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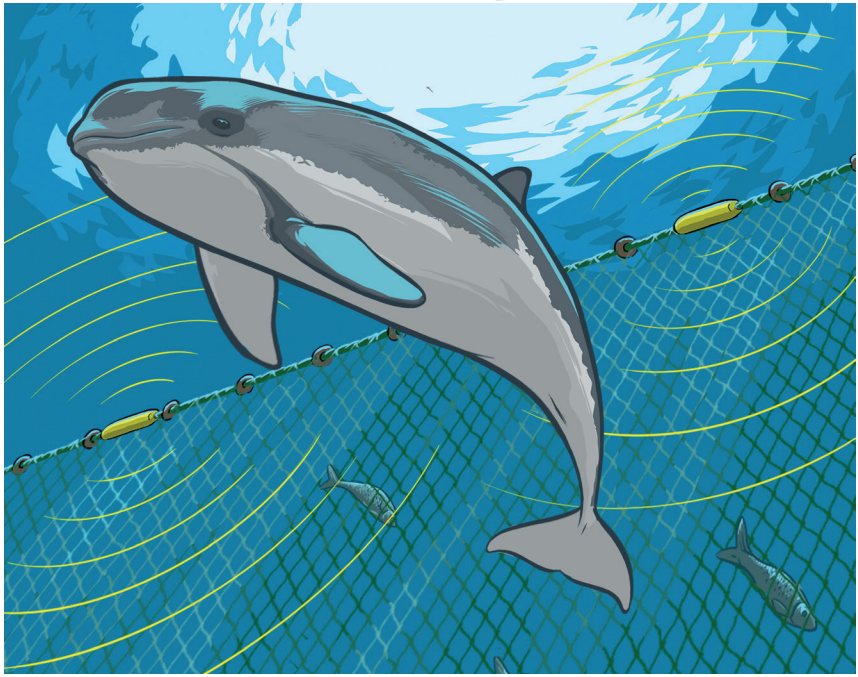
FAO
TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES

1

Suppl. 4

# FISHING OPERATIONS

## 4. Guidelines to prevent and reduce bycatch of marine mammals in capture fisheries



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## PREPARATION OF THIS DOCUMENT

This document contains the guidelines to prevent and reduce the bycatch of marine mammals in capture fisheries, which were prepared by FAO in consultation with relevant experts and FAO Members. The guidelines were drafted and developed through a series of activities undertaken by FAO at the request of COFI at its Thirty-second and Thirty-third sessions, namely:

- the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations (Rome, 20–23 March 2018), and
- the Expert Meeting to Develop Technical Guidelines to Reduce Bycatch of Marine Mammals in Capture Fisheries (Rome, 17–19 September 2019).

The activities and process which led to the finalization of the guidelines were led by the FAO Fishing Operations and Technology Branch (NFIO), with support from the National Oceanic and Atmospheric Administration (NOAA) of the United States of America, and the participation of experts from FAO Members.

Timothy Werner and Steven Kennelly acted as resource persons for the activities mentioned above and provided technical advice throughout the process. FAO technical backstopping was conducted by Matthew Camilleri, Raymon van Anrooy and Jon Lansley, assisted by FAO consultants Pingguo He, Haraldur Einarsson, Joanna Toole and Ingrid Giskes.

## ABSTRACT

The *Guidelines to Prevent and Reduce Bycatch of Marine Mammals in Capture Fisheries* are directed at decision-makers, planners, managers and all those involved in developing and implementing policy and technical interventions which relate to the bycatch of marine mammals in fisheries. The guidelines were drafted and developed through a series of activities undertaken by FAO, including the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations and the Expert Meeting to Develop Technical Guidelines to Reduce Bycatch of Marine Mammals in Capture Fisheries. They outline options for marine mammal bycatch reduction through the application of technical measures, including: spatial closures, the use of acoustic deterrents or alerting devices, modifications to fishing gear, changes in fishing operations and other strategies. The document refers to policy instruments and institutional frameworks that support the implementation of the guidelines and the conservation of marine mammals, in addition to awareness raising, communication and capacity-building actions, together with the special requirements of developing States. Finally, the guidelines address the future research and development needs for the prevention and reduction of marine mammal bycatch in capture fisheries.

