Food and Agriculture Organization of the United Nations

General Fisheries Commission for the Mediterranean

ACCOBAMS

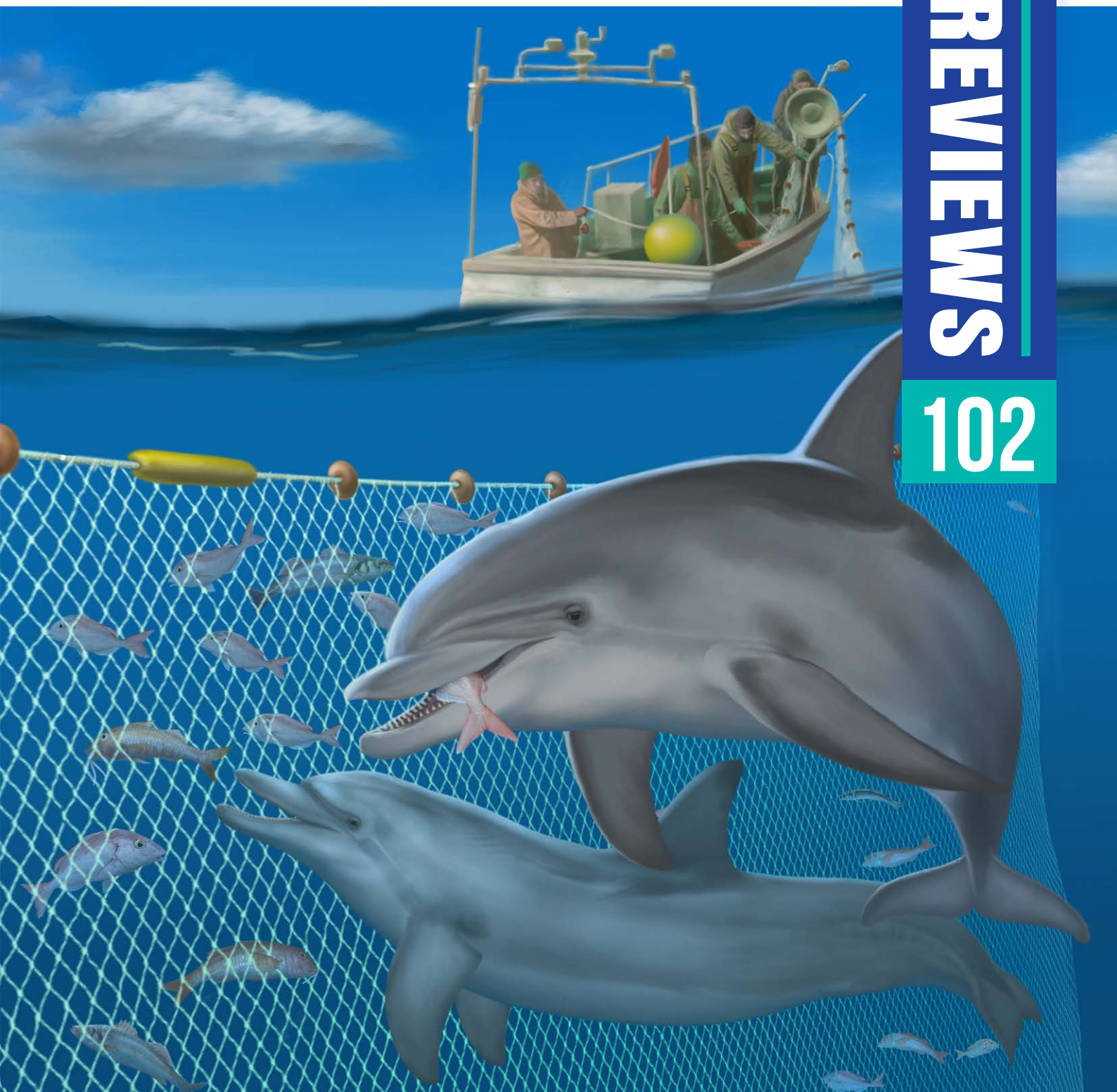
STUDIES & REVIEWS

102

ISSN 1020-9549

Depredation by marine mammals in fishing gear

A review of the Mediterranean Sea, Black Sea and contiguous Atlantic area



GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

STUDIES & REVIEWS
102

Depredation by marine mammals in fishing gear

A review of the Mediterranean Sea, Black Sea and contiguous Atlantic area

Joan Gonzalvo

Agreement on the Conservation of Cetaceans in the Black Sea, the Mediterranean Sea and contiguous Atlantic area

Paolo Carpentieri

Food and Agriculture Organization of the United Nations

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2023

Required citation:
Gonzalvo, J. & Carpentieri, P. 2023. *Depredation by marine mammals in fishing gear – A review of the Mediterranean Sea, Black Sea and contiguous Atlantic area.* Studies and reviews (General Fisheries Commission for the Mediterranean), No. 102. Rome, FAO.
https://doi.org/10.4060/cc6210en

ISBN 978-92-5-137903-5

Preparation of this document

This publication was prepared by the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) and the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO), in the context of the joint project "Mitigating dolphin depredation in Mediterranean fisheries – Joining efforts for strengthening cetacean conservation and sustainable fisheries" (also known as the Depredation project), carried out in collaboration with the Specially Protected Areas Regional Activity Centre (SPA/RAC) of the United Nations Environment Mediterranean Action Plan and the Low Impact Fishers of Europe (LIFE) platform and supported by the MAVA Foundation. This publication contributes to fulfilling the mandates of the project partners by providing a harmonized framework to increase knowledge on depredation by marine mammals in fishing gear in the Mediterranean and the Black Sea.

Between 2018 and 2020, activities were launched by these organizations at pilot sites in different Mediterranean areas. They assessed the depredation issue in different fishing types of fishing gear, with the goals of identifying technical or management solutions to mitigate depredation and expanding the regional network of expertise on this issue. These efforts enabled comparisons between experiences and results from the different pilot sites, as well as the consolidation of lessons learned and the dissemination of best practices at the regional level at the end of the project. The project has built on all these experiences to develop a standardized methodology for monitoring depredation impacts (Carpentieri and Gonzalvo, 2022), with a view to providing a harmonized framework to increase knowledge of depredation in the Mediterranean and the Black Sea. It is within this context that the present publication was prepared.

Joan Gonzalvo is the Task Manager on Interactions with Fisheries for the ACCOBAMS Scientific Committee and was responsible for the development of the review and the general coordination and the compilation of this document. Paolo Carpentieri, GFCM Fishery Resources Monitoring Officer, provided expert insights which were instrumental during the final stages of this work.

Abstract

Marine mammal depredation – when marine mammals partially or completely remove catch from fishing gear – is a growing cause for concern in several Mediterranean fisheries. Interactions between marine mammals and fisheries in the Mediterranean and the Black Sea involve mainly coastal fisheries and cetacean species such as bottlenose dolphins (*Tursiops truncatus*), which are typically found along the continental shelf, common dolphins (*Delphinus delphis*) and harbour porpoises (*Phocoena phocoena relicta*). Static nets – the main fishing gear used by small-scale Mediterranean and Black Sea fisheries – are prone to interactions with marine dolphins. Reports of dolphins removing or damaging catch, damaging fishing gear, disturbing fishing activities, and, in some cases, causing severe economic losses come from several areas across the region.

This publication offers an overview of historical and current trends in depredation by marine mammals in the Mediterranean, Black Sea and contiguous Atlantic area, with the aims of assessing and improving:

- the information available on the dolphin populations involved in depredation;
- knowledge of the typology of current fishing practices that lead to depredation events (e.g. fisheries behaviour, fishing area, main commercial species predated, seasonality);
- knowledge of the dolphin behaviours associated with feeding on fish captures and dolphins' selection of particular types of fishing gear;
- the information available on the reported economic losses caused by dolphin–fisheries interactions;
- the information available on the Mediterranean monk seal (Monachus monachus) populations involved in depredation; and
- the regional magnitude of depredation.

The depredation records included in this review derive from a variety of approaches (e.g. surveys completed by on-board observers and interviews of fishers). Data are presented according to type of fishing gear and by GFCM subregion (western, central and eastern Mediterranean, Adriatic Sea and Black Sea), as well as for the contiguous Atlantic area. Though many geographic areas and types of fishing gear remain underrepresented in the available data, coverage has generally increased in recent years and new insights continue to emerge.

Marine mammal depredation is primarily associated with catch losses and gear damage but often lacks accurate assessments. Conflicts frequently occur on a seasonal basis rather than all year round. Therefore, this seasonality must also be considered when envisioning possible mitigation strategies, which may need to be implemented during a specific season rather than throughout the year. In many of the studies reviewed in this publication, deterrence methods were also tested, to various degrees of effectiveness.

Addressing this complex issue requires the active participation of fishers. Their cooperation is essential not only to provide improved localized knowledge on interactions between local fisheries and marine mammals, but also to define specific management and mitigation strategies in agreement with key stakeholders.

Contents

TABLE AND FIGURE

Acknowledgements

The authors thank the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) and the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) for their support. Special appreciation goes to Celia Le Ravallec (ACCOBAMS Programme and Project Officer) and Julie Belmont (ACCOBAMS Depredation Project Officer). The support of the GFCM Secretariat staff throughout this process was essential for the authors, particularly from Margherita Sessa (Programme and Liaison Officer), who offered her experience and strategic guidance, as well as from Dominique Bourdenet (Knowledge Management Officer), who coordinated the editing and publishing with the valuable support of Ysé Bendjeddou (Publications and Documentation Coordinator), Matthew Kleiner (Publications Specialist) and Amandine Abraham (Editing and Publications Intern). The publication also benefited from the expertise of Alex Chepstow-Lusty, who performed the technical editing and from José Luis Castilla, who handled the graphic design and layout. Gratitude also goes to Alberto Gennari, who designed the cover.

Many colleagues conducting research on marine mammals and their conservation have provided important inputs by sharing information on ongoing activities as well as through valuable comments and suggestions on earlier versions of this review. Many fishers, whom the authors have had the privilege of interacting with and learning from over more than two decades of work in this field, have also contributed to this report by sharing their insights and experiences.

Finally, the MAVA Foundation is warmly thanked for making this work possible and for promoting it through its many projects and initiatives.

Abbreviations and acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area
CI	confidence interval
CPUE	catch per unit effort
EEZ	exclusive economic zone
FAO	Food and Agriculture Organization of the United Nations
GFCM	General Fisheries Commission for the Mediterranean
IMMA	important marine mammal area
LEK	local ecological knowledge
LIFE	Low Impact Fishers of Europe
SPA/RAC	Specially Protected Areas Regional Activity Centre
SSF	small-scale fisheries
UNEP/MAP	Mediterranean Action Plan of the United Nations Environment Programme
WWF	World Wide Fund for Nature

Introduction and methodology

Marine mammals have long held great significance in the lives of humans, both practically and spiritually. This deep history is recorded in artefacts dating back some 10 000 years, spoken myths and legends and the writings of Greek and Roman philosophers (Allen, 2014). Interactions between marine mammals and fisheries in the Mediterranean Sea probably began as early as the first human attempts to catch fish with a net. The earliest reports of these interactions describe idyllic relationships between dolphins and people, but the situation changed as fisheries developed (Bearzi, 2002).

Conflicts between fisheries and marine mammals generally take one or both of two forms. The first is the incidental capture of marine mammals during fishing operations (i.e. as bycatch); the second is depredation in fishing gear by marine mammals, who have learned to adapt to a human activity (i.e. fishing) by enhancing their foraging strategies, leading to losses of catch and damage to fishing gear. In many cases, these two problems occur simultaneously in the same fisheries, and resolving the latter issue may help resolve the former. As the present review will show, increasing evidence from a number of studies and from fishers' observations describe coastal dolphins using fishing nets as an easily accessible feeding source in the Mediterranean, Black Sea and contiguous Atlantic area, resulting in damage to and/or depredation of fish caught in the nets.

It has been recently suggested by Bearzi and Reeves (2022) that using the term "depredation" to refer to marine mammals responding to the expansion of fisheries by modifying their behaviour to take advantage of the new foraging opportunities could strengthen misperceptions and misunderstandings, thus reinforcing, at least to some, the belief that fish and other marine resources "belong" only to humans. While the authors of this publication agree with Bearzi and Reeves that alternative wording may help to prevent ambiguity in communications, for the purpose of this review, which is largely based on scientific reports and peer-reviewed publications, it was considered more straightforward to use primarily the term "depredation", as it was employed in most of those papers. However, alternative terminology, such as "removing prey from fishing gear", "foraging from" and "preying on", to describe the behaviour of free-ranging marine mammals interacting with fisheries has been also used as deemed necessary.

Marine mammals are well known for their advanced learning abilities and fast knowledge transfer within populations that enable them to quickly discover new foraging grounds and opportunities (Whitehead *et al.*, 2004). Nevertheless, marine mammal adaptations to fishing are certainly not limited to depredation, nor are they always detrimental to the fishery (Bearzi, Piwetz and Reeves, 2019). For instance, Rocklin *et al.* (2009) reported that dolphin interactions in the Bonifacio Strait Natural Reserve in southern Corsica were significantly associated with higher values of catch per unit effort (CPUE). This dynamic could be explained either by dolphins foraging from nets only when the catch is notable or by them driving the fish into the nets, thereby increasing fish catch and CPUE. If the latter assumption is accurate, dolphin depredation may be benefitting fishers. However, as Rocklin and colleagues (2009) also pointed out that, although the quantity of fish caught in foraged nets was higher, dolphins preying on free-swimming fish close to these nets may also result in a lost opportunity for fishers (this connection is hard to establish) and additionally, depredation often causes damage to the nets, thereby reducing catching efficiency and capacity, leading to increased repair time and fishing gear costs (Reeves, Read and Notarbartolo di Sciara, 2001).

Depredation by marine mammals in fisheries is a major issue globally, in terms of both conservation and fisheries economics. Depredation on fish by cetaceans, usually dolphins, appears to be recurrently perceived by Mediterranean fishers as causing economic hardship, particularly in small-scale fisheries (Bearzi, 2002). In these cases, bottlenose dolphins are the main species involved in interactions with coastal fisheries. Depredation by bottlenose dolphins affects primarily gillnets and trammel nets, with different estimates being reported for the economic impacts on fishers (Brotons, Grau and Rendell, 2008; Gazo, Gonzalvo and Aguilar, 2008; Bearzi, Bonizzoni and Gonzalvo, 2011; Lauriano *et al.*, 2004, 2009; Brotons *et al.*, 2008). For instance, Bearzi, Bonizzoni and Gonzalvo (2011) estimated the annual mean economic loss per artisanal fisher as EUR 2 561, while Brotons *et al.* (2008) calculated that trammel net fishers may lose around

5.3 percent of their total catch value due to interactions with cetaceans. Dolphin depredation is not limited exclusively to small-scale fisheries and has been also reported, for example, from purse seiners (Benmessaoud *et al.*, 2018) and bottom trawlers (Scheinin, 2010; Gonzalvo *et al.*, 2008; Genov *et al.*, 2019; global review by Bonizzoni *et al.*, 2022). Ecosystem damage resulting from overfishing and habitat degradation in the Mediterranean Sea has probably also exacerbated the perception that dolphins reduce fishery yields (Reeves, Read and Notarbartolo di Sciara, 2001). Therefore, the economic damage caused by dolphins leads to conflict with fishers and, rarely, to intentional kills in retaliation, as well as occasional demands for organized culls in some places (Gonzalvo, Giovos and Moutopoulos, 2014).

In recent years, several organizations (e.g. ACCOBAMS, GFCM, UNEP/MAP-SPA/RAC, WWF) are trying to address this issue through different projects (e.g. "Mitigating dolphin depredation in Mediterranean fisheries – Joining efforts for strengthening cetacean conservation and sustainable fisheries") and initiating activities in different Mediterranean areas and fisheries (e.g. monitoring programmes, testing mitigation measures).

However, to better understand the extent of dolphin depredation in Mediterranean and Black Sea fisheries, it is necessary to develop more robust data collection monitoring programmes so as to increase temporal and spatial coverage and involve all different countries. This information may help to identify depredation hotspots and, in turn, be useful for applying adequate mitigation measures to reduce negative impacts on both marine mammals and the fishing industry (Carpentieri and Gonzalvo, 2022).

Unfortunately, even though direct interactions (i.e. depredation) between marine mammals and fishing gear are increasingly under consideration, there remains a lack of detailed and robust information on the nature and scale of the depredation issue throughout the Mediterranean and the Black Sea. This report intends to shed some light by reviewing the available information on depredation studies conducted across the Mediterranean Sea, Black Sea and contiguous Atlantic area.

For the elaboration of this report, the literature available on dolphin depredation (mostly peer reviewed papers, but not exclusively) was reviewed, and a questionnaire was produced (Annex 2). The questionnaire was shared with researchers and conservationists currently dealing with studies relevant to this issue in order to collect the latest information possible, which, in many cases, had not been published yet. The results derived from the responses to this questionnaire are provided in Annex 1 on "Ongoing studies on marine mammal depredation in the Black Sea, Mediterranean Sea and contiguous Atlantic area."

The information gathered through this exercise is presented for the five GFCM subregions, namely the Black Sea, eastern Mediterranean, central Mediterranean, Adriatic Sea and western Mediterranean, and for the contiguous Atlantic area.

