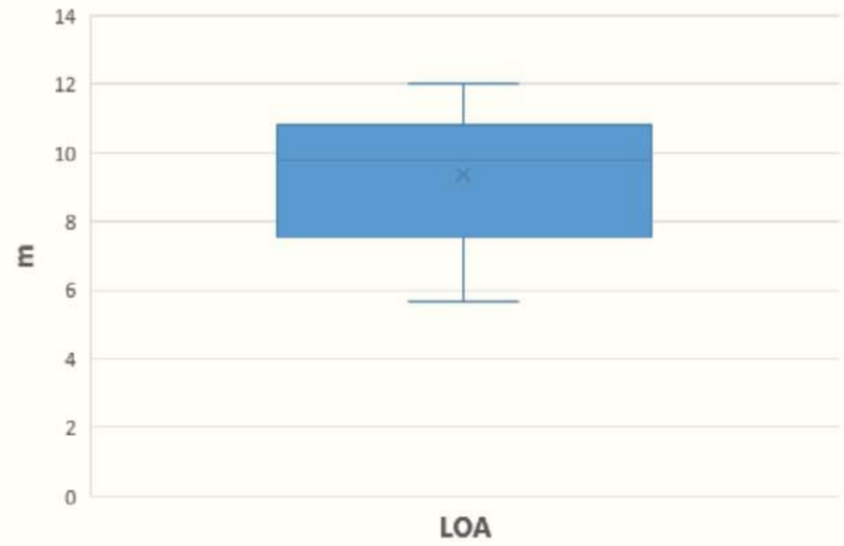


Figure 38. Length overall of the fishing vessels belonging to the fleet involved in the interviews (Eastern Sicily, 2019). Our elaboration.

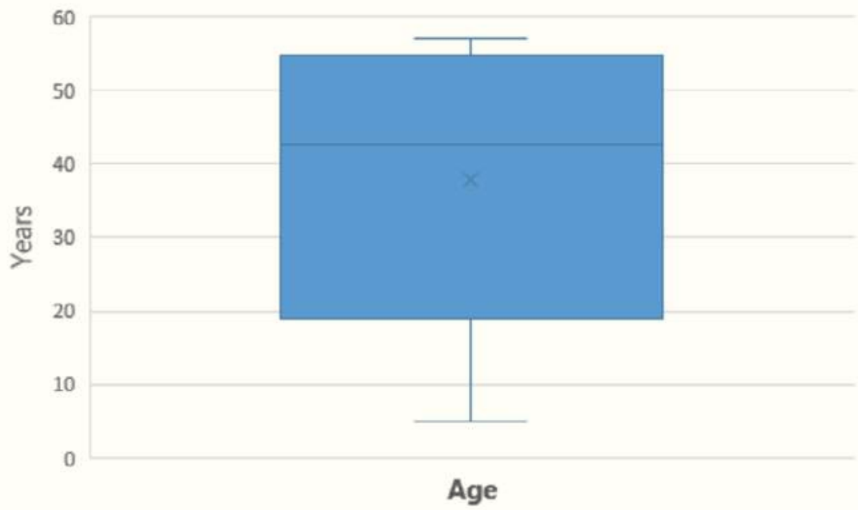


Figure 39 Age of the fishing vessels belonging to the fleet involved in the interviews (Eastern Sicily, 2019). Our elaboration.

All the fishing vessels belong to the "MFL - Pesca Costiera Locale (001)" segment and are authorized to operate within 3 or 6 NM from the coast. However, normally they move away from their harbor of origin until 10 NM but remaining inside 3 NM offshore. Instead, the fishing vessels belonging to the North zone, although they have similar technical characteristics, almost the entire fleet is enabled and go until 12 NM from the coast. This is largely due to the environment because most of the North fleet fishes around the Aeolian Islands. In particular, since the first island is at about 10-12 nautical miles from the Sicilian coast, fishers take advantage of the proximity of the two coasts to always be not too far from one coast or the other, and can use the entire Aeolian archipelago as a large port.

Differences between the North and East areas can be also found in the diverse polyvalence of the fishing units, with the prevalence of the use of longlines, pots and encircling gears in the Aeolian area, and greater use of single wall nets and trammel nets in the remaining zones.

Fishing depends by weather conditions in both the areas, so that **fishers spend about 200-300 days at sea in one year,** depending on the size of the vessels and composition of the crew. Most of the fishing gears are used all year round, many métiers share the same technique and change only the mesh size of the nets during the seasons. Favorite times of the activities are at sunrise and sunset.

Looking at the different **fishing gears, materials** of which the nets are composed are nylon, cork, leads and floats. Only in the Aeolian area is possible to find some net made in cotton yet as many years ago in the rest of Sicily.

Regarding longlines, **natural lures** used are pilchard, flying squid, living cuttlefish, sardinella sp., sprat, squid, Atlantic mackerel, shrimp, and octopus. Sardinella and pilchard could be used together with artificial baits. Mediterranean moray is used also for the totanara (gear for squids).

Characteristics of the main *métiers* active in the study area are summarized in Annex 13. Minimum and maximum values of the mesh size indicated in the table shows that, depending on the season, gears such as single wall net and trammel net can be distinguished in different *métiers* according to their target species, consequently, also the sales prices change.

Among the more selective gears we highlight two that have a unique target species: the “Menaida” for fishing the European anchovy (*Engraulis encrasicolus*) or the European Pilchard, the “Totanara” for fishing the European flying squid (*Todarodes sagittatus*). In particular, the ability of the menaida to catch the same species in all seasons lies in the fact that its meshes are adapted during the year to the size of growth of the specimens (Table 11).

Size	cm
30	0,86
27	0,96
25	1,041
20	1,31
18	1,47

Table 11. Conversion to measure mesh size in the menaida net, where the mesh size is attributed by a number which indicates how many knots are in 25 cm. Generally, size from 18 (largest) to 30 (smallest) are used, including no. 19, 20, 22, 24, 25, 26, 27, 28. For example, the 27-28 are used in winter, when smaller anchovies are taken. Our elaboration.

Moreover, the Aeolian pots used to fish the Octopus, and the “Schiabichella” net used for the deep-water rose shrimp have a very low rate of non-target species. To note that the latter gear represents a unique fishing technique for shrimps, practiced only in a very restricted area of the Gulf of Catania, where a canyon is present near the coast. Reducing the mesh size, the sciabichella is recently used in the experimental fishing of the Mediterranean sand eel (*Gymnammodytes cicerelus*) for the definition of a plan for the sustainable exploitation of fish species in the Sicilian waters.

Finally, also other *métiers* belonging to the single wall net type are mono target species: this is the case of the "Monofilo" for picarel, the "Paurara" for red porgy, and the "Palermitana" for a limited number of bluefish, that are used only in short periods of the year.

Considering the entire investigated fleet, the interviews and the direct observations permitted to assess the **capture of 98 seafood species distributed among 10 main categories of fishing gears**, where a single species is catch by no more than 3 different gears (Figure 40; Annex 14). The highest number of target species for the monofilo (single wall net), tremaglio (trammel net), and palangaro (longline) gears are due to the fact that they include different similar métiers, each one having a few target species captured in low quantity. For example, the palangaro includes different longlines having the lines of the main arm and of the little arms of different lengths, and hooks of different sizes; the monofilo includes many single wall nets of different mesh sizes; and the tremaglio includes many trammels of different mesh sizes.

Annual variations of the sale prices are resume in Table 12 reporting the most marketed species. The figures change not only according to the season but also to the port of landing considered.

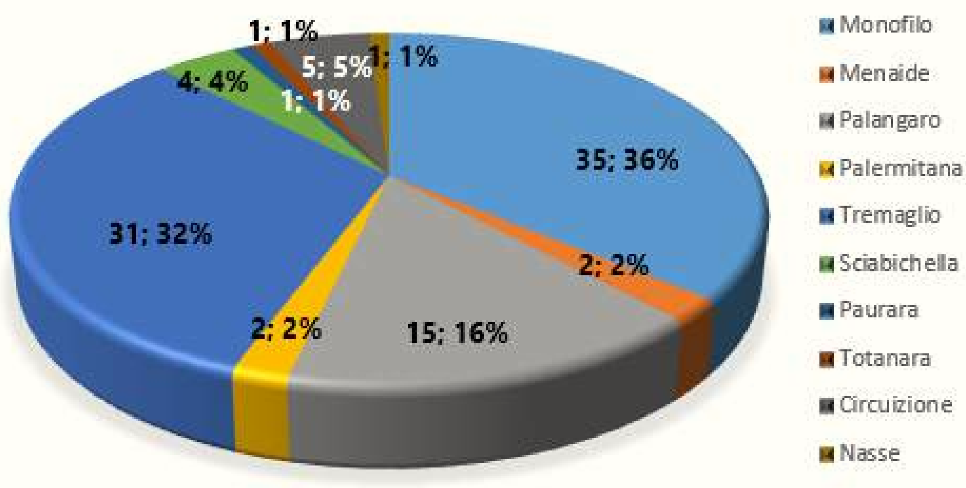


Figure 40. Number of species that can be catch by the different fishing gears used in North-Eastern Sicily. Our elaboration.

Common name	Scientific name	Price €/kg
Albacore	*Thunnus alalunga*	3-5
Atlantic bonito	*Sarda sarda*	4-5
Barracuda	*Sphyraena sp.*	5
Common cuttlefish	*Sepia officinalis*	8-20
Common dolphinfish	*Coryphaena hippurus*	10
Common pandora	*Pagellus erythrinus*	8-10
Deep-water rose shrimp	*Parapenaeus longirostris*	7-10
Dusky grouper	*Epinephelus marginatus*	8-10
European anchovy	*Engraulis encrasicolus*	0-14
European flying squid	*Todarodes sagittatus*	5-15
European hake/Cod	*Merluccius merluccius*	10-20
European seabass	*Dicentrarchus labrax*	12
Forkbeard	*Phycis phycis*	10-15
Frigate tuna	*Auxis thazard*	2
Giant red shrimp	*Aristaeomorpha foliacea*	15
Greater amberjack	*Seriola dumerili*	10
Little tunny	*Euthynnus alletteratus*	3-5
Lobster	*Palinurus sp.*	25-50
Mackerel	*Scomber scombrus*	5-10
Octopus	*Octopus vulgaris*	10
Painted comber	*Serranus scriba*	5
Parrotfish	*Sparisoma cretense*	5
Red mullet	*Mullus barbatus barbatus*	5-20
Red scorpionfish	*Scorpaena scrofa*	12-13
Seabream	*Diplodus sp.*	10
Shi drum	*Umbrina cirrosa*	10
Stargazer	*Uranoscopus scaber*	10

Table 12. Annual variations of the sale prices of the most marketed species by the investigated fleet. Our elaboration.

5.2. Preliminary information on depredation and by-catch cases

Fishers' perceptions about the presence of dolphins and the damage they cause to fishing gears and catches, show geographical differences according to which 80% of fishermen from the northern ports (8) consider that interaction cases with these animals are increasing in the last 5 years. Only the 55% (11) of the Eastern coast until the southernmost ports have the same opinion, while the remaining interviewed (9) are divided between the convictions that the phenomenon is stable or decreasing. Moreover, fishers of the Eastern area report an increasing in depredation caused by sharks.

Despite the widespread belief about the ubiquitous presence of dolphins, the face to face **interviews allowed to identify 14 focal areas more susceptible to cases of cetacean-fishing interaction** where negative interaction occurred and therefore causing damage to fishing. Indeed the greater rate of depredation by dolphin is focused in the Aeolian area, in the center part of the East Sicily, and in the extreme South as showed in Figure 41.

Figure 41. Areas (red stars) with high rate of depredation by dolphin in North-Eastern Sicily (based on face to face interviews). Our elaboration with Google Earth.

In fact, analyzing answers of the interviewed fishers and basing on the direct observations onboard the Floating Laboratories, **all gears, although in different ways and degrees, are affected by depredation caused by dolphins, sharks and other large fish, except the sciabichella (little encircling net) and the nasse (pots)**. Instead, only the monofilo, tremaglio e palangaro appear to be responsible of by-catch of seafood catalogued as non-target species, indeed, in rare cases these gears catch sharks and tuna (Table 13).

In particular, onboard the floating labs using gears close to the sea bottom, has been observed the **catch of benthos** such as starfish, sea urchins, invertebrates, and parts of coralligenous (i.e. *Stylocidaris affinis, Myriapora truncata, Centrostephanus longispinus, Pennatulacea sp., Ophiothrix fragilis, Astropecten irregularis, Medorippe lanata, Pleurobranchus testudinarius, Filograna sp., Sphaerechinus granularis, Ophidiaster ophidianus*). Furthermore, the monofilo used in the South part of the Gulf of Catania caused in summer the by-catch of one specimen of the alien species Blunthead puffer (*Sphoeroides pachygaster*) and of 22 **Smooth-hound** (*Mustelus mustelus*) of various size (Figure 42) during 7 different fishing trips (11% of the total catches on 15 fishing trips), that is a vulnerable species.

Gear type	Depredation	By-catch
GTR	Dolphin, shark, moray, crab	Shark (rare)
LLD	Shortfin mako shark and other sharks, dolphins	Blue shark and other sharks (rare)
LLS	Shortfin mako shark and other sharks, dolphins	Shark (rare)
GND (monofilo type)	Sharpnose sevengill shark and other sharks, dolphins	Angel shark, common thresher, and other sharks (rare)
LHM	Dolphins, sperm whale	N
PS	Dolphins	N
PS (small)	Lesser spotted dogfish	N
LHP/LTL	N	N
FPO	N	N
GND (menaida type)	Dolphin, shark, tuna	N

Table 13. Gear categories per group of species involved in depredation and by-catch events. “N” indicates “No species”; “Rare” indicates that one or a few cases of by-catch occurred in the entire experience of the interviewed fishers. Our elaboration.

Figure 42. Specimens of Smooth-hound (*Mustelus mustelus*) caught in the Southern Gulf of Catania, Brucoli place, with the monofilo gear. Source LIFE.

Depending on the size and if alive, fishers decide to keep and sell the Smooth-hounds or to reject them in the sea; in any case, rejected animals have not many chances to survive due to the suffered shock linked to fast changes of depth and traumas of the entanglement. In some cases, the monofilo could capture **Bluefin tuna** (3% of the monofilo catches in the Brucoli area), those longer than 115 cm, with consequent problem of having to discard them, due to not having quota.

Although no by-catch of cetaceans has been observed in this study, analyzing the photos of striped dolphins and bottlenose dolphins of the Gulf filed by the MareCamp association, **some individuals of cetaceans present evidence of surviving prior fishery interaction, especially with fishing lines,** suggesting that depredation is a behavior that could put at risk the individuals who practice it. Figure 43 and Figure 44 show the injured peduncle of some dolphins probably survived to the interaction with a palangaro in the Gulf of Catania.

Evidence of by-catch events is also verified through strandings reported by local associations from North-East (Aeolian Islands, Capo Milazzo) to East and South-East Sicily (Catania, Ognina di Catania, Siracusa, Pozzallo, Ragusa). Figure 45 shows a collection of photos of injured cetaceans like **Sperm whale** (*Physeter macrocephalus*) and **Striped dolphin** (*Stenella coeruleoalba*) having the cut tail, nets tangled in the peduncle, or signs of harpoon (a). Other stranded vulnerable species like **Loggerhead sea turtles** (*Caretta caretta*) presents hooks in its mouth and in the cloaca, lines around their fins and neck, or nets tangled to their body; **seabirds** as Scopoli's shearwater (*Calonectris diomedea*) show to have ingested hooks and lines; **sharks** as Bluntnose sixgill (*Hexanchus griseus*) and Shortfin Mako (*Isurus oxyrinchus*) probably got trapped in tuna longlines (b).

However, although for cetaceans and sea turtles there are the dedicated national databases mentioned in chapter 3, which include part of the known strandings in Italy, for the other species no shared system capable of regularly quantifying any cases of shark and seabird by-catch is available, therefore it is not possible to make a precise estimation of the real frequency of these cases.

The entire studied fleet agree with the perception that so far no effective solution to solve the depredation problem exists. Some of them (26%; 8) have experienced the use of pingers without results, or with a reduction of the interaction cases only for the first few months, or even having a "call" effect. Some admit that they occasionally used bombs, guns, and nails in the lures in the past; other fishers of the Gulf of Catania think that many years before, when the fishing with the "Spadara" gear (today an illegal driftnet) was allowed, dolphin interaction was lower because, closing the Gulf with this net, it kept cetaceans further from the coast and also resized populations by capturing several dolphins per year as by-catch.

All the fishers declare to be available to participate in the experimentation of new devices aimed at mitigating interaction events with marine wild fauna. Moreover, they express their interest to participate in the on-line voluntary survey launched by LIFE.

The territorial investigation showed that 45% of the fishing trips made in one year are affected by negative interactions with cetaceans. All the involved *métiers* highlight the happening of depredation events so that, while in the North area are visible though bite marks on the catch, in the remaining zones frequent are also the head of the eaten fish left on the net. 40% of the interviewed in the Eastern side said also that dolphins cause scattering of fish schools, especially during the setting phase of the gears. Longliners of the East area report also depredation of lures when they set down the gear into the water.

Figure 43. A bottlenose dolphin in the Gulf of Catania with an injured peduncle, survived to the interaction with a longline. Source MareCamp.

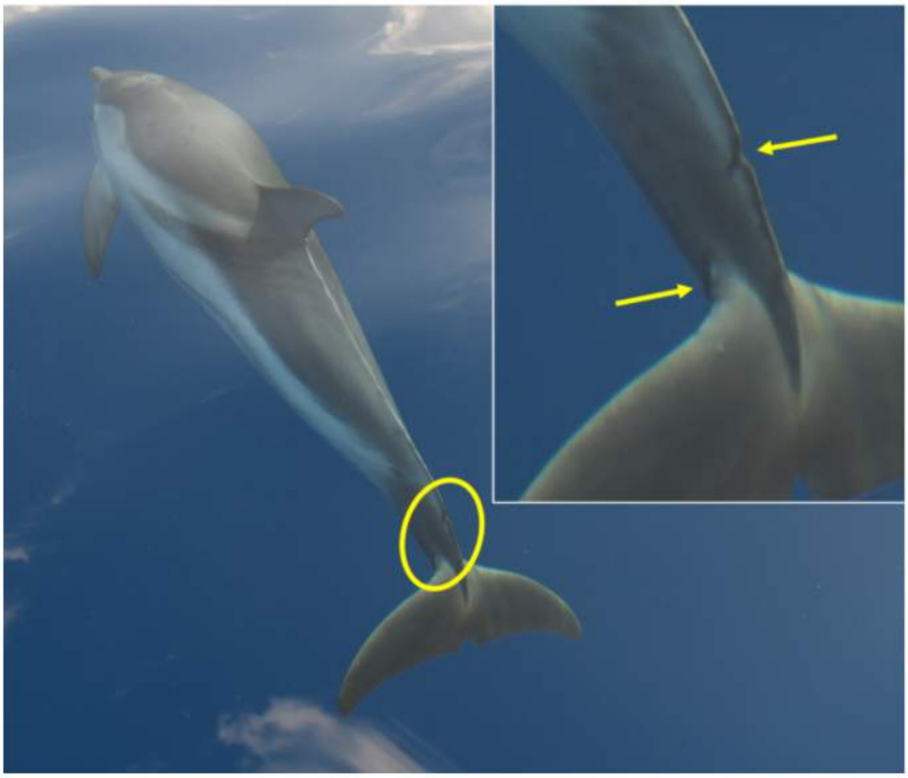


Figure 44. A striped dolphin in the Gulf of Catania with an injured peduncle, survived to the interaction with a longline. Source MareCamp.

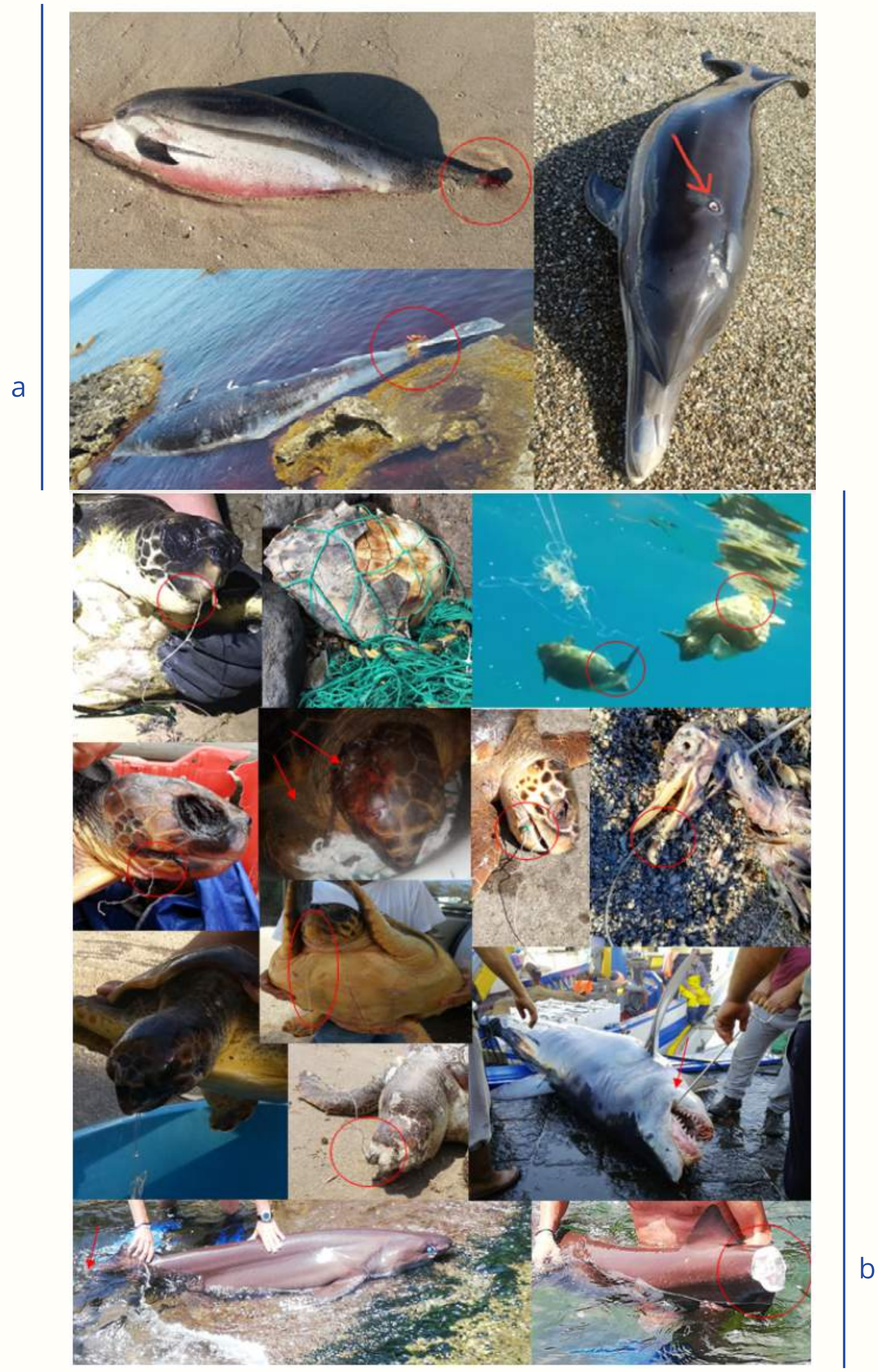


Figure 45. Strandings compatible with by-catch events of cetacean (a) and other vulnerable species (b) along the coasts of East Sicily, reported by local associations (2016-2020). Sources WWF Sicily (O. Prato), MareCamp, MuMa (C. Isgrò), Jonio ProDive.

Regarding the holes generated in the nets, 30% are of medium size (31-80 cm) and can be more than 30 in a unique gear per set. However, in certain cases, a low number of very big (>120cm) holes could cause a greater damage. In fact, a unique conflict with dolphin can cause a 60% average damage of the net, which in particular cases is extended to the total destruction of the gear (Figure 46).

Depending on the damage, the repair of the nets can take from 2 to 10 days for 1-4 fishers, the preparation of a new longline can take up to 3 days. However, even in the case of gears that cannot be used immediately, the vessels that have suffered a conflict do not give up fishing days but continues their activity by using another gear until the damaged one is repaired or bought again.

The **costs that a captain has to bear for a fishing trip**, even when it fails due to conflicts with marine wildlife, are: fuel and maintenance of the boat, sailors' salary, purchase of ice to maintain fresh the catch, salary for the days passed repairing the damage and, in case of longlines, purchase of the natural lures (Table 14).

Gear	Fuel and maintenance of the boat	Sailors salary	Ice	Lures purchased	Salary to repair the damage
Nets	100	0-100	20	0	400
Longlines	100	100	30	200	300

Table 14. Costs in € of one fishing trip carried out in North-Eastern Sicily by SSF. Our elaboration.

However, fishers often tend to ignore the time spent repairing gear when counting expenses, as they consider it a normal fisherman routine. In addition, in case of a failure fishing trip without catch, 70% of the gillnetters adopt the "alla parte" system according to which the crew members do not have a fixed salary, but divide the revenue of the day among all. This means that in case of loss of the catch due to interaction with cetaceans, the whole crew does not earn anything and the captain has to support only the basic expenses of the fishing boat and the gears used that corresponds at about 46% of the total normal expenses in one day, excluding eventual costs to purchase a new fishing gear, and the failure of the capture.

Considering the repair costs, fishers can decide to buy all the raw materials, or to recover elements as floats and weights from old damaged nets. However, a new fishing gear can have different prices also basing on the quality of the materials, in fact, complete nets for the same *métier* can cost from € 1 500 to 5 000.

While sometimes the monofilo and the tremaglio nets are used even if slightly damaged, albeit implicating 35% of reduction in the potential caught, the same cannot be done for the menaida because the type of fishing requires that the net is fairly intact, otherwise the anchovies "see" the net and are not fished. Placing an already damaged gear into the sea, however, increases the risk that the damage will be aggravated.