# CONTENTS

Preparation of this document iii
Abstract iv
Acronyms and abbreviations vii
Background ix

**1. INTRODUCTION 1**

**2. DECISION-MAKING PROCESS FOR MARINE MAMMAL BYCATCH REDUCTION 6**

**3. TECHNICAL MEASURES 10**
3.1 Spatial closures 12
3.2 Acoustic alerting or deterrent devices 17
3.3 Modifications to fishing gear 25
3.4 Changes to fishing operations 37
3.5 Other strategies 46

**4. RESEARCH AND DEVELOPMENT: ISSUES AND FUTURE DIRECTIONS 50**
4.1 Modeling bycatch probabilities 50
4.2 Marine mammal and target catch sensory biology and behaviour 51

**5. POLICY INSTRUMENTS AND INSTITUTIONAL FRAMEWORKS SUPPORTING THE CONSERVATION OF MARINE MAMMALS FROM BYCATCH IN CAPTURE FISHERIES 54**
5.1 National instruments 54
5.2 International instruments 54
5.3 Regional instruments 55

**6. IMPLEMENTATION OF THESE GUIDELINES 57**
6.1 Driving change to prevent and reduce marine mammal bycatch 57
6.2 Roles of various entities 59

7. AWARENESS, COMMUNICATION AND CAPACITY-BUILDING MEASURES 67

8. SPECIAL REQUIREMENTS OF DEVELOPING STATES 73

REFERENCES 77

APPENDIX 97

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACCOBAMS | Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area |
| AFMA | Australian Fisheries Management Authority |
| AHD | Acoustic harassment device |
| AIDCP | Agreement on the International Dolphin Conservation Programme |
| ALDFG | Abandoned, lost or otherwise discarded fishing gear |
| ASCOBANS | Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish, and North Seas |
| BMI | Bycatch Mitigation Initiative (IWC) |
| BYCELS | Working Group on Bycatch, Entanglements and Live Strandings (NAMMCO) |
| CBD | Convention on Biological Diversity |
| CCAMLR | Commission for the Conservation of Antarctic Marine Living Resources |
| CCRF | FAO Code of Conduct for Responsible Fisheries |
| CCSBT | Commission for the Conservation of Southern Bluefin Tuna |
| CIRVA | Comité Internacional para la Recuperación de la Vaquita (International Committee for the Recovery of the Vaquita) |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| CPUE | Catch per unit of effort |
| COFI | Committee on Fisheries of the Food and Agriculture Organization of the United Nations (FAO) |
| CMS | Convention on the Conservation of Migratory Species of Wild Animals |
| CPC | Contracting parties and cooperating non-contracting parties |
| DML | Dolphin mortality limits |
| EAF | Ecosystem approach to fisheries |
| FAD | Fish aggregating device |
| FAO | Food and Agriculture Organization of the United Nations |
| GFCM | General Fisheries Commission for the Mediterranean |
| FIP | Fisheries improvement project |
| GGGI | Global Ghost Gear Initiative |
| GTR | Galvanic timed release |