TABLE 1. Cetacean species occurring, or having occurred, in the Mediterranean Sea, Black Sea and adjacent areas

Species/ subspecies	English common name	Classification	Subarea	Presence	Habitat	Current or proposed status for Mediterranean and Black Sea population (IUCN)	Reference
Eubalaena glacialis	North Atlantic right whale	Mysticeti, Balaenidae	Mediterranean, contiguous Atlantic area	Very rare			
Balaenoptera a. acutorostrata	North Atlantic minke whale	Mysticeti, Balaenopteridae	Mediterranean, contiguous Atlantic area	Visitor			
Balaenoptera b. borealis	Northern sei whale	Mysticeti, Balaenopteridae	Mediterranean, contiguous Atlantic area	Very rare			
Balaenoptera physalus physalus	North Atlantic fin whale	Mysticeti, Balaenopteridae	Mediterranean, contiguous Atlantic area	Regular	**Oceanic**, slope, neritic	Endangered	Panigada, Gauffier and Notarbartolo di Sciara, 2021
Megaptera n. novaeangliae	North Atlantic humpback whale	Mysticeti, Balaenopteridae	Mediterranean, contiguous Atlantic area	Visitor			
Eschrichtius robustus	Grey whale	Mysticeti, Eschrichtiidae	Mediterranean, contiguous Atlantic area	Very rare			
Physeter macrocephalus	Sperm whale	Odontoceti, Physeteridae	Mediterranean, contiguous Atlantic area	Regular	**Slope**, oceanic	Endangered	Pirotta *et al.*, 2021
Kogia sima	Dwarf sperm whale	Odontoceti, Kogiidae	Mediterranean, contiguous Atlantic area	Very rare			
Hyperoodon ampullatus	Northern bottlenose whale	Odontoceti, Ziphiidae	Mediterranean, contiguous Atlantic area	Very rare			
Mesoplodon bidens	Sowerby's beaked whale	Odontoceti, Ziphiidae	Mediterranean, contiguous Atlantic area	Very rare			
Mesoplodon densirostris	Blainville's beaked whale	Odontoceti, Ziphiidae	Mediterranean, contiguous Atlantic area	Very rare			
Mesoplodon europaeus	Gervais' beaked whale	Odontoceti, Ziphiidae	Mediterranean, contiguous Atlantic area	Very rare			
Ziphius cavirostris	Cuvier's beaked whale	Odontoceti, Ziphiidae	Mediterranean, contiguous Atlantic area	Regular	**Slope**, oceanic	Vulnerable	Cañadas and Notarbartolo di Sciara, 2018
Delphinus delphis delphis	Common dolphin	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Regular	**Neritic, slope, oceanic**	Endangered	Bearzi *et al.*, 2022
Delphinus delphis ponticus	Black Sea common dolphin	Odontoceti, Delphinidae	Black Sea	Regular	**Neritic, slope, oceanic**	Vulnerable	Birkun, 2008
Globicephala macrorhynchus	Short-finned pilot whale	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Very rare			
Globicephala melas melas	North Atlantic long-finned pilot whale	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Regular	**Oceanic**, slope, neritic	Endangered	Gauffier and Verborgh, 2021
Grampus griseus	Risso's dolphin	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Regular	**Slope**, oceanic	Endangered	Lanfredi *et al.*, 2022

TABLE 1. Continued

Species/ subspecies	English common name	Classification	Subarea	Presence	Habitat	Current or proposed status for Mediterranean and Black Sea population (IUCN)	Reference
Orcinus orca	Orca	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Regular in contiguous Atlantic area, visitor in the Mediterranean	**Neritic, slope, oceanic**	Critically Endangered	Esteban and Foote, 2019
Pseudorca crassidens	False killer whale	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Visitor			
Sousa plumbea	Indian Ocean humpback dolphin	Odontoceti, Delphinidae	Mediterranean	Very rare			
Stenella coeruleoalba	Striped dolphin	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Regular	**Oceanic,** slope	Least Concern	Lauriano, 2022
Steno bredanensis	Rough-toothed dolphin	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Regular in the Levantine Sea, visitor elsewhere	**Oceanic, slope,** neritic	Near Threatened	Kerem *et al.*, 2021
Tursiops truncatus truncatus	North Atlantic bottlenose dolphin	Odontoceti, Delphinidae	Mediterranean, contiguous Atlantic area	Regular	**Neritic,** oceanic	Least Concern	Natoli *et al.*, 2021
Tursiops truncatus ponticus	Black Sea bottlenose dolphin	Odontoceti, Delphinidae	Black Sea	Regular	**Neritic**	Endangered	Birkun, 2012
Phocoena phocoena phocoena	North Atlantic harbour porpoise	Odontoceti, Phocoenidae	contiguous Atlantic area, Mediterranean	Regular in contiguous Atlantic area, very rare in the Mediterranean	**Neritic**	Least Concern	Braulik *et al.*, 2020
Phocoena phocoena relicta	Black Sea harbour porpoise	Odontoceti, Phocoenidae	Black Sea, Mediterranean	Regular in Black Sea and northern Aegean Sea	**Neritic**	Endangered	Birkun and Frantzis, 2008

Source: Adapted from ACCOBAMS. 2021a. *Conserving whales, dolphins and porpoises in the Mediterranean Sea, Black Sea and adjacent areas: An ACCOBAMS status report (2021).* G. Notarbartolo di Sciara & A.M. Tonay, eds. Monaco.

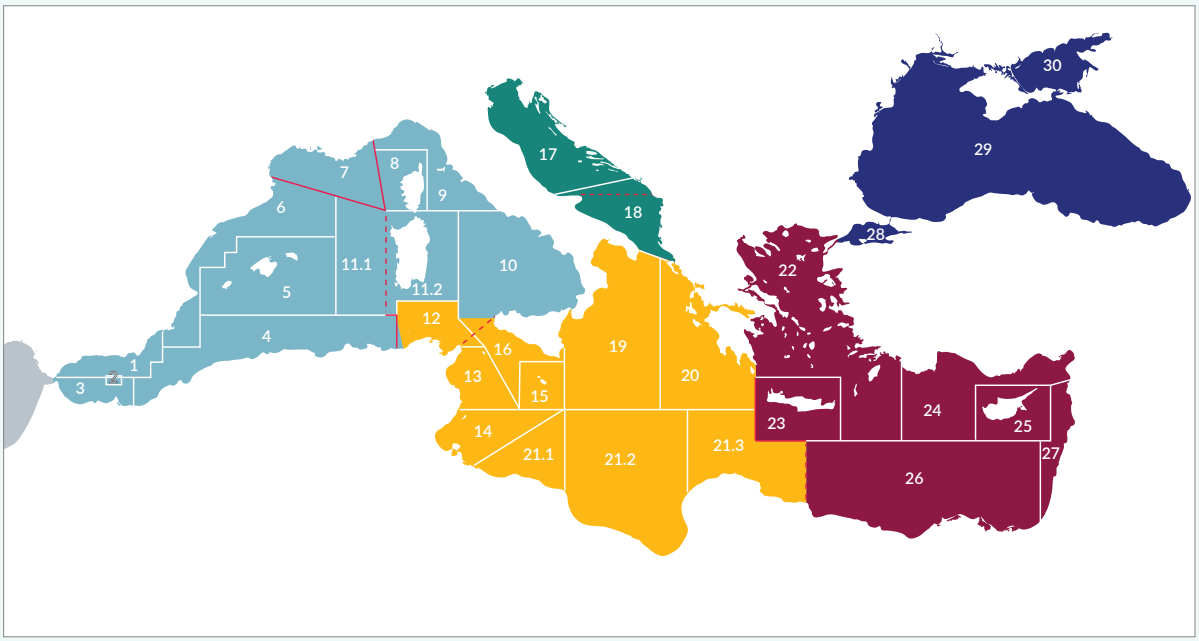
Notes:

Rows describing species regularly present in the Mediterranean and the Black Sea are grey.

Names of species reportedly involved in depredation are in red.

Habitat (preferred habitat is highlighted in bold) and status are given only for species recognized as regularly occurring in the Mediterranean and the Black Sea.

FIGURE 1. GFCM subregions and geographical subareas and the contiguous Atlantic area



FAO statistical divisions GFCM geographical subareas (GSAs)

GFCM subregions

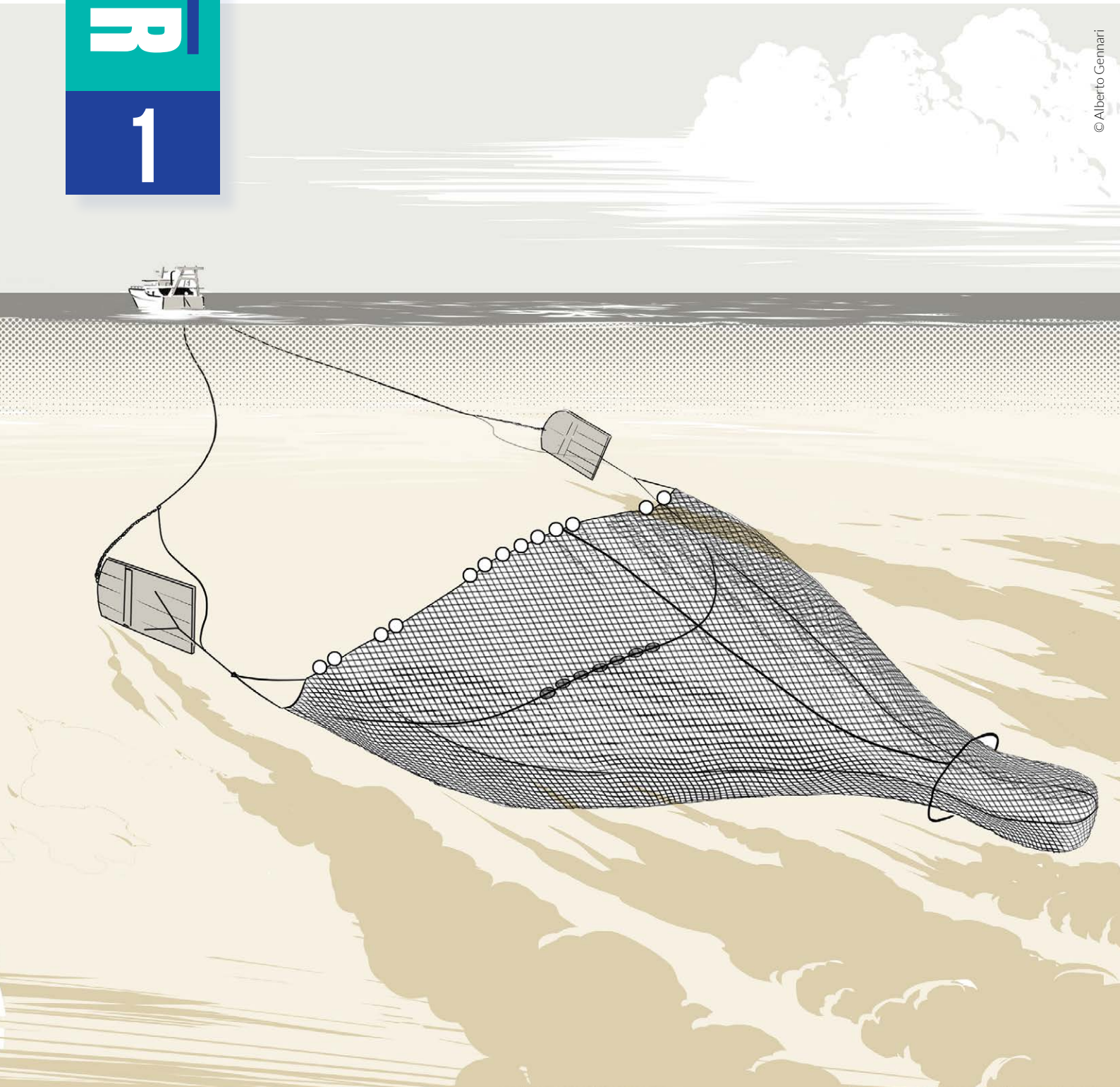
Contiguous Atlantic area | Western Mediterranean | Central Mediterranean | Adriatic Sea | Eastern Mediterranean | Black Sea

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 Gabès	20. Eastern Ionian Sea	26. Southern Levant Sea
03. Southern Alboran Sea	09. Ligurian Sea and northern Tyrrhenian Sea	15. Malta	21.1. Southwestern Ionian Sea 21.2. South-central Ionian Sea 21.3. Southeastern Ionian Sea	27. Eastern Levant Sea
04. Algeria	10. Southern and central Tyrrhenian Sea	16. Southern Sicily	22. Aegean Sea	28. Marmara Sea
05. Balearic Islands	11.1. Western Sardinia 11.2. Eastern Sardinia	17. Northern Adriatic Sea	23. Crete	29. Black Sea
06. Northern Spain	12. Northern Tunisia	18. Southern Adriatic Sea	24. Northern Levant Sea	30. Azov Sea

Source: FAO. 2023. Area of application. In: *General Fisheries Commission for the Mediterranean – GFCM*. Rome. Cited 15 April 2023. gfcm/about/area-of-application

CHAPTER 1

FISHING GEAR DESCRIPTIONS



"A fishing gear is any physical device or part thereof, or combination of items that may be placed on or in the water or on the seabed with the intended purpose of capturing or controlling for subsequent capture or harvesting marine or freshwater organisms." (He *et al.*, 2021)

1.1. Bottom trawls

A bottom trawl is a cone-shaped net towed along the seabed and designed to catch fish living on or near the seabed (FAO, 2023a). Bottom trawls often consist of components such as heavy-duty ropes, chains, discs, bobbins and weights to ensure that seabed contact is maintained during fishing while minimizing the risk of damage to the net. Otter boards (used in single-boat bottom trawls) also assist in keeping the net in contact with the seabed. The horizontal opening of the net mouth may be maintained by a rigid beam (beam trawl), by a pair of otter boards (otter trawl) or by towing the net between two boats (pair trawl). Floats and weights or a rigid frame often maintain the vertical opening of the trawl net. Two or more trawl nets may be rigged adjacently between the otter boards (twin or multi-rig trawls). One trawl may have more than one codend (i.e. the terminal section of a fishing gear where the catch is accumulated before being landed on board), splitting the catch to reduce fish damage and improve fish quality and/or to facilitate the handling of large catch. Bottom trawls can be towed from the stern or from outriggers; in the latter case, an even number of trawls are towed to balance the load.

The bottom trawl is one of the most versatile types of gear, capable of operating over many kinds of seabed and at depths of over 1 000 m. However, bottom trawls have also become the subject of controversy, in part due to their poor selectivity, high discard rates and physical impact on the benthos. The estimated discard rate for bottom trawls is above 20 percent of their total landings. Bottom trawls have been reported to modify the physical characteristics of the seabed and may impact benthic species and ecosystems.

1.2. Midwater trawls

A midwater trawl is a cone-shaped net towed in midwater by one or two boats to catch pelagic or semi-demersal fish in the water column (FAO, 2023b). Midwater trawls are also called pelagic trawls, and their components are not intended to have contact with the seabed while fishing. Target species often include schooling species, such as clupeids and scombrids, and catch rates are often very high. Towing speeds usually range from 3 to 5 knots, but 6 knots may be required for faster-swimming species. Midwater trawl nets are usually much larger than bottom trawl nets, especially in their vertical openings. The front part of the net is normally made with very large meshes or ropes in order to reduce drag but still be able to herd the targeted fish. The vertical opening of a midwater trawl is often maintained with weights attached to the lower wingends (i.e. the terminal points of the wing of a trawl), which are often called clump weights. As entrapped fish tire, they fall back and are overtaken by smaller meshes in the aft sections of the net and the codend. The codend may be designed to hold a large catch, including circumferential strengthening ropes to prevent bursting when the fish reach the surface with expanded swim bladders. Detecting schools of fish in midwater requires the use of echo sounders and/or scanning sonars. Aiming the trawl to intercept the school requires the use of a net sounder (also called "Netsonde") attached to the trawl's headrope in order to determine the position of the net relative to the depth of fish in real time. As such, careful adjustment of the towing speed and/or the length of warp allows the boat operator to adjust the depth of the net to intercept the school. Midwater trawls may be towed by one or two boats.

1.3. Purse seines

A purse seine is a wall of netting designed to encircle a school of pelagic fish near the surface, after which a purse line is used to close the bottom of the net (FAO, 2023c). Purse seines use weights, lead lines or chains attached to the footrope and dense netting materials, such as polyamide or polyester, to increase the sinking velocity

of the net and prevent fish from escaping horizontally. The purse seine is characterized by a purse line threaded through purse rings spaced out along the bottom edge of the net, through which the purse line can be drawn tight – hence the name "purse seine". The middle sections of the netting are widest and gradually taper towards the wing and the bunt where fish finally accumulate. The bunt can also be found at the middle of the net; in this case, hauling starts from both wings.

When a target fish school is identified, the vessel manoeuvres into a favourable position and the seine net is prepared for deployment. The vessel follows a course around the edge of the school, attempting to encircle it. With the net fully deployed, ropes attached to the ends of the net are hauled in order to close the seine around the school. At the same time, the purse line is drawn to close the seine net beneath the school. Typically, the headrope is longer than the footrope so as to reduce tension and prevent it from submerging beneath the surface and allowing fish to escape over it.

1.4. Trammel nets

A trammel net is a gillnet that has three layers of netting – two outer layers of large-mesh netting and one inner layer of slackly hung (i.e. with a low horizontal hanging ratio) small-mesh netting – and operates by either entrapping fish in a pocket or entangling them in the netting (FAO, 2023d). When a fish pushes the small-mesh netting through one of the outer layers of large-mesh netting, the netting forms a bag that can retain the fish. Trammel nets are usually set on the bottom in a similar manner to set gillnets and are widely used as a small-scale fishing gear all over the world for various species.

1.5. Gillnets

Gillnets and entangling nets are long rectangular walls of netting that catch fish by gilling, wedging, snagging, entangling or entrapping them in pockets (FAO, 2023e). These nets are kept open vertically by floats attached to the head rope (also called the float line or cork line) and by weights added to the footrope, but they can also be held open vertically by hanging the net on stakes. These nets are usually employed in long fleets, with a number of nets tied together to form a long string of nets (which may extend up to several kilometres), but they can also be used singly. Depending on their design, they may be used to fish at the surface, in midwater or near the seabed. They may also be anchored to the seabed or allowed to drift freely along with marker buoys or attached to the boat. Several types of net may be combined into one gear (for example, a trammel net combined with a gillnet). With the introduction of synthetic materials in the 1950s and 1960s and a subsequent reduction in prices, the use of gillnets made of synthetic materials has drastically increased. The spike in use is also attributable to the low visibility of monofilament twine and the materials' light weight and rot resistance.

The set gillnet is the most common type of gillnet and is also referred to as "bottom gillnet" or simply "gillnet". A set gillnet is a long, rectangular, single-walled netting anchored or otherwise fixed to the seabed, catching fish when they come into contact with it. It is held open vertically in the water by a headrope, usually with strung with floats, and by a footrope weighted with sinkers. Flotation and lead weights may be built into the ropes, which are often called float-ropes and lead-ropes. The net is kept in position by anchors or other weights, usually at both ends, and marked on the surface with buoys and/or highflyers.