Depending on the damage present on the fishing gear, it is possible to recognize the guilty species. **In general, single small holes are made by crabs, octopuses, and moray eels. In the case of larger tears, dolphins or sharks are the responsible.**

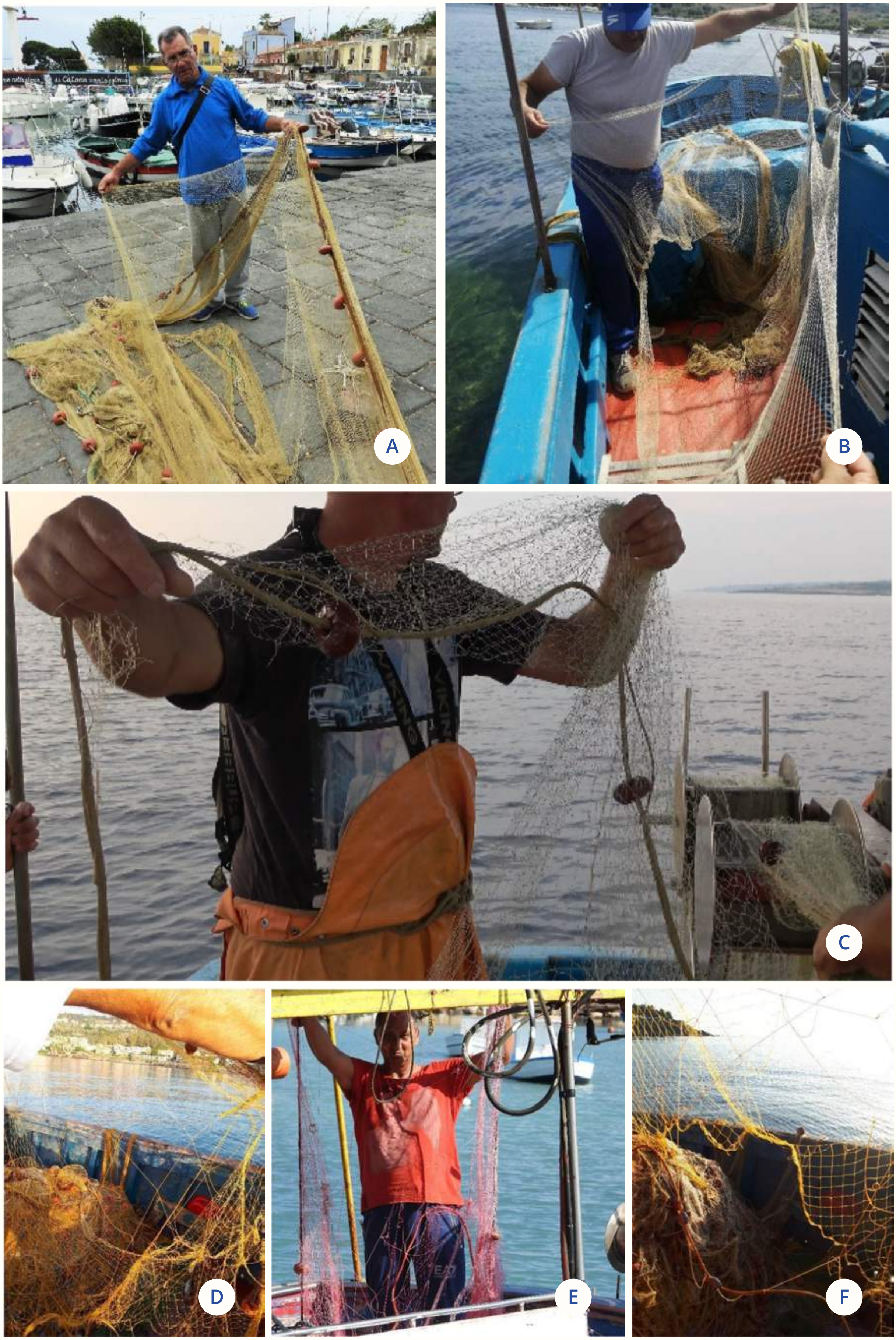


Figure 46. Damages caused by dolphins on menaida (A), monofilo (B, C), and two type of tremaglio (D, E, F). Source LIFE.

The different fleets agree that also the signs left by shark and dolphins are different. Mainly, **dolphins act in areas closer to the coast, they cause missing meshes, pinched net and thread pulled in the nets and they are the only ones responsible for leaving the fish head in the gear**. On the other side, sharks produce not more than one hole and cause missing of entire pieces of the net, they make larger bites with tears and can also damage the rope.

In the case of longlines, when the depredation takes place, hooks are bended and the entire secondary line arm is damaged both by dolphins and by sharks, but with different signs leaved on the catch.

According to the descriptions made by fishermen, among dolphins the main species at fault of depredation is the bottlenose dolphin, while only 20% of the damage seems to be attributable to the striped dolphin. Several descriptions of the species most inclined to intervene during the fishing for squid, suggest it could be the Risso's dolphin.

Different data emerge between the North and the East area because in the first one dolphins use to interact in herds composed up of about 10 individuals. Instead, in the second they can act either individually or in small groups of 3, or in pods of up to 20 specimens.

Finally, some fishers of the Gulf of Catania, basing on ancient experiences using pingers, think that the dolphins resident in that area are habituated to a high noise mainly due to maritime traffic so they are not affected by dissuasive pulses emitted by the devices.

5.3. Fishing effort of SSFs in the Gulf of Catania

Considering the data so far exposed, taking into account the overall tonnage of the sample involved for this study in Eastern Sicily, and that the average fishing days in one year in the area is about 250, we can say that the general fishing effort of the investigated fleet is equal to 15 000 (GT*fishing days average).

Looking in more details at the **effort implemented by the 10 floating laboratories during the 37 experimental fishing trips, a total of 1 500 hours has been passed at sea, with an average of 5 hours per day per boat** (Table 15).

The **time spent in the water by the fishing gears is about 2 hours and half per set, for a total of 1 122 hours in the trial period**, but in some days, in case of detection of the presence of dolphins, can be also null because of the immediate haul up of the net onboard in order to avoid incurring damage (Table 16).

Total **landings reported in the fishers' registers amount to 5 834 kg of which 3 656 are anchovies, with catch per vessel and set generally not exceeding 13 kg** (Table 17).

	Hours
TOT	1462
μ	5,04137
Min	2
Max	10,25

Table 15. Hours at sea per fishing trip passed by the 10 Floating Laboratories during the 37 trials days in the Gulf of Catania. Our elaboration.

	Hours
TOT	1122,56
µ	2,47806
Min	0,16667
Max	5,41667

Table 16. Duration of fishing sets made by the 10 Floating Laboratories during the 37 trials days in the Gulf of Catania. Our elaboration.

	kg
TOT	5834,44
µ	12,8796
Min	0
Max	250

Table 17. Total catches per set of the 10 Floating Laboratories during the 37 trials days in the Gulf of Catania. Our elaboration.

Distinguishing the **395 analyzed sets per fishing gear**, the most productive gear appears to be the **menaida, capable to catch a major quantity of fish, small pelagics in this case, for the same amount of time deployed in the water rather than other gears** that catch other type of species. This gear is that which also requires the minor time to be deployed and hauled, but it need to be managed by a higher number of sailors (4-6). Indeed, the **tremaglio appear to be the fishing gear that necessitates to remain underwater the highest amount of time** in order to be capable to catch a good amount of fish (Table 18). However, this and the other remaining gears can be used by just 1 or 2 fishers.

Also, it is to note that **while fishing trips with the tremaglio and the palangaro are characterized by 1 set**, **those with the other gears can count many sets in the same trip depending on the result of the first set**, generally they are 1-3 for the menaida and the monofilo, and more than 10 for the totanara.

Gear	Type of event	µ	Min	Max
Menaida	Time for deploying underwater	0.26	0.08	0.75
	Time for hauling onboard	0.77	0.22	2.00
	Time of a set	1.95	0.80	3.50
	kg per fishing set	20.30	0.00	250.00
Monofilo	Time for deploying underwater	0.46	0.03	0.92
	Time for hauling onboard	1.41	0.07	2.58
	Time of a set	3.38	0.17	5.42
	kg per fishing set	7.79	0.00	20.00
Tremaglio	Time for deploying underwater	0.70	0.17	1.08
	Time for hauling onboard	1.30	0.60	1.67
	Time of a set	4.79	4.03	5.33
	kg per fishing set	11.33	0.00	45.00
Palangaro	Time for deploying underwater	0.60	0.00	3.00
	Time for hauling onboard	1.52	0.00	5.00
	Time of a set	2.21	2.00	5.33
	kg per fishing set	8.11	0.00	35.00
Totanara	Time for deploying underwater	0.51	0.00	0.58
	Time for hauling onboard	0.05	0.02	0.12
	Time of a set	0.98	0.65	1.75
	kg per fishing set	0.38	0.00	0.80

Table 18. Fishing trips during the 37 trials days in the Gulf of Catania, analyzed by time required for sets expressed in hours, and quantity of catches in kg. Our elaboration.

Regarding the spatial distribution of the fleet studied in the Gulf, the area in front of Catania appear to be favorite by vessels using the menaida. All types of **nets remain within the bathymetric depths of -100 meters and are concentrated near their ports of origin**, while **longlines is the gear used more offshore,** also in correspondence of high deep up to -3000 meters (Annex 15).

Analyzing the capability of the different fishing gears to capture one or more species, it is possible to see that the monospecific gears keep on depths between -50 and -100 meters, while the multispecific ones fish on both greater and lesser depths. **There are no major overlaps between the areas of action of different gears**, moreover, a non-exploited zone appears to be at the mouth of the Simeto river (Annex 16).

The **Hot Spot Analysis** (Getis-Ord Gi) applied to the fishing effort recorded, permitted to identify statistically significant spatial clusters of high values related to the time during which gears are set underwater to catch (Annex 17), and the kg of captured seafood for each set (Annex 18). Results show that the **areas most exploited in terms of time fall in the far North and in the far South of the Gulf**, and cover all the bathymetries. Despite this, the area that provides the **highest amount of landings is the central part of the Gulf**. However, it must be considered that the different effort depends on the gear used and of its target species.

Using a **Kernel density function** to calculate the magnitude-per-unit area from the points of each set, fishing effort in terms of time show a **major incidence near the MPA of the Ciclops Island (Aci Trezza) and offshore the harbours of Catania and Ognina di Catania**, and a medium occurrence in correspondence of the end of the Gulf in the South (Brucoli bay) (Annex 19).

In terms of **quantity of catches**, the exploited area of action appears rather homogeneous, with **higher values off the coast of Catania and corresponding to the catches of the menaida gear** (Annex 20). However, by changing the reading scale, it is possible to look to more details that show several small areas more exploited in the North and in the South of the Gulf, which do not always correspond to the areas where fishing gear remains for longer (Annex 21).

By comparing these overall data with those collected only by observers onboard the floating laboratories, also in this case it can be noted that the longest sets are concentrated in the North of Aci Trezza, medium times are highlighted off the coast of Brucoli, and low times near the coast of Catania (Annex 22).

On a total of **93 sets supervised by the observers on the Floating Laboratories**, considering the biomass landed in kg per 100 m of net, the **mean CPUE** for the three first groups of species most fished with the correspondent *métiers* are: anchovies and sardines **(menaida) 224.2** (μ 5.38; σ 5.957); hake, sparidae etc. **(monofilo) 5,97** (μ 0.994; σ 0,406); surmullets etc. **(tremaglio) 0.835** (μ 35,92; σ 0.974). The sale of this product generates a **total income of 9 531 €** of which 6 622 € coming from fishing with menaida, followed by monofilo (2 349 €) and tremaglio (560 €) (Figure 47).

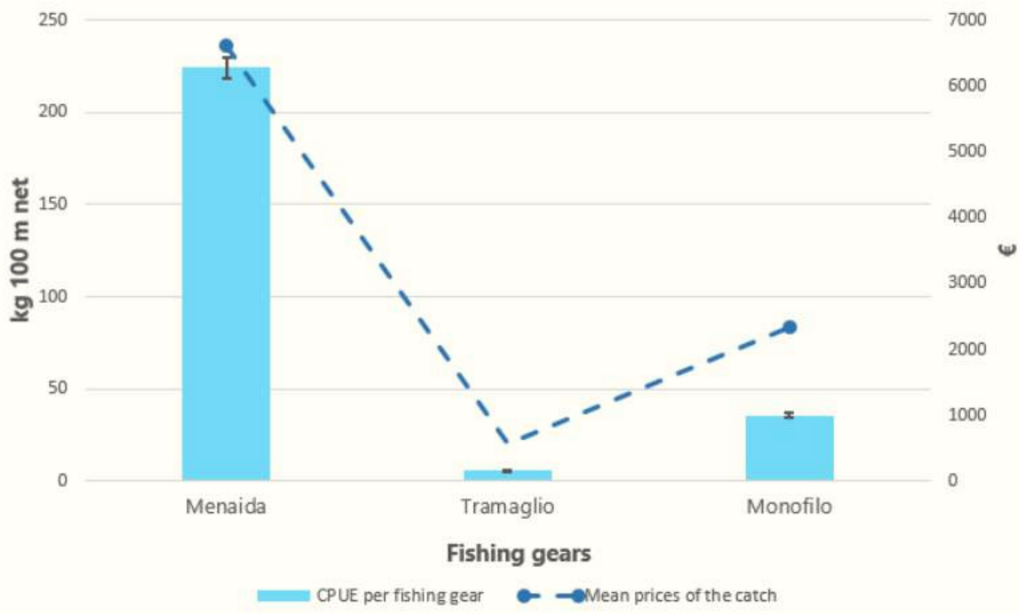


Figure 47. Mean CPUE and standard error of the three main investigated métiers of the Floating Laboratories programme calculated as kilograms per 100 m of net, and estimated income from the sale of their catches. Our elaboration.

The framework outlined so far shows how different fishing strategies are applied within the same small fleet. In fact, those who use nets for multiple target species usually limit themselves to operating in waters very close to their home port, almost always exploiting the same narrow restricted area. **Those who exploit a single species are instead led to follow its distribution in the Gulf, therefore the smaller boats continue to fish in nearby waters with the risk of not fishing anything in some periods; larger vessels make longer trips, increasing management costs but having greater catch possibilities.** However, even in the case of fishing boats that go from one side of the Gulf to another in search of large quantities, fruitless days occur in which not only fishing sets are unsuccessful, but fishers have to deal with more expenses.

Another aspect to consider is the sale, as the first crew to land and arrive at the fish shop have the possibility of determining the price of the catch and can sell it all. On the contrary, those who capture more fish are not always advantaged because they spend more time hauling the gear on board and when they come back to the port risk the devaluation of their product or they fail to sell it all.

Interesting would be to investigate those areas of the Gulf apparently not exploited, as well as with a lower incidence of interaction between fishing and cetaceans, maybe because of peculiar environmental characteristics or of the presence of other type of activities not here investigated, and which could be potential areas for small-scale fishing.

5.4. Catch depredation operated by dolphins: incidence factors and consequences

During the trial period a total of 45 depredation events occurred, which represents 60% of the 50 fishing days investigated, having in the majority of the cases the bottlenose dolphin (*Tursiops truncatus*) species as responsible, followed by the sperm whale (*Physeter macrocephalus*), while data from fisher's registers reported many not identified dolphins which could be the striped dolphin (*Stenella coeruleoalba*) or the bottlenose dolphin. Also, in 6 cases the striped dolphin was observed but without any type of interaction with fishing activities. This percentage is close to that risen up from the territorial investigation according to which negative interactions with cetaceans interested about 45% of the fishing trips in one year.

Considering data coming from the fishers' registers, no by-catch of cetacean happened. Indeed, **depredation events took place in every area of the Gulf where fishing activities are carried out** (Annex 23). Reports on cetacean-fishing interaction have also been collected from areas bordering the Gulf.

The effects of the depredation events

The most affected gear is the monofilo (single wall type net) which presents a very low CPUE in case of conflicts with dolphins. Its value calculated during this fishing trial is 30.2 in days without interaction, and 5.9 in case of conflicts, which is only 20% of the normal CPUE (Figure 48).

The main observed negative effects of dolphins applying an opportunistic feeding behavior on the gears of the Floating Laboratories confirm those reported during the interviews and are: **damage to nets in the form of holes torn while dolphins attempt to remove the captured fish; damage to longline hooks while dolphins pull and eat the captured catch; reduction in the amount or value of the catch because of the mutilation or removal of the caught or of the lures from the gear, caused by dolphins; reduction in the quantity of catch due to scattering of the preys because of the presence of dolphins hunting in the vicinity of the nets; loss of time for repairing the damaged fishing gears** (Figure 49; Figure 50). Thus, in addition to the fixed costs (indicated in the previous Table 14, cap. 5.2) to be incurred even in case of lack of income, the overall size and condition of the landed catch cause a reduction in profit, which if persisting in long term may lead to a serious economic decline of the local fleet.

Considering the total size of landings of the Floating Laboratories in the trial period (5 834 kg), and excluding sets characterized by conflict with wild fauna (271 kg), we calculated a potential value of 16 kg of catch per set. Comparing these results with the real landings **referred to the 45 recorded cases in which the depredation phenomenon involving dolphins occurred, we estimate a 78% loss of catches (565 kg less)** with a consequent very low landing (161 kg) against the expected (726 kg), **for a loss in economic terms of about 8 000 €** (Table 19).

According to Noureddine et al. (2017), a complete estimate of the damage could be made having data of landings and prices referred to the same sample fleet in the previous years, in order to compare the outcomes of the fishing trips based on the same gear in the same season, and in the same place, permitting also to analyze possible changes in frequency of the attacks.

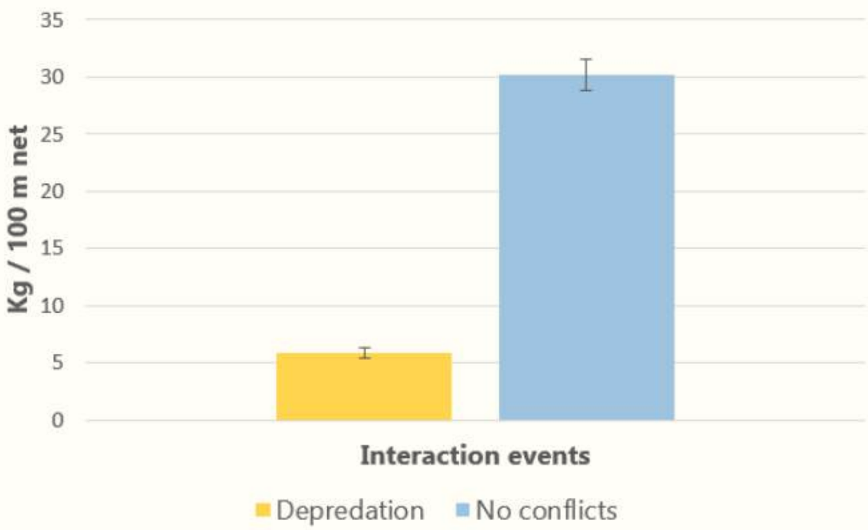


Figure 48. CPUE and standard error calculated as kilograms per 100 m of net, applied to the fishing with the single wall nets in case or not of interaction with dolphins during the trial period. Our elaboration.

Figure 49. A fisherman repairing a single wall net in the harbor of Catania. Source LIFE.

Figure 50. A fisherman repairing a menaida in the harbor of Catania. Source LIFE.

However, multiplying the average cost of repairing the damaged gears by the number of recorded conflicts between cetaceans and fishing vessels, we obtain the estimated cost of damage to fishing gear (15 750 €) in the trial period, which is to add to the loss of fixed costs (13 500 €) and catches (8 000 €). **The total loss of 37 250 € involved 5 fishing vessels on 10 Floating Laboratories**, and it does not include the costs associated with the purchase of new materials for the repair of the gears, which may be different depending on the type of gear and quality of the various pieces, according to previous table in Annex 13.

Economic indicators	July-October 2019
Total fishing sets	395
Positive fishing sets (included those with conflicts)	382
Number of fishing trips	306
Total catches	5 834 kg
Medium weight of catch per day	260 kg
Frequency of conflicts	11%
Loss of catch	78%
Income loss	8 000 €
Potential daily income loss	78%
Potential daily income loss	444 €

Table 19. Estimate of losses due to depredation caused by dolphins to the investigated SSF fleet in the Gulf of Catania. Our elaboration.

Focusing on the damage verified by the observers on board the Floating Laboratories, and on the conditions of the fishing nets assessed in terms of integrity before and after each fishing set, we compared the number and extent of holes recorded in the presence and absence of dolphin depredation events.

It turned out that **the nets, even when fairly new, have a basic number of small holes** (0-30 cm) which, even in absence of interaction, and with the sole use of the gear, tend to increase or widen. Fishermen tend to not repair these small holes but only if they get bigger. The holes of medium and large size remain stable if no conflicts with wildlife occur (Figure 51).

Considering only fishing sets affected by dolphin depredation, all the size categories of the holes undergo a clear increase, far greater than that recorded in the fishing without interactions. Medium and big holes (31-120 cm) are the more important, while very big holes are less but much more extensive (Figure 52).

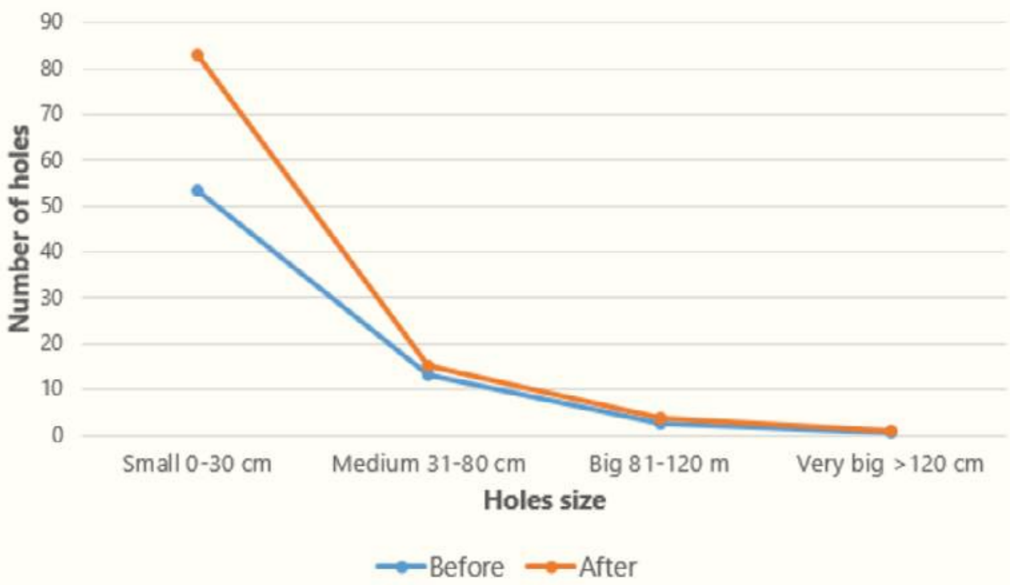


Figure 51. Total number of holes before and after the fishing sets without dolphin interactions, counted by the observers on the Floating Laboratories (31 sets). Our elaboration.

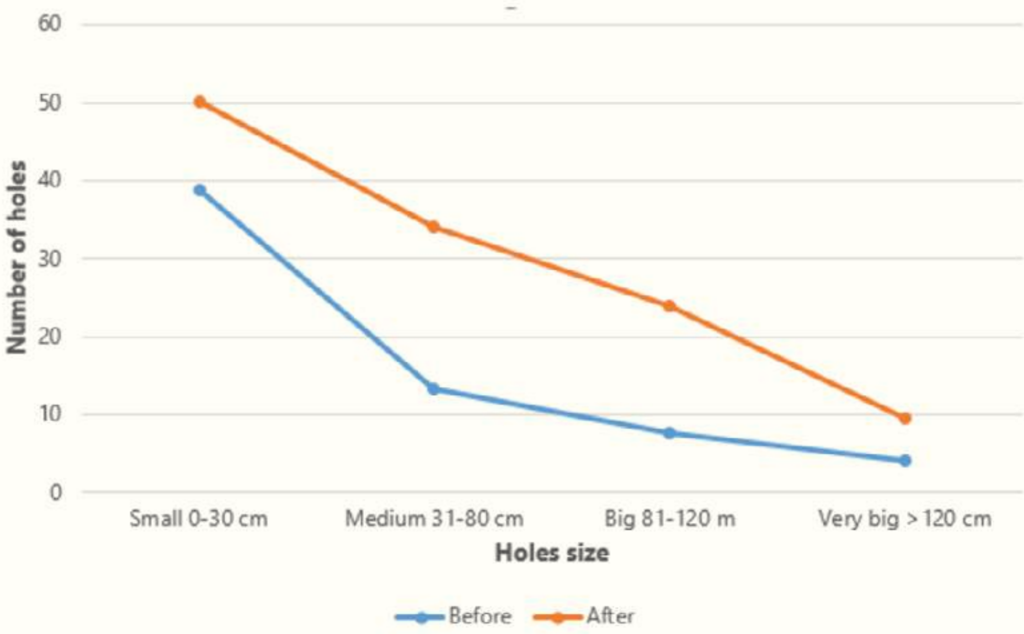


Figure 52. Total number of holes before and after the fishing sets without dolphin interactions, counted by the observers on the Floating Laboratories (31 sets). Our elaboration.

It is to be considered that the hole count has been in many cases underestimated due to the light conditions, the observer's proximity to the gear, and the moments of set or haul that are sometimes too rapid, especially in the presence of dolphins. The holes tend to be underestimated even when there are many, however, those attributable to the action of the dolphins have been associated not only to a greater damage than that recorded during the set down of the gear, but have also been recognized on the basis of the tear-off mode the net and the remains of damaged catch.

The cases in which the gear was immediately hauled up on board as the dolphins had been sighted (2% of 395 fishing sets), were not considered.

The characteristics of damaged fish found on the fishing gear after a depredation event correspond to those previously indicated in correspondence of the interviews results. In the majority of the observed cases, **dolphins leaved on the gear only the head of different target species** (Figure 53).

Figure 53. Damages to catch in different gears of the Floating Labs. Source LIFE.

Investigated factors that are influential to depredation

Knowing the effects of depredation is not enough to understand the phenomenon of depredation. For this reason, despite having a relatively small dataset available as it refers to a very small time frame, we investigated which factors are most influential in determining this type of opportunistic behavior applied by dolphins.

Basing on Table 4 on the classification of the variables established to make the Multiple Correspondence Analysis (MCA), we constructed a matrix with the data of the 45 depredation cases recorded (Table 20), so we processed the information using the SPSS software. Table 21 and Table 22 show the history of the iterations in the analysis, and summarize the features of the two-dimension model we used.

Valid active cases	45
Active cases with missing values	0
Supplementary cases	0
Total	45
Used cases in the analysis	45

Table 20. Case processing summary for the Multiple Correspondence Analysis. Our elaboration

	Variance explained		
No. of iterations	Total	Increase	Decline
28[a]	7,169276	,000008	12,830724

a. The iteration process stopped because the convergence test value was reached.

Table 21. History of the iterations in the Multiple Correspondence Analysis. Our elaboration.