| | |
|---|---|
| GWERN | Global Whale Entanglement Response Network (IWC) |
| IATTC | Inter-American Tropical Tuna Commission |
| ICES | International Council for the Exploration of Seas |
| IMR | Institute of Marine Research (Norway) |
| IOTC | Indian Ocean Tuna Commission |
| ITQ | Individual transferable quota |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| IUU | Illegal, unreported and unregulated (fishing) |
| IWC | International Whaling Commission |
| LED | Light emitting diode |
| MoU | Memorandum of Understanding |
| MSC | Marine Stewardship Council |
| NMFS | National Marine Fisheries Service (United States of America) |
| NAMMCO | North Atlantic Marine Mammal Commission |
| NGO | Non-governmental organization |
| NOAA | National Oceanic and Atmospheric Administration (United States of America) |
| NRC | National Research Council (United States of America) |
| PAL | Porpoise alert |
| PBR | Potential biological removal |
| PST | Population sustainability threshold |
| RFMO/A | Regional fisheries management organization/arrangement |
| SED | Seal (or sealion) exclusion device |
| SETFIA | Southeast Trawl Fishing Industry Association (Australia) |
| SMRU | Sea Mammal Research Unit (University of St. Andrews) |
| SWG | Standing Working Group (IWC) |
| TED | Turtle excluder device |
| UN | United Nations |
| UNCLOS | United Nations Convention on the Law of the Sea |
| UNEP | United Nations Environment Programme |
| UNFSA | Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (Fish Stock Agreement) |
| WCPFC | Western and Central Pacific Fisheries Commission |
| WCPO | Western Central Pacific Ocean |
| WGBYC | Working Group on Bycatch of Protected Species (ICES) |
| WWF | World Wildlife Fund for Nature |

## BACKGROUND

1. From ancient times, fishing from oceans, seas, lakes and rivers has been a major source of food and a provider of employment and other economic benefits for humanity. Living aquatic resources, an essential part of the aquatic ecosystem, are finite and their use, like that of other renewable natural resources, needs to be properly managed if their contribution to the nutritional, economic and social well-being of the growing world's population is to be sustained.

2. The adoption of the United Nations Convention on the Law of the Sea (UNCLOS) in 1982 was instrumental in the protection of living marine resources in the sea. The legal regime of the oceans gave coastal States rights and responsibilities for the management and use of fishery resources within the areas of their national jurisdiction.

3. After a long period of growth, capture fisheries landings began to level off from the end of the 1980s, due to sustainability issues, including overfishing, marking the end of the continued development paradigm of global fisheries. Overfishing has negative implications for food and nutrition security and for economic development, whilst also reducing social welfare in countries worldwide. This is especially the case for small-scale fishers and fish workers in developing countries who depend upon fish as their main source of essential nutrients, animal protein and income, while other fishers and fish workers employed in the medium and industrial sectors are reliant on these fisheries for income and livelihoods. The exploitation and use of living aquatic resources need to be properly managed and overfished and depleted stocks need to recover, ensuring that they can continue to benefit society.

4. Following rapid development, aquaculture started to play an increasing role in supplying fish for human consumption in the 1990s.

5. The 19th Session of the FAO Committee on Fisheries (COFI), held in March 1991, recommended the development of new approaches to fisheries and aquaculture management, embracing conservation and environment, as well as social and economic considerations. FAO was asked to develop the concept of responsible fisheries and elaborate a code of conduct to disseminate its principles and foster its application.

6. The Declaration of Cancun, endorsed at the International Conference on Responsible Fishing in Cancun in May 1992, and the United Nations Conference on Environment and Development Summit in Rio de Janeiro in June 1992, reinforced the concept of responsible fisheries and supported the preparation of a code of conduct for responsible fisheries. The FAO Technical Consultation on High Seas Fishing held in September 1992 further recommended the elaboration of a code to address the issues regarding high seas fisheries.

7. In November 1992, the FAO Council formally approved the preparation of a draft of this code. The formulation was carried out through a participatory process involving FAO Members and designed so as to be interpreted and applied in conformity with the relevant rules of international law, as reflected in the 10 December 1982 United Nations Convention on the Law of the Sea. It was also formulated in line with the Agreement for the Implementation of the Provisions of the 1995 Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks and, *inter alia*, the 1992 Declaration of Cancun and the 1992 Rio Declaration on Environment and Development, in particular Chapter 17 of Agenda 21.