1.6. Longlines

A longline is a type of hook-and-line gear in which hooks are connected to branch lines, in turn attached to a long horizontal mainline at certain intervals (FAO, 2023f, 2023g). Longlines are usually baited, set in open water and left untended for a period of time. The number of hooks and the length of the mainline depend on the scale of the operation and the area of fishing grounds, ranging from a few hundred metres in coastal set longlines to more than 80 km in large-scale drift (pelagic) longlines. The basic longline gear units include mainline, branch line snood (also known as simply "branch line" or "gangion"), hook and bait. Hooks and branch lines can be attached to the

mainline through conventional knots or through the use of mechanical crimps or clamps, which often incorporate swivels. Longlines may be hauled by hand or by powered reels or drums, while the baiting of hooks may be done manually or by a machine.

CHAPTER 2

ANALYSIS OF DATA BY AREA

© Claudia Amico

2.1. Black Sea

The first synoptic, collaborative and coordinated aerial survey of cetaceans in the Black Sea, carried out in the summer of 2019 under the umbrella of the ACCOBAMS Survey Initiative (ASI), within the framework of the CeNoBS project and through a collaboration with the EMBLAS-Plus projects, with support from the European Commission, yielded initial insights into the abundance, distribution and density of all three Black Sea cetacean subspecies, namely bottlenose dolphin (*Tursiops truncatus ponticus*), common dolphin (*Delphinus delphis ponticus*) and harbour porpoise (*Phocoena phocoena relicta*). The data revealed that Black Sea common dolphins were quite abundant in the southern part of the Black Sea, along transects off the coasts of Türkiye and Bulgaria and rather scarce in the northwestern part (i.e. Ukrainian and Romanian waters), while they were fairly abundant and evenly distributed in Russian Federation waters. Sightings of Black Sea bottlenose dolphins in the CeNoBS area (the territorial waters and exclusive economic zones of Romania, Bulgaria, Türkiye, Ukraine, Georgia and the Russian Federation) were least frequent compared to the other species, while they were the most observed species off the coast of the Russian Federation specifically. Black Sea harbour porpoises were the most observed cetacean species during the CeNoBS survey, with sightings peaking in Bulgarian waters. By contrast, they were the least observed cetacean species during the Russian survey (ACCOBAMS, 2021b).

It is known from Ukrainian and Georgian fishers that marine fishing activities can attract bottlenose and common dolphins, but perhaps not harbour porpoises. Both dolphin species may rely on fisheries as additional food sources and incorporate visits to fishing boats and stationary nets into their foraging strategies. Common dolphins reportedly interact predominantly with pelagic trawling operations targeting schooling fish and will often hunt in the immediate proximity of a hauling trawl. Bottlenose dolphins, by contrast, are interested in both active and passive fishing activities operating inshore. Reportedly, solitary individuals of this species were seen foraging within trap nets in the Kerch Strait and in trammel nets set near Cape Meganom, southeast Crimea. During the latter depredation events, the dolphin fed on red mullet (*Mullus barbatus*) caught in the net, leaving behind only the fish heads in the mesh (Birkun, 2002). Recently, during opportunistic on-board observations aboard a bottom trawler, depredation by both common and bottlenose dolphins was observed. Dolphins were predating on fish discards during trawl hauls and would occasionally bite the trawl (D. Popov, personal communication, 2022).

A study aimed at reviewing adverse fisheries impacts on cetacean populations in the Black Sea (Birkun *et al.*, 2014) interviewed leaders of 39 fishing associations, cooperatives and organizations representing over 4 600 fishers (>2 100 fishing vessels or boats) operating in the Black Sea and Azov Sea across the internal waters, territorial seas and exclusive economic zones of Bulgaria, Romania, Türkiye and Ukraine. The study reported that most leaders of fishing cooperatives and ordinary fishers from Ukraine, the Russian Federation, Bulgaria and Georgia did not voice strong dislike for cetaceans nor report serious rivalry with them. Coastal fishers from these countries had no concerns with common dolphins, but they expressed discontent over the incidental capture of harbour porpoises. Nevertheless, they identified bottlenose dolphins as the species often damaging their nets or catch or stealing caught fish from the nets. The same issue is known to occur along the Turkish and Bulgarian coasts. However, very limited data are available on such conflicts and ensuing financial losses, and, as in most Mediterranean countries, no compensation is stipulated for fishers from their governments. Fishers interviewed from Bulgaria claimed that losses in catch due to cetacean depredation in coastal pound nets total up to 100 tonnes of fish per season (Mikhailov, 2008). Between April 2007 and February 2008 in Sinop Bay, in the middle of the Turkish Black Sea coast, the average loss due to depredation by bottlenose dolphins calculated for red mullet fishing activities conducted using commercial bottom gillnets was TL 2 191.72 (approximately EUR 125) for each fishing boat throughout the season (Gönener and Özdemir, 2012). Moreover, a project testing acoustic deterrent devices (pingers) on the traditional Bulgarian static fishing gear known as "dalyan",[7] in an attempt to reduce small cetacean bycatch and depredation along the Bulgarian Black Sea coast, reported that severe damages were incurred, including metres of torn nets and loss of catch (Zaharieva, Spasova and Gavrilov, 2016). When interviewed, about 50 percent of Bulgarian fishers using dalyans unanimously confirmed that they had experienced dolphins entering them. Reportedly, cetaceans caused destruction and damage to fishing gear (e.g. holes torn in

[7] The "dalyan" is a stationary fish trap net used for passive commercial fishing. It is attached to both the seabed and the beach and located at about 150 m from the shore. Its size varies from 25–30 to 35–50 m. It is deployed at about 12 m depth, and the net usually reaches above the waterline with the trap open at the surface. The mesh size is 6 mm, and the main fish caught are pelagic species. It is used mainly in Bulgaria, Greece and Türkiye (Zaharieva *et al.*, 2020).

the nets) and reductions in fish capture both through direct consumption and by scaring fish away. All interviewed fishers noted that fish stocks had fallen sharply over the last 10 years, which may also help to explain why marine mammals prey in fishing gear. Furthermore, most of the fishers manifested strong concerns for their livelihoods, as they were not being compensated for the damages caused by cetaceans (Zaharieva *et al*., 2020).

2.2. Eastern Mediterranean

Interactions between bottlenose dolphins and bottom trawl fisheries are notable in Israel, and depredation occurs on a regular basis. It is estimated that the bottlenose dolphin population along the Israeli coastline consumes roughly 1 280 tonnes of prey annually, i.e. similar to the mean annual trawl-fishery yield of 1 300 tonnes (Scheinin *et al*., 2014). Moreover, fishers operating bottom trawlers claim that dolphins – probably bottlenose dolphins – cause severe damage to their gear, which has led them to begin securing an additional loose net with a large mesh size around the trawl, referred to as a "dolphinera" (A. Scheinin, personal communication, 2022). Furthermore, common dolphins, in addition to their association with purse seiners, have also been documented accompanying bottom trawlers by both day and night. Catch of slender bandtooth conger (*Ariosoma balearicum*), which is frequently found protruding from the nets, presumably offers easy prey for both dolphin species (Brand *et al*., 2021). Likewise, Kerem *et al*. (2012) reported that trawl boat skippers easily distinguish between the "regular" large, grey, stout-beaked dolphins (i.e. bottlenose dolphins) and the less frequently observed small, black or bicoloured and slender-beaked dolphins (a description that could easily apply to either striped or common dolphins when unable to distinguish between the two).

Depredation in gillnets also occurs frequently involving both bottlenose and common dolphins, and it is not uncommon that young animals become consequently caught in nets, probably while attempting to depredate (A. Scheinin, personal communication, 2022). As a case study, Levy and colleagues (2009) reported laryngeal snaring by an ingested fishing net in a dead female bottlenose dolphin found stranded off the Israeli shoreline. Although the circumstances by which the netting material was ingested cannot be confirmed, a feasible explanation is that it happened while the dolphin was wresting prey items from active fishing gear.

It seems that in Israel, limited culling (e.g. by shooting or harpooning) occurred as a consequence of retaliation measures taken by aggravated fishers in response to depredation. However, this information dates back a decade. More recently, fishers in Israel have begun to report and protest against depredation in fishing gear by dolphins, which potentially may result in retaliation (Bearzi, 2017).

A recent study conducted in Cyprus, aimed at understanding the extent, level and type of cetacean depredation on the albacore tuna (*Thunnus alalunga*) pelagic longline fishery through data obtained from fishers' logbooks, interviews and on-board observations between June and August 2018, revealed an estimated economic loss per fishing trip of EUR 313.07 ± 486.19 and an estimated annual economic loss for the entire fleet of EUR 259 272 from depredation caused by cetaceans (Papageorgiou *et al*., 2022). The study also estimated a mean depredation rate of 17 percent per fishing trip. As such, depredation by bottlenose dolphin and striped dolphin (*Stenella coeruleoalba*) was reported in more than 50 percent of the fishing trips and occasionally by Risso's dolphin (*Grampus griseus*).

Another study that combined questionnaires, acoustic monitoring and participatory experiments in Cyprus to examine interactions between bottlenose dolphins and fisheries and the extent of conflicts with set nets (i.e. trammel nets) found that dolphins were present in fishing grounds throughout the year and detected them in 28 percent of sets (Snape *et al*., 2018). Although no precise estimate was produced, the authors concluded that the damage to nets resulting from dolphin depredation can be very costly. As an example, they reported one set suffering a net loss of 79 percent of its area, damaging it beyond repair.

During interviews conducted to gather information for the preparation of the Action Plan for the conservation of cetaceans in the Syrian Arab Republic (Gonzalvo and Bearzi, 2008), fishers regularly reported gear damage and depredation by dolphins, consistently identifying bottlenose dolphins as the species involved and claimed greater net damage occurred when fishing targeted red mullet. Conversely, there were also claims that the catch may increase due to dolphins occasionally herding fish into the nets. In Lebanon, bottlenose dolphins were also

reported as the species regularly involved in gear damage and depredation (Gonzalvo, 2009). In addition, there have been reports of fishers using dynamite to deter dolphins from approaching their nets. However, although intentional killing of dolphins in retaliation may occur, it remains conjectural (Gonzalvo, 2009).

Anecdotal information on dolphin–fisheries interactions voluntarily provided by fishers during a survey monitoring damage to coastal fisheries caused by dolphins along Greece's northern Aegean Sea coastline allowed Pardalou and Tsikliras (2018) to identify bottlenose dolphins as the species primarily interacting with coastal fisheries, followed by common dolphins. All fishers maintained that dolphins mainly interact with passive gear, specifically static bottom nets (i.e. gillnets and trammel nets), damaging them by creating large holes and tears and spoiling and devaluating the catch (Pardalou and Tsikliras, 2018). Furthermore, in this case, nets targeting red mullet were reported as the most heavily depredated due to dolphin preference for the species. Indeed, follow-up studies by the same authors confirmed that the types of gear most heavily depredated were gillnets and trammel nets with small mesh sizes, mainly targeting red mullet, striped red mullet (*Mullus surmuletus*), common sole (*Solea solea*), European hake (*Merluccius merluccius*) and caramote prawn (*Melicertus kerathurus*) and that the probability of depredation was also significantly dependent on the fishing area (Pardalou and Tsikliras, 2020). They also proposed that fishers adapt their fishing tactics by opting for the use of more selective fishing gear for all target species and by not using mesh sizes smaller than 22 mm (bar length) as well as avoiding high net concentration areas by choosing deeper fishing grounds, in order to further ameliorate interactions with dolphins (Pardalou, Adamidou and Tsikliras, 2022).

Finally, in the Gulf of Corinth, Bonizzoni *et al.* (2016) reported a perceived annual economic loss as a result of dolphin depredation ranging from EUR 81 to 1 398 per boat. Their results suggested that depredation occurred primarily in the north, where bottlenose dolphins and fishing effort overlap, while in the southern ports, dolphin depredation was unlikely despite a high abundance of striped dolphins.

2.3. Adriatic Sea

The northern Adriatic Sea has been identified as an important marine mammal area (IMMA) because of the regular occurrence of bottlenose dolphins, who often follow midwater pair trawlers, bottom otter trawlers (Genov *et al.*, 2008, 2019; Fortuna *et al.*, 2010; Carlo *et al.*, 2012) and bottom-beam "rapido" trawlers (Bonizzoni, Furey and Bearzi, 2021; Bonizzoni *et al.*, 2022). Reportedly, the chance of encountering bottlenose dolphins increased by a factor of about 30 near active midwater pair trawlers, 16 near bottom otter trawlers, and five near bottom-beam "rapido" trawlers (Bonizzoni, Furey and Bearzi, 2021). Moreover, bottlenose dolphins have been observed in the area "switching" from one operating trawler to another, sometimes even approaching a different type of trawl gear (Bonizzoni *et al.*, 2022). The social structure of bottlenose dolphins in the Gulf of Trieste and adjacent waters of the northern Adriatic Sea is composed of two mixed-sex clusters or social units: one was found to be regularly interacting with trawlers and the other not (Genov *et al.*, 2019), showing how similar animal populations can interact differently with human activities (e.g. fisheries).

Gomerčić *et al.* (2009) reported the first record of bottlenose dolphin depredation resulting in larynx strangulation through ingestion of gillnet parts. The group investigated 12 bottlenose dolphin mortalities from the Adriatic Sea, where small-scale commercial and private fisheries use gillnets throughout the year. In Italy, depredation seems to represent a major issue in the northern and southern Adriatic Sea, corresponding to the Friuli and Puglia regions, where the set bottom trammel net is the most commonly used fishing gear to catch scorpion fish (*Scorpaena* spp.), octopus (*Octopus vulgaris*), cuttlefish (*Sepia officinalis*), mullet (*Mullus* spp.), wrasse (*Labrus* spp.) and bogue (*Boops boops*), with conflicts frequently occurring on a seasonal basis rather than year-round (Lauriano *et al.*, 2009). For instance, in the marine protected area (MPA) of Torre Guaceto, Puglia, fishers complain about operational conflicts with dolphins that lead to severe depredation and fishing gear damage. A pilot study conducted in 2020 that included interviews with fishers, monitoring of fishing net damage and surveys-at-sea confirmed that depredation by bottlenose dolphins in trammel nets causes significant loss to local fishers. A follow-up study is being organized at the moment to estimate the impacts of depredation on local small-scale fisheries (SSF) and provide training to MPA staff on surveys-at-sea and dolphin photo identification (J. Gonzalvo, personal communication, 2022).

2.4. Central Mediterranean

Bottlenose dolphins co-exist with artisanal fisheries in the Kerkennah Islands, off the eastern coast of Tunisia in the Gulf of Gabès and are blamed for damage to some fisheries. The resulting loss in catch has engendered hostility from fishers, and, as occurs elsewhere, fishing can result in bycatch mortality during interactions with dolphins. Aquamark 210 pingers, a type of acoustic deterrent device and a potential mitigation measure, were tested on trammel nets in 2010 over a short period, though results were inconclusive. According to Ayadi, Ghorbel and Bradai (2013), instead of deterring dolphins, the pingers possibly produced a "dinner bell" effect, which might explain the increase in observed depredation rates and fishery-targeted species damage.

Bottlenose dolphin depredation is also being monitored in Tunisian purse seines by Benmessaoud and colleagues (2021), who have observed an average frequency of 14 percent of fishing trips experiencing depredation. It is reported that depredation tends to occur mainly during fishing when electric lights are lit to attract fish, as well as during the encircling and pursing phases, producing mostly circular or oval holes along the entire length of the seine, though predominantly around the bunt and the lower bunt part. Catch per unit effort (CPUE) was generally found to be higher in the absence of depredation (for further details, Annex 1 on "Ongoing studies on marine mammal depredation in the Black Sea, Mediterranean Sea and contiguous Atlantic area". Hence, depredation causes considerable economic losses for purse seiners, mostly due to damage inflicted directly as fishing gear costs and indirectly as a consequence of days lost without fishing while fishers make required repairs or replacements to damaged fishing gear. Total mending costs linked to depredation are, on average, EUR 186 ± 154 per year. It is reported that the highest repair costs were incurred in April and November, while the lowest were in December (Benmessaoud *et al*., 2021).

In Malta, fishers engage in small-scale fishing, utilizing a variety of artisanal fishing gear types, including the following: surface longlines, mainly used to target swordfish (*Xiphias gladius*) and bluefin tuna (*Thunnus thynnus*); set longlines; trammel nets and entangling nets, used to target groupers (*Epinephelus* spp.), various species of bream (e.g. *Pagellus* spp., *Diplodus* spp.), red snappers (*Lutjanus* spp.) and red porgies (*Pagrus* spp.); and pots and traps, generally used to capture octopus and bogue. However, trammel nets continue to be the most popular gear type employed in Maltese waters. A recent study, focusing on fishers' perceptions of SSF–cetacean interactions, showed that around 33 percent of the fishing gear deployed over the previous year suffered damages, which cost an average of EUR 178.33 per year to each Maltese fisher for repairs and replacements and were caused exclusively by bottlenose dolphins (Laspina, Terribile and Said, 2022).

An overview of dolphin depredation in Italian artisanal fisheries by Lauriano *et al.* (2009), which included interviews with fishers from 49 Sicilian fishing ports, showed that 62.8 percent of Sicilian fishing boats reported damage in set gillnets and/or trammel nets, while 81.2 percent of fishers reported damage to catch. Furthermore, among the types of fishing gear liable to depredation, jigging lines used to catch mesopelagic squid, though of minor economic importance, are reported to interact with bottlenose dolphins in Sicily (G. Lauriano, unpublished data, 2022). Likewise, interactions between bottlenose dolphins and fishing activities in the Egadi Archipelago, part of an MPA off the northwestern coast of Sicily, are notable, with at least 38 percent of fish catch occurring with dolphins present in the vicinity of the nets (Buscaino *et al*., 2009). Moreover, in the Egadi Archipelago, the economic damage caused by fish loss due to bottlenose dolphin depredation in gillnets was found to be EUR 77.65 per 50 m of net (Maccarrone *et al.*, 2014).

A study examining instances of dolphins and whales interacting with SSF activities along the eastern coast of Sicily and in the southern Tyrrhenian Sea and the Aeolian Islands area showed that some individuals of striped dolphins and bottlenose dolphins in the Gulf of Catania presented injured peduncles[8] as evidence of surviving interactions with longlines (Monaco, 2020). In addition, 45 percent of the fishing trips monitored by the same research team over one year were affected by negative interactions with cetaceans (bottlenose dolphin being the species involved in the observed encounters). One case was also recorded of a sperm whale (*Physeter macrocephalus*) interacting with a "totanara", which is used to catch cuttlefish and squid (e.g. *Loligo* spp., *Illex* spp., *Todaropsis* spp.). Indeed, depredation events took place in every area of the Gulf of Catania where fishing activities occurred, with the most affected gear being netting of the

[8] The dolphin's peduncle is a very muscular part of the body found in the tail section, located between the dorsal fin and the flukes.

single wall type. The average daily loss for the entire fleet was calculated as EUR 444, excluding the costs associated with purchasing new materials to repair the gear (Monaco, 2020; for more details, see Annex 1 on "Ongoing studies on marine mammal depredation in the Black Sea, Mediterranean Sea and contiguous Atlantic area").