		Variance explained		
Dimension	Alpha of Cronbach	Total (autovalues)	Inertia	% di variance
1	,919	7,877	,394	39,385
2	,890	6,462	,323	32,308
Total		14,339	,717	
Average	,906[a]	7,169	,358	35,846

Table 22. Summary of the model used for the Multiple Correspondence Analysis. Our elaboration.

Looking at the table in the Annex 24, values associated to the transformed correlation variables indicate that depredation events are not depending on environmental characteristics but they can occur in every moment of the day, moon phase, weather conditions, and type of bottom. On the other hand, elements in yellow such as the type of fishing gear and target species, features of the nets, gear depth and length, and the entity of the holes in the nets are strictly correlated and influence the species that will interact with the gear. Therefore, the **relationship between the fishing system and the species of cetacean causing depredation is evident and include both type of gear and the related one or more target species.**

Although the variables are dispersed in a similar way in the two considered dimensions, it is possible to note some specific groupings which in Figure 54 are gathered in rectangles of different colors.

The orange one explains that the events with the greatest damage on the nets, during which the gear can be totally destroyed, or, when the animals are clearly visible and the fisherman has time to haul up the net without suffering damage but also by not fishing anything, occur mainly at dawn and when the gear retrieval last between 21 and 30 minutes.

The light blue rectangle clarifies that fishing gears other than nets attract species that prey on them which might be different from the bottlenose dolphin, such as the sperm whale. In this case the damage occurs on the hooks or lures at depths higher than -100 meters, and can affect even a single individual, especially in the evening.

Reading between the fuchsia and the red traced areas, we can say that **the degree of residence of a cetacean population affects the determination of cases of depredation** in the Northern area of the Gulf of Catania, as much as in the Southern and central area. The fuchsia rectangle describes also that depredation in the North area **happens generally at more than 1 miles from the coast during fishing sets that last over 180 minutes**, and in correspondence of the gear retrievals that require more time (over 60 minutes).

From the red area it seems that the depredation events depend on the first quarter phase of the Moon only in the South area of the Gulf. Moreover, **cetacean-fisheries interaction in the South area involve only the *Tursiops truncatus* species which apply its opportunistic behavior preferentially at very low distance from the coast (less than 1 NM) on nets of medium length deployed at no more than 50 meters of depth.**

Finally, the green oval underlines that medium size of catches are linked to gears deployed at low depths and appear to be not tied to other variables.

Looking at the entire figure, it could be noted that **from North to South the probability of cetacean interacting with fishing gear in pods increase**, sure enough single individuals or couples were observed during depredation in the North part, many specimens together in the center, and more than 6 dolphins in the South.

The variables of all the descriptors considered for the analysis are also distributed in Figure 55 according to their measures of differentiation that reflect the grouping of their classes, from the environmental characteristics, to the fishing features, till the elements related to cetaceans. The average of the variance measured for these variables is 36% (Table 23).

After all, by placing the 45 depredation cases recorded in the space of the two-dimensional graph, it is possible to observe the way in which the variables considered act on the set of elements analyzed. There is a swarm that tends upwards, affirming a positive correlation between the majority of the variables, and a smaller one tending downwards, denoting the lack of correlation in other cases (Figure 56).

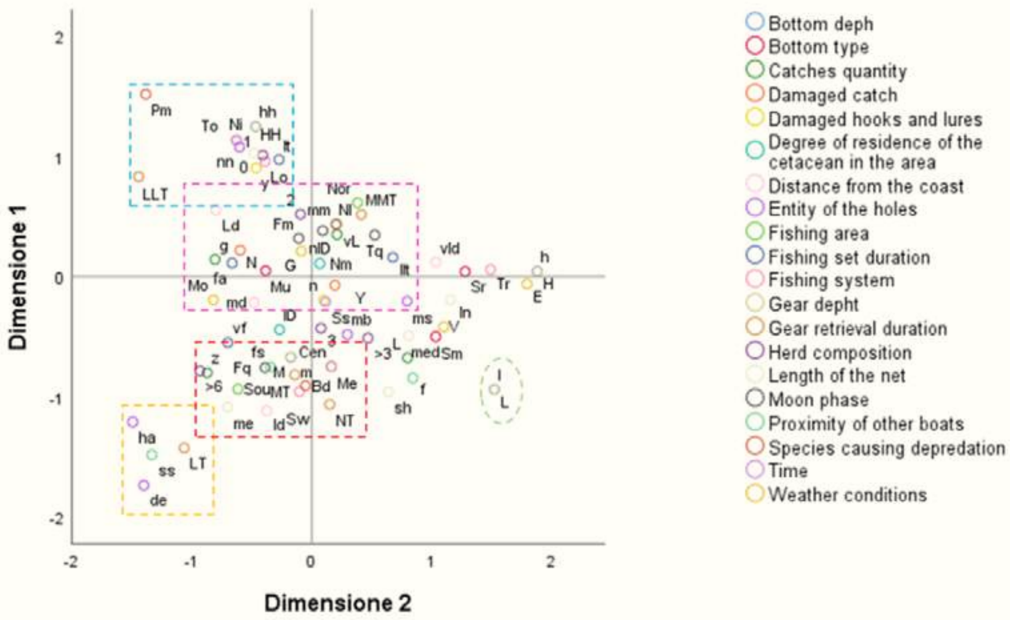


Figure 54. Joint chart of category points with normalized variables showing the connection between the various elements considered during depredation cases. The code of each variable is summarized in the Table 4, chap. 4 (methodologies). Our elaboration with SPSS.

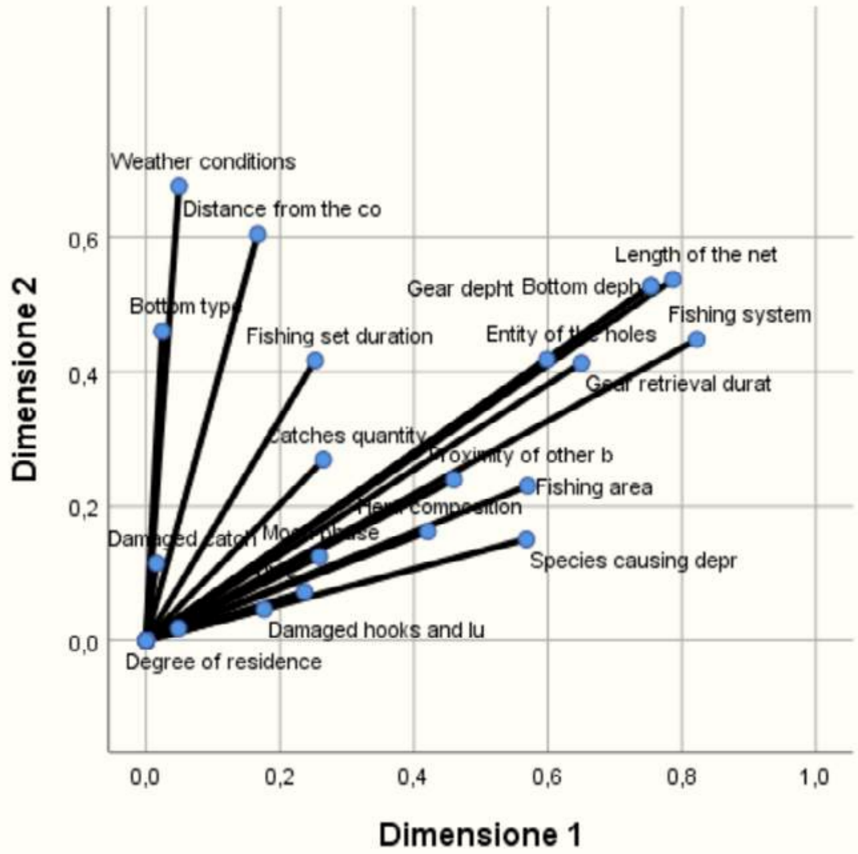


Figure 55. Measures of differentiation in the MCA applied to our case study. Our elaboration with SPSS.

	Dimensione 1	Dimensione 2	Media
Time	,237	,072	,155
Moon phase	,259	,125	,192
Weather conditions	,049	,677	,363
Bottom type	,024	,460	,242
Bottom deph	,754	,528	,641
Fishing system	,822	,448	,635
Gear depht	,754	,528	,641
Catches quantity	,265	,269	,267
Length of the net	,787	,538	,662
Proximity of other boats	,460	,240	,350
Fishing set duration	,253	,417	,335
Gear retrieval duration	,650	,413	,532
Distance from the coast	,167	,605	,386
Fishing area	,570	,230	,400
Degree of residence of the cetacean in the area	,048	,018	,033
Herd composition	,421	,162	,292
Species causing depredation	,568	,151	,359
Entity of the holes	,599	,418	,509
Damaged hooks and lures	,176	,046	,111
Damaged catch	,016	,115	,065
Totale attivo	7,877	6,462	7,169
% di varianza	39,385	32,308	35,846

Table 23. Measures of differentiation in the MCA applied to our case study. Our elaboration with SPSS.

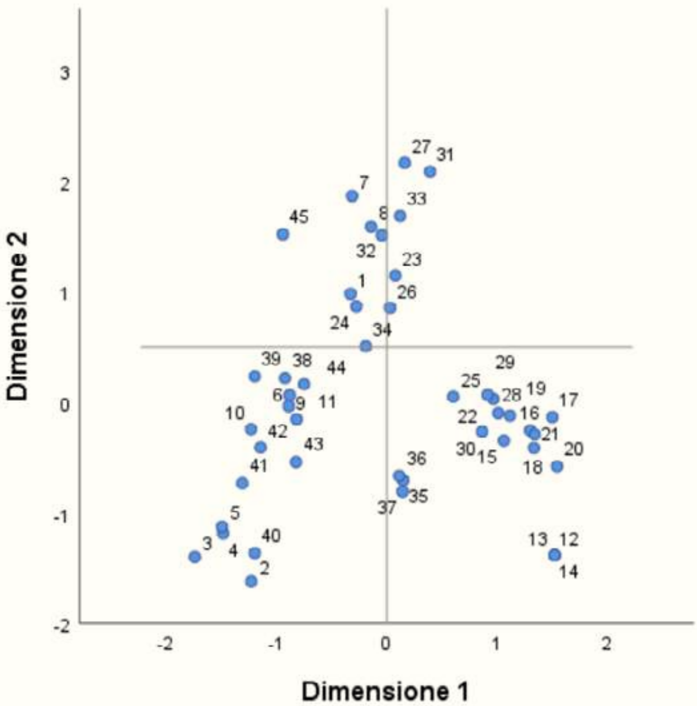


Figure 56. Points of the objects labeled with their number case (45 sets characterized by depredation applied by dolphins). Our elaboration with SPSS.

5.5. Bottlenose dolphin behavior during depredation events

Bottlenose dolphin sightings recorded during this study near fishing gears, through a careful compilation of field surveys and repeated viewing of recorded photos and videos, have been examined in order to create an ethogram referred to its opportunistic feeding behavior on fishing nets (Figure 57; Figure 58).

The data analyzed come from all the different portions of the Gulf and include cases of depredation committed by individuals as well as by couples or larger groups.

In some cases, the **presence of calves was also highlighted, supposing they were learning from adults how to hunt on fishing gears**. However, the presence of immature dolphins observed during the monitoring confirms that the Gulf of Catania is important not only for foraging but also as area used for breeding and initiation to group life.

In most cases, depredation occurred on unproductive fishing days, while in occasion of copious catches no interaction event was recorded, underlined the dependency from the availability of the preys.

Figure 57. A frame of a video showing a bottlenose dolphin surfacing closeness to a fishing vessel while the crew is hauling up a monofilo (single wall net) in the Northern Gulf of Catania. The net reported some big holes compatible with depredation operated by dolphin. Sighting from the sentry boat. Source LIFE.

Figure 58. Bottlenose dolphins in the Gulf of Catania during depredation activities on the monofilo net (single wall type). Sightings from a Floating Laboratory operating in the Brucoli bay. Source LIFE.

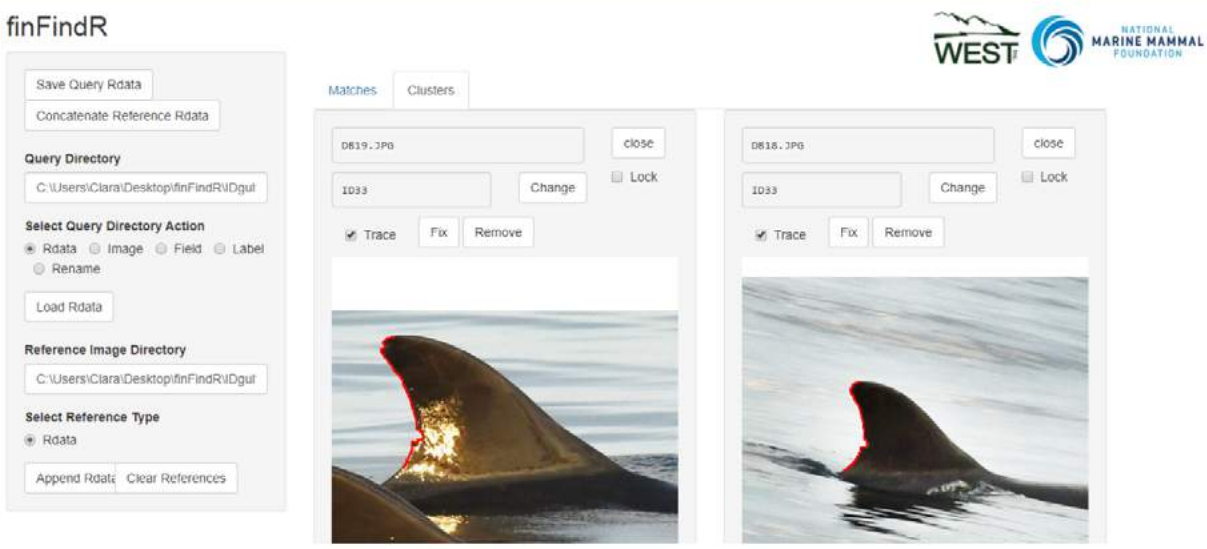


Figure 59. ID 33, an adult bottlenose dolphin sighted during the study applying a feeding in net behavior. Trace of its dorsal fin during the matching using the finFindR software. Our elaboration.

From the Photo-ID analysis using the finFindR software (Figure 59), it results that **3 of the dolphins sighted in interaction belong to the existing catalogue of bottlenose dolphins identified in the Gulf of Catania** by the MareCamp association (Bruno et al., 2006; Monaco et al., 2019). Precisely, the individuals have been previously "captured" through photographic session in summer-autumn 2018, and also other times in the years before, in the North part of the Gulf with other individuals of the same species **during a "feeding in wild" behavior. The fact to have "recaptured" them together with new pods, both in the North and in the South areas, and applying a "feeding in net" behavior suggest us that it is a local population based on a typical "fission-fusion" social structure and with a great site fidelity for the Gulf.** All the individuals appear to be inclined towards depredation actions, without particular specialization **but been opportunistic depending on the availability of the preys,** so when they need to optimize their foraging.

The 3 adults identified dolphins are: ID 06, ID 33, and ID 45. They were sighted respectively in locality Ognina di Catania, Aci Castello, and Brucoli.

Behavioral patterns observed during depredation events are summarized in Table 24 and include typical surface behaviors. Generally, **depredation on fishing nets starts in correspondence of the first portion deployed in the sea, which is the one remaining more time underwater and having more possibility to capture preys**. Indeed, in many cases it is also the part presenting the higher number or extent of holes. Once the fishing vessel responsible of the net approach the gear for its retrieval, depending on prey availability dolphin can stop to depredate the net or displace towards the farthest portion from the vessel in order to continue undisturbed feeding in net. When leaving the gear, the dolphin can apply subsurface or surface behaviors basing on the size of the herd it composes (Figure 60; Figure 61).

In addition to the depredation behavior, **cetaceans can interact with fishermen also** in other ways. For example, they can react **with the tail slapping** to actions that can endanger them. A tail slap, also known as “lobtailing”, is the act of a cetacean lifting its tail fluke out of the water and forcefully slapping it repetitively onto the surface of the water, resulting in a loud slap. Like breaching, is a form of non-vocal communication that can be heard underwater for long distances. Reasons of this behavior in nature can be different in whales and dolphins like foraging and scaring prey, defense, play, annoyance and acquire aggressive posturing (Figure 62).

In other cases, when dolphins are not feeding, they can just **approach and follow the fishing vessel making a “bowriding”**, that is a swimming or forward movement alongside the boat while positioned off the bow between the surface and less than a meter underwater (Müller et al., 1998). This is the case in which fishers understand that their presence will not determine any damage or loss (Figure 63).

Observed behavior and code	Foraging state	Ethogram description
Not visible (NV)	Search	Exact behavior cannot be seen or determined from the observation platform used. Slow swimming with minimal surface movements and long underwater displacements are supposed.
Feeding in fishing net (FN)	Approach - Attack - Capture	Opportunistic behavior related to feeding activity which includes search and acquisition of preys along a fishing gear. It is represented by the succession of long dives and short emersions near a fishing gear with which one or more individuals interact. The dolphin can use the net as a wall to which conduct its preys, or depredate the fish already entangled. The latter case requires to interact with the net generating holes of various entity. Respiration, and surfaces and submergence behavioral units like silent vaporous breath, surface exhalation with a few large bubbles, drop foresection submergence, and flat foresection surfacing are applied.
Leaving net (LN)	End	In case on a single individual, movements are quite not visible, and the animal go away from the area avoiding to be noted. Slow swimming with minimal surface movements and long underwater displacements are supposed. In case of more animals, longer surface swimming is alternated with aerial behaviors like bow and leap, also made by more than 2 synchronized individuals.

Table 24. Proposed ethogram of the behavior of the bottlenose dolphin interacting with small-scale fishing gears during depredation. Behavioral units indicated follow the classification made by Müller et al. (1998). Our elaboration.

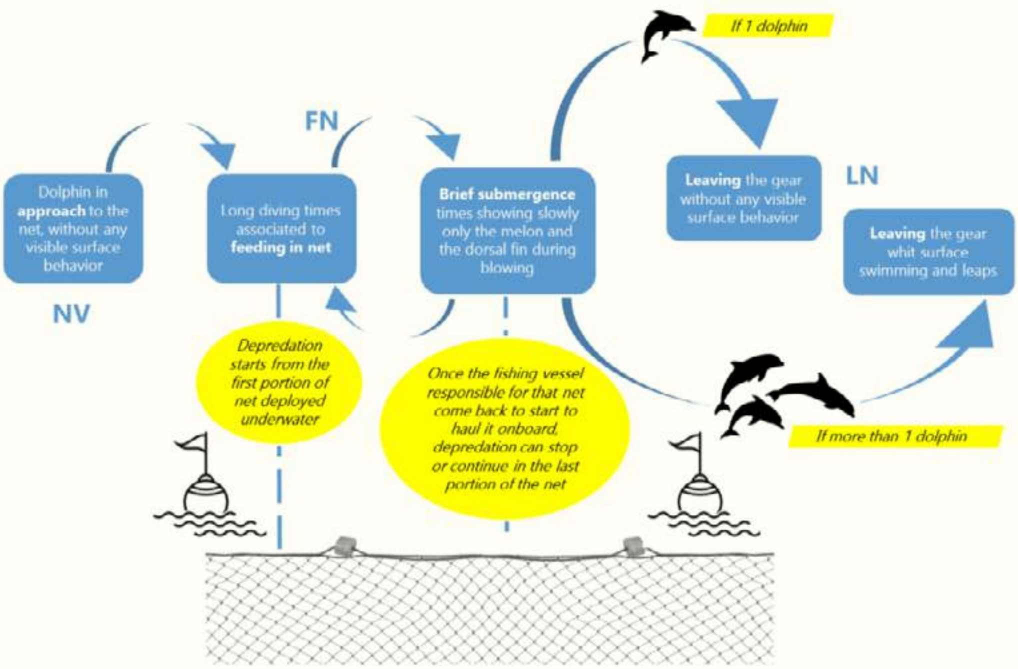


Figure 60. Schematization of the proposed ethogram of the bottlenose dolphin interacting with small-scale fishing gears during depredation. Our elaboration.

Figure 61. A frame of a video showing the final sequence of surfacing of a pod of bottlenose dolphins closeness to a buoy of a monofilo (single wall net) in the Southern Gulf of Catania. The net reported a lot of very big holes compatible with depredation operated by dolphin. Sighting from the sentry boat. Source LIFE.

Figure 62. A bottlenose dolphin recorded from a SSF vessel of Portopalo di Capo Passero (Siracusa, South Sicily), bothered by such behavior of the fishers onboard and showing its disappointment executing a series of violent "Tail slaps". Source https://www.facebook.com/giorgio.scollo.9/videos/2106744492682797/UzpfSTEwMDAwMDQxODAwMjUxMzoyMTA2NzQ1NTM2MDE2MDI2/

Figure 63. Dolphins sighted from the fishing vessels during transfers, so without occurrence of depredation events. Source Floating Labs network.

5.6. Acoustic evidences from the surveys

Approximately **380 minutes of acoustic recordings**, corresponding to about 6 hours and 30 minutes, **were collected during 15 surveys at sea**. Among these, a total of 241,42 minutes of acoustic recordings were acquired in 12 surveys during fishing operations. Table 25 shows recording duration per fishing gear and area.

Place	Fishing gear	REC duration
Brucoli	Single wall net	5,00
Brucoli	Trammel net	1,01
Ognina	Drifnets	16,43
Catania	Menaida driftnet	17,88
Aci Trezza	Longlines	10,32
Catania	Menaida driftnet	37,76
Aci Trezza	Gear for flying squids	12,39
Aci Trezza	Trammel net	88,17
Ognina	Single wall net	20,23
Ognina	Single wall net	32,24
Total REC duration during fishing operations (min)		***241,42***

Table 25. Duration of acquired acoustic recordings (REC) in minutes in relation to fishing gear and operational vessel. Our elaboration.

During 8 field trips, odontocetes species were encountered and acoustically recorded for about 221 minutes, corresponding approximately to the 92% percent of all acquired data. During 3 surveys it was not possible to recognize the emitter at the species level due to the similarity of the vocal repertoire between bottlenose and striped dolphin. In two cases the survey was performed at night when darkness prevented the visual sighting and species photo-identification. In the third case, no visual sighting occurred, but the animals were only detected acoustically. Table 26 shows all information concerning recorded species and the extent of the acoustic data (duration in minutes) acquired in relation to the detected sound type, according to each species repertoire. **Echolocation clicks were the most represented category among all recorded dolphin sounds**, whilst click trains were mostly recorded during the acoustic encounter with a solitary acoustically active sperm whale.

Delphinidae species were recorded acoustically in four different surveys for about 165 minutes during fishing operations. Among these surveys, there was no visually authenticated record of striped dolphin, whilst about 33 recording minutes were acquired in ascertained presence of bottlenose dolphins. In addition, about 37 minutes of acoustic recordings were acquired in presence of an emitting sperm whale during one survey performed at night in coincidence with flying squid fishing operations. Table 27 resumes available data per species, in relation to the different fishing systems.

	N Survey	REC duration	Regular clicks	Click trains	Creaks	
Sperm whale	1	36,84	22,41	31,84	4,17	
	N survey	**REC duration**	**Clicks**	**Burst pulsed**	**Whistles**	**Moans**
Bottlenose dolphin	4	73,12	53,03	31,34	11,23	2,34
Striped dolphin	1	10,26	10,26	1,80	5,26	5,26
Unknown *Delphinidae* (no visual sighting)	3	137,69	132,69	36,98	90,27	21,98
All *Delphinidae*	8	221,07	195,99	70,11	106,75	29,58

Table 26. Acoustically detected species and related acoustic data duration in minutes per sound type identified. Our elaboration.

The occurrence of sounds specifically related to feeding activities and predation was studied for dolphins (Delphinidae) and sperm whales. **Burst-pulsed sounds were recorded in all surveys when dolphin presence was noted** (eight surveys) and they represented about the 28,8% of recording minutes over all dolphin recordings **during fishing operations**. Concerning sperm whales, percentage of recording minutes with echolocation runs (click trains and creaks) represented the 86,43 % of all acoustic recording time.

Delphinidae REC duration	Place	Fishing gear
90,72	Aci Trezza	Gear for flying squids
12,39	Aci Trezza	Trammel net
5,00	Aci Trezza	Longlines
5,00	Brucoli	Single wall net
9,18	Catania	Menaida driftnet
20,23	Ognina	Single wall net
22,18	Ognina	Single wall net
Sperm whale REC duration	**Place**	**Fishing gear**
36,84	Aci Trezza	Gear for flying squids

Table 27. Duration (in minutes) of dolphin and sperm whale acoustic recordings in relation to the observed fishing operation of the various vessels. Our elaboration.

Looking in detail, Figure 64 and Figure 65 show a series of **echolocation clicks and burst pulses emitted by bottle-nose dolphin that can be associated to foraging, feeding activities, and intra-specific communication in presence of an active fishing vessel**. Tonal sounds as whistles and moans of striped dolphins are shown in Figure 66 and Figure 67 and are related to intraspecies communication.

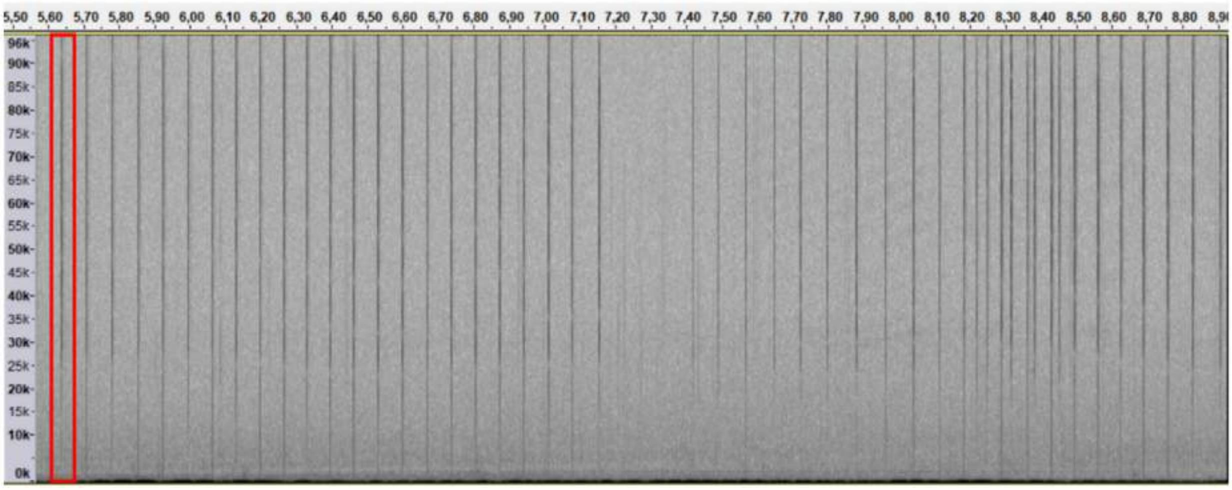


Figure 64. Spectrogram performed at 1024 fft points with 80 % overlap, showing a series of echolocation clicks recorded during one of the surveys and emitted by bottlenose dolphins (grey scale indicates relative intensity gradient of 100 dB). The red rectangle indicates the first click of the series. Our elaboration.