In the Porto Cesareo MPA in the Gulf of Taranto, southern Italy, Bearzi, Bonizzoni and Gonzalvo (2011) investigated dolphin occurrences and interactions with fisheries by conducting boat surveys and interviews. Depredation was reported by 92 percent of the fishers operating in or near the MPA, and 67 percent of them claimed an economic loss of over EUR 1 000 per year, with a mean reported cost of EUR 2 561. However, contrary to the significant depredation reportedly suffered, more than 1 000 km of visual surveys reported no encounters with cetaceans (Bearzi, Bonizzoni and Gonzalvo, 2011). Moreover, a comparative analysis carried out in the wider Gulf of Taranto showed that fishing exploitation has greater impacts on the investigated food web than does cetacean predation (Carlucci *et al.*, 2021).

In coastal waters of western Greece, in the semi-enclosed Gulf of Ambracia, bottlenose dolphin is the only cetacean present. This increasingly degraded coastal ecosystem hosts one of the highest observed densities in the Mediterranean Sea of this species, which shows high levels of year-round site fidelity (Bearzi *et al.*, 2008a; Gonzalvo *et al.*, 2016). The bottlenose dolphin subpopulation in the Gulf of Ambracia is classified as critically endangered in the IUCN Red List of Threatened Species, while local commercial fisheries are limited to about 300 small-scale artisanal vessels, working mainly with trammel nets and gillnets (Gonzalvo *et al.*, 2016). In stark contrast to the Gulf of Ambracia, the oligotrophic and heavily overfished waters of the neighbouring Inner Ionian Sea Archipelago host a much lower dolphin density (Gonzalvo *et al.*, 2011). In recent times, formerly abundant common dolphins in the area have suffered a precipitous decline, which has been convincingly linked to overfishing of their main epipelagic prey. Meanwhile, bottlenose dolphins, also present in the area, are mostly transient, with only a few individuals displaying high levels of residency (Bearzi *et al.*, 2008b; Piroddi *et al.*, 2011). Therefore, these areas, despite their geographic proximity, are remarkably different in terms of their environmental features, human activities and dolphin species composition and densities. Nevertheless, according to information gathered through formal interviews with professional small-scale fishers (Gonzalvo *et al.*, 2016), damage as a consequence of dolphin predation was almost unanimously reported from both sites. Consequently, there seems to be a genuine interest in future collaborative research initiatives in order to evaluate the damage caused by dolphins and to explore potential mitigation strategies among the fishing community. Dolphins were reported as damaging fishing gear when stealing fish, as well as damaging fish entangled in nets and scaring them away from nets. While most fishers in the Gulf of Ambracia claimed to suffer significant annual economic losses, almost one out of every four fishers from the Inner Ionian Sea Archipelago reported no damage to nets. In both areas, the cost of damages most frequently reported ranged between EUR 500 and EUR 1 000 per year. Details on the ongoing project "Addressing the interaction between small-scale fisheries and marine megafauna in Greece (InCa)", conducted by WWF Greece, which aims to estimate the economic losses incurred by small-scale fishers due to interactions with marine mammals, as well as the rates of incidental catch of marine mammals, seabirds, marine reptiles and elasmobranchs, can be found in in Annex 1 on "Ongoing studies on marine mammal depredation in the Black Sea, Mediterranean Sea and contiguous Atlantic area".

2.5. Western Mediterranean

The western Mediterranean is the area in which the most research has been conducted on cetacean depredation. On its eastern side, a study carried out in Italy during 2002, based on in situ interviews with fishers, aimed at determining the extent of interactions between dolphins and artisanal fisheries, evaluating the effects of such interactions on both fishing gear and catch, and deriving a regional depredation ranking table. The results showed that in Italy, 72.2 percent of fishing boats reported fish damage in trammel nets and gillnets directly linked with dolphin sightings (Lauriano *et al.*, 2009). The regions most affected were Sardinia and Campania, with fleets reporting net damage frequencies of 75.8 percent and 83.1 percent, respectively. Moreover, damage to catch was always recorded when dolphins were sighted. According to Lauriano *et al.* (2009), the interaction rankings (i.e. risk of cetacean interactions) for the Italian regions of the western Mediterranean area are in the following descending order: Campania (7), Sardinia (7), Sicily (6), Tuscany (6), Liguria (4), Calabria (3) and Lazio (2).

In the Aeolian Archipelago off southern Italy, ecosystem degradation and overfishing have led to increasing reports of bottlenose dolphins and striped dolphins in conflict with fishers (Bruno *et al.*, 2021). According to Blasi, Giuliani and Boitani (2015), bottlenose dolphin encounter rates in the area are significantly higher in early summer, coinciding with the period of highest trammel net abundance and of dolphin residency times spatially correlating with the mean number of trammel nets, indicating strong dolphin–SSF interactions. Moreover, Leone *et al.* (2019) used photo identification data from 2005–2014 of resident bottlenose dolphins to show that the skin mark patterns of the Aeolian population are strongly related not only to age and sex, but also to the degree of interaction with trammel nets.

In 1999, the Italian Central Institute for Applied Marine Research (ICRAM), in response to reports made by local fisheries, conducted a study on interactions between bottlenose dolphins and the artisanal fishery in the Asinara Island National Park in Sardinia. Lauriano *et al.* (2004) established that interactions occurred primarily with trammel nets targeting striped red mullet. Although considered negligible, cetacean interactions also occurred with trammel nets set for common spiny lobster (Palinurus elephas), common cuttlefish and scorpionfish (*Scorpaena* spp.). Loss of catch was found to be significant only in the case of nets deployed during the striped red mullet fishing season; the annual mean economic loss per boat each season was estimated at EUR 1 100 (Lauriano *et al.*, 2004). It has likewise been suggested that bottlenose dolphins in this area take advantage of the presence of trawlers (Lauriano, 1997). To evaluate the veracity of this hypothesis, an initial attempt at analysing interactions between bottlenose dolphins and gillnets along the northeastern coast of Sardinia, Italy was conducted between October 1999 and December 2004. Another study along the coast of northeastern Sardinia, which combined interviews of fishers with boat-based direct observations and behavioural and group size analysis of the dolphins, established that gillnet damage was caused by bottlenose dolphins on 68.7 percent of total fishing days, with no difference observed between seasons and a worrisome annual bottlenose dolphin bycatch estimate of 1.47 (0.98 immatures and 0.49 adults; Díaz-López, 2006). Bottlenose dolphin interactions with artisanal trammel nets were also examined by Pennino *et al.* (2015) in waters of the Maddalena Archipelago, located to the northeast of Sardinia, where the CPUE for fishing operations with no dolphin interactions was found to be significantly higher than for operations with dolphin interactions. Nevertheless, these data do not clearly confirm a direct causal link, while the associated economic losses were estimated to be insignificant. In addition, it was observed that geographic location, season, depth of seabed, moon phase and mesh size were all important factors affecting the amount and species composition of the catch, suggesting that these differences in species composition were not due exclusively to dolphin depredation, but also to a mixture of habitat-induced effects (Pennino *et al.*, 2015).

Observations of coastal dolphins using fishing nets as an easily accessible feeding source and either damaging or depredating fish caught in artisanal trammel nets has been also reported in the Bonifacio Strait Natural Reserve, between Corsica and Sardinia, where bottlenose dolphin foraging impacted, on average, 12.4 percent of the nets and damaged 8.3 percent of the catch (Rocklin *et al.*, 2009). Results suggest that dolphins are attracted by high fish densities in the fishing area or nets and that their feeding induces specific fish avoidance behaviour, according to the position of the fish in the water column. According to Rocklin and colleagues (2009), although dolphins may depredate only a small part of the catch, the damage they cause to nets may compromise the benefits that the reserve provides to local artisanal fisheries.

In the Balearic Islands, interactions between artisanal fisheries and the local bottlenose dolphin population have been reported for decades. However, the frequency of interactions officially reported in terms of fish loss, net damage and bycatch has increased dramatically over the last two decades (Brotons, Grau and Rendell, 2008). In a study conducted in 2001 in Alcudia Bay, northeastern Majorca, bottlenose dolphin depredation was reported from trammel nets targeting red mullet that resulted in net damage, reductions in the value of catch due to mutilation or removal of fish from nets and a decline in the total amount of fish caught, probably caused by the dolphins' presence forcing fish to flee from the vicinity of the fishing nets (Gazo, Gonzalvo and Aguilar, 2008). The economic cost attributed to loss of catch as a result of dolphin depredation was estimated at about EUR 1 100 per year, although a more realistic figure would be significantly higher if the damage to nets was incorporated into the calculation (Gazo, Gonzalvo and Aguilar, 2008). A later study, covering the complete Balearic Archipelago and all types of fishing gear, included both fish loss and net damage in an estimate of the economic cost that these interactions with dolphins represent, totalling 6.5 percent (95 percent confidence interval: 1.6–12.3 percent) of the value of landed catch (Brotons, Grau and Rendell, 2008). In the Balearic Islands,

beyond interacting with set nets, bottlenose dolphins approach operating trawlers during towing, hauling and discarding, while only a fraction of the group approach the trawlers once the net is hauled in or during the release of discarded fish, indicating that different dolphins from the same group may differ in the resources they use (Gonzalvo *et al.*, 2008). Indeed, bottlenose dolphins and the local trawling fleet may be seen as behaving as two sympatric species[9], whereby dolphins play a parasitic role on the fishing activity; Gonzalvo *et al.* (2008) concluded that depth represented the main factor influencing this interaction. Moreover, no incidental capture was recorded during this study. Hence, the only negative impact of trawling on the bottlenose dolphin population off the Balearic Archipelago appears to be the alteration of the sea bottom and the reduction in food availability caused by overexploitation, which is a general issue throughout the Mediterranean (Bearzi, 2002).

A study of bycatch of marine mammals in the Spanish longline fleet operating in the western Mediterranean was conducted by the Spanish Oceanographic Institute (Instituto Español de Oceanografía), aiming to improve knowledge of the fleet's possible effects on cetacean populations, particularly Risso's dolphin. The investigation concluded that Risso's dolphin is the cetacean most affected by the longline fishery (López *et al.*, 2012), which may indicate significant depredation by this odontocete on longlines.

In the Strait of Gibraltar, where killer whales (*Orcinus orca*) feed on tuna through active hunting and depredation in dropline fisheries, recent changes in fishing effort have reduced tuna stocks and the delicate balance between the bluefin tuna, killer whales and human activities has been broken (Esteban *et al.*, 2016). Between 1999 and 2011, during observations of a small killer whale community of 39 individuals in the Strait of Gibraltar in spring and summer, it was noted that all individuals displayed active hunting while 18 of them also depredated the fishery. In addition, Esteban and colleagues (2016) established that the killer whale population growth rate was positive, at 4 percent for those individuals interacting with the fishery and with no growth observed for non-interacting individuals, implying that whales benefit from access to larger tuna through depredation and therefore require more tuna to meet their daily energy requirements while actively hunting.

2.6. Contiguous Atlantic area

To the west of the Strait of Gibraltar, the contiguous Atlantic area, i.e. the coastal waters off the western Iberian Peninsula, hosts an important fishing ground, in addition to being a major marine megafaunal foraging area. Hence, overlaps between fishery target species and the diet of several air-breathing marine megafauna, including marine mammal species, can lead to negative interactions and consequent conservation and economic issues (Alexandre *et al.*, 2022). A recent study, involving face-to-face interviews with fishers from local and coastal artisanal fishing fleets in the landing sites along the Portuguese southern coast of Algarve was conducted by Alexandre *et al.* (2022) with the main goal of identifying and evaluating problematic interactions causing bycatch or economic loss through depredation. The latter problems were mostly associated with cetaceans. The investigation showed that purse seining is associated with significant bycatch numbers, especially of common dolphins, while bottom set nets resulted in considerable bycatch of all animal groups, with depredation closely linked to bottlenose dolphins. In addition, it is reported that depredation led to catch and gear damage and was widely denounced by bottom set net fishers, with related economic losses ranging from 7 percent to 21 percent of their revenue. Moreover, interactions with bottlenose dolphins showed a significant geographical bias, with higher depredation rates reported by fishers from the leeward area.

Interactions between cetaceans and the purse seine fishery in the coastal waters of mainland Portugal were investigated via on-board observations over a period of 15 years (2003–2018) by Dias *et al.* (2022). The findings revealed that in 10 percent of fishing sets, there were interactions with one of three species of cetaceans, namely common dolphin, bottlenose dolphin and harbour porpoise. The data indicated that common dolphin was most frequently observed, occurring in 89 percent of all interaction events, and was the only species with observed mortality cases, which prompted the investigation to turn its focus on exclusively interactions with this species. In this study covering all Portuguese coastal waters, Dias *et al.* (2022) suggest that the probability of interactions and the number of common dolphins interacting with the fishery were affected by the local abundance of sardine

[9] Two related species or populations are considered sympatric when they exist in the same geographic area and thus frequently encounter one another.

(*Sardina pilchardus*) and chub mackerel (*Scomber colias*). However, when examining the frequency of presence and interactions of cetaceans with the purse seine fishery and ensuing incidental capture and mortality in relation to the total number of trips and fishing sets by region, the following data are extracted for southern Portugal: from 147 fishing trips (161 sets), 19 percent reported cetaceans present; in 12 percent direct interactions were recorded, and in 1.9 percent, incidental captures occurred, leading to 1.2 percent of cetacean mortality.

CHAPTER 3

DEPREDATION IN FISHING GEAR BY THE MEDITERRANEAN MONK SEAL

Mediterranean monk seals (*Monachus monachus*) were once widely and continuously distributed across the Mediterranean and the Black Sea and in North Atlantic waters from Morocco to Mauritania, including around the Cape Verde and Canary Islands, Madeira and the Azores (Johnson *et al.*, 2006). Today, fewer than 700 individuals are thought to survive in isolated subpopulations in the eastern Mediterranean, the archipelago of Madeira and the Cabo Blanco area in the Northeast Atlantic Ocean (Karamanlidis *et al.*, 2015). The largest aggregations of Mediterranean monk seals are found near Cabo Blanco (González and Fernandez de Larrinoa, 2012; Martínez-Jauregui *et al.*, 2012). Principal sites in the Mediterranean are located in the Ionian Sea and the Aegean Sea, including the National Marine Park of Alonissos (Trivourea *et al.*, 2011) and the Gyaros Marine Protected Area (Dendrinos *et al.*, 2008), both in Greece. This flagship species for marine conservation has teetered on the brink of extinction for about half a century (Notarbartolo di Sciara and Kotomatas, 2016). After having been classified as critically endangered for almost two decades, the status of *M. monachus* was reassessed as endangered on the IUCN Red List (Karamanlidis and Dendrinos, 2015).

The diet of the Mediterranean monk seals consists largely of demersal fishes, cephalopods (with the common octopus [*Octopus vulgaris*] being the most frequent prey item) and crustaceans (Kiraç and Ok, 2019; Salman, Bilecenoglu and Güçlüsoy, 2001; Pinela *et al.*, 2010; Pierce *et al.*, 2011; Karamanlidis *et al.*, 2014). Body parts of green turtles (*Chelonia mydas*) were also found in the stomach of an adult seal stranded in Türkiye (Tonay *et al.*, 2016). To gain access to such a varied diet, Mediterranean monk seals interact frequently with small-scale fisheries. When depredation occurs, monk seals leave behind a characteristic three-hole pattern, with one large hole (usually smaller than that made by dolphins) and two smaller peripheral holes that presumably correspond to where the flippers grasped at the net (Karavellas, 1994).

The main threats faced by Mediterranean monk seals include critical habitat deterioration, destruction and fragmentation, disturbances caused by tourists entering breeding caves during the reproductive season and other seal–boat interactions, fishers retaliating against depredation and net damages, and bycatch in fishing gear, mainly of young inexperienced individuals (Karamanlidis and Dendrinos, 2015; Notarbartolo di Sciara and Kotomatas, 2016; Androukaki *et al.*, 1999; Güçlüsoy *et al.*, 2004; Karamanlidis *et al.*, 2008, 2020; Mpougas *et al.*, 2019).

Between 1994 and 2002, in the Foça Pilot Monk Seal Conservation Area, an archipelago situated at the entrance of Izmir Bay on the central Aegean coast of Türkiye, Güçlüsoy (2008) gathered information on 142 direct interactions with monk seals near fishing gear through interviews with fishers and direct net inspections. Net damage was recorded in 90 of those cases, concentrated primarily in gillnets (53 percent) and trammel nets (37 percent), followed, to a much lesser extent, by longlines (9 percent) and lures (1 percent). Although the damage inflicted by seals per event could be substantial – for example, as much as EUR 465.85 – the overall annual economic impact on the artisanal fishery was considered modest. Güçlüsoy (2008) suggested limits on net soaking times, concentrating on fishing effort with longlines instead of with nets, and low interest credits for fishers affected by seal depredation as appropriate management practices. Mediterranean monk seals also depredate on fish in marine fish farms (Güçlüsoy and Savas, 2003). It is reported that these interactions occur at night, typically involving single seals causing damage to both cage netting and fish, and on most occasions result in fish escaping from the cages.

A study conducted in the Ionian islands of Kefalonia, Ithaca and Lefkada, Greece from July 1986 to April 1988 reported damage by seals to fishing gear in 136 of 1 864 (7.3 percent) monitored fishing trips and claimed that even one seal may cause considerable damage in one night (Panou, Jacobs and Panos, 1993). A series of interviews with fishers conducted over a decade later in the same area by Gonzalvo, Giovos and Moutopolos (2014) showed that, when asked about the species causing damage to net through depredation, 85 percent of fishers put the Mediterranean monk seal at the top of their list, followed to a much lesser extent by the Mediterranean moray (*Muraena helena*), dolphins and sea turtles. Similarly, in Greek waters of the northern Aegean Sea, Pardalou and Tsikliras (2018) found that depredation by monk seals in static nets, as well as longlines, was reported as a frequent and disturbing event by fishers operating in areas of higher seal density (outer Thermaikos Gulf, Chalkidiki and Alonissos Island). A more recent nationwide survey relying on questionnaires distributed among fishers and port police authorities was carried out in Greece to understand the nature, and assess the magnitude, of negative interactions between monk seals and small-scale fisheries. The survey revealed that Mediterranean monk seals caused damage mainly during the spring and summer, affecting on average 21 percent of all fishing trips and 1 percent of nets deployed during a fishing trip, and were accidentally entangled in fishing gear throughout Greece (Karamanlidis *et al.*, 2020).

Final considerations

The sustainable mitigation of human–wildlife conflicts has become a major societal and environmental challenge globally. Among these conflicts, large marine predators feeding on fisheries catch (i.e. through depredation) has grown more frequent concomitantly with the expansion of the world's fisheries (Tixier *et al.*, 2021). A recent global review of marine mammal interaction studies showed that marine mammal bycatch remains a major conservation concern, the focus of 187 studies, followed by marine mammal depredation in fishing gear, the focus of 56 studies (Jog *et al.*, 2022).

As the present review shows, depredation offers short-term benefits for marine mammals, as it creates new foraging opportunities directly facilitated by fishing operations. When examining marine mammal depredation in fisheries, it is not rare to observe a relatively high disparity between reported and actual depredation levels, particularly for small-scale fisheries (SSF) (Bearzi, Bonizzoni and Gonzalvo, 2011; Gonzalvo, Giovos and Moutopoulos, 2014; Jog *et al.*, 2022), which may lead to an overestimation of the economic damage due to depredation. Indeed, unsustainable fishing has contributed to dramatic ecological changes in the Mediterranean Sea (Sala, 2004; Coll *et al.*, 2010), and with SSF becoming increasingly economically marginal, even relatively small losses due to dolphin depredation can have a disproportionately large impact on a fisher livelihoods. Consequently, this economic distress may prompt fishers to complain more about depredation by marine mammals and to increasingly perceive these animals as competitors (Reeves, Read and Notarbartolo, 2001). Moreover, several factors other than depredation may cause gear damage and catch loss – for example, depredation by fish or other invertebrate species or marine debris (Gazo, Gonzalvo and Aguilar, 2008; Lauriano *et al.*, 2009).

The work on marine mammal depredation reviewed in this report varies in terms of methodologies used, but most projects include, to some extent, the following features: interviews with fishers, direct observations on board vessels, fishing gear damage monitoring (both on board and at landing sites), fish capture monitoring, local marine mammal population monitoring through surveys-at-sea (e.g. line transects) and photo identification. Some studies also incorporate the use of new technologies, such as passive acoustic monitoring and underwater cameras and drones for behaviour assessment of the species involved in depredation. In addition, stranding networks provide a valuable source of information on both depredation and bycatch through forensic analysis of stranded marine mammals. However, the lack of uniformity in the approaches implemented in many of these studies makes it difficult to compare their results and findings. In this regard, a recent publication by Carpentieri and Gonzalvo (2022), prepared under the auspices of the GFCM and ACCOBAMS, proposes a protocol for data collection on dolphin depredation with the aim of lending support to regional monitoring programmes and providing a framework for the development and implementation of an efficient, standardized data collection and monitoring system for depredation events.

Human behaviour and socioeconomics play a key role in marine mammal–fisheries interactions (Jog *et al.*, 2022) and, more specifically, in depredation. Taking these two factors into consideration will be key to shifting from a purely data collection-based and in situ analysis of the conflict to a management context and crucial to setting marine mammal conservation priorities, as well as safeguarding the viability and livelihoods of the fishing communities affected. The latter effort is particularly relevant for SSF, as this sector is more broadly affected by depredation and typically supports larger numbers of fishers compared to more industrialized fisheries (Jacquet and Pauly, 2008), and the economic impacts of depredation are felt at the level of single individuals and families.

The impacts of depredation on fishers are primarily associated with catch losses and gear damage, but they often lack accurate assessments. In many of the studies reviewed here, deterrence methods were also tested, to various degrees of effectiveness. Conflicts frequently occur on a seasonal basis rather than all year round. This aspect must be also considered when envisioning possible mitigation strategies, which may need to be implemented during a specific season rather than throughout the year. The active participation of fishers is essential when dealing with depredation, because this relationship not only provides improved localized knowledge on interactions between local fisheries and marine mammals, but also enables specific management and mitigation strategies to be defined in agreement with key stakeholders.

References

ACCOBAMS. 2021a. *Conserving whales, dolphins and porpoises in the Mediterranean Sea, Black Sea and adjacent areas: an ACCOBAMS status report (2021).* G. Notarbartolo di Sciara & A.M. Tonay, eds. Monaco. https://accobams.org/wp-content/uploads/2022/03/ACCOBAMS_ConservingWDP_web_2022.pdf

ACCOBAMS. 2021b. *Estimates of abundance and distribution of cetaceans in the Black Sea from 2019 surveys*. R.M. Paiu, S. Panigada, A. Cañadas, P. Gol'din, D. Popov, L. David, A. Amaha Ozturk & D. Glazov, eds. ACCOBAMS – ACCOBAMS Survey Initiative/CeNoBS Projects. Monaco. https://accobams.org/wp-content/uploads/2021/04/ASI_CeNoBS-Black-Sea-report.pdf

Alexandre, S., Marçalo, A., Marques, T.A., Pires, A., Rangel, M., Ressurreiçao, A., Monteiro, P., Erzini, K. & Gonçalves, J.M.S. 2022. Interactions between air-breathing marine megafauna and artisanal fisheries in Southern Iberian Atlantic waters: Results from an interview survey to fishers. *Fisheries Research*, 254.

Allen, S. 2014. From exploitation to adoration: The historical and contemporary contexts of human–cetacean interactions. In: J. Higham & R. Williams, eds. *Whale-watching: Sustainable tourism and ecological management*, pp. 31–47. Cambridge, UK, Cambridge University Press.

Androukaki, E., Adamantopoulou, S., Dendrinos, P., Tounta, E. & Kotomatas, S. 1999. Causes of mortality in the Mediterranean Monk Seal (*Monachus monachus*) in Greece. *Contributions to the Zoogeography and Ecology of the Eastern Mediterranean Region*, 1: 405–411.

Ayadi, A., Ghorbel, M. & Bradai, M.N. 2013. Do pingers reduce interactions between bottlenose dolphins and trammel nets around the Kerkennah Islands (Central Mediterranean Sea)? *Cahiers de Biologie Marine*, 54(3): 375–383.

Bearzi, G. 2002. Interactions between cetaceans and fisheries: Mediterranean Sea. In: G.N. di Sciara, ed. *Cetaceans in the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies*, pp. 78–97. Monaco, ACCOBAMS.

Bearzi, G. 2017. *Action Plan for Marine Mammals in Israel, 2017–2022*. Israel, Israel Marine Mammal Research & Assistance Center (IMMRAC).

Bearzi, G. & Reeves, R.R. 2022. Marine mammals foraging around fishing gear or preying upon fishing catch and bait: it may not be "depredation". *ICES Journal of Marine Science*, 79(8): 2178–2183.

Bearzi, G., Bonizzoni, S. & Gonzalvo, J. 2011. Dolphins and coastal fisheries within a marine protected area: Mismatch between dolphin occurrence and reported depredation. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 21(3): 261–267.

Bearzi, G., Genov, T., Natoli, A., Gonzalvo, J. & Pierce, G.J. 2022. *Delphinus delphis* (Inner Mediterranean subpopulation) (errata version published in 2022). The IUCN Red List of Threatened Species 2022: e.T189865869A210844387. Accessed on 21 March 2023.

Bearzi, G., Piwetz, S. & Reeves, R.R. 2019. Odontocete adaptations to human impact and vice versa. In: B. Würsig, ed. *Ethology and Behavioral Ecology of Odontocetes*, pp. 211–235. Cham, Switzerland, Springer Nature.

Bearzi, G., Agazzi, S., Bonizzoni, S., Costa, M. & Azzellino, A. 2008a. Dolphins in a bottle: Abundance, residency patterns and conservation of common bottlenose dolphins *Tursiops truncatus* in the semi-closed eutrophic Amvrakikos Gulf, Greece. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 18: 130–146.

Bearzi, G., Agazzi, S., Gonzalvo, J., Costa, M., Bonizzoni, S., Politi, E., Piroddi, C. & Reeves, R. 2008b. Overfishing and the disappearance of short-beaked common dolphins from western Greece. *Endangered Species Research*, 5: 1–12.

Benmessaoud, R., Cherif, M., Jaziri, S., Koched, W. & Zaara, K. 2018. Mitigation of interaction of bottlenose dolphin "*Tursiops truncatus*" and purse seiners in Kelibia (Tunisia). Side Event on Fisheries Science in the Mediterranean and the Black Sea at the General Fisheries Commission for the Mediterranean Fish Forum 2018: Fisheries Science in the Mediterranean and Black Sea, 10–14 December 2018. Rome, FAO.

Benmessaoud, R., Cherif, M., Koched, W., Chakroun, A., Benabdelhamid, S., Jaziri, S., Zaara, K. & Ben Moumen, Y. 2021. *Vers des solutions aux interactions entre communautés de pêcheurs et cétacés dans les eaux tunisiennes*. ACCOBAMS mid-term report No. 05/2019. Monaco.

Birkun, A., Jr. 2012. *Tursiops truncatus ssp. ponticus*. The IUCN Red List of Threatened Species 2012: e.T133714A17771698. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T133714A17771698.en

Birkun, A., Jr. 2002. Interactions between cetaceans and fisheries in the Black Sea. In: G. Notarbartolo di Sciara, ed. *Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies*, pp. 10.1–10.11. Monaco, ACCOBAMS.

Birkun, A., Jr. 2008. *Delphinus delphis ssp. ponticus*. The IUCN Red List of Threatened Species 2008: e.T133729A3875256.Cited21March2023.https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T133729A3875256.en

Birkun A., Jr. & Frantzis, A. 2008. *Phocoena phocoena ssp. relicta*. The IUCN Red List of Threatened Species 2008: e.T17030A6737111. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T17030A6737111.en

Birkun, A., Jr, Northridge, S.P., Willsteed, E.A., James, F.A., Kilgour, C., Lander, M. & Fitzgerald, G.D. 2014. *Studies for Carrying Out the Common Fisheries Policy: Adverse Fisheries Impacts on Cetacean Populations in the Black Sea*. MacAlister Elliot & Partners, Ltd. Final report to the European Commission, Brussels.

Blasi, M.F., Giuliani, A. & Boitani, L. 2015. Influence of trammel nets on the behaviour and spatial distribution of bottlenose dolphins (*Tursiops truncatus*) in the Aeolian Archipelago, Southern Italy. *Aquatic Mammals*, 41(3): 295–310.

Bonizzoni, S., Furey, N.B. & Bearzi, G. 2021. Bottlenose dolphins (*Tursiops truncatus*) in the north-western Adriatic Sea: Spatial distribution and effects of trawling. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 31: 635–650.

Bonizzoni, S., Hamilton, S., Reeves, R.R., Genov, T. & Bearzi, G. 2022. Odontocete cetaceans foraging behind trawlers, worldwide. *Reviews in Fish Biology and Fisheries*, 3: 827–877.

Bonizzoni, S., Bearzi, G., Santostasi, N.L., Furey, N.B., Valavanis, V.D. & Würsig, B. 2016. Dolphin depredation of bottom-set fishing nets in the Gulf of Corinth, Mediterranean Sea. In: L. Freitas & C. Ribeiro, eds. *Into the deep: Research and conservation on oceanic marine mammals*. Paper presented at the Thirtieth Annual Conference of the European Cetacean Society, Madeira, Portugal.

Brand, D., Edelist, D., Goffman, O., Hadar, N., Scheinin, A. & Kerem, D. 2021. Common dolphins, common in neritic waters off southern Israel, demonstrate uncommon dietary habits. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 31: 15–21.

Braulik, G., Minton, G., Amano, M. & Bjørge, A. 2020. *Phocoena phocoena*. The IUCN Red List of Threatened Species 2020: e.T17027A50369903. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T17027A50369903.en

Brotons, J.M., Grau, A.M. & Rendell, L. 2008. Estimating the impact of interactions between bottlenose dolphins and artisanal fisheries around the Balearic Islands. *Marine Mammal Science*, 24(1): 112–127.

Brotons, J., Munilla, Z., Grau, A. & Rendell, L. 2008. Do pingers reduce interactions between bottlenose dolphins and nets around the Balearic Islands? *Endangered Species Research*, 5: 301–308.

Bruno, C.A., Caserta, V., Salzeri, P., Bonanno Ferraro, G., Pecoraro, F., Lucchetti, A., Boitani, L. & Blasi, M.F. 2021. Acoustic deterrent devices as mitigation tool to prevent dolphin–fishery interactions in the Aeolian Archipelago (Southern Tyrrhenian Sea, Italy). *Mediterranean Marine Science*, 22(2): 408–421.

Buscaino, G., Buffa, G., Sarà, G., Bellante, A., Tonello, A.J., Hardt, F.A.S., Cremer, M.J. *et al.* 2009. Pinger affects fish catch efficiency and damage to bottom gillnets related to bottlenose dolphins. *Fisheries Science*, 75(3): 537–544.

Cañadas, A. & Notarbartolo di Sciara, G. 2018. *Ziphius cavirostris* (Mediterranean subpopulation) (errata version published in 2021). The IUCN Red List of Threatened Species 2018: e.T16381144A199549199. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T16381144A199549199.en.

Carlo, F.D., Virgili, M., Luchetti, A. & Fortuna, C.A. 2012. Interactions between bottlenose dolphin and midwater pair trawls: Effect of pingers on dolphin behaviour. *Biologia Marina Mediterranea*, 1: 206–207.

Carlucci, R., Capezzuto, F., Cipriano, G., D'Onghia, G., Fanizza, C., Libralato, S., Maglietta, R. *et al.* 2021. Assessment of cetacean–fishery interactions in the marine food web of the Gulf of Taranto (Northern Ionian Sea, Central Mediterranean Sea). *Reviews in Fish Biology and Fisheries*, 31: 135–156.

Carpentieri, P. & Gonzalvo, J. 2022. *Dolphin depredation in Mediterranean and Black Sea fisheries: Methodology for data collection*. FAO Fisheries and Aquaculture Technical Paper No. 688. Rome, FAO. https://www.fao.org/3/cc2943en/cc2943en.pdf

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Lasram, F.B.R., Aguzzi, J., Ballesteros, E. *et al.* 2010. The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats. *PLoS One*, 5.

Dendrinos, P., Karamanlidis, A.A., Kotomatas, S., Paravas, V. & Adamantopoulou, S. 2008. Report of a new Mediterranean monk seal (*Monachus monachus*) breeding colony in the Aegean Sea, Greece. *Aquatic Mammals*, 34: 355–361.

Dias, I.C., Marçalo, A., Feijó, D., Domingos, I. & Silva, A.A. 2022. Interactions between the common dolphin, *Delphinus delphis*, and the Portuguese purse seine fishery over a period of 15 years (2003–2018). *Aquatic Conservation: Marine and Freshwater Ecosystems*, 32(8): 1351–1364.

Díaz-López, B. 2006. Interactions between Mediterranean bottlenose dolphins (*Tursiops truncatus*) and gillnets off Sardinia, Italy. *ICES Journal of Marine Science*, 63(5): 946–951.

Esteban, R. & Foote, A. 2019. *Orcinus orca* (Strait of Gibraltar subpopulation). The IUCN Red List of Threatened Species 2019: e.T132948040A132949669. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T132948040A132949669.en

Esteban, R., Verborgh, P., Gauffier, P., Giménez, J., Guinet, C. & Stephanis, R. 2016. Dynamics of killer whale, bluefin tuna and human fisheries in the Strait of Gibraltar. *Biological Conservation*, 194: 31–38.

FAO. 2019. *Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection*. FAO Fisheries and Aquaculture Technical Paper No. 640. Rome. https://www.fao.org/3/ca4991en/ca4991en.pdf

FAO. 2023a. *Fishing Gear Type. Bottom trawls. Technology Fact Sheets*. Fisheries and Aquaculture Division. Rome. Cited 5 March 2023. https://www.fao.org/fishery/en/geartype/205?lang=en

FAO. 2023b. *Fishing Gear Type. Midwater trawls (nei). Technology Fact Sheets*. Fisheries and Aquaculture Division. Rome. Cited 5 March 2023. https://www.fao.org/fishery/en/geartype/400/en

FAO. 2023c. *Fishing Gear Type. Purse seines. Technology Fact Sheets*. Fisheries and Aquaculture Division. Rome. Cited 5 March 2023. https://www.fao.org/fishery/en/geartype/249/en

FAO. 2023d. *Fishing Gear Type. Trammel nets. Technology Fact Sheets*. Fisheries and Aquaculture Division. Rome Cited 5 March 2023. https://www.fao.org/fishery/en/geartype/223/en

FAO. 2023e. *Fishing Gear Type. Set gillnets (anchored). Technology Fact Sheets*. Fisheries and Aquaculture Division. Rome Cited 5 March 2023. https://www.fao.org/fishery/en/geartype/219/en

FAO. 2023f. *Fishing Gear Type. Set longlines. Technology Fact Sheets*. Fisheries and Aquaculture Division. Rome. Cited 5 March 2023. https://www.fao.org/fishery/en/geartype/232?lang=en

FAO. 2023g. *Fishing Gear Type. Drifting longlines. Technology Fact Sheets*. Fisheries and Aquaculture Division. Rome Cited 5 March 2023. https://www.fao.org/fishery/en/geartype/233/en

Fortuna, C.M., Vallini, C., Filidei, E., Ruffino, M., Consalvo, I., Di Muccio, S., Gion, C. *et al.* 2010. By-catch of cetaceans and other species of conservation concern during pair trawl fishing operations in the Adriatic Sea (Italy). *Chemistry and Ecology*, 26: 65–76.

Gauffier, P. & Verborgh, P. 2021. *Globicephala melas* (Inner Mediterranean subpopulation). The IUCN Red List of Threatened Species 2021: e.T198785664A198787672. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T198785664A198787672.en

Gazo, M., Gonzalvo, J. & Aguilar, A. 2008. Pingers as deterrents of bottlenose dolphins interacting with trammel nets. *Fisheries Research*, 92(1): 70–75.

Genov, T., Centrih, T., Kotnjek, P. & Hace, A. 2019. Behavioural and temporal partitioning of dolphin social groups in the northern Adriatic Sea. *Marine Biology*, 166(1): 1–14.