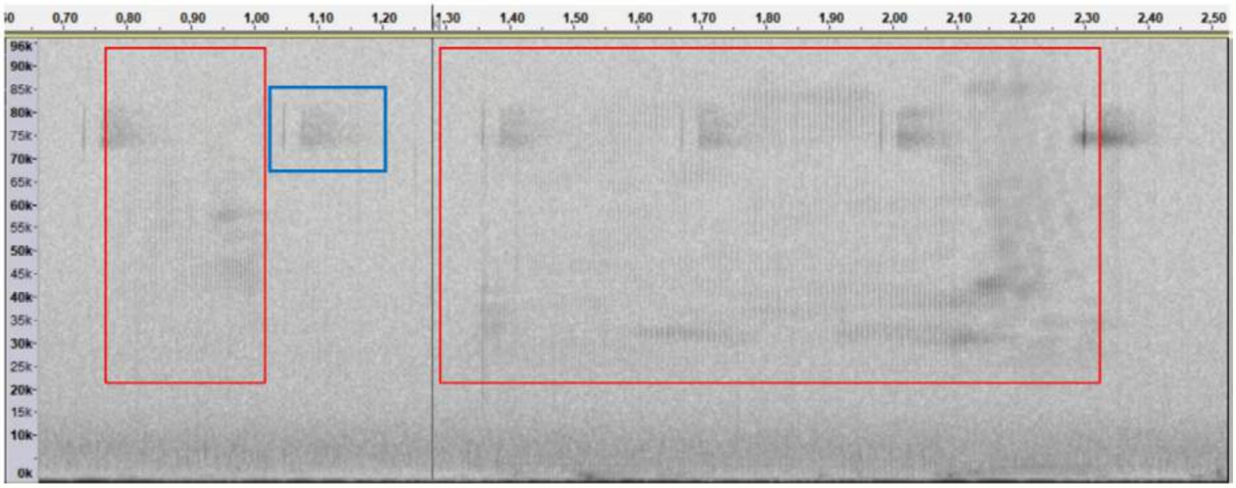


Figure 65. Spectrogram (1024 fft points, 80% overlap, 60 dB grey scale interval) showing two sequences of burst-pulses emitted by bottlenose dolphin (red boxes). The pulses from a fish-finder sonar are also visible around 75 kHz (blue box). Our elaboration.

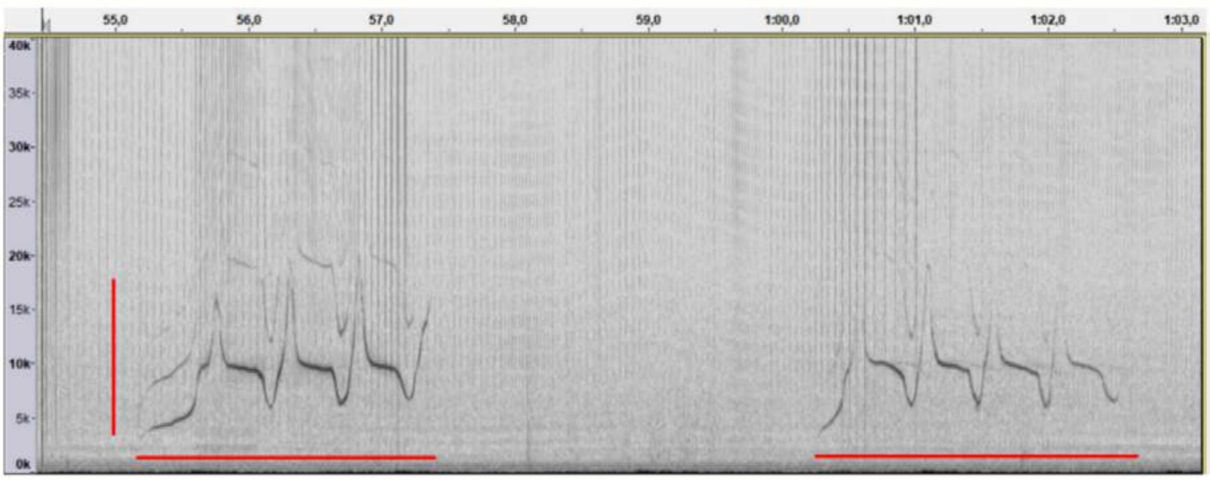


Figure 66. Spectrogram (20148 fft points, 80% overlap, 100 dB gray scale gradient) showing two whistles emitted by bottlenose dolphins. Despite they differ in terms of number of modulation slopes, duration of both whistles (horizontal axis) is of approximately 2.2 seconds and they show a frequency range going from 4 kHz up to about 18 kHz. Our elaboration.

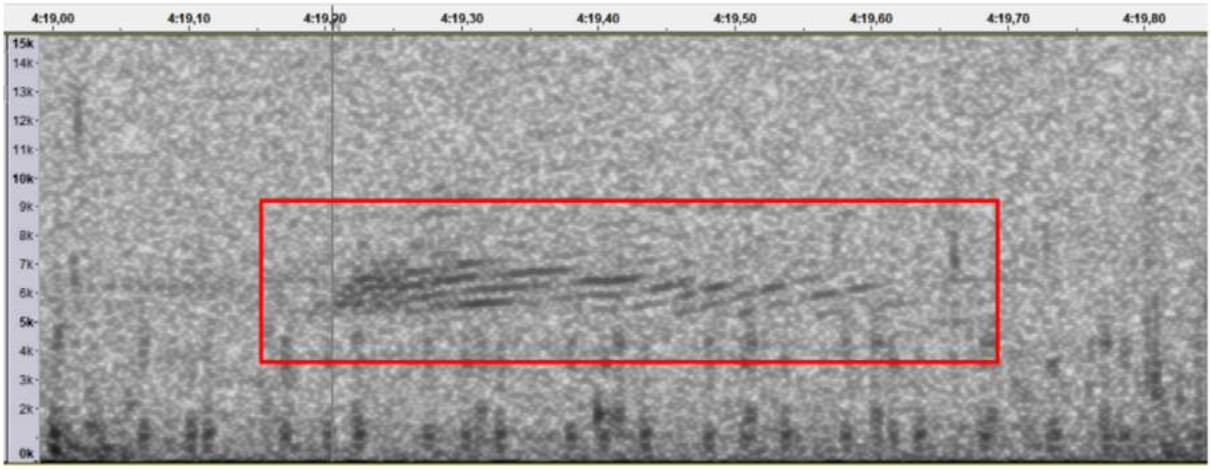


Figure 67. Spectrogram performed at 2048 fft points with 80 % overlap showing a "moan" sound emitted by a striped dolphin (grey scale indicates relative intensity gradient of 60 dB). Our elaboration.

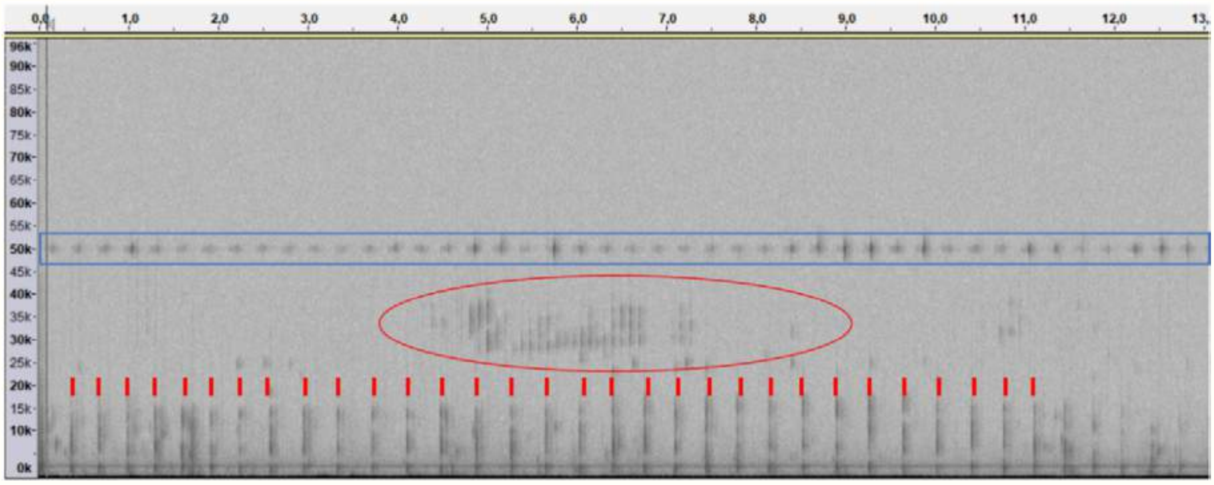


Figure 68. Spectrogram (4096 fft points, 80% overlap, 100 dB grey scale intensity gradient) showing a series of sperm whale regular clicks (red bars indicate the position of each click in the sequence). Dolphins echolocation clicks are also visible above 25 kHz (red circle). Impulsive sonar sounds from a fish-finder are also visible around 50 kHz (blue box). Our elaboration.

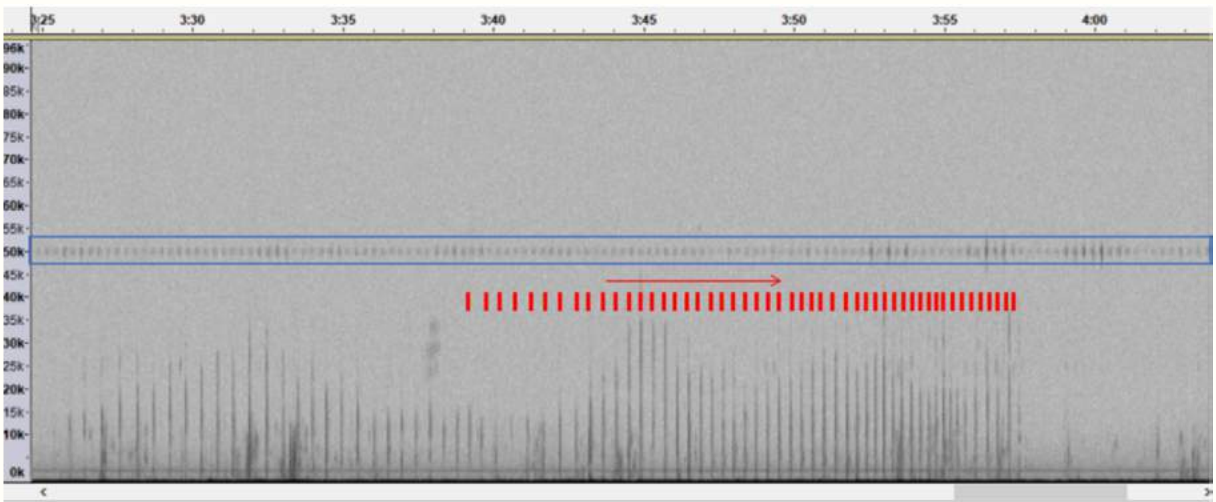


Figure 69. Spectrogram (4096 fft points, 80% overlap, 100 dB grey scale intensity gradient) showing a sperm whale click train sequence. Red bars and arrow show the position of clicks where Inter-Click-Interval decreases rapidly as the animal is approaching its target (prey). Impulsive sonar sounds from a fish-finder are also visible around 50 kHz (blue box). Our elaboration.

The spectrograms resulting from sperm whale recording shows the concurrence of an active fishing vessel too, while the big cetacean emit clicks and click trains attributable to prey capture close to the totanara (gear for squids) used during the related survey (Figure 68; Figure 69).

Despite the relatively small number of surveys performed due to the lack of dedicated funding, it has been possible to obtain interesting new data concerning cetacean acoustic activity and interaction with small scale fishery in the Gulf of Catania. It was not possible to obtain synchronized audio-video data underwater. However, the experimental set up allowed the acquisition of acoustic data with **cetacean sounds occurring in 92% of all recordings acquired during fishing operations.** Furthermore, it was possible to assume that **dolphins were undertaking underwater feeding and predatory activities during at least approx. the 30 % of the sightings occurred during fishing operations.** The percentage is consistently higher for the sperm whale, which however has been only detected once, during a flying squid fishing operation. This difference is easily explained with the different behavior of the species which undertakes long deep dives, predating mainly on cephalopods.

5.7. Activation of the on-line permanent voluntary survey

As underlined in the previous paragraphs, interviewed fishers declared to have no idea of possible mitigation measures able to solve the cetacean-fishery interaction problem, also because those few proven methods did not work. Moreover, they think that since dolphins eat the same species that they fish, competition will never end, especially now that their availability is decreasing. Anyway, they declared to be available for new trials of devices aimed at mitigating interaction events with marine wild fauna, and they expressed their interest to participate in future voluntary surveys designed for a continuous understanding of the problem.

With this aim, the project included the **creation of an online permanent and voluntary survey for professional fishers to help the international network gathering data on depredation cases caused by wildlife on fishing gears** (Figure 70).

Questions to pose were agreed among the representatives of each country belonging to the various partner of the project, following an exchange of ideas about the key elements to ask in order to make possible they report personal experiences on negative interaction with cetaceans, and cost-damages incurred during their fishing trips.

The survey was promoted through meeting with fishers, promotional video shared on websites and social networks, and during conferences.

The questionnaire was created in four different languages and it is available through the following links.

- English >>> https://forms.gle/sCJvgZeX7DperQuZ9
- Italian >>> https://forms.gle/kaeHna9wV2VybcNE8
- French >>> https://forms.gle/dki6RuYaau7cS42YA
- Spanish >>> https://forms.gle/xmE4s7xi1EkcXBo37

First answers arrived from the English (4) and the Italian (4) forms, many fishers of the Floating Laboratories network continue to send to LIFE and MareCamp photos and videos of new interaction cases, and also other fishers of the Mediterranean are starting to report their experiences (Figure 71).

Main categories of negative interaction indicated into the survey until today are: catch eaten; catch damaged (bite marks); only fish head remaining in the gear; very big holes (bigger than 120 cm); lures taken; medium holes (31-80 cm); big holes (81-120 cm).

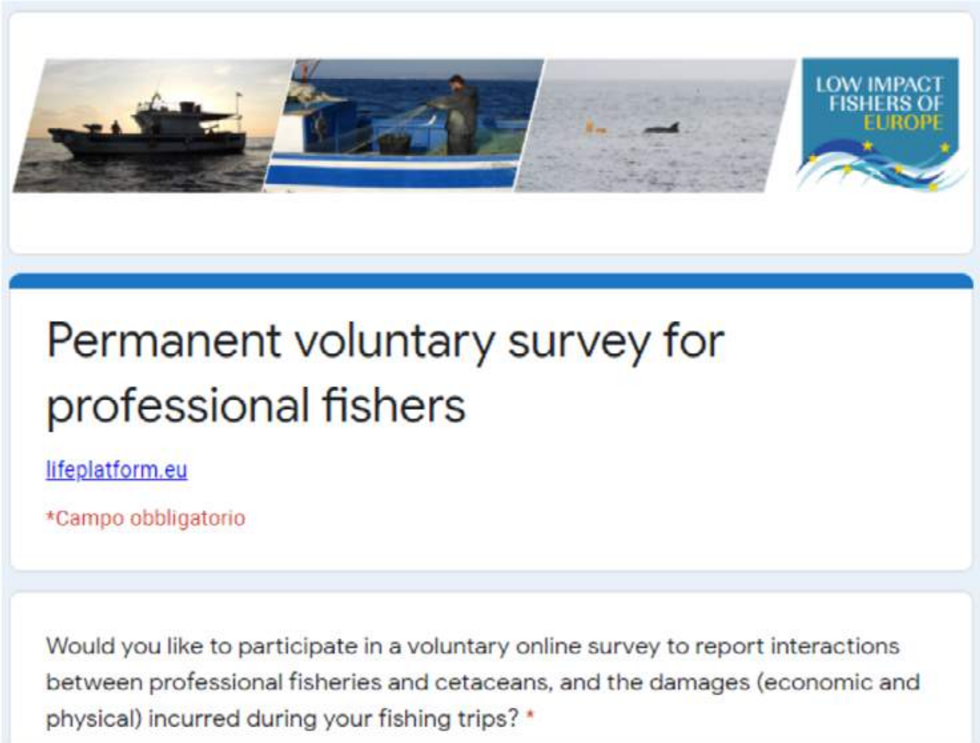


Figure 70. Home page of the English voluntary survey for professional fishers to report negative interaction with cetaceans. Source LIFE.

Figure 71. Screenshot of a video sent by a Sardinian fisherman recorded while he was fishing red mullets with a single wall net. The fisher came to know about the depredation project through the LIFE promotional video and then participated at the on-line voluntary survey. Source G. Cussu.

5.8. Main Outputs and Findings from the Floating Laboratories Network

This study explored the issue of the interaction between cetaceans and small-scale fisheries in the Mediterranean from various points of view with a multidisciplinary approach. For this purpose, various sources have been used to arrive at an exhaustive level of knowledge of the subject, and of all its related factors.

An essential source of knowledge was the contribution of the fishers who, through their conversations, provided the basis of the state of the art of the local fleets, and helped to reconstruct how the different fishing system work, and what are the problems that afflict them, including that of the depredation of fishing gears made by cetaceans.

Their indications on the frequency, modalities, and effects of this type of interaction were confirmed during the investigations carried out in the field with the surveys at sea and the direct observation of fishing trips and interaction events. These field activities made possible to define more precisely the factors that are influential to depredation and the variables that characterize it, and to quantify real impact and consequences.

In this regard, Table 28 summarises the main outputs and findings of the study, specifying with which type of source they have been reached, and at what initial question or objective they respond. This list confirms the integrated approach that guided the entire research and that led to as many results of a multidisciplinary nature.

Initial questions and purposes	Main outcomes and findings	*results from* Research on statistical and bibliographic sources	Interviews and focus groups	Surveys at sea
To start the study from an exhaustive base of data and information	Overview on conflicts between cetaceans and fisheries in the world	■		
	Inventory of the existing mitigation measures and devices	■	■	
	Summary on the status of the SSF Mediterranean fleet	■		
To create a systematic method to investigate conflicts between cetaceans and fisheries	Draft of a monitoring protocol and specific survey sheets to be followed in the different countries with which they were shared and approved		■	
To carry out a participated work recognized by all the actors involved in the study issue	Integrated data from the application of a multidisciplinary and systemic approach	■	■	■
	Multidisciplinary data and activation of the Floating Laboratories network	■	■	
	Activation of a permanent voluntary survey for fishers		■	
Characterization of the local fleet	Data on the Sicilian fleet (number of vessels, length, tonnage, power, revenue)	■		
	Description of the main fishing gears and metiérs used in the investigated area		■	■
	Table on SSF target species per fishing gear used by SSF in North-Eastern Sicily		■	■
	Reconstruction of the seafood local supply chain	■	■	
	Data on the structure of the sample in North-Eastern Sicily (vessels' age, licences, authorizations, segment)	■	■	
Quantification of the effort of the small-scale fishing fleet investigated	Data on fishing gear lengths, sets times, type and quantity of catches, CPUE, incomes		■	■
	Maps (spatial distribution) of the exploited areas per fishing gear, degree of selectivity, duration of the fishing sets, and quantity of catch		■	■
To collect a good amount of information about conflicts that happen between wildlife and SSF	Data on stranding of cetacean ad other vulnerable species due to human interaction in Sicily	■		
	Estimate of the frequency of interaction cases		■	■
	Census and frequency on non-target species captured as by-catch		■	■
	Identification of 14 focal areas more susceptible to cases of cetacean-fishing interaction in North-Eastern Sicily	■	■	
	Maps on distribution of cetacean depredation events in the Gulf of Catania	■	■	
	Identification of the type of damage to the catch and to the fishing gear caused by dolphins and other marine species	■	■	
	Estimate of the economic losses for the fleet	■	■	
	Identification of correlation of some environmental factors and characteristics of fishing systems that favour the establishment of depredation events by dolphins	■	■	
Interpret the feeding in net behaviour applied by dolphins	Ethogram of a bottlenose dolphin during a depredation event		■	■
	Identification of bottlenose dolphins' individuals applying an opportunistic behaviour		■	■
To have acoustics evidences during depredation events	Recording of cetacean sounds compatible with feeding and predatory activities during fishing sets		■	
To go towards the mitigation of the cetacean-fishery interaction problem	Insights on the issue for a better knowledge and management of SSF activities, and on the elements to be considered for related research activities		■	■
	Suggestions for implementing the study in the Mediterranean, and of possible mitigation measures and devices to apply in next phases	■	■	■

Table 28. Resume of the main outputs and findings of the study. Our elaboration.

5.8.1. Further rising issues of the case study

The Floating Laboratories experience, in close contact with the fishermen and living their rhythms, has allowed scientists to observe and interpret local reality more carefully. The intense activities in the field have revealed some problems both in research and fishing activities that are briefly listed below. They are a collection of assertions inferring from the talks with fishers and the direct experience of the boarded observers that should be considered for future interventions for a better management of the SSF, and for the continuation of the experimentation aimed at mitigating conflicts with cetaceans.

Research activity

- The excessive bureaucracy makes difficult to authorize the boarding of observers on multiple boats and for long periods. In addition, release times can reach months.
- The underwater drone proved to be poorly suited to the oceanographic conditions of the Gulf, and to the needs of fishers. It is not able to oppose the currents and risks to be trapped in the nets while the fishing boats are engaged in their recovery. In addition, the battery has a low life (40 minutes compared to 3 hours declared in the technical sheet), and the viewer does not favor orientation. Probably, its use in an experimental fixed fishing station will be able to reach better outcomes.
- In some cases, damaged fish with signs of dubious origin have been found in fishing gears. The use of action cameras attached to the gears could clarify this issue.

Fishing activities

- Existence of unfair competition with non-regulatory fishermen who exploit marine resources and influence market prices.
- Excessive presence of sport and recreational fishermen who became competitors, especially during summer.
- Growth of imports of seafood products on the local market, with consequent decrease of the value of SSFs products.
- Deficit in the control system of many Institutions related to fishing activities.
- Constant illegal trawling activity inside the Gulf of Catania, that spoil the seabed causing a decrease in resource availability.
- Routes of ferries and large ships overlapping with fishing areas, with frequent cases of damage of the fishing nets, and risk of collision with fishing vessels.
- Increasing pollution of sea waters (Figure 72), disappearance of some target species, and introduction of non-indigenous species.

Figure 72. Marine litter found in a trammel net operative in the Gulf of Catania. Source LIFE.

- Climate-driven changes to the marine environment causing variation in species distribution (e.g. "Once upon a time anchovies were within 3 miles, now the water is warmer so fish schools are more offshore, but we can't go there!").
- The smallest boats are the most limited by bad weather. Moreover, they cannot make long displacements when their target species is in an area of the gulf too distant from their home port.
- Costs and times for storing boats are very high and heavily affect the fisherman's activity.
- Many floats are made of plastic and can pollute the sea. It would be advisable to develop prototypes of buoys made of biodegradable material.
- All fishermen claim to have learned the fisher profession by embarking since they were children. However, the law does not allow boarding of unregistered people, including fishermen's sons and retired elderly people who are not part of the official crew. How will this job continue to be handed down? For example, not many fishers are able to sew the nets already today.
- Métiers like that of the menaida require about 5 fishermen in a boat to carry out all the fishing operations. However, some boats are enabled for no more than 2-3 people on board for structural reasons, therefore are forced to embark sailors informally, with the violation of the navigation code, no protection for the embarked, and the risk of sanction both for the captain and the sailor.
- Small-scale fishermen continue to be discriminated for not being able to access to tuna quotas. Furthermore, although the percentage of accidental catch of tuna has changed from 5 to 20% of the catch, it is not applicable to "non-tuna like" fishing systems.

CHAPTER 06

Suggestions towards finding solutions

INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN

Study Area 1:
The Case of Central Mediterranean
Sicily, Italy

Previous studies and the experience of our project indicate that solutions to the problem of cetacean-fishery interaction can be found only by studying its dynamics thoroughly and distinguishing cases involving different fishing systems in single contexts. The approach to be used, therefore, should not suggest a universal solution to the problem but, rather, specific adaptations according to the case.

The activation of the floating laboratories network represents an excellent answer to know the real state of art and conditions that exist in a given fleet, and the fact of being able to repeat them in different areas allows us to be able to join multiple networks to get an overall picture of the existing situation throughout the Mediterranean. When looking for real data on the occurrence of depredation and by-catch cases of vulnerable species, as well as on fishing effort and any damage suffered by the fishing units belonging to it, their involvement is to be considered essential.

The experience focused on small-scale Sicilian fishing fleets has highlighted the **need to investigate the possible application of depredation mitigation measures on three different types of gear: longlines; nets that are deployed at sea for several hours even leaving the area, such as trammels and single wall nets; nets that require a short stay underwater and that are always checked on sight by the fisherman.**

This distinction is suggested not only in relation to the different fishing techniques and target species that determine the modalities of depredation, but also to the most probable moment in which interaction can take place, and to the presence-absence of the fisherman on the site at that time.

Without ever underestimating the high degree of intelligence of cetaceans and therefore foreseeing their responses and adaptations to each type of mitigation solution that we intend to implement, any prototypes of new devices useful to respond to the problem of interaction must be made assuming not only their effect on the environment, but also possible reactions from the megafauna, capable of damaging or bypassing them.

For new experimental phases, where possible, it is also useful to consider the distribution and the group composition gradient of the different species of cetaceans susceptible to interaction, in order to carry out tests at first in areas with a lower incidence of depredation in order to verify the operation of the mitigation device and its influence on the size and composition of the catches; subsequently, in areas with high possibility of interaction in order to observe their functioning in the presence of cetaceans.

Since it is not easy to develop resolution devices for each type of fishing, in certain cases the actions to be taken should be directed towards a better definition of the elements that characterize the depredation event, in order to be able to distinguish it from other cases, recognize its effects, and allow to direct any compensation for damages suffered only when certain factors are present.