Genov, T., Kotnjek, P., Lesjak, J., Hace, A. & Fortuna, C.M. 2008. Bottlenose dolphins (*Tursiops truncatus*) in Slovenian and adjacent waters (northern Adriatic Sea). *Annales Series Historia Naturalis*, 18: 227–244.

Gomerčić, M.D., Galov, A., Gomerčić, T., Škrtić, D., Ćurković, S., Lucić, H., Vuković, S., Arbanasić, H. & Gomerčić, H. 2009. Bottlenose dolphin (*Tursiops truncatus*) depredation resulting in larynx strangulation with gillnet parts. *Marine Mammal Science*, 25(2): 392–401.

Gönener, S. & Özdemir, S. 2012. Investigation of the interaction between bottom gillnet fishery (Sinop, Black Sea) and bottlenose dolphins (*Tursiops truncatus*) in terms of economy. *Turkish Journal of Fisheries and Aquatic Sciences*, 12: 115–126.

González, L.M. & Fernandez de Larrinoa, P. 2012. Mediterranean monk seal *Monachus monachus* distribution and fisheries interactions in the Atlantic Sahara during the second half of the 20th century. *Mammalia*, 77(1): 41–49.

Gonzalvo, J. 2009. *Action Plan for the conservation of cetaceans in Lebanon*. ACCOBAMS, Monaco.

Gonzalvo, J. & Bearzi, G. 2008. Action Plan for the conservation of cetaceans in Syria. Regional Activity Centre for Specially Protected Areas.

Gonzalvo, J., Giovos, I. & Moutopoulos, D.K. 2014. Fishermen's perception on the sustainability of small-scale fisheries and dolphin–fisheries interactions in two increasingly fragile coastal ecosystems in western Greece. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 25: 91–106.

Gonzalvo, J., Moutopoulos, D.K., Bearzi, G. & Stergiou, K.I. 2011. Fisheries mismanagement in a Natura 2000 area in western Greece. *Fisheries Management and Ecology*, 18: 25–38.

Gonzalvo, J., Valls, M., Cardona, L. & Aguilar, A. 2008. Factors determining the interaction between common bottlenose dolphins and bottom trawlers off the Balearic Archipelago (western Mediterranean Sea). *Journal of Experimental Marine Biology and Ecology*, 367(1): 47–52.

Gonzalvo, J., Lauriano, G., Hammond, P.S., Viaud-Martinez, K.A., Fossi, M.C., Natoli, A. & Marsili, L. 2016. The Gulf of Ambracia's common bottlenose dolphins, Tursiops truncatus: A highly dense and yet threatened population. In: G. Notarbartolo di Sciara, M. Podestà & B. E. Curry, eds. *Advances in Marine Biology, Vol. 75*, pp. 259–296. London, Academic Press.

Güçlüsoy, H. 2008. Damage by monk seals to gear of the artisanal fishery in the Foça Monk Seal Pilot Conservation Area, Turkey. *Fisheries Research*, 90: 70–77.

Güçlüsoy, H. & Savas, Y. 2003. Interaction between monk seals *Monachus monachus* (Hermann, 1779) and marine fish farms in the Turkish Aegean and management of the problem. *Aquaculture Research*, 34: 777–783.

Güçlüsoy, H., Kýraç, C.O., Veryeri, N.O. & Savas, Y. 2004. Status of the Mediterranean monk seal, *Monachus monachus* (Hermann, 1779) in the coastal waters of Turkey. *E.U. Journal of Fisheries and Aquatic Sciences*, 21: 201–210.

He, P., Chopin, F., Suuronen, P., Ferro, R.S. & Lansley, J. 2021. *Classification and illustrated definition of fishing gears*. FAO Fisheries and Aquaculture Technical Paper. No. 672. https://www.fao.org/3/cb4966en/cb4966en.pdf

Jacquet, J. & Pauly, D. 2008. Funding priorities: Big barriers to small-scale fisheries. *Conservation Biology*, 22(4): 832–835.

Jog, K., Sutaria, D., Diedrich, A., Grech, A. & Marsh, H. 2022. Marine mammal interactions with fisheries: Review of research and management trends across commercial and small-scale fisheries. *Frontiers in Marine Science*, 9.

Johnson, W.M., Karamanlidis, A.A., Dendrinos, P., Fernández de Larrinoa, P., Gazo, M., González, L.M., Güçlüsoy, H., Pires, R. & Schnellmann, M. 2006. Monk Seal Fact Files. Biology, behaviour, status and conservation of the Mediterranean monk seal, *Monachus monachus*. In: *The Monachus Guardian*. Cited 15 March 2023. http://www.monachus-guardian.org/factfiles/medit01.htm

Karamanlidis, A.A. & Dendrinos, P. 2015. *Monachus monachus* (errata version published in 2017). *The IUCN Red List of Threatened Species*. Version 2021–3. Cited 21 March 2023. https://www.iucnredlist.org

Karamanlidis, A.A., Adamantopoulou, S., Kallianiotis, A.A., Tounta, E. & Dendrinos, P. 2020. An interview-based approach assessing interactions between seals and small-scale fisheries informs the conservation strategy of the endangered Mediterranean monk seal. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 30(5): 928–936.

Karamanlidis, A.A., Curtis, P.J., Hirons, A.C., Psaradellis, M., Dendrinos, P. & Hopkins, J.B. 2014. Stable isotopes confirm a coastal diet for critically endangered Mediterranean monk seals. *Isotopes in Environmental and Health Studies*, 50(3): 332–342.

Karamanlidis, A.A., Dendrinos, P., Fernández de Larrinoa, P., Gücü, A.C., Johnson, W.M., Kiraç, C.O. & Pires, R. 2015. The Mediterranean monk seal *Monachus monachus*: Status, biology, threats, and conservation priorities. *Mammal Review*, 46(2): 92–105.

Karamanlidis, A.A., Androukaki, E., Adamantopoulou, S., Chatzispyrou, A., Johnson, W. M., Kotomatas, S., Papadopoulos, A. *et al.* 2008. Assessing accidental entanglement as a threat to the Mediterranean monk seal *Monachus monachus*. *Endangered Species Research*, 5(2): 205–213.

Karavellas, D.P. 1994. *The state of fisheries in the Ionian Sea with particular reference to the habitat of the Mediterranean monk seal*, Monachus monachus. Athens, WWF Greece.

Kerem, D., Hadar, N., Goffman, O., Scheinin, A., Kent, R., Boisseau, O. & Schattner, U. 2012. Update on the cetacean fauna of the Mediterranean Levantine basin. *Open Marine Biology Journal*, 6: 6–27.

Kerem, D., Frantzis, A., Scheinin, A. & Goffman, O. 2021. *Steno bredanensis* (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2021: e.T160158217A160158353. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T160158217A160158353.en. Accessed on 21 March 2023.

Kiraç, O.C. & Ok, M. 2019. Diet of a Mediterranean monk seal *Monachus monachus* in a transitional post-weaning phase and its implications for the conservation of the species. *Endangered Species Research*, 39: 315–320.

Lanfredi, C., Arcangeli, A., David, L., Holcer, D., Rosso, M. & Natoli, A. 2022. *Grampus griseus* (Mediterranean subpopulation) (errata version published in 2022). The IUCN Red List of Threatened Species 2022. Cited 21 March 2023.

Laspina, M., Terribile, K. & Said, A. 2022. Interactions between cetaceans and small-scale fisheries around the Central Mediterranean Maltese Islands. *MCAST Journal of Applied Research & Practice*, 6(2): 113–126.

Lauriano, G. 1997. Distribution of bottlenose dolphin around the Island of Asinara (north-western Sardinia). *European Research on Cetaceans*, 11: 153–155.

Lauriano, G. 2022. *Stenella coeruleoalba* (Mediterranean subpopulation) (errata version published in 2022). The IUCN Red List of Threatened Species 2022. Cited 21 March 2023.

Lauriano, G., Caramanna, L., Scarno, M. & Andaloro, F. 2009. An overview of dolphin depredation in Italian artisanal fisheries. *Journal of the Marine Biological Association of the United Kingdom*, 89(5): 921–929.

Lauriano, G., Fortuna, C.M., Moltedo, G. & Notarbartolo Di Sciara, G. 2004. Interactions between common bottlenose dolphins (*Tursiops truncatus*) and the artisanal fishery in Asinara Island National Park (Sardinia): Assessment of catch damage and economic loss. *Journal of Cetacean Research and Management*, 6: 165–173.

Leone, A.B., Bonanno Ferraro, G., Boitani, L. & Blasi, M.F. 2019. Skin marks in bottlenose dolphins (*Tursiops truncatus*) interacting with artisanal fishery in the central Mediterranean Sea. *PLOS ONE*, 14(2).

Levy, A.M., Brenner, O., Scheinin, A., Morick, D., Ratner, E., Goffman, O. & Kerem, D. 2009. Laryngeal snaring by ingested fishing net in a common bottlenose dolphin (*Tursiops truncatus*) off the Israeli shoreline. *Journal of Wildlife Diseases*, 45(3): 834–838.

López, D.M., Barcelona, S.G., Báez, J.C., Serna, J.M.D. & Urbina, J.M.O. 2012. Marine mammal bycatch in Spanish Mediterranean large pelagic longline fisheries, with a focus on Risso's dolphin (*Grampus griseus*). *Aquatic Living Resources*, 25: 321–331.

Maccarrone, V., Buffa, G., Stefano, V.D., Filiciotto, F., Mazzola, S. & Buscaino, G. 2014. Economic assessment of dolphin depredation damages and pinger use in artisanal fisheries in the Archipelago of Egadi Islands (Sicily). *Turkish Journal of Fisheries and Aquatic Sciences*, 14(1): 173–181.

Martínez-Jauregui, M., Tavecchia, G., Cedenilla, M.A., Coulson, T., Fernández de Larrinoa, P., Muñoz, M. & González, L.M. 2012. Population resilience of the Mediterranean monk seal *Monachus monachus* at Cabo Blanco peninsula. *Marine Ecology Progress Series*, 461: 273–281.

Mikhailov, K. 2008. *Overview on the current status of cetacean-fisheries conflicts including by-catch and depredation with a critical review of historical data: Bulgaria*. ACCOBAMS and GFCM, International Workshop on Cetacean Bycatch within the ACCOBAMS Area, Rome, FAO, 17–18 September 2008.

Monaco, C. 2020. *Interaction between cetaceans and small-scale fisheries in the Mediterranean. The case of Central Mediterranean, Sicily, Italy*. Low Impact Fishers of Europe. https://lifeplatform.eu/wp-content/uploads/2021/02/Report_Sicily_updated-compressed.pdf

Mpougas, E., Waggitt, J.J., Dendrinos, P. Adamantopoulou, S. & Karamanlidis, A.A. 2019. Mediterranean Monk Seal (*Monachus monachus*) behavior at sea and interactions with boat traffic: Implications for the conservation of the species in Greece. *Aquatic Mammals*, 45(4): 419–424.

Natoli, A., Genov, T., Kerem, D., Gonzalvo, J., Lauriano, G., Holcer, D., Labach, H. *et al.* 2021. *Tursiops truncatus* (Mediterranean subpopulation) (errata version published in 2022). The IUCN Red List of Threatened Species 2021. Cited 21 March 2023. e.T16369383A215248781

Notarbartolo di Sciara, G. & Kotomatas S. 2016. Are Mediterranean monk seals, *Monachus monachus*, being left to save themselves from extinction? *Advances in Marine Biology*, 75: 359–386.

Panigada, S., Gauffier, P. & Notarbartolo di Sciara, G. 2021. *Balaenoptera physalus* (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2021: e.T16208224A50387979. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.

Panou, A., Jacobs, J. & Panos, D. 1993. The endangered Mediterranean monk seal *Monachus monachus* in the Ionian Sea, Greece. *Biological Conservation*, 64: 129–140.

Papageorgiou, M., Hadjioannou, L., Jimenez, C., Georgiou, A. & Petrou, A. 2022. Understanding the interactions between cetaceans and other megafauna with the albacore tuna fishery: A case study from the Cyprus' pelagic longline fishery. *Frontiers in Marine Science*, 9.

Pardalou, A. & Tsikliras, A.C. 2018. Anecdotal information on dolphin–fisheries interactions based on empirical knowledge of fishers in the northeastern Mediterranean Sea. *Ethics in Science and Environmental Politics*, 18: 1–8.

Pardalou, A. & Tsikliras, A.C. 2020. Factors influencing dolphin depredation in coastal fisheries of the northern Aegean Sea: Implications on defining mitigation measures. *Marine Mammal Science*, 36(4): 1126–1149.

Pardalou, A., Adamidou, A. & Tsikliras, A.C. 2022. Dolphin depredation and damage accumulation on different set nets in the northeastern Mediterranean Sea. *Estuarine, Coastal and Shelf Science*, 271.

Pennino, M.G., Rotta, A., Pierce, G.J. & Bellido, J.M. 2015. Interaction between bottlenose dolphin (*Tursiops truncatus*) and trammel nets in the Archipelago de La Maddalena, Italy. *Hydrobiologia*, 747: 69–82.

Pierce, G.J., Hernandez-Milian, G., Santos, M.B., Dendrinos, P., Psaradellis, M., Tounta, E., Androukaki, E. & Edridge, A. 2011. Diet of the monk seal (*Monachus monachus*) in Greek waters. *Aquatic Mammals*, 37: 284–297.

Pinela, A.M., Borrell, A., Cardona, L. & Aguilar, A. 2010. Stable isotope analysis reveals habitat partitioning among marine mammals off the NW African coast and unique trophic niches for two globally threatened species. *Marine Ecology Progress Series*, 416: 295–306.

Piroddi, C., Bearzi, G., Gonzalvo, J. & Christensen, V. 2011. From common to rare: The case of the Mediterranean common dolphin. *Biological Conservation*, 144(10): 2490–2498.

Pirotta, E., Carpinelli, E., Frantzis, A., Gauffier, P., Lanfredi, C., Pace, D.S. & Rendell, L.E. 2021. *Physeter macrocephalus* (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2021. e.T16370739A50285671. Cited 21 March 2023. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T16370739A50285671.en

Reeves, R.R., Read, A.J. & Notarbartolo di Sciara, G. 2001. *Report of the workshop on interactions between dolphins and fisheries in the Mediterranean: evaluation of mitigation alternatives*. ICRAM. International Whaling Commission, Fifty-third Meeting of the Scientific Committee, 4–5 May 2001, Rome, Italy. https://www.monachus-guardian.org/library/icram01a.pdf

Rocklin, D., Santoni, M.C., Culioli, J.M., Tomasini, J.A., Pelletier, D. & Mouillot, D. 2009. Changes in the catch composition of artisanal fisheries attributable to dolphin depredation in a Mediterranean marine reserve. *ICES Journal of Marine Science*, 66(4): 699–707.

Sala, E. 2004. The past and present topology and structure of Mediterranean subtidal rocky-shore food webs. *Ecosystems*, 7: 333–340.

Salman, A., Bilecenoglu, M. & Güçlüsoy, H. 2001. Stomach contents of two Mediterranean monk seals (*Monachus monachus*) from the Aegean Sea, Turkey. *Journal of the Marine Biological Association of the United Kingdom*, 81(4): 719–720.

Scheinin, A.P. 2010. The population of bottlenose dolphins (*Tursiops truncatus*), bottom trawl catch trends and the interaction between the two along the Mediterranean continental shelf of Israel. Haifa, Israel, University of Haifa. PhD thesis.

Scheinin, A.P., Kerem, D., Lojen, S., Liberzon, J. & Spanier, E. 2014. Resource partitioning between common bottlenose dolphin (*Tursiops truncatus*) and the Israeli bottom trawl fishery? Assessment by stomach contents and tissue stable isotopes analysis. *Journal of the Marine Biological Association of the United Kingdom*, 94(6): 1203–1220.

Snape, R.T.E., Broderick, A.C., Çiçek, B.A., Fuller, W.J., Tregenza, N., Witt, M.J. & Godley, B.J. 2018. Conflict between dolphins and a data-scarce fishery of the European Union. *Human Ecology*, 46(3): 423–433.

Tixier, P., Lea, M., Hindell, M.A., Welsford, D., Mazé, C., Gourguet, S. & Arnould, J.P.Y. 2021. When large marine predators feed on fisheries catches: Global patterns of the depredation conflict and directions for coexistence. *Fish and Fisheries*, 22(1): 31–53.

Tonay, A.M., Danyer, E., Dede, A., Öztürk, B. & Öztürk, A.A. 2016. The stomach content of a Mediterranean Monk Seal (*Monachus monachus*): Finding of green turtle (*Chelonia mydas*) remains. *Zoology in the Middle East*, 62(3): 211–216.

Trivourea, M.N., Karamanlidis, A.A., Tounta, E., Dendrinos, P. & Kotomatas, S. 2011. People and the Mediterranean monk seal (*Monachus monachus*): A study of the socioeconomic impacts of the National Marine Park of Alonissos, Northern Sporades, Greece. *Aquatic Mammals*, 37(3): 305–318.

Whitehead, H., Rendell, L., Osborne, R.W. & Würsig, B. 2004. Culture and conservation of non-humans with reference to whales and dolphins: Review and new directions. *Biological Conservation*, 120(3): 427–437.

Zaharieva, Z., Spasova, V. & Gavrilov, G. 2016. First attempt to understand the effect of pingers on static fishing gear in Bulgarian Black Sea coast. *ZooNotes*, 91: 1–3.

Zaharieva, Z., Racheva, V., Parvanov, D. & Delov, V. 2020. The conflict between fisheries and cetaceans in Bulgaria's Black Sea territorial waters. *Aquatic Mammals*, 46(1): 99–110.

Annex 1

Ongoing studies on marine mammal depredation in the Black Sea, Mediterranean Sea and contiguous Atlantic area

All records of depredation monitoring activities currently in progress, as shared with the authors by data providers, are summarized in following pages and presented by country, species and gear, together with a brief explanation of their activities.

Country: Cyprus; **Location/area:** Within the exclusive economic zone of the Republic of Cyprus; **Species:** *Tursiops truncatus*, *Delphinus delphis*; **Fishing gear types:** Longlines, trammel nets, gillnets; **Start Year:** 2021.

Activities: Cyprus is located in the eastern Mediterranean in the Levantine Basin and has the characteristics of an ultra-oligotrophic area. Most interactions with cetaceans here occur in two types of fisheries: the albacore longline fishery (offshore) and the set and gillnet fishery (coastal). Within the framework of the European Maritime and Fisheries Fund (EMFF) and through collaboration between fishers and scientists, a two-year study is being carried out to assess interactions between cetaceans and these two fisheries. The study will consist of on-board and harbour interviews, questionnaires distributed amongst both fisheries and the collection of information from fisheries with a history of interactions so that the impacts can be economically assessed. Damage to gear and catch will be documented, as well as measurements of net areas damaged, etc.