Suggestions for repeating the study in other areas

Depending on the degree of knowledge of the problem in the area, the same investigation described up to here can be repeated, following these steps:

- territorial survey and consulting of official registers in order to understand the composition of the local fleet, characteristics of the fishing gears, main issues, and select fishing vessels to be involved in a new local network of Floating Laboratories.
- face to face interviews to small-scale fishermen to know their situation about interaction with cetacean and other vulnerable species;
- data collection on fishing effort, depredation and bycatch cases through appropriate register for fishers;
- activation of a network of fishing vessels (Floating Laboratories) practicing different métiers susceptible to interactions with cetaceans and other vulnerable species, equally distributed in the case study area;

- monitoring onboard the fishing vessels to document capture activities and potential cases of depredation and by-catch for their better understanding;
- monitoring with a scientific boat in connection with the Floating Laboratories that have not observers onboard to document fishing activities and potential interactions to better comprehend.

Once the expected knowledge results have been achieved, it is possible to focus the attention on the emerging elements, design new mitigation actions, and to carry out tests.

Suggestions for the next steps to follow in Sicily and in Western and Central Mediterranean Sea

The subsequent investigation and test phases should take into account the results obtained with this first study and allow to maintain a constant link and collaboration between the bodies involved in order to continue the exchange of information and to better adapt possible interventions.

A possible new study should investigate the phenomenon of interaction and the parameters that condition it, through both visual and acoustic investigations to have further details on the phenomenon and identify new potentially effective wave emission systems. It should also allow to investigate more deeply the fishing effort and the state of the stocks exploited by the small fishing fleet in the Gulf of Catania and in the surrounding areas, in order to define management plans for the exploitation of marine resources in a participatory manner.

The research could focus on:

- deepen the elements that emerged from the Kernels and Multiple Correspondence Analysis which suggest which situations are most subject to interaction. For example: the South area of the Gulf of Catania, and that in correspondence of the Cyclops Islands MPA; medium length nets deployed at medium depth close to the coast; the bottlenose dolphin populations resident in the Gulf for a long time;
- fill the lack of information on some key factors which characterize the targeted fleet, but which have not been studied in depth enough. For example: verify what other activities affect areas less exploited by Floating Laboratories and the possible presence / absence of interactions with cetaceans and other vulnerable species; monitor artisanal longline fishing with observers on board fishing vessels;
- widen the field of action of the investigation to have a clearer and more comprehensive picture of Sicilian waters, extending the boarding of observers on fishing vessels that practice small-scale fishing even outside the Gulf of Catania (Aeolian Area, Syracuse, etc.); and to fishing boats excluded from the small-fishing category but operating in the vicinity of the Gulf and whose activity can be the cause of by-catching of animals that reside mainly in the Gulf; interviews with further fishermen to enlarge the local sample.

Beyond which aspects to investigate, a new phase of the study should be directed to a concrete and operational action that is ever closer to reaching some solution. The actions that can be carried out according to the available resources are summarized below.

1. Monitoring surveys at sea where, in addition to the use of instrumentation in fixed configuration from the support monitoring boat (sentry boat), it may foresee the use of autonomous acoustic and video recording systems deployed near or attached directly to the fishing gears. This would allow us to obtain a more complete information concerning the occurrence, acoustic activity and interaction of the animals with the different fishing gears. An acoustic "alert" system indicating the presence and the occurrence of feeding sounds close to the nets may be also developed and tested. A similar system may find its application for those fishing types such as trammels and single wall nets which would be recovered by fishermen in presence of dolphins engaged in depredation activities to limit the economic damage. Gaining additional information on dolphin acoustic feeding behavior will be essential towards the development of forecasting behavioral models needed to improve available acoustic deterrent devices. Depending on the model, the autonomous acoustic and video recording systems can also be activated by observers or fishermen on board the fishing vessels once trained.
2. Trial of cases of depredation through a fixed audio-video monitoring system, capable of constantly monitor a semi-fixed experimental fishing net susceptible to interaction by type of gear, sea bottom, etc., and equipped with various action cameras and hydrophones. It can be possible to choose to always use the same place where to install the fishing gear and leave it for several days, or to make special catches in areas where dolphins have been spotted in advance in order to increase the possibility of interaction and data collection. Any catches may be used for further scientific purposes. The activity must include a budget dedicated for repairing the fishing gear after interactions when particularly damaged.

3. Study of the feeding habits and feeding behavior of the bottlenose dolphin in open water and near fishing gears by positioning temporary and reusable tags, preferably on individuals already known to apply the "feeding in net" behavior. Although it is a more invasive monitoring method than others, it must be considered that the tag adheres to the animal's body with suction cups and it is lost by the dolphin after a few days. The tag can also be applied in the case of sperm whale sightings. The device should include sensors for light, pressure, depth, acceleration, compass, gyroscope, GPS, audio and HD video recorder.
4. Modification of the closing method of the "Umbrella-and-stones" mechanism (Hamer et al., 2010; Goetz et al., 2011) seen in chapter 2, and adaptation to the totanara (gear for squids) and longlines to prevent interaction with dolphins and sperm whales. Experimental setting has to be done first in a controlled environment (a swimming pool) to test its operation, and then at sea in order to test differences in size of catches and measure the eventual mitigation action when activated.
5. Test of latest generation acoustic dissuaders such as the "banana pinger" or variants of optical / light deterrents, both on nets and on longlines. In the case of longlines, the trial can also be addressed to cases of by-catch of sea turtles.
6. For cases of interaction that are difficult to mitigate, search for appropriate methods of detecting the presence of cetaceans in order to clearly demonstrate their presence and the possible influence in scattering preys, for the purpose of receiving compensation related to the presence/absence of the animals and the decreasing in catch quantities. An example is the case of the sperm whale whose presence can be ascertained by hydrophones and recorders positioned under the fishing boats or on the gears to check the presence of cetaceans.

7. Creation of a handbook for the recognition of the damages caused by cetaceans that feed on fishing gears and catch, so that it can be a point of reference for scientists and also for the authorities that will have to ascertain the damage in case of assignment of compensations and reimbursements. Indeed, often Administrations prefer to not allocate any refund for damages suffered because they are not able to distinguish if a net was depredated or broken by the current or entangled in the rocks, etc. The action may include the installation of cameras on board the fishing boats to record the moments of setting and hauling up the gears, and check the *ex ante* and *ex post* conditions of the gears.
8. Investigate the possibility of developing artificial baits prototypes for longlines made of more sustainable materials than plastic and capable of reducing the attraction of cetaceans.
9. Vessel Monitoring System (VMS) installation in fishing vessels of the Floating Laboratories network to strengthen the monitoring of fishing activities and simplify the data collection of their tracing. A mapping of the exploited areas will be useful both to investigate the relationships with the presence and interaction of cetaceans, and to identify the best solutions concerning the management of marine resources.
10. Regarding the vulnerable species subject to by-catch, investigation through interviews and boarding on fishing boats to circumscribe the areas of finding in order to map them and suggest priority areas to be considered in the local management plans.
11. Underwater photo surveys to better observe scars and wounds of anthropogenic origin on the body of the dolphins, which are good signs for estimating the fishing gear impact upon cetacean populations (Vanderzee et al., 2019).

12. Evaluation of the adaptability of existing acoustic and visual dissuaders (acoustic emitters and reflectors, masking nets) to our case study, and of their impact on the environment, as well as monitoring of project results recently activated such as the "Life Delfi - Lowering Fishing Interactions" project in the Tyrrhenian and Adriatic seas, and the "DOLPHINFREE: Dolphins free from fishery by-catch" in the Mediterranean and in the Atlantic Ocean. This could lead to better analyse lessons learned and search synergies with other working projects and trials.
13. Sharing and implementing the protocols developed in this study to investigate depredation in a standardized way in other small-scale fleets at local and regional level.

In order to optimize the results and promote their dissemination, a joint international collaboration between the various bodies operating on the problem of depredation in the Mediterranean would be desirable. Experts of the sector could gather to propose new ways of trials starting from the results achieved in their experiences, while fishers could be involved in exchange programs on the assessment of damages and the use of new mitigation devices.

A unique coordinated observer programme could serve to monitor cetacean interaction and establish annual estimates of depredation and by-catch rate by fishery. Collaborations from one area to another in the Mediterranean could also allow an exchange of the different existing mitigation devices or in the trial phase, in order to test the same gears in different environments, checking their operation and conditionality, and amortizing the costs.

A continuous comparison between research groups would also be useful to create a guide that lists the elements common to the various existing fishing systems affected by cetacean-fishing interaction, in order to recognize in which cases the same mitigation measures can be applied.

The continuation of the depredation project in various countries, as well as in Sicily, requires large financial resources since it has to deal with a very complex, multidisciplinary subject, which imply the involvement of a large number of specialists (fishermen, engineers, biologists, technicians, etc.). In addition, some monitoring plans need to be conducted over a long period covering all seasons of the year, and they are bound by weather conditions.

Generally, samplers that are students or trainees are often used to balance costs, and no compensation is given to fishermen taking for granted their presence at sea or their willingness to provide information. However, greater recognition of the fisherman category would have positive effects on their trust in scientific research and participation in the definition of management plans, while the involvement of a greater number of experts in the field would help to fill those gaps in data collection due to the lack of experience (e.g. incomplete questionnaires, unidentified sighted species, poor quality photos, etc.).

With reference to this study, the fishers participating in the research received a reimbursement of expenses, both for the interviews and for the activation of the Floating Laboratories. This solution has proven to encourage fishermen's willingness to collaborate, also in-network, both in providing more detailed information, in welcoming observers onboard their fishing vessels, and in compiling the registers. Being an active part of the project allowed them to better understand the purpose of the research and to become promoters of the same.

New phases of this project in Sicily should include the continuation of the actions carried out with the "sentry boat", with the possibility of moving quickly from the North Cape to the South Cape of the Gulf based on real-time interaction reports by fishers. The on-board instrumentation should be implemented with a new Reflex camera with telephoto lens to better succeed in documenting events at a greater distance, and to apply the Photo-IDentification in a more fruitful way. Instead, Bridge type cameras should be assigned to each observer on the Floating Laboratories in order to record high quality shooting too. The observers should be equipped also with a GPS to easily record tracks, and suitable clothing adapted to boarding on fishing vessels.

As regards fishermen, their level of involvement and participation should continue to be high. However, up to now the people most consulted have been the commanders or owners of the fishing vessels (which are fishers in the same boat too), therefore the information given to the remaining components of each crew about the purpose of the project and the role of the Floating Laboratories should be greater.

The inclusion of fishers must also take place at the level of dissemination of results starting from the Port Authorities, up to the categories of retailers, restaurateurs, and consumers, in order to strengthen the meaning and validity of their work. The most collaborative should be rewarded, as well as those who participating in the project suffer more damage due to interaction with cetaceans.

In order to simplify the interpretation of the data entered by them in the fisherman's registers, the new surveys should be compiled digitally, through the choice of predefined fields and information to avoid errors and to lighten the work of uploading the databases.

CHAPTER 07

Conclusions

INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN

Study Area 1:
The Case of Central Mediterranean
Sicily, Italy

The project "Interaction between cetaceans and small-scale fisheries in the Mediterranean" promoted by the Low Impact Fishers of Europe platform (LIFE) and sustained by the MAVA Foundation, **involved the fleets of three countries (Italy, Spain, Malta) in a programme named "Floating Laboratories"** where fishers and scientists worked together exchanging their expertise and cooperating in data collection with the aim to assess the socio-economic and ecological impacts linked to the phenomenon of cetacean-fishery interaction, and to lay the foundations for suggesting innovative strategies capable of mitigating this old phenomenon.

The study was **based on standardized research protocols and survey sheets** shared between the participating countries in order to allow its extension to other areas and the comparison of the results across the Mediterranean in the future.

In order to answer specific questions related to the status of the operational fleet in North-Eastern Sicily, and about the existence and the dynamics of by-catch and depredation events in the area, a **territorial investigation** followed by **face to face interviews** to small-scale fishermen, **monitoring onboard the Floating Laboratories** (the fishing vessels) **and also with a research boat** (the "sentinel") had been carried out through a multidisciplinary and systemic approach.

Sicily counts 1 887 traditional multipurpose fishing vessels less than 12 meters of length, with non-towed gears, and operating mainly within 6 NM from the coast which represents 23% of the Italian small-scale fishing fleet. For over a decade, it has had an ongoing negative trend in number of vessels (-16%), GT (-29%), and kW (-20%) which jeopardize the subsistence of the local sector. The targeted fishing fleet is composed by vessels having **6 main recurring licenses: tremaglio** (trammel nets), **palangaro** (longlines), single layered nets (primarily including the **monofilo,** and also the **menaida net**), hooks and lines (mainly used for the **totanara** métier), encircling nets (like the **sciabichedda**), and the **nassa** (pots). **Diversification of fishing techniques and their alternation in the seasons permit to access to a wide range of resources which include 98 seafood species**, even if each métier capture only a few of them and in low quantity.

The selectivity of the fishing gears resulted also a discerning factor for the occurrence of by-catch of non-target species events. Sure enough **monospecific nets appear to have no impact on vulnerable fauna** (e.g. the menaida net for fishing the European anchovy, and the totanara gear for fishing the European flying squid), while a remarkable number of sharks belonging to the Smooth-hound (*Mustelus mustelus*) and Angel shark (*Squatina squatina*) species are captured using single wall nets in a small confined zone of the Gulf of Catania and in South Sicily.

Although **no by-catch of cetaceans has been observed** in this study, some individuals of Striped dolphin (*Stenella coeruleoalba*) and Bottlenose dolphin (*Tursiops truncatus*) of the Gulf **present injured peduncles as evidence of surviving to prior fishery interactions with longlines**. Moreover, many are the sea turtles (*Caretta caretta*), and seabirds like the Scopoli's shearwater (*Calonectris diomedea*) which annually are found stranded along the coasts of the East Sicily because of the ingestion of hook and lines, as well as sharks (*Hexanchus griseus, Isurus oxyrinchus*) entangled in longlines. Further investigations could explain if this type of almost always lethal interaction occurs with artisanal gears in coastal waters, or with other categories of fishing gears mainly operating offshore, and if potential mitigation measures for cetaceans could also prevent the impact to other species as well which require urgent interventions. Furthermore, the existence of shared national databases on strandings of all these species could help to a greater extent to understand the phenomenon.

Technical characteristics of the main métiers active in the study area, and prices of the related fishing gears have been described, underlining existing differences between the North and the South-East zones in terms of polyvalence and length of daily displacements for fishing. Regarding the fishing effort, a discordance has emerged between the most exploited areas (the far North and the far South of the Gulf of Catania) and those who give the highest landings (the central part of the Gulf). However, the **top three most productive fishing systems in the Gulf** (menaida for anchovies and sardines; monofilament gillnets for hake, sparidae, etc.; trammels for surmullets, etc.) **have a little CPUE and very low income** (e.g. 224.2 CPUE and € 6 622 for the menaida on 93 sets supervised by the observers on the Floating Laboratories).

The territorial investigation found that **45% of the fishing trips in one year are affected by negative interactions with cetaceans**. While **14 focal areas more susceptible to conflicts with cetaceans** have been identified through interviews in all the study area, 45 events of depredation were confirmed in the Gulf of Catania during **trial fishing trips which have covered 6 000 Nautical Miles (NM) per 1 721 hours of observation, including 395 fishing sets with different gears**. Interactions were verified with the concomitance of the sighting of the cetaceans, the presence of damages on the fishing gears or on the catches, the behavioral reading of the animals, and the listening of their **sound emissions compatible with the feeding behavior** as echolocation clicks, burst pulses, click train and creaks.

The species involved in the observed attacks is the bottlenose dolphin (*Tursiops truncatus*), sighted in herds of different size and also in presence of calves. Moreover, one case of interaction with the **sperm whale** (*Physeter macrocephalus*) has been recorded, as well as other with not identified dolphins which could be **striped dolphin** (*Stenella coeruleoalba*) or bottlenose dolphin. Nevertheless, it would be useful to explore the frequency of the sightings not only in one season but during the whole year, and consequently the number of interaction cases, in order to have a clearer view of the evolution of the events compared with those recorded by local associations and reported by local fishers in the previous years.

Depredation events caused by dolphins took place in every area of the Gulf where fishing activities are carried out, however, the most affected gear is the single wall type, especially the monofilo net. Recurring damages include holes in the nets, bended hooks, reduction in the amount or value of the catch, and loss of time for fishers. **The majority of the holes due to depredation on the nets are of medium size** (31-80 cm), but in certain cases a low number of very big holes (>120cm) could cause a greater damage. The resulting estimated costs of repair and loss of earnings must be added to the usual fixed costs of the vessels.

The total damage estimated for the 5 Floating Laboratories affected by these negative events during the study corresponds to 78% of their normal catches, with an overall loss of € 37 250, and a medium daily income loss of € 444 for the entire fleet, excluding the costs associated with the purchase of new materials for the repair of the gears.

This type of opportunistic behavior applied by dolphins appears to be not depending on environmental characteristics, saving the case of the Brucoli bay, where depredation events appear to be synchronized by moon phases. Instead, the **relationship between the degree of residence of a cetacean population, the type of fishing system** (gear and related one or more target species), **and the species of cetacean responsible of the depredation is evident.** However, a biggest amount of data is necessary to further investigate the various variables for having stronger results.

Direct observations of the animals in interaction made possible to construct an **ethogram of the "feeding in net" behavioral pattern, defining 3 principal attack phases including respiration, and surfaces and submergence behavioral units.**

Through a thought on these behaviors and an overall vision about mitigation methods experimented in the world, **we have suggested a series of useful strategies to further investigate the issue and to propose first solutions to be tested.** Between these, an **acoustic "alert" system** indicating the presence and the occurrence of feeding sounds close to the nets is proposed **for nets that are deployed at sea for several hours during which normally fishers leave the area,** such as trammels and single wall nets, permitting them to haul up it in presence of dolphins engaged in depredation activities and to limit the economic damage. Anyway, **many fishers declared to be available to participate in the trial of new devices aimed at mitigating interaction** events with marine wild fauna. Moreover, they express their interest also in participating in the on-line voluntary survey for professional fishers launched by LIFE, to report possible new negative interaction events in the future.

The study permitted to be aware also about other problems which deserve to be deepened, affecting the investigated fleet, as well as the entire marine ecosystem, such as difficult access to benefits, overfishing, climate change, pollution and invasion of exotic species at local level that influence resources distribution and availability. In this framework, it should be noted that **the Gulf of Catania is an area of great importance for the occurrence of marine mammals, but also asking for attention due to an existing strong anthropogenic impact.** The presence of immature dolphins observed during the monitoring confirms that **it is a breeding area,** and behavioral assessments shows the interest of this area from the point of view of **food and initiation to group life**. Accordingly, it should be proposed the possibility to nominate the Gulf and its surrounding waters as **Areas of Importance for Marine Mammals** (IMMA).

According to the programs of the General Fisheries Commission for the Mediterranean (GFCM), the objectives of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), the Marine Strategy Framework Directive (MSFD), and the goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) of the United Nations, it would be desirable a continued effort on data and information collection, including biological parameters related to the structure of cetacean populations, and economic indicators to evaluate the efficiency of the fishing fleets, in order to better understand the situation (status and trends) of the different species resident in the Gulf, and their interactions between fishing fleets. **Spatio-temporal dynamics about the animals, and also on the SSFs activities will be a crucial component to manage fishing areas in the future** by close collaboration between scientists, fishers, and local managers in a framework of mutual benefits and respect, while strengthening data availability, accessibility and reliability will help policy and decision making processes.

The Fisheries Department of the Sicilian Region has addressed € 855,000 of the national allocation of the European Maritime and Fisheries Fund (EMFF) to the measure 1.40 related to compensation for damage due to interaction with marine wild fauna. In this framework, Sicilian fishers might benefit of future local initiatives for the purchase and testing of new mitigation devices, and of reimbursements for the recognition of the damages suffered. To date, the Department has not yet initiated any procedure to allocate this budget to fishers, however, the development of resolving mitigation strategies could favor the allocation of the funds in order to proceed with their application.

This project has been included in the Sicilian regional database of projects related to fishing activities, in the International System on small-scale fisheries (ISSF) (https://issfcloud.toobigtoignore.net/), and also in the international map on projects contributing to the Regional Plan of Action of SSF, recently launched by the GFCM (http://www.fao.org/gfcm/activities/fisheries/small-scale-fisheries/mapping-tool/en/).

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Annexes

Annex 1. Status of Mediterranean stocks based on the analysis of biomass indicators. Source FAO 2018.

Species	Western Mediterranean									Central Mediterranean						Adriatic Sea		Eastern Mediterranean		
	1	3	4	5	6	7	9	10	11	12	13	14	15	16	19	17	18	22	25	26
Anchovy (p)						green										red	red			
Sardine (p)																red	red			
Blue and red shrimp (d)	yellow			red	green		red													
Common cuttlefish																red (dm)				
Common sole (d)																red				
Deep-water rose shrimp (d)				yellow	green		green	yellow		red	red	red	red	red	red	green	green			
European hake (d)	red	red		red	red	red	yellow	yellow		red	red	red	red	red		red	red	red (dm)		
Giant red shrimp (d)							yellow													
Lizardfish (d)																				
Mantis shrimp (d)																yellow	yellow			
Peregrine shrimp (d)																				red
Picarel (d)																			green	
Red mullet (d)	yellow	yellow	yellow	green	green	green		green			yellow	yellow	yellow	yellow	yellow	green	green	green (dm)	green	
Striped mullet (d)				red																red

Notes: Based on 62 validated stock assessments. Red indicates low biomass, yellow intermediate biomass, and green high biomass.

(p) pelagic species whose biomass level was decided based on the comparison between the current estimate and the reference point (low: $B_{curr} < B_{pa}$; intermediate: $B_{curr} > B_{pa}$); *(d)* demersal species whose biomass level was decided based on the comparison between the current estimate and the 33rd and 66th percentile of the time series (low: B_{curr} < 33rd percentile; intermediate: 66th percentile > B_{curr} > 33rd percentile; high: B_{curr} > 66th percentile); *(dm)*: demersal species whose biomass level was decided based on the comparison between the current estimate and B_{MSY} (low: Bcurr < B_{MSY}; high: Bcurr > B_{MSY}).

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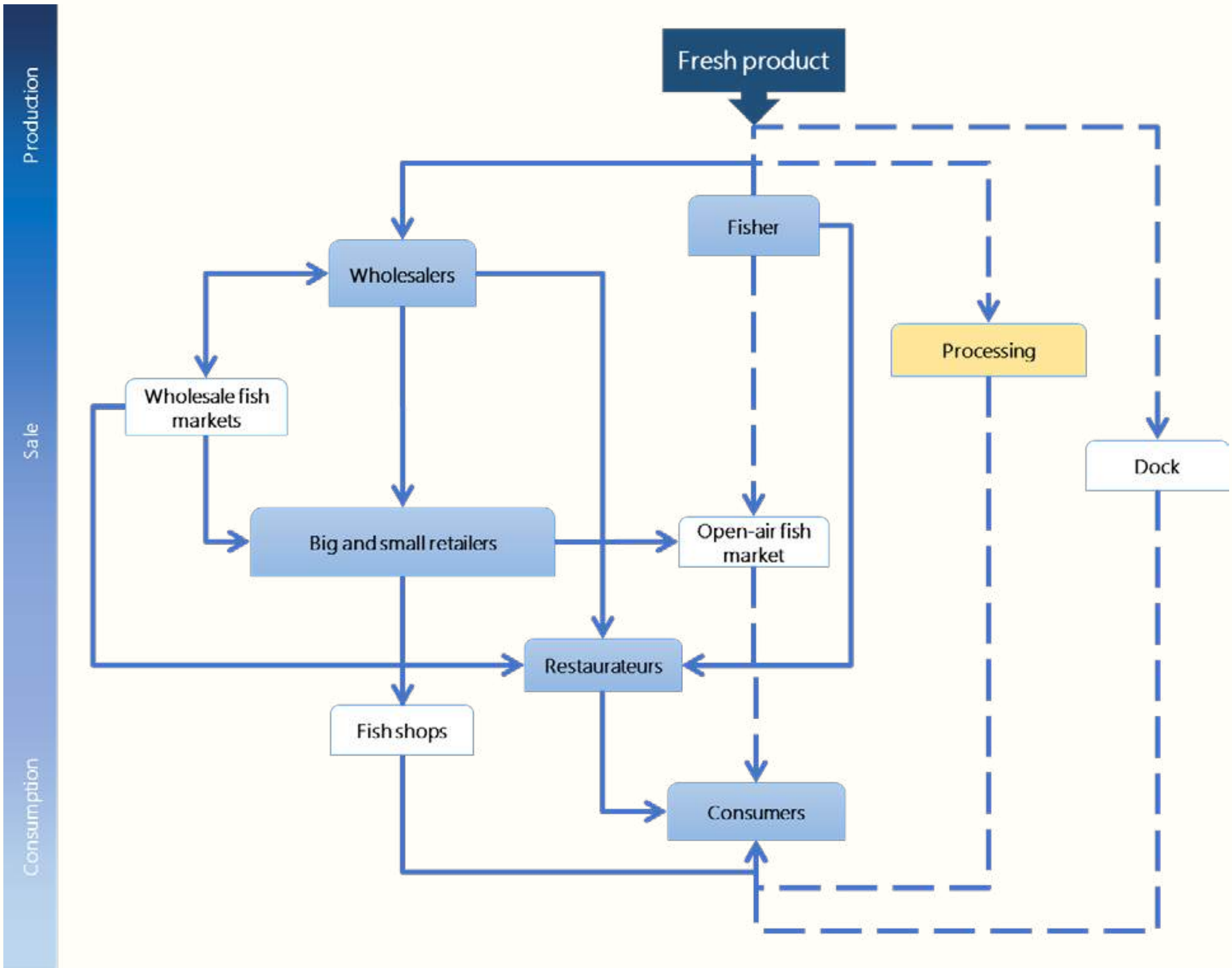
Annex 2. Reconstruction of the marketing circuit of the fresh caught product coming from the practice of artisanal fishing in North-Easter Sicily. Actors (blue boxes), place for sale (white boxes). Update of Monaco, 2016.



Annex 3. Minimum and maximum sales prices (€/kg) at the "Pescheria" of Catania, an historical big open air fishing market. Source ISMEA.

Market	Species	2018 P. min €/Kg	2019 P. max €/Kg
Calamari, calamaretti e totani	CALAMARO	11,24	12,36
Calamari, calamaretti e totani	TOTANI	4,78	6,17
Cappesante e ostriche	OSTRICHE	3,78	5,46
Cozze	COZZE O MITILI	1,6	1,8
Polpi e moscardini	MOSCARDINO	5,97	7,84
Polpi e moscardini	POLPI	14,4	15,62
Seppie e seppiole	SEPPIA	15,62	17,06
Vongole, cannolicchi, telline, cuori, fasolari	VONGOLA VERACE	9,29	10,46
Acciughe e sardine	ACCIUGA O ALICE	4,78	5,71
Acciughe e sardine	SARDINA	3,61	4,93
Aguglie, lampughe, bisi o tombarelli	AGUGLIA	0	0
Aguglie, lampughe, bisi o tombarelli	BISI O TOMBARELLI	4,94	6,46
Boghe, menole, busbane e suri o sugarelli	SURI O SUGARELLI	4,46	5,98
Cefali e latterini	CEFALI	1,89	2,75
Cernie	CERNIE	14,42	15,68
Naselli e merluzzi	NASELLI O MERLUZZI	13,74	15,67
Pagelli, occhiate e pesce S. pietro	PAGELLO	4,46	6,01
Pesce spada, barracuda e ricciola	PESCE SPADA	11,49	22,8
Pesce spada, barracuda e ricciola	RICCIOLA	14,24	15,49
Rombi e rane pescatrici	ROSPO O RANA PESCATRICE	5,02	6,42
Saraghi, mormore e pagri	SARAGHI	13,03	14,26
Saraghi, mormore e pagri	SARAGO	13,85	15,2
Sogliole, linguattole e zanchette	SOGLIOLA	17,02	18,78
Sgombri, lanzardi e palamiti	SGOMBRO	4,56	6,61
Spigole e orate	ORATA	6,53	7,53
Spigole e orate	SPIGOLA O BRANZINO	8,08	9,07
Tonni, tonnetti e alalunghe	PALAMITA	6,01	7,65
Triglie	TRIGLIA DI FANGO	8,23	10,17
Trote e salmoni	SALMONE	8,43	9,4
Gamberetti e scampi	SCAMPO	16,11	17,78
Gamberi	GAMBERI	5,7	7,23
Gamberi	GAMBERO ROSSO	11,31	12,56

Annex 4. Minimum and maximum sales prices (€/kg) at the fishing market of Aci Trezza, Catania. Source ISMEA.

Category	Market	Species	2018 P. min €/Kg	2019 P. max €/Kg
Molluschi	Calamari, calamaretti e totani	CALAMARO	7,53	15,37
Molluschi	Cozze	COZZE O MITILI	3,4	6,77
Molluschi	Polpi e moscardini	MOSCARDINI	3,6	7,1
Molluschi	Polpi e moscardini	POLPI	6,21	12,21
Molluschi	Seppie e seppiole	SEPPIA	7,64	13,01
Molluschi	Vongole, cannolicchi, telline, cuori, fasolari	VONGOLE	3,66	7,27
Pesci	Acciughe e sardine	ACCIUGA O ALICE	3,64	7,22
Pesci	Acciughe e sardine	SARDINA	3,62	7,14
Pesci	Aguglie, lampughe, bisi o tombarelli	BISI O TOMBARELLI	3,62	7,15
Pesci	Aquile e razze (raiformi)	RAZZE	3,55	7,17
Pesci	Boghe, menole, busbane e suri o sugarelli	BOGA	3,55	6,82
Pesci	Boghe, menole, busbane e suri o sugarelli	SURI O SUGARELLI	3,43	6,82
Pesci	Cefali e latterini	CEFALI	3,24	6,42
Pesci	Cernie	CERNIE	11,24	22,11
Pesci	Dentici, ombrine e corvine	DENTICE	10,76	21,38
Pesci	Naselli e merluzzi	MERLUZZI	4,73	9,34
Pesci	Pagelli, occhiate e pesce S. Pietro	PAGELLO FRAGOLINO	3,45	6,89
Pesci	Pesce spada, barracuda e ricciola	PESCE SPADA	10,76	19,57
Pesci	Pesce spada, barracuda e ricciola	RICCIOLA	8,69	18,08
Pesci	Rombi e rane pescatrici	ROSPO O RANA PESCATRICE	3,65	7,06
Pesci	Saraghi, mormore e pagri	SARAGO SPARAGLIONE	10,31	20,56
Pesci	Sogliole, linguattole e zanchette	SOGLIOLA	4,07	9,66
Pesci	Sgombri, lanzardi e palamiti	SGOMBRO	3,52	6,97
Pesci	Spigole e orate	ORATA	6,59	12,85
Pesci	Spigole e orate	SPIGOLA O BRANZINO	6,58	13,55
Pesci	Tonni, tonnetti e alalunghe	PALAMITA	6,54	12,88
Pesci	Tonni, tonnetti e alalunghe	TONNI	6,93	13,17
Pesci	Triglie	TRIGLIE	4,11	8,09
Crostacei	Gamberetti e scampi	SCAMPO	3,68	7,09
Crostacei	Gamberi	GAMBERO BIANCO	10,9	21,61
Crostacei	Gamberi	GAMBERO ROSSO	12,31	24,46

Annex 5. Model of questionnaire for professional fishers who practice small-scale fishing. Our elaboration.

LOW IMPACT FISHERS OF EUROPE

ASSOCIAZIONE ONLUS

ASOCIACIÓN HERPETOLÓGICA ESPAÑOLAS

MCAST Malta College of Arts, Science & Technology

Project: Interaction between cetaceans and small-scale fisheries in Mediterranean Sea

QUESTIONNAIRE

Date ____________________

Sampler __________________

Single general module

Technical characteristics

Ext. Marking ____________________ , Name of the vessel ____________________ *(optional)*

or Port ____________ , GT tonnage ___ , LOA ___ , Main Power ___ , Year of construction _____

Licenses *(gear type acronym)* ____

Segment ____ , Permission ________________

WHAT FISHING GEARS (METIERS) DO YOU USE ALONG THE YEAR:

Put an "X" on the number of the metier with which you have had any interaction with cetaceans

N.	Name of the gear, mesh size	Target species	Period (months)	Depth	Time of fishing	Distance from the base port
1						
2						
3						
4						
5						

N.	Name of the gear, mesh size	Target species	Period (months)	Depth	Time of fishing	Distance from the base port
6						
7						
8						
9						
10						

Did you ever see cetaceans while fishing? ◻ No ◻ Yes (specify if : ◻ dolphins or ◻ whales)
In the last 5 years, interference with cetaceans or any other vulnerable species is

◻ increased ◻ the same ◻ decreased Specify what other species ___________________________

Does any fishing area you use more subject of interference? ◻ No ◻ Yes

If Yes, specify ____

Do you know solutions implemented in other fisheries to reduce the interactions?

____

Personal suggested solutions ____

____

Are you able to implement in your own vessel some interactions reducer devices and/or alternative fishing gears if a pilot project could be applied in your area/port of activity?

◻ No ◻ Yes ◻ Maybe ◻ Why ____

Notes and other opinions ____

____

____

____

____

Would you like to participate in a permanent voluntary on-line survey for fishers to report SSF-Cetaceans interactions and cost-damages incurred during your fishing trips?

If yes, give our preferential contacts ______________________________________

INDICATE THE AREAS SUBJECTED TO NEGATIVE INTERACTION DURING THE SEASONS

Winter *Repeat 4 times a map of the investigated area in your country.* *Preferable with indication of the North, the scale used and the bathymetries.*	Spring
Summer	Autumn

Module to repeat for each metier experienced in interaction with cetaceans

Metier N.___ Gear type _______ Common names ________________________________

Material __________ Mesh size __________ Length ________ Height ________ Age _______

Number of pieces or hooks _______ Size _______ Quantity of other parts _______________

When using lures, specify if ◻ artificial baits or ◻ natural (species) ___________________

Number of days using this gear in one year ____ , Number of times using this gear in one day ____

Bottom ________________ , Price of a complete new gear € ____________________

Kg of catch per day: Minimum ____ Maximum _____ Average value of the catch €/kg _______

Number of bycatch events per species in one year ◻ dolphin ___ ◻ whale ___ ◻ shark ____ ◻ turtle ____ ◻ bird ____ ◻ __________________________

Incidence of **positive or cooperative interaction** with cetaceans _____ */100 times*

Type ____

Incidence of **indifferent presence** of cetaceans _____ */100 times*

Incidence of **negative interaction** (damage for fishermen) _____ */100 times*

Types of **damage** (per one event)

◻ depredation on catch → If yes, specify if leaving: ◻ bite marks ◻ fish head in the gear ◻ *other signs*

◻ scattering prey

◻ lures depredated → If yes, specify ____________________________

◻ holes → If yes, specify size and number: ◻ small (0-30 cm) ____ ◻ medium (31-80 cm) ____ ◻ big (81-120 cm) _______ ◻ very big (>120cm) ______

Losses incurred: (per one event) ◻ reducing catch How much _____ *%* ◻ complete loss of the catch

Costs incurred per one event of negative interaction (€ or time):
Medium percentage of the fishing gear damaged ______ % Fishing days not worked _________
Number of people working in for fixing up the gear ______ Number of days in which they are involved to repair ______ Material used ____________________

Price of the piece to substitute (€ per piece) ____

Price of the other parts to substitute ____

____

Total cost of a failed fishing trip (*considering n. of operators, fuel consumed, missing catch etc.)*

____

Number of pieces necessary to eliminate after one event of interactions ___________________

During one year, are you sure that all the damages have been caused only by cetaceans?

□ No □ Yes □ Other suggestion? ____

How many times animals different to cetacean damage your fishing gear? ____ /100

How do you recognise differences? ____

____

If responsible are cetaceans, what species? (name and %) ________________________

____

Generally, how many individuals of cetacean interact with the same gear? __________

Do you usually continue to fish with a damaged gear? □ No □ Yes If yes, how many times? ____

In the case above, describe the entity of the damage of the fishing gear ______________

____

Amount of reducing catch using a damaged fishing gear ______ *%*

Mitigation measures employed □ No □ Yes What ________________________

→ Results ________________________

____

____

What and how many parts do you lose in one year? ________________________

____

Other notes related to this specific metier ________________________

____

____

Return at the first page if you have any other general comment to do.

Annex 6. Extract of the protocol used to stratify the samples of fishers in the fleets belonging to the three countries of the project. Our elaboration.

INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN THE MEDITERRANEAN SEA

A PROTOCOL TO STRATIFY THE SAMPLE OF FISHERMEN FOR PRELIMINARY FACE TO FACE INTERVIEWS

1. **List** of the active vessels with regular licenses operating in the investigated area, consulting the local or the European **fishing fleet register**.
2. **Extrapolation** of the vessels belonging to **small-scale** fisheries operating in coastal waters.
3. **Calculate** the **10%** of the total number of the vessels resulting from the previous steps.
4. **Divide** the result for the **total number of harbours** in the study area which are far from the nearest one more than 10 km. The **result is the average number** of fishing units to be interviewed **in each harbour**/fleet. (In case of two harbours far from the nearest one less than 10 km, consider only the biggest one for the count).
5. **Check** the presence of fishing units registered in a harbour and operating near another one. Considerate these cases as belonged to the second harbour/fleet.
6. For each harbour/fleet at the point n. 4, **list the number of licences** for each fishing gear.
7. Consider for the sample one fishing unit for each type of gear in each harbour. If this selection gives a smaller number than the result at the point n. 4, add new fishing units starting repeating the category most representative and then the others, giving priority to vessels using the same fishing gear but in different areas or times.
8. If this selection give a bigger number than the result at the point n. 4, reduce the number of units having the same fishing gears in nearby fleets or, lacking of these, eliminate fishermen that are not full-time/year-round involved.
9. Going in the field, **verify the status** of the vessels included in the registers. In case of differences, update the initial total number and recalculate the sample starting from the step 1.
10. **Add up** all the fishing boats resulting from the point n. 7.
11. If the result at the point n. 9 is lower than the expected 10% at the point n. 3, add one or more fishing units for each little harbour not yet considered, choosing possible peculiar cases or, lacking of these, the most subjected to depredation events.
12. If the result at the point n. 9 is greater than the expected 10% at the point n. 3, eliminate one or more fishing units that are not full-time/year-round involved.

- The final sample should be 10%±3 of the total fleet active in the investigated area.
- Fishing unit: fisherman with his vessel.
- Fishermen interviewed will give information on their main fishing gear and also on the others he uses. In this way, the technical polyvalence will acquire the right value.
- No data will be collected on fishing gears for which a fisherman has a license but he doesn't use it.

Annex 7. Survey used by the observers onboard the Floating Laboratories. Our elaboration.

MONITORING CAMPAIGN 2019
ON THE CASES OF INTERACTION OF CETACEANS
WITH SMALL-SCALE FISHERIES IN THE MEDITERRANEAN SEA

Contact: Dr Clara Monaco | clamonaco@unict.it | +39 3493618052

FLOATING LABORATORIES REGISTER

ID SURVEY ____ DATE _______ OBSERVER ____________ WEATHER _______

HARBOR ________ VESSEL ________ N. FISHERMEN ONBOARD _____ SEA ____

TIME OF DEPARTURE ___________ TIME OF RETURN _____________

Activate the GPS track or the Navionics "Boating HD" App and then download geodata.

	1° FISHING TRIP	2° FISHING TRIP	3° FISHING TRIP	4° FISHING TRIP
FISHING GEAR, SIZE, DEEP UW				
DEEP AND TYPE OF BOTTOM				
GPS POSITION WHEN STARTING TO FIRST PUT THE FISHING GEAR IN THE WATER				
TIME WHEN FISHING GEAR IS FIRST PUT IN THE WATER				
TIME WHEN FISHING GEAR IS ALL PUT IN THE WATER				
TIME OF START OF RECOVERY ON BOARD OF THE FISHING GEAR				
TIME WHEN FISHING GEAR IS FULLY RECOVERED ON BOARD				
OBSERVATION OF CETACEANS (No/Yes: number, which species)				
DAMAGES CAUSED BY CETACEAN (No/Yes)				
BY-CATCH OF VULNERABLE SPECIES (No/Yes: which number / species / size)				
kg of ______________ caught				
kg of ______________ caught				
kg of ______________ caught				
kg of ______________ caught				
kg of ______________ caught				
kg of ______________ caught				
kg of ______________ caught				

Notes in case of damages/losses: ____

Check of the status of the longlines **Before** the fishing trip

N. artificial baits _____ N. natural baits _____ Type of lures _____________

Type of artif. baits ________ Length of the line (m) ___ Quantity of lures ___

N. hooks ______________ Size of the hooks ________________

Check of the status of the longlines **After** the fishing trip

N. damaged artificial baits _____ N. damaged natural baits/lures _______

N. missing artificial baits _____ N. missing natural baits/lures _______

Check of the status of the catches (for all fishing gears)

Depredation leaving:
□ bite marks □ fish head in the gear □ other signs _________________

N. _______ N.______________ N. ________

Interaction causing:
□ scattering prey
□ reducing catch How much (%) __________
□ complete loss of the catch

Video or photos of reference: ______________________________________
(author)

The pages on the BEFORE/AFTER status of the gear need to be repeated for each fishing trip of the same day.

Check of the status of the net **After** the fishing trip

Hole	Size				Notes
	Small (0-30 cm)	Medium (31-80 cm)	Big (81-120 cm)	Very big (> 120 cm)	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
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38					
39					
40					
41					
42					
43					
44					
45					
46					

For sequential fishing trips, the status of the net at the final control is equivalent to the initial status of the next fishing trip.

	Size				
Hole	Small (0-30 cm)	Medium (31-80 cm)	Big (81-120 cm)	Very big (> 120 cm)	Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
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35					
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38					
39					
40					

Annex 8. Observation survey used during monitoring activities onboard the sentry boat. Our elaboration.

CAMPAGNA DI MONITORAGGIO INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN SICILY

SURVEY OSSERVAZIONE N° ______ DATA ______________

PIATTAFORMA DI OSSERVAZIONE ______________________

OSSERVATORI: ____

LOW IMPACT FISHERS OF EUROPE

MARE CAMP

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	POSIZIONE		PIATTAF. DI OSERVAZ.			CONDIZIONI METEO-MARINE					
ORARIO	LATITUDINE	LONGITUDINE	ROTTA	VEL.	ATTIV.	CIELO	VISIB.	MAR.	VENTO	NATANTI	NOTE
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									
	N	E									

LEGENDA SURVEY OSSERVAZIONE

La seguente scheda deve essere compilata con continuità durante l'attività di osservazione dedicata alla cetofauna.
Una nuova riga dovrà essere compilata ogni qualvolta si verifichi il cambiamento di una delle variabili in tabella (es. rotta, velocità, meteo, natanti, avvistamento, attività, etc.).

1. ORARIO
Indicare la **data** solamente ad eventuale cambio giorno, negli altri casi indicare esclusivamente **l'orario**.
Es. 01/07/14 13.30; es. 5.00

2. POSIZIONE
Indicare le **coordinate geografiche** nelle apposite caselle di **Latitudine N** e **Longitudine E**.
Es. 37°29.094 N, 15°12.900 E

3. NAVE (piattaforma di osservazione)
ROTTA – Indicare la **rotta** della nave in gradi. Es. 144°
VEL. – Indicare la **velocità** della nave in nodi (KN). Es. 5

4. CONDIZIONI METEO-MARINE
CIELO – Indicare il grado di **copertura del cielo** in percentuale. Indicare inoltre la presenza di **precipitazioni atmosferiche** (Pioggia=**P**; Grandine=**G**) e la loro intensità (Lieve=**L**; Moderata=**M**; Forte=**F**; Molto forte=**FF**). Es. 70% PF
VISIB. – Indicare il grado di **visibilità** (Ottima=**O**; Buona=**B**; Media=**M**; Scarsa=**S**). Es. B
MAR. – Indicare lo stato del **mare** secondo la scala Douglas (vedi tabella 1). Es. 1
VENTO – Indicare la provenienza del **vento** (N-S-O-E) e la sua intensità secondo la scala Beaufort (vedi tabella 1). Es. S-O 2

5. NATANTI
Indicare il numero di imbarcazioni visibili ad occhio nudo e distinguerle in Vicine=**V** (entro il raggio di un miglio–NM) e Lontane=**L** (oltre 1NM). Per ciascuna, indicarne la **categoria** (vedi tabella 2), le dimensioni (Piccola=**P**; Media=**M**; Grande=**G**), e specificare se in moto=**T** o ferma=**R**. Nei casi possibili, indicare anche l'**attività** (vedi tabella 3). Es. (2FM2+1GM+1CP1) V T + (2IG) L T

6. NOTE
Indicare la presenza di meduse, uccelli, pesci, rettili, cetacei (numero e specie) e specificare l'ID della relativa **scheda di avvistamento**. Segnalare la presenza di grosse quantità di **rifiuti** galleggianti, oltre che boe, reti, bandierine, ed ogni altro elemento/evento che si ritenga utile. Inoltre, ove possibile, indicare la **temperatura** dell'acqua in gradi centigradi (es. 27 °C) e la **salinità** in parti per mille (es. 38.27‰). Indicare nei pressi di quale peschereccio (nome o matricola) si rilevano dati video-fotografici.

Tabella 1

FORZA VENTO	NOTE DESCRITTIVE	FORZA MARE
0	Mare come uno specchio	0
1	Piccole increspature, niente spuma	
2	Piccole onde, le creste non si infrangono	1
3	Onde più grandi, le creste cominciano ad infrangersi, qualche ciuffo di spuma	2
4	Molti ciuffi di spuma	3
5	Molti ciuffi di spuma, qualche spruzzo	4
6	Prime onde grosse	5
7	Cavalloni	6
8	Onde piuttosto grandi	
9	Onde alte	
10	Onde molto alte	7

Tabella 2

CATEGORIE PER LE IMBARCAZIONI	
A	Barca a vela con vele giù
B	Barca a vela con vele su
C	Gommone
D	Motoscafo (< 7 m)
E	Motoscafo (> 7 m)
F	Barca da pesca
G	Peschereccio a strascico
H	Imbarcazione di gruppi DIVING
I	Imbarcazione transito passeggeri
L	Rimorchiatore di gabbie
M	Imbarcazioni di corpi operativi: G di F, C di P, CF, PM, MM
N	Nave oceanografica

Tabella 3

CATEGORIE DI ATTIVITÀ	
1	Pesca a traina
2	Pesca con reti
3	Pesca con palamiti
4	Pesca con canna
5	Pesca in apnea
6	Pesca con bombole
7	Snorkeling
8	Nuoto
9	*Divers*

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Annex 9. Sighting survey used during monitoring activities onboard the sentry boat. Our elaboration.

CAMPAGNA DI MONITORAGGIO INTERACTION BETWEEN CETACEANS AND SMALL-SCALE FISHERIES IN SICILY.

SURVEY AVVISTAMENTO CETACEI N° ______

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AVV. N.	AVVISTATORI	DATA E ORA	POSIZIONE					CETACEI			COMPORTAMENTO >>PIATTAF. OSSER.			N. NATANTI			NOTE
			LATIT.	LONGIT.	DIST.	ANG.	DIR.	SPECIE	N. TOT.	N. JUV.	AV.	AL.	I.	P	M	G	
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													
			N	E													

Campagna di Monitoraggio Interaction between cetaceans and small-scale fisheries in Sicily.

LEGENDA SURVEY AVVISTAMENTO CETACEI

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La seguente scheda deve essere compilata ogni qualvolta vengano avvistati uno o più cetacei.

1. AVV. N.

Scrivere il **numero progressivo** dell'avvistamento. Es. 1 per il primo, 2 per il secondo e così via.

2. AVVISTATORI

Scrivere il **nome** del primo o dei primi avvistatore/i. Es. Clara

3. DATA E ORA

Es.

01/07/14
6.20
6.33

Indicare la **data** e l'orario di inizio avvistamento nella riga superiore, e l'orario di fine avvisamento nella riga inferiore.

4. POSIZIONE

LATIT. – Indicare le coordinate geografiche della **Latitudine** di inizio avvistamento nella riga superiore, e quelle di fine avvistamento nella riga inferiore.

LONGIT. – Indicare le coordinate geografiche della **Longitudine** di inizio avvistamento nella riga superiore, e quelle di fine avvistamento nella riga inferiore. Nel caso in cui non fosse possibile annotare entrambe le posizioni, annotarne almeno una. Es.

37°29.094 N	15°12.900 E
37°28.063 N	15°08.020 E

DIST. – Stimare la **distanza** cetaceo-piattaforma di osservazione ad inizio avvistamento, in metri o miglia nautiche (NM). Es. 700 m

ANG. – In riferimento al primo animale avvistato, indicare l'**angolo** rispetto alla prua della piattaforma di osservazione (aiutarsi con il goniometro). Es. 30°

DIR. – Scrivere la **direzione** in cui nuotano i cetacei ad inizio avvistamento, secondo i punti cardinali (N, S, O, E). Es. SO

Tabella 4			
Codice	**Specie**	**ITA**	**ESP**
Bp	*Balaenoptera physalus*	Balenottera comune	Rorcual común
Pm	*Physeter macrocephalus*	Capodoglio	Cachalote
Gg	*Grampus griseus*	Grampo	Delfin de Risso
Tt	*Tursiops truncatus*	Tursiope	Tursion
Sc	*Stenella coeruleoalba*	Stenella striata	Estenella listada
Dd	*Delphinus delphis*	Delfino comune	Delfin comun
Zc	*Ziphius cavirostris*	Zifio	Zifio de Cuvier
Gm	*Globicephala melas*	Globicefalo	Calderón comun
Sb	*Steno bredanensis*	Steno	Esteno
NI	Specie non identificata		

5. CETACEI

SPECIE – Indicare la **specie avvistata** (tabella 4). In caso di NI, specificarne le dimensioni (**P=piccole**; **M=medie**; **G=grandi**). Es. Tt

N. TOT. – Indicare il **numero totale** di animali avvistati. Es. 10; es. 6Tt + 1 Dd

N. JUV. – Indicare il numero di individui **giovani=J** o **cuccioli=C**. Es. 2J + 1C

6. CONPORTAMENTO

NAVE – Segnare con una "X" il comportamento assunto dagli animali nei confronti della piattaf. di osservaz. sulla quale ci troviamo. **AV.** per **avvicinamento**, **AL.** per **allontanamento**, **I.** per **indifferente**.

7. N. NATANTI

Es.

P	M	G
/	2	1

Scrivere il numero di imbarcazioni in prossimità dei cetacei avvistati, suddividendole tra le tre colonne riferite alle dimensioni dei natanti (**P=piccole**; **M=medie**; **G=grandi**).

8. NOTE

Indicare la presenza di associazioni (uccelli, pesci, rettili, altre specie di cetacei, attrezzi da pesca, etc.), i cambiamenti direzionali del nuoto dei cetacei, la variazione di qualunque altro elemento/evento, o comportamenti particolari. Annotare se esistono **foto** o **video** di riferimento ed i loro autori (es. Clara **V**, Mario **F**).

Annex 10. Survey used to collect data about cetacean-fishery interaction during sightings from the sentry boat. Our elaboration.

Campagna di Monitoraggio Interaction between cetaceans and small-scale fisheries in Sicily

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SURVEY OSS. INTERAZIONE N° ______ Data ____________

Piattaforma di osservazione ____________ Peschereccio coinvolto ____________

Osservatori: ____

ID Survey osservazione collegata ___ ID Survey di avvistamento ___ Avvistamento su segnalazione ___________

Caratteristiche dell'attrezzo di pesca:

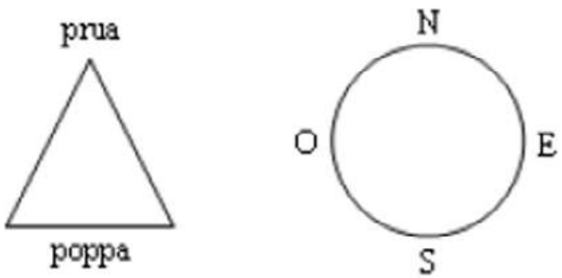
Specie target:

Durata interazione: N. animali in interazione: Animali riconosciuti:

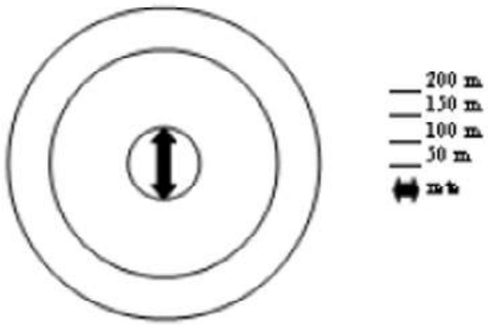
Elementi concomitanti:

Materiale video-fotografico:

DIREZIONE DEGLI ANIMALI



POSIZIONE RELATIVA ALLA RETE



Annex 11. Register compiled by fishers for each fishing trip. Our elaboration.