A further aim is to assess the effectiveness of pingers that are already in use through on-board data collection at a future point in this project. Pingers have been funded by the EMFF in Cyprus and are showing encouraging results, but no scientific assessment has been made so far. Both interactive and non-interactive pingers are currently in use in Cyprus, as well as other models.

Research goals: Assess impacts on fisheries economics.
Methods or technologies used/tested to collect data: 1) Questionnaires on board and at harbours/landing sites; 2) Monitoring of net and catch damage.
Data provider: Antonis Petrou (*AP Marine Environmental Consultancy Ltd*).

Project name: iNOVPESCA; **Country:** Portugal; **Location/area:** Algarve, Atlantic waters, Gulf of Cadiz; **Species:** *Tursiops truncatus*; **Fishing gear types:** Gillnets, small longlines; **Start Year:** 2020.

Activities: This work aimed to assess interactions between fisheries and marine megafauna (cetaceans, marine birds and marine turtles) through face-to-face interviews with fishers operating local and coastal artisanal fisheries out of the most important fishing harbours along the Portuguese southern coast (Algarve). The main goal was to identify and quantify problematic interactions known to cause bycatch or economic losses through depredation. Depredation problems were found to be mostly associated with cetaceans. Of the fishing gear types used in the sampled artisanal fisheries (longlines, pots and traps, bottom set nets and purse seines), the gear of most concern in terms of depredation was coastal bottom set nets, which were closely associated with bottlenose dolphins (*Tursiops truncatus*). Depredation was found to be species-, gear-, area- and vessel size-dependent. Economic losses caused by depredation led to catch and gear damage and was widely noted by bottom set net fishers of all vessel sizes, especially when targeting hake (*Merluccius merluccius*) and red mullet (*Mullus surmuletus*). Work was also performed toward identifying mitigation options, which has continued under a new project (CetAMBICion).

Research goals: Determine and assess 1) which species are causing damage through depredation; 2) which types of gear are most impacted; 3) the economic impacts of depredation; and 4) bycatch levels and if relevant, which species are bycaught.
Methods or technologies used/tested to collect data: 1) Harbour questionnaires; 2) On-board observations; 3) Logbooks for captains.
Data provider: Ana Marçalo and Jorge M.S. Gonçalves (*The Algarve Centre of Marine Sciences – CCMAR*).

Project name: ElasmoCatch; **Country:** Greece; **Location/area:** Northern Aegean Sea; **Species:** *Tursiops truncatus*, *Delphinus delphis*, *Monachus monachus*; **Fishing gear types:** Bottom trawls, trammel nets, gillnets (*Tursiops truncatus*); bottom trawls, purse seines, trammel nets, gillnets (*Delphinus delphis*); trammel nets, gillnets (*Monachus monachus*); **Start Year:** 2020.

Activities: The ElasmoCatch project focuses on studying interactions between elasmobranch species and fisheries, as well as vulnerable species in general in the northern Aegean Sea, using an adapted protocol based on *Monitoring incidental catch of vulnerable species in the Mediterranean and the Black Sea: Methodology for data collection* (FAO, 2019). Over 2020–2022, systematic seasonal monitoring was conducted via direct monitoring on board and interviews with fishers regarding nets, longlines, bottom trawls and purse seines in order to gather data on bycatch and depredation.

Overall, 272 fishing trips (sets) were monitored, with 7 percent using purse seines, 27 percent bottom trawls, 20 percent longlines, 26 percent trammel nets, 18 percent gillnets and 2 percent other types of gear. Depredation was recorded either through on-board observations of animals feeding from gear or from fisher reports on the given day, accompanied by depredated fish. Bottom trawlers and netters had the highest depredation rates, recording 80 percent and 65 percent, respectively, while longliners had the lowest (<0.5 percent). The most common species depredating the catch was bottlenose dolphin (95 percent), followed by common dolphin (*Delphinus delphis*) at 4.9 percent and, lastly, Mediterranean monk seal (*Monachus monachus*) at 0.1 percent.

Research goals: Assess vulnerable species interactions with fishing gear.
Methods or technologies used/tested to collect data: *Monitoring incidental catch of vulnerable species in the Mediterranean and the Black Sea: Methodology for data collection* (FAO, 2019).
Data provider: Ioannis Giovos (*iSea, not-for-profit non-governmental organisation for the preservation of the aquatic ecosystems*).

Project name: Life Delfi; **Country:** Italy, Croatia; **Location/area:** Tyrrhenian Sea (Tuscany, Aeolian Archipelago, Tavolara MPA, Egadi Islands MPA, Punta Campanella MPA), northern and central Adriatic Sea (Veneto, Marche, Torre del Cerrano MPA, Cres and Lošinj Islands); **Species:** *Tursiops truncatus*, *Stenella coeruleoalba*; **Fishing gear types:** Bottom trawls, pelagic trawls, trammel nets, gillnets (*Tursiops truncatus*); squid jigging[10] (*Stenella coeruleoalba*); **Start Year:** 2020.

Activities: Following the first year of use and dissemination of deterrent and alternative devices, a total of 241 days at sea were spent monitoring the effectiveness of mitigation systems, with more than 60 different fishers directly involved in the on-board activities, and many more participating in the meetings and dissemination carried out before and during the sea trials. The results obtained on the efficiency of pingers are generally in line with findings from other studies. Nevertheless, mixed results were obtained considering the catch as an indirect indicator of depredation prevention. In fact, catch data seem to vary insignificantly whether pingers are used or not. On the other hand, considering the effectiveness in terms of reducing damage to nets, some insightful results emerge, at least in certain areas.

Though a low number of observations does not allow clear conclusions to be drawn on the effectiveness of visual deterrent devices, net illumination systems remain one of the most promising and challenging approaches to reducing dolphin–fishery conflicts. Lastly, the results on data obtained from pots as alternative fishing devices are encouraging. For example, the *Squilla* pots tested in the central Adriatic Sea were found to be very efficient at catching target species. In addition, new prototypes tested by the Institute for Biological Resources and Marine Biotechnologies of the National Research Council (CNR-IRBIM) demonstrated how small technical modifications (e.g. changing the netting colour from black to white) can lead to a significant increases in catch efficiency. However, further tests are required to better understand and improve the catch performance of these newly designed pots (for example, in other seasons and areas of the project).

Research goals: Reduce dolphin mortality caused by fishing activities, by 1) reducing interactions; 2) promoting citizen science and increasing public awareness; 3) engaging fishers and training them to deal with bycatch events; and

[10] Squid jigging vessels use overhead lights to illuminate the water and attract squid, which then gather in the shaded area under the boat. The squid are caught using barbless lures on monofilament fishing lines, which are jigged up and down in the water by machines.

4) investigating interactions through passive acoustic and visual monitoring.
Methods or technologies used/tested to collect data: 1) On-board observers; 2) Self-reporting (logbooks); 3) Interviews.
Data provider: Alessandro Lucchetti (*CNR-IRBIM*).

Country: Italy; **Location/area:** Northeastern Sicily, with a focus on the Gulf of Catania (Phase 1), Gulf of Catania, specifically the coastal waters including the Cyclopean Isles MPA (Phase 2); **Species:** *Tursiops truncatus*, *Stenella coeruleoalba*, *Physeter macrocephalus*; **Fishing gear types:** Trammel nets, artisanal longlines, "totanara", "menaida", other single wall nets (*Tursiops truncatus)*; gillnets, small longlines, "totanara" (*Stenella coeruleoalba*); "totanara" (*Physeter macrocephalus*); **Start Year:** 2019.

Activities: The first phase of the study enabled: 1) a description of interaction cases between cetaceans and fisheries; 2) an assessment of existing strategies for mitigating this issue, including an overview of the status of small-scale fisheries (SSF) and the presence of cetaceans in the Mediterranean; 3) placing emphasis on the importance of cetacean bioacoustics; 4) a description of the Italian and Sicilian fishing fleets, including the *métiers*[11] prevailing in the SSF fleet of northeastern Sicily; 5) the production of standardized research protocols and survey sheets on fisheries and depredation; 6) the collection and analysis of survey data with a multidisciplinary approach in order to show results at environmental and socioeconomic levels; 7) the creation of a specific ethogram referred to as the "feeding in net" behaviour of the bottlenose dolphin; and 8) the provision of suggestions and conclusions linked to a follow-up of the project. For additional information, see Monaco (2020).

The second phase involves the Marecamp Association carrying out a trial on an "acoustic alert system" or alarm indicating the presence of dolphins and the occurrence of feeding sounds emitted close to the nets. The detection of vocalizations alerts the fisher to haul up the net in time. Visual and acoustic surveys are carried out in proximity of trammel nets and single-wall nets deployed at sea during fishing sets. Statistical analysis will evaluate the utility of the system in limiting the damage suffered by fishers. Initial results indicate that such types of technology could be improved to limit bycatch events of dolphins.

Research goals: Assess the socioeconomic and ecological impacts linked to the phenomenon of cetacean–fishery interactions and suggest new mitigation techniques (Phase 1); Test the usefulness of an acoustic alert system on the nets as a mitigation measure (Phase 2).
Methods or technologies used/tested to collect data: Face-to-face questionnaires for fishers, observers on board fishing vessels evaluating the presence of dolphins and the damage caused, fishers self-reporting (floating laboratories, logbooks), direct observations (visual and acoustic) from a scientific boat during fishery-based surveys, photo identification, ethograms, GIS (geographic information systems) (Phase 1); Direct observations (visual and acoustic) from a scientific boat during fishery-based surveys, monitoring of net and catch damage, cameras on board fishing vessels, simulation of mitigation measures (Phase 2).
Data provider: Clara Monaco (*Marecamp Association*).

Country: Malta; **Location/area:** Within the 25-nautical mile Malta Fisheries Management Zone; **Species:** *Tursiops truncatus*; **Fishing gear types:** Trammel nets; **Start Year:** 2019.

Activities: In Malta, the use of local ecological knowledge (LEK) from fishers is being applied to understand the occurrence of interactions between SSF and cetaceans in the Mediterranean, with the aim of conserving cetacean populations while ensuring sustainable fisheries. Locally, during the first phase of this project, interviews with small-scale fishers were conducted using a pre-defined questionnaire. These questionnaires investigated interaction characteristics and found that in coastal regions, including the Maltese Islands, such cetacean depredation often involved the bottlenose dolphin. When asked about the situation over the past five years, 76 percent of the surveyed fishers agreed that interactions had increased. The average reduction in catch sustained by fishers due to one encounter was 59.2 percent, suggesting that dolphin depredation does result in catch losses, a reality mostly experienced by fishers using trammel nets. During the second phase of the project, which is currently underway, on-board observers are joining fishers on a regular basis to determine the frequency, type and location of dolphin interactions. The factors leading to an increase in the incidence of depredation by dolphins and other vulnerable marine species in recent years are being examined in depth. Such an integration of LEK with scientific data regarding the status of dolphin depredation and its effects on SSF in

[11] A *métier* is a group of fishing operations targeting a similar assemblage of species, using similar gear, during the same period of the year and/or within the same area and that are characterized by a similar exploitation pattern.

the Maltese Islands provides a more holistic picture and allows for bottom-up management. This approach can subsequently be used in the compilation of regulations and mitigation measures for the sustainability of the fisheries sector and cetaceans alike.

Research goals: Analyse interactions between cetaceans and SSF around the central Mediterranean Maltese Islands in order to: 1) understand the status of cetacean depredation in Maltese waters through integration of LEK with scientific data; 2) provide mitigation measures if/where cetacean depredation occurs; and 3) strengthen cetacean conservation and ensure sustainable fisheries.
Methods or technologies used/tested to collect data: 1) Questionnaires in different fishing ports around Malta and Gozo to obtain fishers' perspectives on the issue of depredation in the Maltese Islands (type of gear most depredated, monetary losses due to depredation, vessel characteristics, species type, depredation characteristics, distance from shore, species of fish depredated and general locations of depredation); 2) On-board surveys to identify cetacean depredation locations in the presence of trammel nets and to identify cetacean locations without the presence of trammel nets.
Data provider: Matthew Laspina and Kimberly Terribile (*Department of Fisheries and Aquaculture*; *Centre of Agriculture, Aquatics and Animal Sciences*, *Institute of Applied Sciences*, *Malta College of Arts*, *Science and Technology*).

Country: Spain; **Location/area:** Mediterranean Cetacean Migration Corridor; **Species:** *Tursiops truncatus*, *Stenella coeruleoalba*; **Fishing gear types:** Bottom trawls, purse seines, trammel nets, gillnets (*Tursiops truncatus)*; Bottom trawls, purse seines (*Stenella coeruleoalba*); **Start Year:** 2019.

Activities: Aerial surveys were carried out to establish cetacean abundance and distribution, including through the use of ad hoc questionnaires distributed to fishers. After identifying areas of highest-intensity maritime traffic, analysis determined the overlap with critical cetacean habitats south of the Mediterranean Cetacean Migration Corridor.

Research goals: 1) Assess cetacean bycatch by different types of fishing gear in the Mediterranean Cetacean Migration Corridor; 2) Assess maritime traffic and collisions between cetaceans and boats; 3) Analyze the abundance and diversity of cetaceans in the Mediterranean Cetacean Migration Corridor.
Methods or technologies used/tested to collect data: 1) Aerial surveys; 2) Questionnaires distributed to fishers in Valencian fishing ports; 3) Official data (www.marinetraffic.com).
Data provider: Jose Antonio Raga (*University of Valencia*).

Country: Bulgaria; **Location/area:** Bulgarian territorial waters in the Black Sea; **Species:** *Tursiops truncatus*, *Delphinus delphis*; **Fishing gear types:** Bottom trawls; **Start Year:** 2019.

Activities: During opportunistic on-board observations on a bottom trawler, interactions with dolphins were observed. Dolphins were observed predating on fish discarded during hauling of the trawl, including biting the trawl. Bottlenose dolphins were mostly involved during these interactions and, to a lesser extent, common dolphins. Usually, the trawler carried out three to four hauls per day, and interactions with dolphins were recorded at highest rates during the first and last hauls, while less frequently or not at all during the hauls in between. It should be noted that usually the number of trawlers operating in the region ranged was from two or three to as many as ten.

Research goals: Analyse interactions between trawling activities and dolphins.
Methods or technologies used/tested to collect data: Opportunistic on-board observations; Photo identification.
Data provider: Dimitar Popov (*Green Balkans*).

Project partners: TartaTur, INVASION, Life DELFI; **Country:** Italy; **Location/area:** Adriatic Sea; Site of Community Importance (SIC) IT3270025 (northern Adriatic [Veneto–Delta del Po]); **Species:** *Tursiops truncatus*; **Fishing gear types:** Bottom trawls, pelagic trawls, trammel nets, gillnets, small longlines; **Start Year:** 2018.

Activities: The monitoring of stranding and free-ranging bottlenose dolphins in the northern Adriatic Sea and in the Po River mouth Natura 2000 site (SIC IT3270025) is helping to evaluate dolphin–fishery interactions. A standardized method is in use for a multidisciplinary assessment of the health status of the local population and the creation of a local population human-induced mortality index, for the identification of seasonal hotspots, to mitigate the impacts of specific types of fishing gear, and to support conservation policy and the establishment and monitoring of protected areas.

Research goals: 1) Assess dolphin–fisheries interactions to assess the local population's health status and create a human-induced mortality index; (2) Identify seasonal

hotspots; (3) Mitigate the impacts of specific types of fishing gear; (4) Support conservation policy and the establishment and monitoring of protected areas.

Methods or technologies used/tested to collect data: 1) Forensic analysis of stranded dolphins; (2) Fishery-based surveys; (3) Photo identification; (4) Underwater cameras and drones for behaviour assessment of free-ranging individuals.

Data provider: Sandro Mazzariol (*Department of Comparative Biomedicine and Food Science, University of Padova*).

Country: Italy; **Location/area:** Northwestern Adriatic Sea; **Species:** *Tursiops truncatus*; **Fishing gear types:** Bottom trawls, pelagic trawls; **Start Year:** 2018.

Activities: A combined generalized additive model and generalized estimation equation framework indicated that trawling, along with other physiographic, biological and anthropogenic variables, influenced dolphin distribution. During trawling days, the chance of encountering dolphins increased by a factor of about 4.5 (95 percent confidence interval = 1.8–11.0) near active beam trawlers, by a factor of about 16.0 (95 percent confidence interval = 7.1–36.0) near otter trawlers, and by a factor of about 28.9 (95 percent confidence interval = 12.0–69.6) near midwater pair trawlers. Spatial modelling was used to create maps of predicted distribution, suggesting differences in habitat use between trawling and non-trawling days.

Research goals: Determine and assess: 1) what types of trawlers are involved; 2) the spatial and temporal distribution of trawler–cetacean interactions 3) dolphin foraging techniques (e.g. feeding on fish and other organisms outside of the net, or stuck in the net mesh; feeding on fish and other organisms within the net; scavenging on discarded organisms; targeting species that are attracted by, or interact with, a trawler); 4) the potential impacts of interactions on dolphins (e.g. effects on movements and distribution; effects on diet; effects on group size; effects on social behaviour, social structure and culture; incidental mortality in trawling gear; exposure to the noise of trawlers; exposure to the noise of acoustic devices deployed on trawl nets; exposure to pollutants; environmental and global effects of trawling) 5) the potential impacts of interactions on trawl fisheries (e.g. catch loss and gear damage); 6) the responses and attitudes of fishers.

Methods or technologies used/tested to collect data: 1) Visual surveys; 2) Direct observations; 3) Photo identification; 4) Spatial modelling; 5) AIS (automatic identification system) data.

Data provider: Silvia Bonizzoni (*Dolphin Biology & Conservation, OceanCare*).

Country: Spain; **Location/area:** Northwestern Mediterranean coast of Catalonia (Cap de Creus MPA, Montgrí, Medes Islands and Baix Ter Natural Park); **Species:** *Tursiops truncatus*; **Fishing gear types:** Bottom trawls; **Start Year:** 2017.