CAMPAGNA DI MONITORAGGIO SUI CASI DI INTERAZIONE DEI CETACEI CON LA PICCOLA PESCA COSTIERA ARTIGIANALE NEL GOLFO DI CATANIA

AGOSTO-SETTEMBRE 2019

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REGISTRO DEL PESCATORE SIG.________________

USCITA N° ______ DATA ________________

ORARIO DI PARTENZA DAL PORTO __________

ORARIO DI RITORNO AL PORTO ___________

N° TOTALE DI PESCATORI A BORDO ________

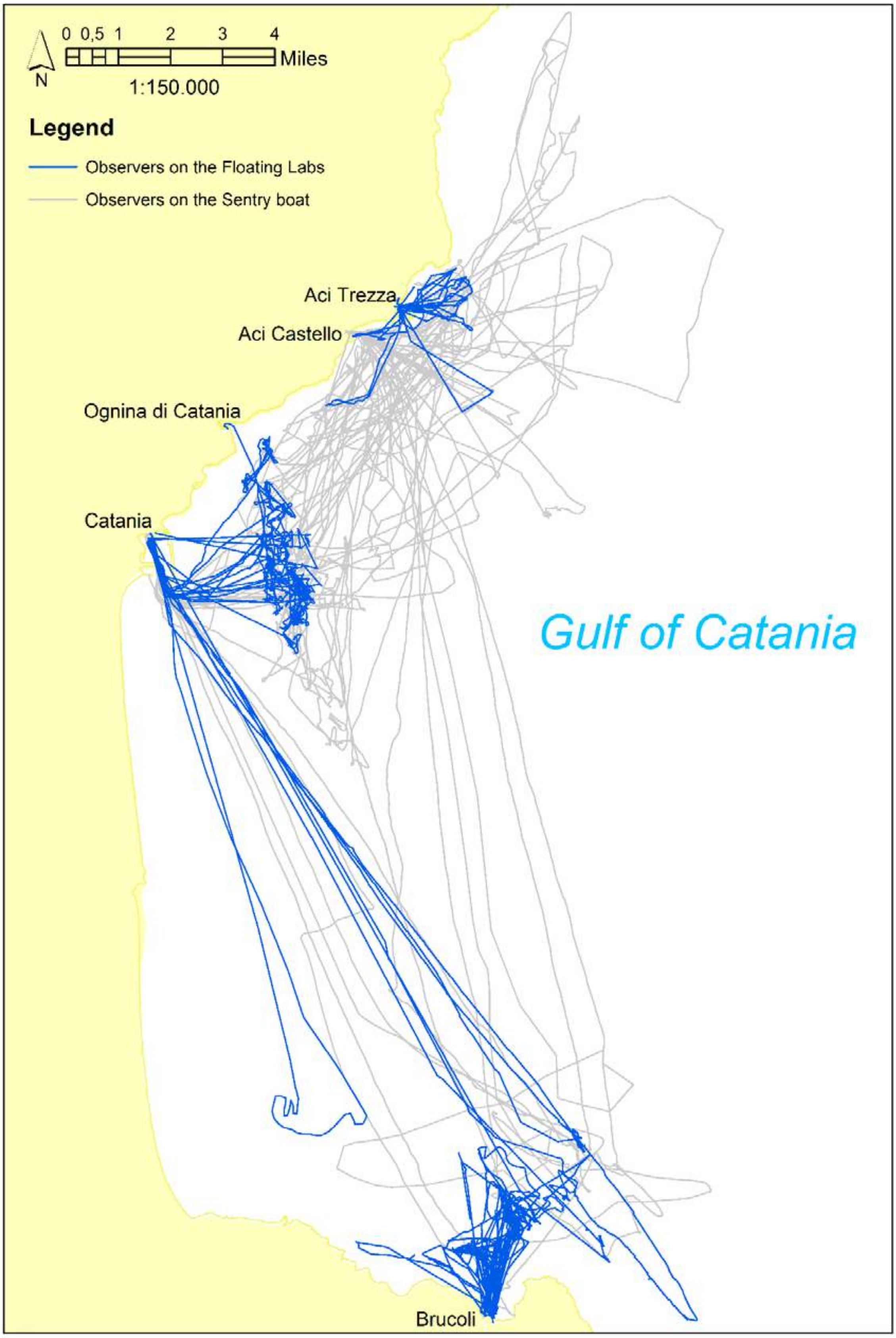
SCRIVERE A STAMPATELLO PER UNA MIGLIORE COMPRENSIONE

	1° BATTUTA DI PESCA	2° BATTUTA DI PESCA	3° BATTUTA DI PESCA	4° BATTUTA DI PESCA
ATTREZZO E PROFONDITÀ				
POSIZIONE GPS INIZIO CALA (indicare le coordinate, oppure, in mancanza di GPS, segnare ogni punto sulla mappa e numerarlo sia nelle seguenti caselle che nella mappa con lo stesso numero)				
ORARIO INIZIO CALA				
ORARIO FINE CALA				
ORARIO INIZIO SALPAMENTO				
ORARIO FINE SALPAMENTO				
PRESENZA DI DELFINI (si/no)				
DANNI SUBITI (si/no)				
kg di ____________ pescati				
kg di ____________ pescati				
kg di ____________ pescati				
kg di ____________ pescati				
kg di ____________ pescati				
kg di ____________ pescati				
kg di ____________ pescati				

In caso di bycatch o di danno subìto, indicare i dettagli: ______________________

Segnalare anche la presenza di altre specie vulnerabili es. squali, tartarughe marine, etc.) ______________

Annex 12. Tracks covered by observers during the "Floating Laboratories" programme, both onboard small-scale fishing vessels and the sentry boat in the Gulf of Catania. Our elaboration with ArcGIS.



Annex 13. Average characteristics of the small-scale fishing gears used in North-Eastern Sicily. In the fourth column, referring to the species caught, the meaning of the acronyms is: N = gear multispecies; Y = gear monospecies; A = single-species gear that can sometimes fish a limited number of other species and in minimum quantities. Our elaboration.

	Category	Gear type	Common name	Monospecies	Size (mesh or hook)	Length	Height	Number of hooks	Lures	Times / day	Depht	Gear price €	Catch average kg	Catch average €/kg
	Hooks and lines	LLD (drifting longlines)	"Palangaro di superficie" or "Conso"	N	2,5-4	5000	–	600-1000	Natural	1	10-15	5000	0-30	5-15
	Hooks and lines	LLS (set longlines)	"Palangaro di fondo" or "Conso"	N	1-4	4000	–	750	Artificial / Natural	1	50-2000	350	0-400	10-15
	Hooks and lines	LHM (Handlines and pole-lines mechanized)	"Totanara"	Y	–	–	–	–	Natural	2-10	200-500	400	0-20	5-15
	Hooks and lines	LHP (handlines and pole-lines hand-operated)/LTL (trolling lines)	"Lenza"	N	–	–	–	1	–	–	–	–	–	–
	Encircling nets	PS (purse seines)	"Circuizione" for swordfish, albacore and dolphinfish	N	0,5-10	200	30	–	–	1-2	500	6000	0-1000	15-30
	Encircling nets	PS (purse seines)	"Sciabichella" or "Sciabicheddu"	A	2,5	50	4	–	–	1	360	2000	0-10	12
3-layer	Gillnets	GTR (trammel nets)	"Tremaglio" or "Tramaglio"	N	6-12	900	1,5	–	–	1-2	6-200	4000	0-40	5-50
1-layer	Gillnets	GND (driftnets)	"Menaide" or "Menaida" or "Tratta" for anchovies	Y	0,5-1,3	200-400	10-12	–	–	1-3	20-70	3000	25	7
1-layer	Gillnets	GND (driftnets)	"Menaide" or "Menaida" or "Tratta" for European pilchard	Y	1,4	200-400	10-12	–	–	1-2	20-70	3000	30	5
1-layer	Entangling nets	GND (driftnets)	"Monofilo", "Peloseta", "Palermitana", "Paurara"	N	2,5-4	80-2000	1-3	–	–	1-2	7-400	2000	0-30	5-20
	Traps	FPO (pots)	"Nassa"	A	–	–	–	–	–	–	–	–	–	–

Annex 14. Target species of the main fishing gears used by small-scale fisheries in North-Eastern Sicily. Update of Monaco, 2016.

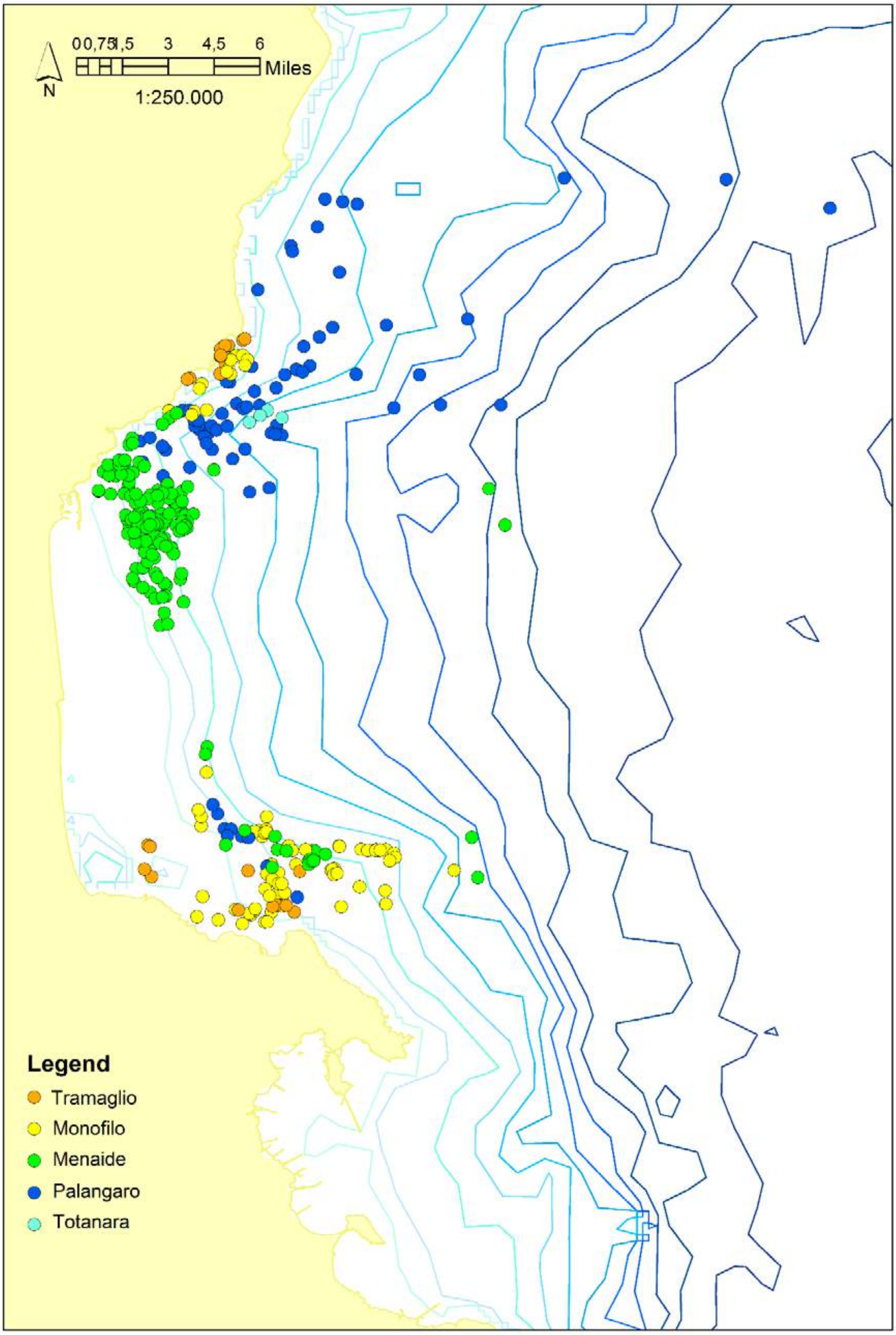
		Fishing gear									
Common name	Species	Monofilo	Menaide	Palangaro	Palermitana	Tremaglio	Sciabichella	Paurara	Totanara	Circuizione	Nasse
Albacore	*Thunnus alalunga (Bonnaterre, 1788)*			✓							
Angelshark	*Squatina squatina (Linnaeus, 1758)*	✓				✓					
Annular seabream	*Diplodus annularis (Linnaeus, 1758)*	✓				✓					
Atlantic bonito	*Sarda sarda (Bloch, 1793)*	✓		✓	✓						
Atlantic horse mackerel	*Trachurus trachurus (Linnaeus, 1758)*	✓								✓	
Atlantic mackerel	*Scomber scombrus (Linnaeus, 1758)*	✓								✓	
Atlantic pomfret	*Brama brama (Bonnaterre, 1788)*			✓							
Atlantic saury	*Scomberesox saurus (Walbaum, 1792)*	✓									
Axillary seabream	*Pagellus acarne (Risso, 1827)*	✓				✓					
Black scorpionfish	*Scorpaena porcus (Linnaeus, 1758)*					✓					
Blackspot/red seabream	*Pagellus bogaraveo (Brünnich, 1768)*	✓									
Caramote prawn	*Penaeus kerathurus (Forskål, 1775)*	✓									

		Fishing gear									
Common name	**Species**	**Monofilo**	**Menaide**	**Palangaro**	**Palermitana**	**Tremaglio**	**Sciabichella**	**Paurara**	**Totanara**	**Circuizione**	**Nasse**
Comber	*Serranus cabrilla (Linnaeus, 1758)*			X							
Common cuttlefish	*Sepia officinalis (Linnaeus, 1758)*					X					
Common dolphinfish	*Coryphaena hippurus (Linnaeus, 1758)*			X						X	
Common pandora	*Pagellus erythrinus (Linnaeus, 1758)*	X				X					
Common torpedo	*Torpedo torpedo (Linnaeus, 1758)*					X					
Common two-banded seabream	*Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)*					X					
Curled picarel	*Centracanthus cirrus (Rafinesque, 1810)*	X									
Deep-water rose shrimp	*Parapenaeus longirostris (Lucas, 1846)*					X	X				
Dusky grouper	*Epinephelus marginatus (Lowe, 1834)*			X							
European anchovy	*Engraulis encrasicolus (Linnaeus, 1758)*	X	X							X	
European barracuda	*Sphyraena sphyraena (Linnaeus, 1758)*	X									
European flying squid	*Todarodes sagittatus (Lamarck, 1798)*	X							X		
European hake/Cod	*Merluccius merluccius (Linnaeus, 1758)*	X									
European pilchard	*Sardina pilchardus (Walbaum, 1792)*	X	X								
European seabass	*Dicentrarchus labrax (Linnaeus, 1758)*	X									

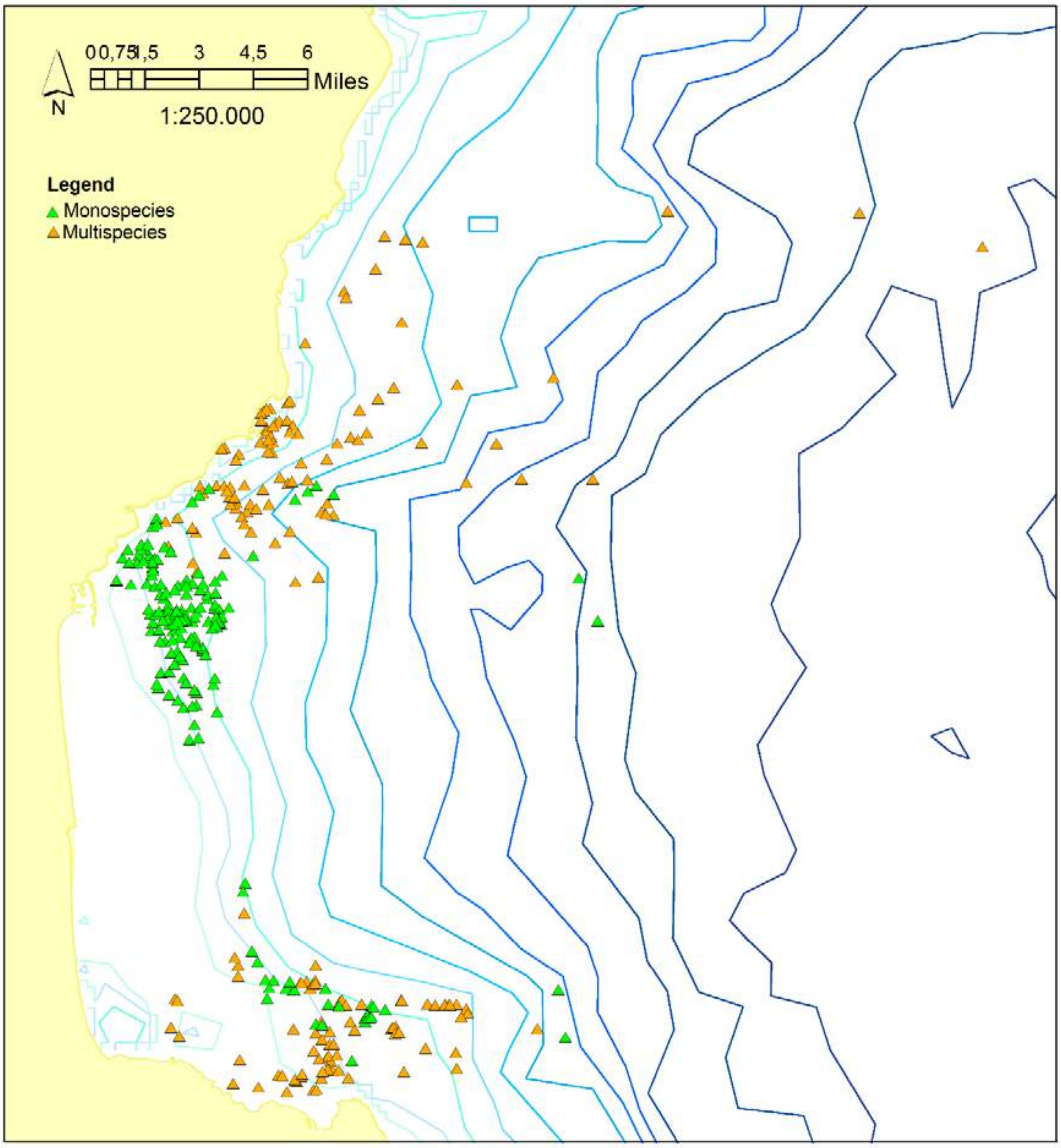
Common name	Species	Monofilo	Menaide	Palangaro	Palermitana	Tremaglio	Sciabichella	Paurara	Totanara	Circuizione	Nasse
Flying gurnard	*Dactylopterus volitans (Linnaeus, 1758)*	■				■					
Forkbeard	*Phycis phycis (Linnaeus, 1766)*	■				■					
Frigate tuna	*Auxis thazard (Lacepède, 1800)*	■								■	
Giant red shrimp	*Aristaeomorpha foliacea (Risso 1827)*						■				
Gilthead seabream	*Sparus aurata (Linnaeus, 1758)*			■							
Goldblotch grouper	*Epinephelus costae (Steindachner, 1878)*			■							
Greater amberjack	*Seriola dumerili (Risso, 1810)*	■				■					
Greater weever	*Trachinus draco (Linnaeus, 1758)*	■				■					
John dory	*Zeus faber (Linnaeus, 1758)*	■									
Lesser spotted dogfish	*Scyliorhinus canicula (Linnaeus, 1758)*						■				
Little tunny	*Euthynnus alletteratus (Rafinesque, 1810)*	■		■	■						
Marbled electric ray	*Torpedo marmorata (Risso, 1810)*					■					
Mediterranean lobster	*Palinurus elephas/Palinurus vulgaris (Latreille, 1803)*					■					
Mediterranean moray	*Muraena helena (Linnaeus, 1758)*					■					
Mediterranean sand eel	*Gymnammodytes cicerelus (Rafinesque, 1810)*						■				
Octopus	*Octopus vulgaris (Cuvier, 1797)*					■					■
				■							

<table>
<tr><th>Common name</th><th>Species</th><th>Monofilo</th><th>Menaide</th><th>Palangaro</th><th>Palermitana</th><th>Tremaglio</th><th>Sciabichella</th><th>Paurara</th><th>Totanara</th><th>Circuizione</th><th>Nasse</th></tr>
<tr><td>Stargazer</td><td>Uranoscopus scaber (Linnaeus, 1758)</td><td></td><td></td><td></td><td></td><td style="background:#92d050"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Surmullet</td><td>Mullus surmuletus (Linnaeus, 1758)</td><td style="background:#92d050"></td><td></td><td></td><td></td><td style="background:#92d050"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Swordfish</td><td>Xiphias gladius (Linnaeus, 1758)</td><td></td><td></td><td style="background:#92d050"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tub gurnard</td><td>Chelidonichthys lucerna (Linnaeus, 1758)</td><td style="background:#92d050"></td><td></td><td></td><td></td><td style="background:#92d050"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>White seabream</td><td>Diplodus sargus (Linnaeus, 1758)</td><td></td><td></td><td></td><td></td><td style="background:#92d050"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Yellowmouth barracuda</td><td>Sphyraena viridensis (Cuvier, 1829)</td><td style="background:#92d050"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

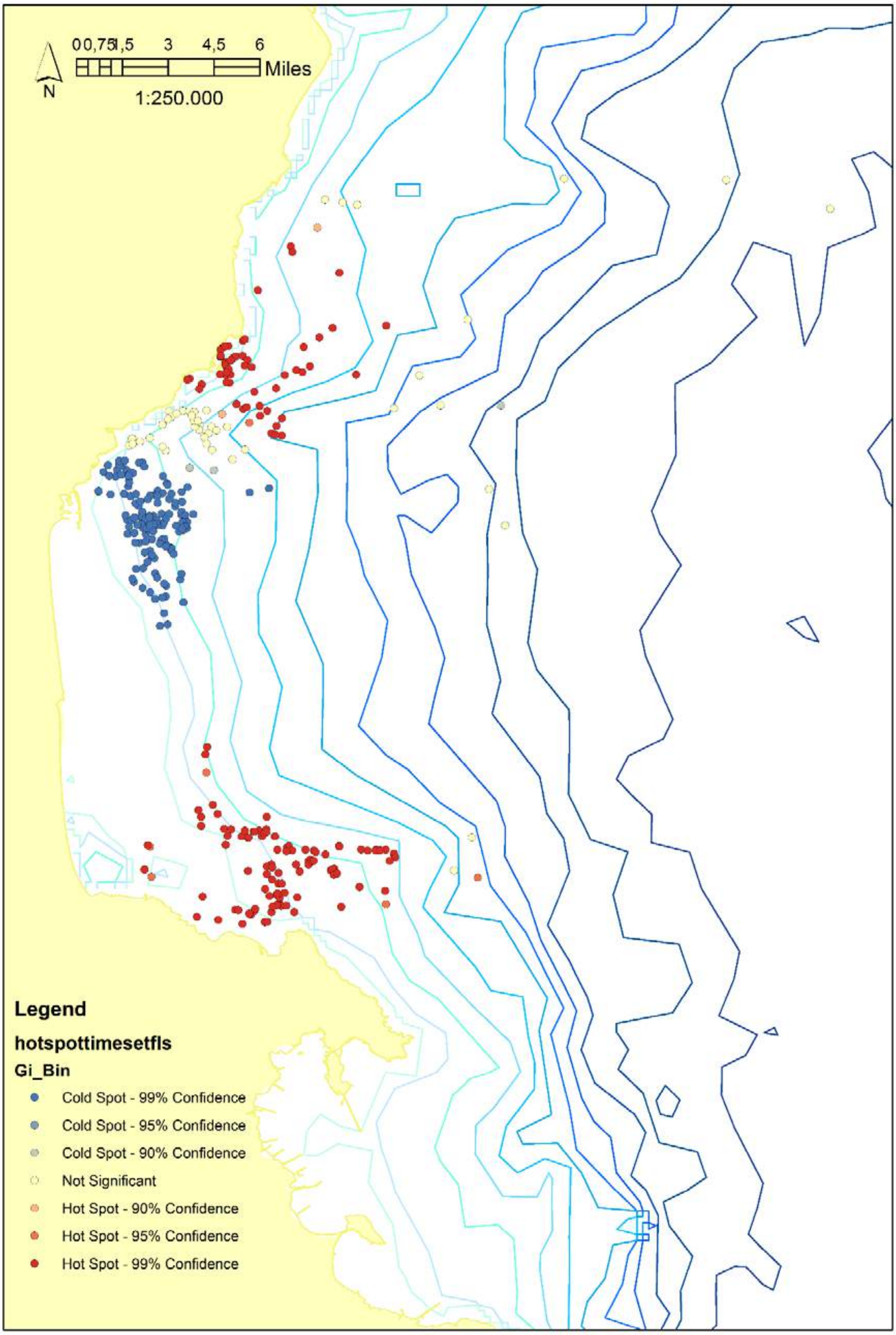
Annex 15. Spatial distribution of the Floating Laboratories units in the Gulf of Catania, grouped per used fishing gear (July-October 2019). Our elaboration with ArcGIS.



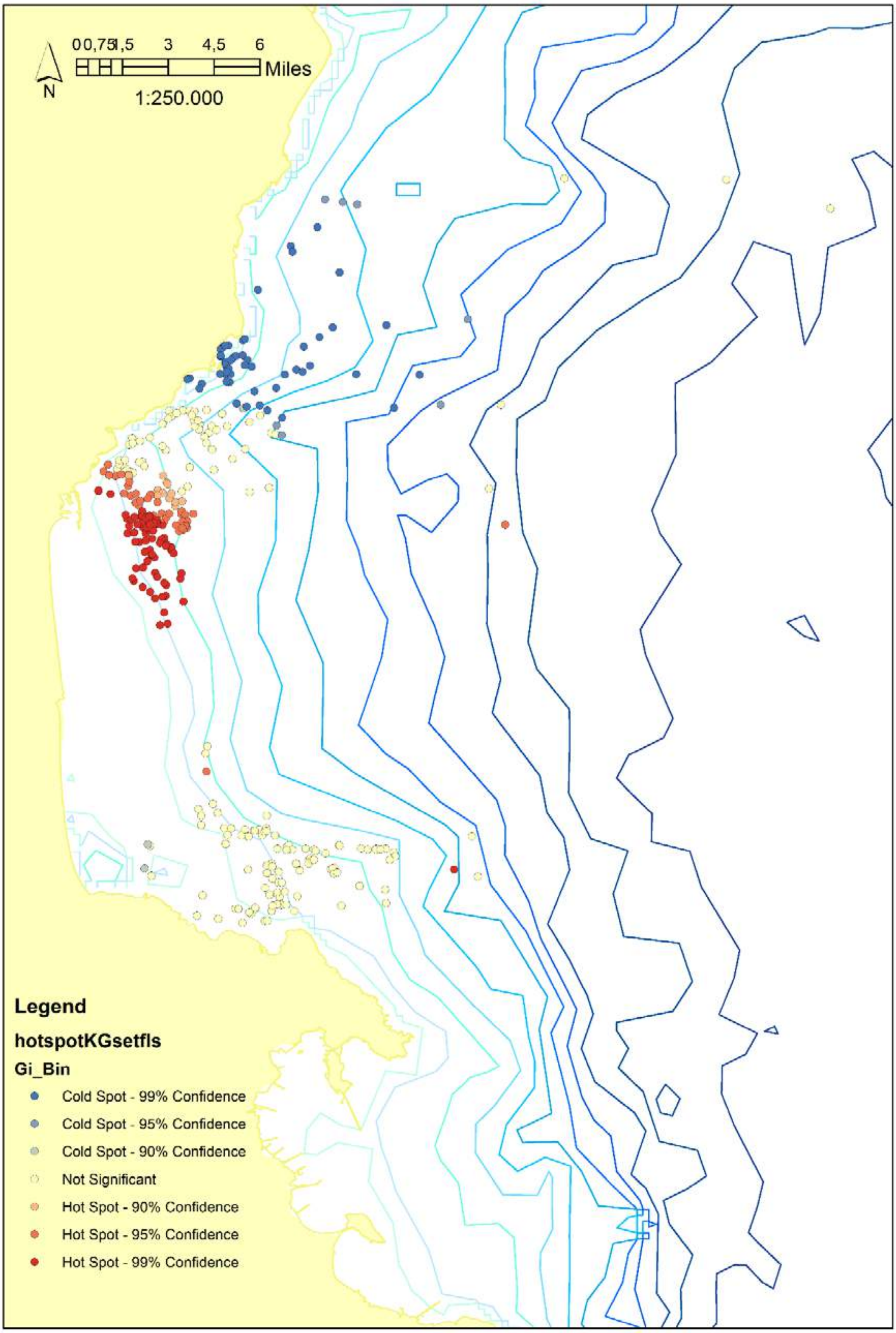
Annex 16. Spatial distribution of the Floating Laboratories units in the Gulf of Catania, grouped per degree of selectivity of the used fishing gears (July-October 2019). Our elaboration with ArcGIS.



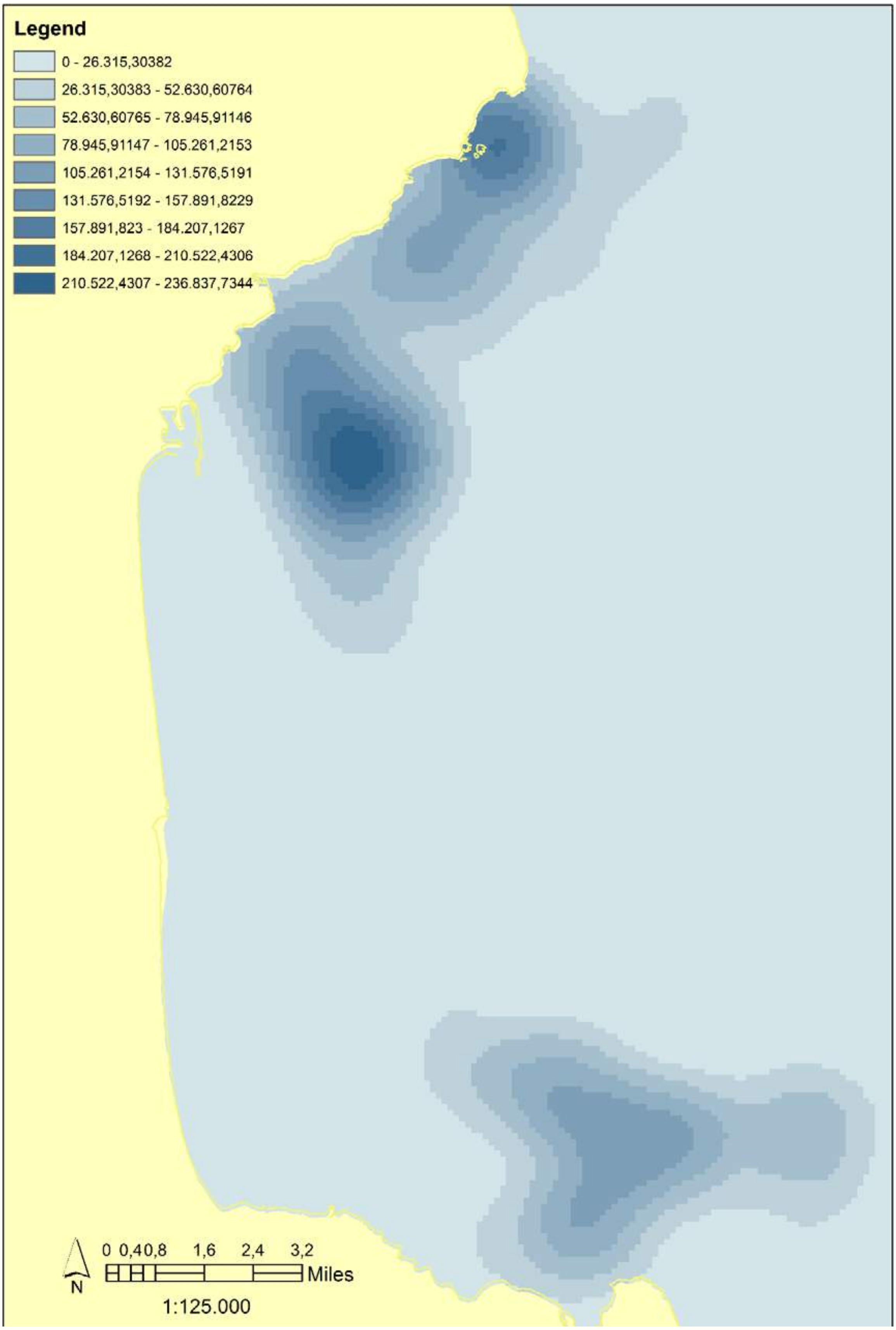
Annex 17. Spatial clusters of high values related to the fishing effort of the Floating Laboratories in the Gulf of Catania, applying a Hot Spot Analysis (Getis-Ord Gi) to the time during which gears are set underwater to catch (July-October 2019). Our elaboration with ArcGIS.



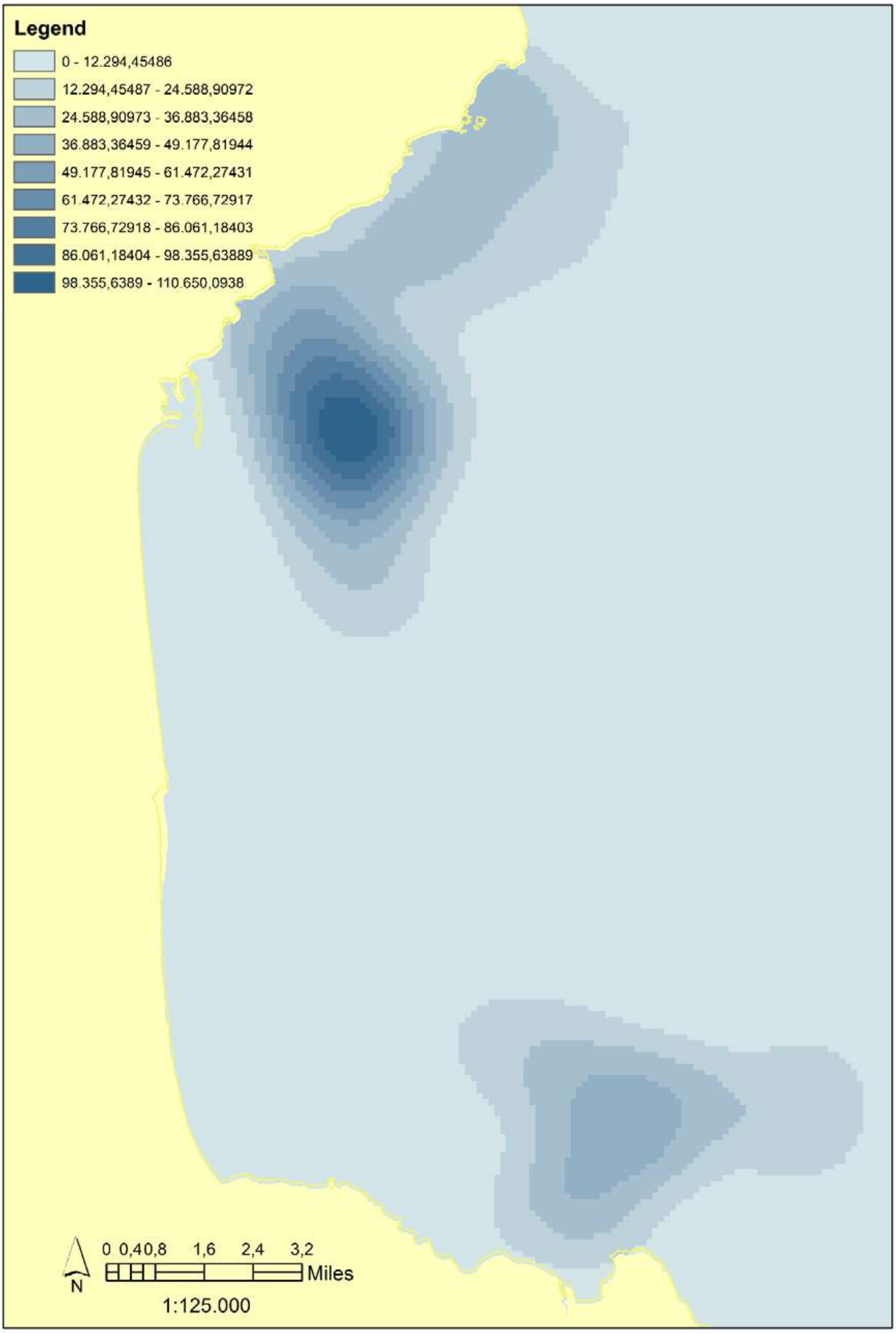
Annex 18. Spatial clusters of high values related to the fishing effort of the Floating Laboratories in the Gulf of Catania, applying a Hot Spot Analysis (Getis-Ord Gi) to kg of captured seafood for each set (July-October 2019). Our elaboration with ArcGIS.



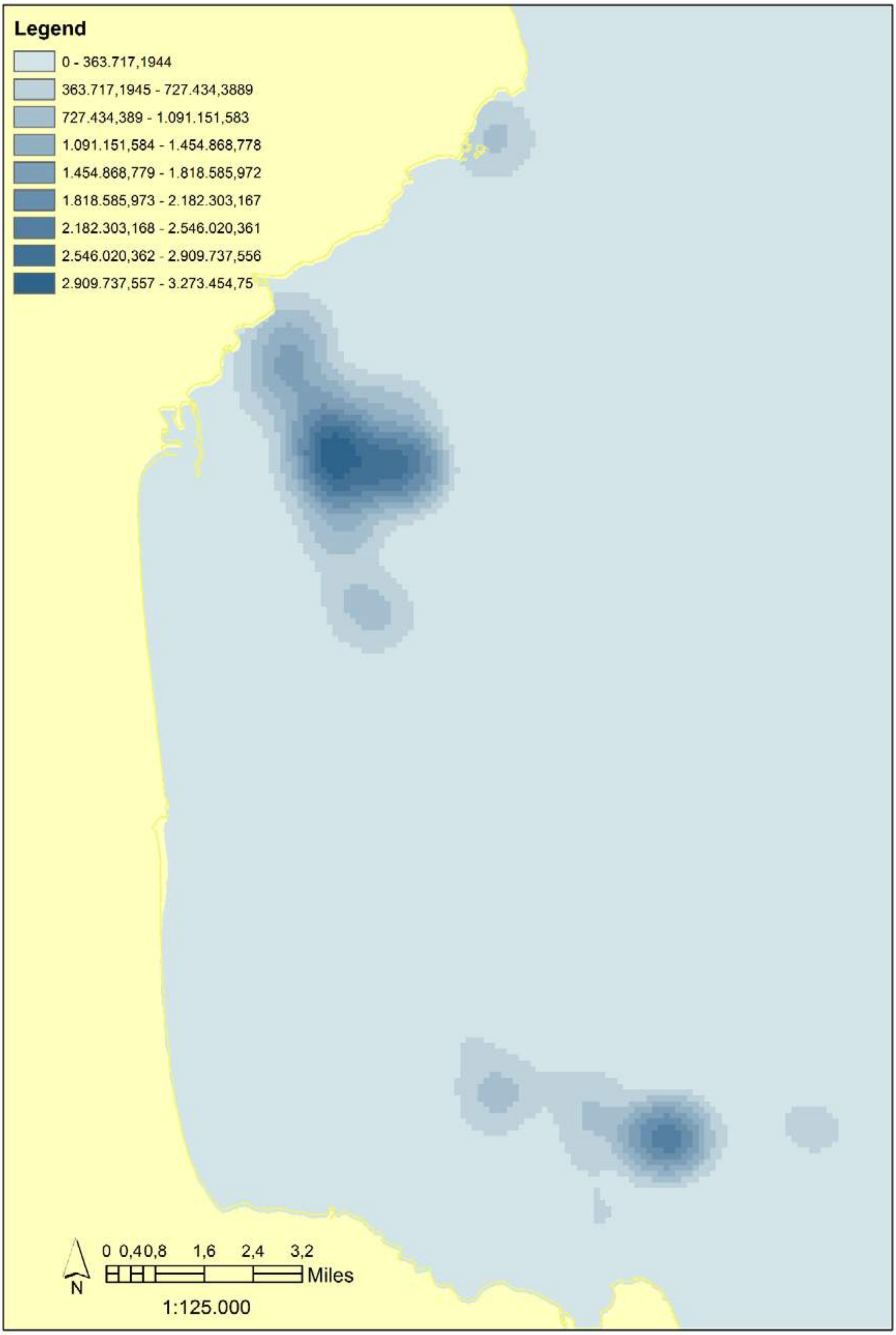
Annex 19. Fishing effort in terms of time spent per set made by the Floating Laboratories in the Gulf of Catania, applying a Kernel density function (July-October 2019). Our elaboration with ArcGIS.



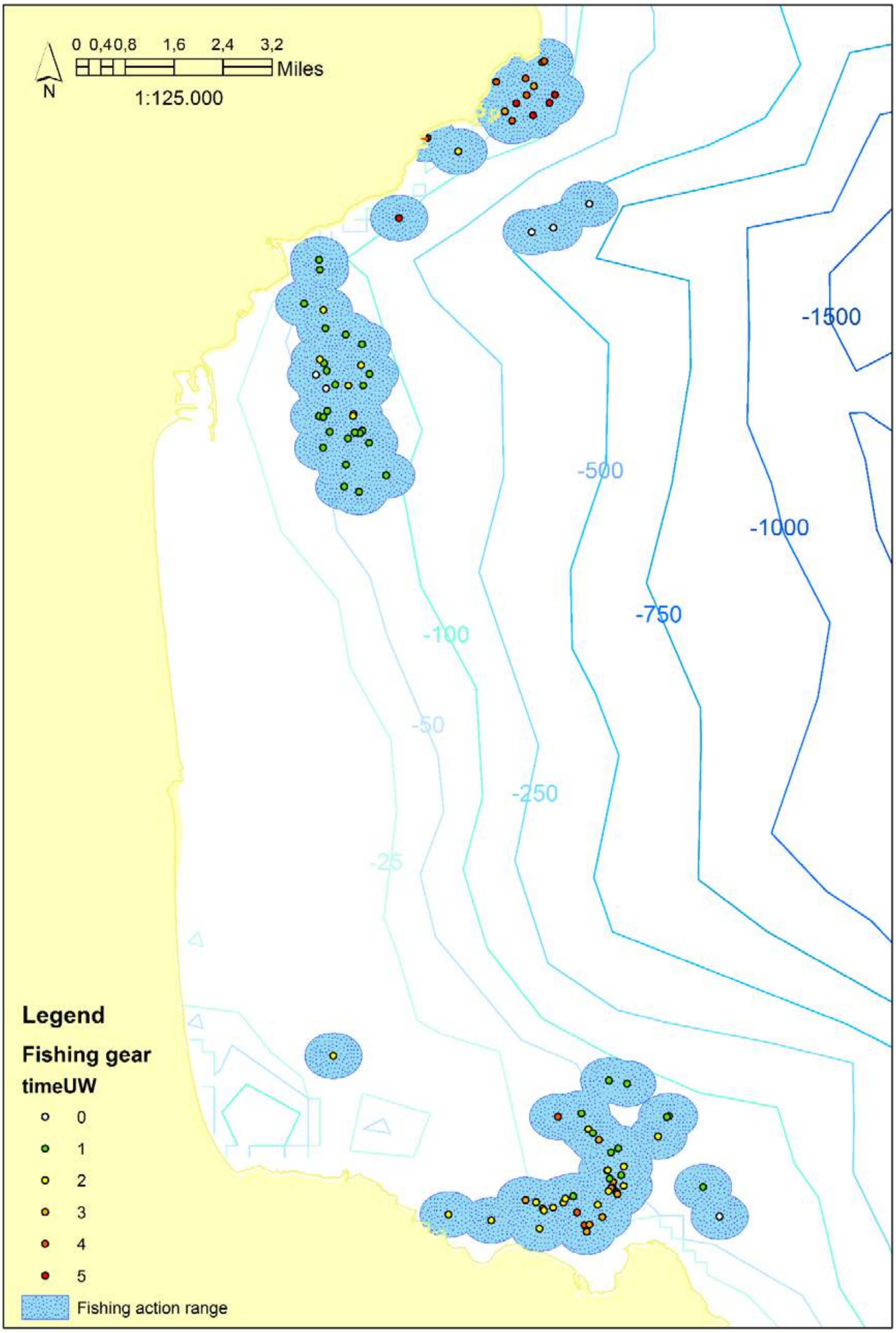
Annex 20. Fishing effort in terms of quantity of catches per set made by the Floating Laboratories in the Gulf of Catania, applying a Kernel density function max 110 650 value (July--October 2019). Our elaboration with ArcGIS.



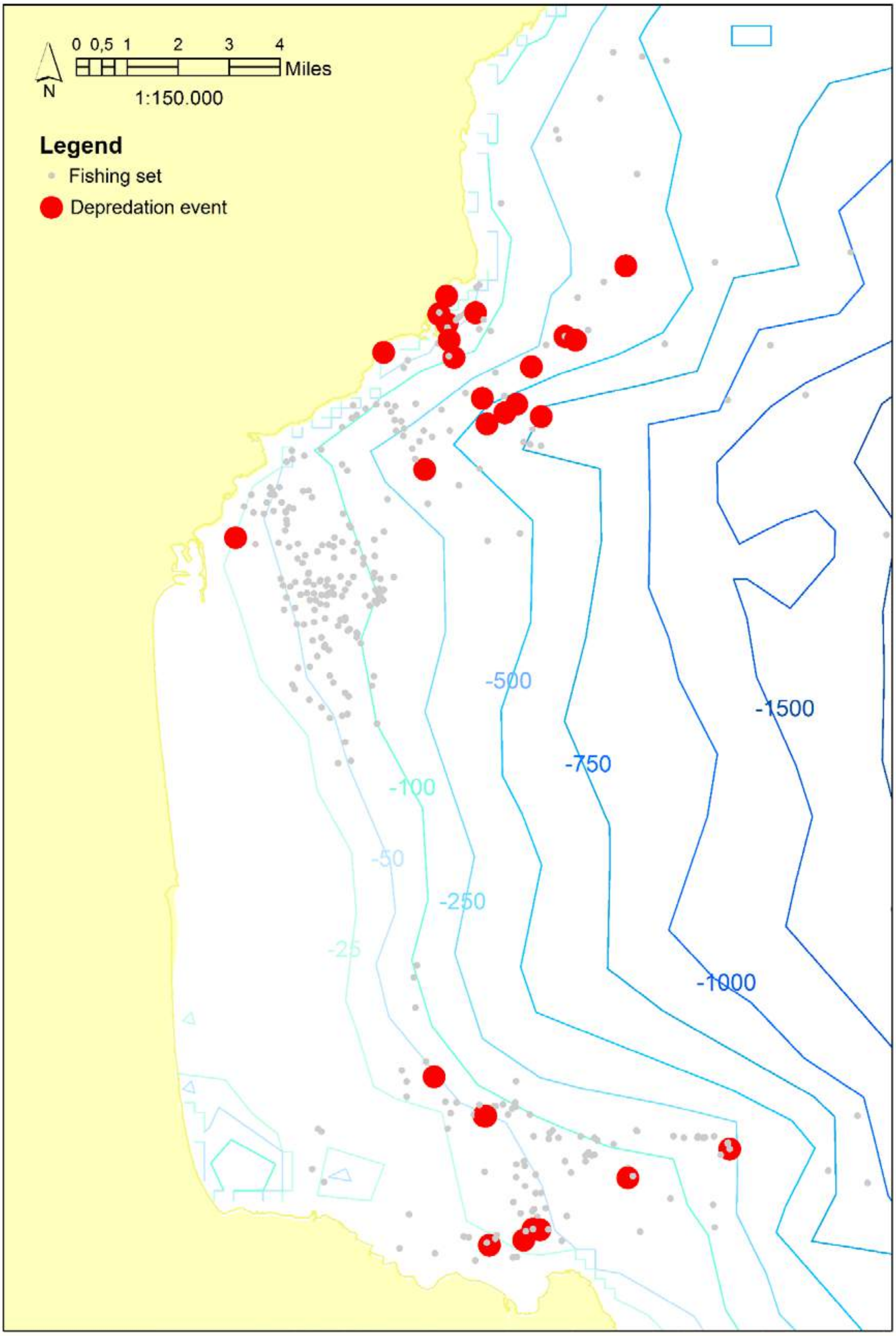
Annex 21. Fishing effort in terms of quantity of catches per set made by the Floating Laboratories in the Gulf of Catania, applying a Kernel density function max 3 273 454 value (July-October 2019). Our elaboration with ArcGIS.



Annex 22. Spatial distribution and duration of the fishing sets made by the Floating Laboratories with observers onboard in the Gulf of Catania, (July-October 2019). Our elaboration with ArcGIS.



Annex 23. Spatial distribution of fishing sets made by the Floating labs network and sighting of cetacean during which depredation events occurred, Gulf of Catania (July-October 2019). Our elaboration with ArcGIS.



Annex 24. Transformed variables of the correlations occurred during 45 sets of the Floating Labs network with the occurrence of depredation events (dimension 1). Our elaboration with SPSS.

	Time	Moon phase	Weather conditions	Bottom type	Bottom deph	Fishing system	Gear depht	Catches quantity	Length of the net	Proximity of other boats	Fishing set duration	Gear retrieval duration	Distance from the coast	Fishing area	Degree of residence of the cetacean in the area	Herd composition	Species causing depredation	Entity of the holes	Damaged hooks and lures	Damaged catch
Time	1,000	,276	-,261	,137	,481	,536	,481	,019	,497	,278	-,122	,347	,323	,350	-,245	,432	,511	,148	-,200	,184
Moon phase	,276	1,000	,222	-,203	,365	,347	,365	,309	,370	,447	,183	,402	,262	,437	,274	,164	,293	,361	,200	,044
Weather conditions	-,261	,222	1,000	-,105	,038	,254	,038	,016	,178	,144	,089	,116	-,071	,015	,368	,151	,275	,445	,444	-,315
Bottom type	,137	-,203	-,105	1,000	,178	,157	,178	,098	,190	-,068	,119	,103	-,115	,061	-,157	,235	,099	,111	,146	,180
Bottom deph	,481	,365	,038	,178	1,000	,756	1,000	,381	,771	,513	,446	,565	,342	,630	-,011	,551	,603	,630	,283	,175
Fishing system	,536	,347	,254	,157	,756	1,000	,756	,366	,952	,508	,355	,726	,316	,561	,081	,580	,699	,758	,491	-,012
Gear depht	,481	,365	,038	,178	1,000	,756	1,000	,381	,771	,513	,446	,565	,342	,630	-,011	,551	,603	,630	,283	,175
Catches quantity	,019	,309	,016	,098	,381	,366	,381	1,000	,393	,301	,415	,389	,041	,459	,279	,266	,373	,412	,164	,157
Length of the net	,497	,370	,178	,190	,771	,952	,771	,393	1,000	,484	,442	,657	,240	,476	,151	,536	,575	,794	,538	,049
Proximity of other boats	,278	,447	,144	-,068	,513	,508	,513	,301	,484	1,000	,479	,618	,238	,705	,410	,268	,496	,377	,097	,034
Fishing set duration	-,122	,183	,089	,119	,446	,355	,446	,415	,442	,479	1,000	,399	,059	,499	,232	,229	,122	,316	,261	-,089
Gear retrieval duration	,347	,402	,116	,103	,565	,726	,565	,389	,657	,618	,399	1,000	,358	,748	,168	,510	,616	,532	,298	,064
Distance from the coast	,323	,262	-,071	-,115	,342	,316	,342	,041	,240	,238	,059	,358	1,000	,468	-,176	,377	,302	,228	-,023	,022
Fishing area	,350	,437	,015	,061	,630	,561	,630	,459	,476	,705	,499	,748	,468	1,000	,048	,418	,585	,357	,021	-,054
Degree of residence of the cetacean in the area	-,245	,274	,368	-,157	-,011	,081	-,011	,279	,151	,410	,232	,168	-,176	,048	1,000	,026	,206	,413	,232	,155
Herd composition	,432	,164	,151	,235	,551	,580	,551	,266	,536	,268	,229	,510	,377	,418	,026	1,000	,492	,423	,218	,226
Species causing depredation	,511	,293	,275	,099	,603	,699	,603	,373	,575	,496	,122	,616	,302	,585	,206	,492	1,000	,529	,164	,183
Entity of the holes	,148	,361	,445	,111	,630	,758	,630	,412	,794	,377	,316	,532	,228	,357	,413	,423	,529	1,000	,648	,071
Damaged hooks and lures	-,200	,200	,444	,146	,283	,491	,283	,164	,538	,097	,261	,298	-,023	,021	,232	,218	,164	,648	1,000	,006
Damaged catch	,184	,044	-,315	,180	,175	-,012	,175	,157	,049	,034	-,089	,064	,022	-,054	,155	,226	,183	,071	,006	1,000
Dimensione	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Autovalore	7,877	2,404	1,697	1,415	1,268	,868	,815	,680	,622	,557	,488	,418	,257	,219	,172	,108	,062	,058	,015	,000

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