Activities: Interactions with fisheries have been described as the most frequent cause of death among striped dolphins (*Stenella coeruleoalba*) and bottlenose dolphins stranded along the Catalan coast (northeastern Spain). The study area (158 644 294 ha) was surveyed from 2017 to 2020 via visual transect and photo-identification surveys. A total of 12 445 nautical miles (nm) of homogeneous effective effort was conducted across the study area. Bottlenose dolphins were the most frequently detected cetaceans, with a total of 77 sightings (encounter rate = 0.0242 sightings/nm). Most of the sightings (66 percent) were associated with trawl fishing activities, indicating a strong relationship between bottlenose dolphins and trawling vessel presence, suggesting potential bottlenose dolphin–fishing interactions in this marine protected area (MPA). The mean group size did not present any significant differences between seasons (Mann-Whitney U test: W = 709.5; number of bottlenose dolphins TTRU = 77; p = 0.7417). Interviews with crew members of trawlers operating in this area were conducted between August and September 2021, covering 68.9 percent of the trawling fleet in the area (36 trawlers), with all fishers reporting interactions with dolphins. Among the interviewed fishers, 79 percent noted that bottlenose dolphins follow trawlers, aiming to seize fish from the net. Despite this observed dynamic, interactions were considered non-negative by 93 percent of respondents due to an increase in catch accompanying the presence of dolphins, their playful behaviour, or a lack of damage caused to fishing gear. Just 7 percent of respondents considered the interactions as negative due to catch loss. While 95 percent of the fishers declared that they had occasionally caught dolphins in their nets, just 9 percent had ever caught an individual alive. The results of this study show that dolphin bycatch occurs in this area as observed through necropsy studies. However, bycatch is relatively rare considering the high level of interactions.

Research goals: Assess dolphin–bottom trawler interactions (including bycatch) occurrence in Catalan waters.

Methods or technologies used/tested to collect data: 1) Surveys-at-sea and collection of dolphin sightings and interactions with trawling activities. 2) Photo identification. 3) Cameras on fishing gear.
Data provider: Carla A. Chicote (*Submon*).

Country: Morocco; **Location/area:** Mediterranean Sea and Strait of Gibraltar; **Species:** *Tursiops truncatus*, *Globicephala melas*, *Orcinus orca*; **Fishing gear types:** Bottom trawls, purse seines (*Tursiops truncatus*); longlines (*Globicephala melas*); longlines (*Orcinus orca*); **Start Year:** 2017.

Activities: In general, the results of experiments with strengthened purse seines tested by the National Institute of Fisheries Research (INRH) have shown that these seines present better fishing efficiency and improved resistance to bottlenose dolphin interactions and thus incur much lower repair costs than ordinary seines.

Nevertheless, taking into account feedback from professionals and from experts from Le Drezen and scientists from the INRH, suggestions have been made to make some improvements to the reinforced seine. Over the longer term, the INRH will continue experiments with reinforced seines, making the suggested improvements in consultation with experts, as well as test potential additional devices that could limit bottlenose dolphin encounters.

The INRH, in collaboration with experts from ACCOBAMS, has launched a photo-identification study of cetaceans, particularly bottlenose dolphin, to understand the population size and distribution of this species in Moroccan Mediterranean waters. The results of this study, supplemented by monitoring the spatio-temporal dynamics of small pelagic fish migration, including through experimental fishing, will provide a better understanding of interactions between bottlenose dolphins and purse seining.

Research goals: To determine and assess: 1) the factors influencing bottlenose dolphin depredation in purse seine fisheries; 2) the economic consequences of depredation; and 3) the abundance and distribution of bottlenose dolphins in the southern Alboran Sea.
Methods or technologies used/tested to collect data: (1) Questionnaires; (2) Boat surveys (photo identification).
Data provider: Malouli Idrissi Mohammed and Jghab Ayman (*INRH*).

Country: Tunisia; **Location/area:** Northeastern Tunisia; **Species:** *Tursiops truncatus*; **Fishing gear types:** Purse seines; **Start Year:** 2015.

Activities: Bottlenose dolphin depredation monitoring has shown an average frequency of about 14 percent of fishing trips experiencing depredation. Depredation induces holes in nets, which are mostly circular or oval in shape with irregular edges and are located along the entire length of the seine with a higher number around the pocket and the front pocket. The most commonly observed class size of holes is between 20 and 60 cm. Interactions occur mainly during the concentration phase under lights (32 percent) and the encircling of fish schools (40.9 percent), causing holes that require costly mending for fishers. Holes induced by bottlenose dolphins are more frequent in terms of occurrence (56 percent), but less costly than those induced by solid structures (TND 247 ± 140 per boat/month). Depredation can lead to reduced fishing effort of sardine vessels (4 percent of days are spent immobilized due to depredation). Close monitoring of catch per unit effort (CPUE) variation shows that the CPUE value for months when depredation occurs can be higher than for months without depredation. However, the CPUE follow-up shows that CPUE is generally higher in the absence of depredation than in its presence (CPUE in the absence of depredation = 198.89 ± 62.28 kg/100 m/day; CPUE in the presence of depredation = 149.96 ± 59.82 kg/100 m/day; $p = 0.05$). Trends in landings composition shows that composition varies from one month to another and according to depredation ($p < 0.05$). An increase in species richness was noted during certain months in the presence of depredation, with an enrichment of CPUE in terms of squid and Clupeiformes. However, no significant statistical variation was detected according to prey groups ($p > 0.05$)

Research goals: 1) Assess dolphin depredation and interactions with fisheries; (2) Raise awareness of fisheries stakeholders; 3) Promote the introduction of fishing tourism and opportunistic whale watching.
Methods or technologies used/tested to collect data: 1) Dolphin monitoring around aquaculture farms; 2) Depredation monitoring.
Data provider: Rimmel Benmessaoud (*National Agronomic Institute of Tunisia*).

Country: Slovenia; **Location/area:** Gulf of Trieste, all national waters of Slovenia; **Species:** *Tursiops truncatus*; **Fishing gear types:** Bottom trawls, pelagic trawls, trammel nets, gillnets; **Start Year:** 2002.

Activities: Interactions between bottlenose dolphins and fishing gear are common in the Gulf of Trieste, mainly involving bottom trawlers, midwater pair trawlers (no longer operating in the area) and bottom-set gillnets and trammel nets. Neither absolute rates of interactions nor the extent of any damage are known. Mortality associated with depredation (ingestion of gear) has been documented.

Main questions addressed/ research goals: Assess: 1) frequency of interactions between bottlenose dolphins and fishing gear; 2) types of gear and behaviour associated with interactions; 3) bottlenose dolphin diet; and 4) injuries and fatal consequences of interactions.
Methods or technologies used/tested to collect data: 1) Boat-based and land-based observations; 2) Photo identification; 3) Passive acoustic monitoring; 4) Post-mortem examinations.
Data provider: Tilen Genov (*Morigenos – Slovenian Marine Mammal Society*).

Country: Israel**; Location/area:** Israeli national waters in the Mediterranean Sea; **Species:** *Tursiops truncatus*, *Delphinus delphis*; **Fishing gear types:** Bottom trawls, trammel nets, gillnets (*Tursiops truncatus*), Trammel nets, gillnets (*Delphinus delphis*); **Start Year:** 2001

Activities: The interaction of bottlenose dolphins and the bottom trawl fishery is very strong (Scheinin *et al*., 2014), with depredation occurring on a regular basis.

There are quite a few reports from bottom trawler fishers that dolphins, probably bottlenose dolphins, cause severe damage to their gear. The response has been that fishers secure a loose net with a large mesh size around the net, called a "dolphinera".

Depredation of gillnets is common also, and young dolphins (bottlenose and common dolphins) are caught in nets accordingly, probably while trying to depredate.

Research goals: Assess the health status of marine mammals in Israeli waters.
Methods or technologies used/tested to collect data: 1) Fisher interviews; 2) Strandings network.
Data provider: Aviad Scheinin (*The Morris Kahn Marine Research Station, University of Haifa. Delphis NGO*).

Country: Spain; **Location/area:** Southern Iberian Peninsula, northern Alboran Sea; **Species:** *Tursiops truncatus*; **Fishing gear types:** Trammel nets; **Start Year:** 2021.

Activities: The technical features of the fishing operation have been shown to be the most important aspect of this research, as was also the case in previous studies (Pardalou and Tsikliras, 2020; Pennino *et al*., 2015; Snape *et al*., 2018).

Target species, month and longitudinal gradient were important variables, but they showed different effects according to fishing strategy. The different fishing strategies used, depending on the target species, also had differential effects. When fishers targeted caramote prawn (*Penaeus kerathurus*), there was no damage to their nets, perhaps because trammel nets are set in deeper waters. However, higher damage was associated with targeting common cuttlefish (*Sepia officinalis*) and striped red mullet (*Mullus surmuletus*), though other studies have observed that cuttlefish nets were less depredated upon by dolphins (Pardalou and Tsikliras, 2020; Lauriano *et al*., 2004). These varying findings may be due to fishers in southern Spain employing some technical peculiarities in their trammel nets targeting cuttlefish that are not used elsewhere in the Mediterranean, or simply to the dolphins of the Alboran Sea having become familiar with the taste of cuttlefish. It is also possible that the fishing strategy of setting trammel nets in shallow water and near rocks to target striped red mullet is more likely to attract dolphins.

Research goals: Understand the main environmental and technical conditions that contribute to damage to trammel nets in the Alboran Sea from dolphin depredation. Moreover, different mitigation measures were tested.
Methods or technologies used/tested to collect data: Net monitoring in the port (548 sets).
Data provider: José Carlos Báez (*Instituto Español de Oceanografía IEO-CSIC & Asociación Herpetológica Española*).

Project name: Addressing the interaction between small-scale fisheries and marine megafauna in Greece (InCa) **Project partners:** World Wide Fund for Nature (WWF) Greece, Aristotle University of Thessaloniki (AUTH), Hellenic Centre for Marine Research (HCMR), Mediterranean Association to Save the Sea Turtles (MEDASSET), Hellenic Ornithological Society (HOS), Pelagos Cetacean Research Institute. **Country:** Greece; **Location/area:** Northeastern Aegean Sea (Thracian Sea, Alexandroupolis Gulf), northwestern Aegean Sea (Thermaikos Gulf), southwestern Aegean Sea, (Cyclades [Kythnos, Andros]), southweastern Aegean Sea (Dodecanese Islands [Rhodes]), Ionian Sea (Ionian Islands [Zakynthos Island]); **Species:** *Tursiops truncatus*, *Monachus monachus*; **Fishing gear types:** Trammel nets, gillnets (*Tursiops truncatus*); trammel nets, gillnets, small longlines (*Monachus monachus*); **Start Year:** 2020.

Activities: Over the course of the year-round on-board survey in the five study areas (Thracian Sea [Alexandroupolis Gulf], Thermaikos Gulf, Cyclades [Kythnos and Andros Islands], Dodecanese Islands [Rhodes], Ionian Sea [Zakynthos Island]), no incidental catch of marine mammals was recorded. Regarding the extent of damage to small-scale fishers' gear and catch, seasonal and also spatial variation was identified between sites, largely determined by the type of fishing gear and the marine mammal species present in each area, as well as marine mammal population densities.

The overall final project results regarding the economic evaluation of damage and the mortality rates of marine megafauna are currently being analysed. This information will be used to feed into national advocacy work towards developing a sustainable national financial compensatory system for SSF and will provide the basis for future implementation of bycatch mitigation measures in Greece.

Research goals: 1) Estimate economic losses of small-scale fishers due to interactions with marine mammals (gear damage and catch loss/devaluation) in Greece; 2) Estimate incidental catch of marine mammals, seabirds. marine reptiles and elasmobranchs in Greece; 3) Promote the development of a fair national compensatory system for small-scale fishers; 4) Complement ongoing advocacy work by proposing feasible and scientifically robust mitigation measures to local and national authorities in order to mitigate marine megafauna–SSF conflicts.

Methods or technologies used/tested to collect data: 1) Face-to-face questionnaires to determine the actual size and distribution of the coastal SSF fleet, information on the *métier*[12] during port visits through *in situ* interviews with small-scale fishers; 2) Year-round on-board observations to collect evidence on depredation per operation per *métier*, the magnitude of depredation, and the presence/absence of incidentally caught animals by SSF vessels in key hotspot areas of interactions.
Data provider: Amalia Alberini (*WWF Greece*).

Country: Spain; **Location/area:** Northern Alboran Sea (GFCM geographical subarea 1); **Species:** *Tursiops truncatus*; **Fishing gear types:** Purse seines, trammel nets, gillnets, sardine trammel nets; **Start Year:** 2018.

Activities: A major part of the investigation was addressed at assessing depredation. Data on technical characteristics of the fishing fleet, catch, incidence of interactions with cetaceans, types of damage in cases of depredation, losses and costs incurred, and mitigation measures employed were collected through interviews with fishers. These responses were based on a common structured questionnaire including closed-ended and open-ended questions that was distributed in all the three focal area countries (Italy, Malta and Spain) and could be entered into a shared database, easing comparison and sharing of data.

During the second phase, information was collected on hundreds of sets (fishing operations) of artisanal fishing using trammel nets. Of these sets, 22 percent were damaged by dolphins, with an average cost for net repair of EUR 1 200 (including the handwork and replacement of the material). During October–December, the data were analysed and the best strategy was designed for the implementation of mitigation measures. Moreover, during this phase, four cameras were installed on the nets of two boats, and two mullet trammel net fishing operations were recorded in two different fishing areas. Low-cost devices (shiny discs and empty plastic bottles) were used as deterrents.

Research goals: 1) Estimate depredation caused by cetaceans (particularly bottlenose dolphins) in artisanal net fisheries in selected pilot fishing ports, namely Caleta de Velez and Fuengirola (Málaga); 2) Accurately determine the number of vessels involved, as well as the main period and the marine areas (hotspots) where most interactions occur.

[12] A *métier* is a group of fishing operations targeting a similar assemblage of species, using similar gear, during the same period of the year and/or within the same area and that are characterized by a similar exploitation pattern

Methods or technologies used/tested to collect data: 1) Monitoring at ports/landing sites; 2) Port questionnaires; 3) Data on fishing production by fleet (SSF and purse seiners) to better understand the evolution of parameters with and without interactions; 4) Cameras on nets; 5) Testing different mitigation measures (e.g. shiny discs, pingers, chemosensory deterrents).
Data provider: Juan Antonio Camiñas (*Spanish Herpetological Association - AHE*).

Country: Spain; **Location/area:** Coastal waters of southeastern Spain, specifically the stretch between Cabo de Palos and Tabarca island and the northern Alboran coast between Malaga and Almeria. **Species:** *Tursiops truncaues*; **Fishing gear types:** Bottom trawls, purse seines, trammel nets, gillnets; **Start Year:** 2021.

Activities: Using data from this study and historical data from the Naturalists Association of the Southeast (ANSE), the project presents the first estimates of abundance and distribution of *Tursiops truncatus* in the study area (coastal waters of southeastern Spain). Both abundance and distribution were estimated through a combination of line transect sampling and photo-identification methods. The results show population growth, though more sightings are needed to obtain a better estimate coverage. Meanwhile, the project tried to measure depredation in small-scale nets using C-POD and F-POD acoustic detectors attached to the gear, in order to better understand patterns of activity in the nets. This information was completed by direct observations from a research vessel that accompanied fishing boats with the aim of collecting data on the individuals depredating in the area (using photo identification).

Main questions addressed/research goals: 1) Estimate the abundance and distribution of the population of *Tursiops truncatus* in southeastern Spanish waters; 2) Measure depredation in artisanal trammel nets and gillnets with direct observations of fishing activity from a research boat; 3) Measure depredation in small-scale fishing nets with passive acoustic detectors (C-POD and F-POD).
Methods or technologies used/tested to collect data: 1) Distance sampling 2) Mark–recapture models (photo identification); 3) Direct observations with fishing vessels; 4) C-POD and F-POD acoustic detectors placed in the fishing gear (trammel nets and gillnets).
Data provider: Aixa Morata (*ANSE – Asociación de Naturalistas del Sureste*).

Annex 2

Questionnaire for marine mammal depredation studies

1. Name:
2. Surname:
3. Affiliation:
4. Country (where the marine mammal depredation research is conducted):
5. Location/area (e.g. all national waters, Gulf of Ambracia, Balearic Islands, XXX MPA):
6. Marine mammal species (if more than one, please list them all in separate lines, adding as many lines in the table below as necessary) and type(s) of fishing gear involved (indicate with an "X"). See examples included in the table below:

Species (scientific name)	Bottom trawls	Pelagic trawls	Purse seines	Longlines	Tuna seines	Small-scale fisheries			
						Trammel nets	Gillnets	Small longlines	Other (please provide detail)
T. truncatus	X					X			
D. delphis			X						

7. Start year of project:
8. End year of project (if the project is ongoing, please write "ongoing" followed by the year when the project is expected to end):
9. Research goals:
10. Methods or technologies used/tested to collect data (please, no references to mitigation measures):
11. Please provide a small abstract, with a summary of the results, on the research being referred to:

Feel free to provide, in addition to this questionnaire, any report or document that you may consider relevant to your depredation work.

DEPREDATION BY MARINE MAMMALS IN FISHING GEAR: A REVIEW OF THE MEDITERRANEAN SEA, BLACK SEA AND CONTIGUOUS ATLANTIC AREA

Marine mammal depredation refers to the phenomenon of marine mammals partially or completely removing catch from fishing gear. Its results, which can include damage to gear or target fish, disturbance to fishing activities and economic losses for fishers, are becoming a growing cause for concern in several Mediterranean and Black Sea fisheries. This review offers an overview of historical and current trends of depredation by marine mammals in the region, including information on the contiguous Atlantic area west of Gibraltar.

The publication aims to assess and synthesize depredation records and describe ongoing projects on depredation in order to improve knowledge on key aspects of depredation, such as the fishing practices associated with depredation events, the economic fallout caused by marine mammal–fisheries interactions and the species and populations most involved in depredation. In the Mediterranean and the Black Sea, coastal fisheries often come into contact with cetaceans, especially bottlenose dolphins (*Tursiops truncatus*), common dolphins (*Delphinus delphis*) and harbour porpoises (*Phocoena phocoena relicta*). These species feature most prominently in the depredation records assessed and are the main research focuses of ongoing monitoring projects in the region. However, Mediterranean monk seals (*Monachus monachus*) are also responsible for depredation, especially in the eastern Mediterranean, and are the subject of their own short chapter in this review.

With the financial support of

MAVA FONDATION POUR LA NATURE

ISBN 978-92-5-137903-5 ISSN 1020-9549

9 789251 379035

CC6210EN/1/06.23