8. At its 27th Session in November 1993, the FAO Conference adopted the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, which, as stated within the FAO Conference Resolution 15/93, should form an integral part of the code of conduct for responsible fisheries.

9. The Code of Conduct for Responsible Fisheries (the Code) was adopted on 31 October 1995 during the 28th Session of the FAO Conference through Resolution 4/95. The same Resolution requested FAO *inter alia* to elaborate appropriate technical guidelines in support of the implementation of the Code in collaboration with FAO Members and interested relevant organizations. This document is one of a series produced in response to this request.

10. The Code is voluntary. However, certain parts of it are based on relevant rules of international law, and it also contains provisions that have already been given binding effect by means of other obligatory legal instruments amongst the Parties.

11. On the implementation of the provisions of the Code, the application of the Ecosystem Approach to Fisheries, as reinforced in the Reykjavik

Declaration (2001), provide strategies for the actual implementation of the Code, contributing to the further development and management of sustainable capture fisheries in the marine and freshwater environments and of the interaction between capture fisheries and aquaculture for sustainability, thereby supporting the technical, ecological, economic and social sustainability of the sectors.

12. Despite significant progress in places where capture fisheries management is implemented, the continued prevalence of illegal, unreported and unregulated (IUU) fishing and the ongoing use of ineffective management measures, means that the global percentage of fish stocks that are classified as overfished has not declined.

13. Since its adoption in 1995, the Code has been supplemented, within its framework, by other internationally negotiated instruments addressing specific provisions of the Code and other related matters on responsible fisheries and aquaculture, in the form of International Plans of Action, Voluntary Guidelines and Strategies. In addition, in 2009, the 36th Session of the FAO Conference adopted the Agreement on Port State Measures to Prevent, Deter and Eliminate IUU Fishing which later came into force in June 2016.

14. Whilst contributing smaller volumes to the global fish catch than marine fisheries, inland fisheries contributes fundamentally to food and nutrition security, livelihoods and rural economies, especially in many developing countries. The existence of a broad range of interests outside the inland fisheries sector emphasizes the need for States to establish negotiation mechanisms to protect inland fisheries under multi-purpose use regimes. The importance and the challenges of ensuring the sustainable and responsible use of inland fisheries are clearly acknowledged in the Rome Declaration which emerged from the Global Conference on Inland Fisheries in 2015: The 'Ten Steps to Responsible Inland Fisheries' emphasize cross-sectoral approaches to sustain livelihoods, food and nutrition security, and aquatic ecosystems.

15. The role of aquaculture in supplying fish for human consumption has continued to increase, reaching approximately 50 percent of global fish available for human consumption in 2018. This has allowed fish to contribute to the transition to more healthy and nutritious diets while not increasing the pressure on capture fisheries. However, aquaculture development, when inadequately managed, has also shown the potential to cause environmentally or socially

adverse impacts. The outstanding issue in aquaculture is that, unlike in capture fisheries, the existing applicable principles of international law and treaty provisions provide little guidance on the conduct of aquaculture operations. The importance of sustainable aquaculture development and management for securing food and nutrition security, alleviating poverty and maintaining the integrity and sustainability of aquatic resources and environments was reinforced in the Bangkok declaration (2000) and the Phuket consensus (2010).

16. Elements of the Code and the subsequent framework of international instruments were reinforced through the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012, which launched a process to develop a set of Sustainable Development Goals (SDGs). The 2030 Agenda for Sustainable Development was adopted with 17 SDGs at the United Nations Sustainable Development Summit in 2015. In particular, SDG 14 "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" includes targets, *inter alia*, for sustainable management of fisheries and aquaculture, ensuring access to resources and markets for small-scale fishers, ending of overfishing, destructive fishing practices, IUU fishing and the implementation of science-based plans to restore fish stocks.

17. FAO produces Technical Guidelines for Responsible Fisheries to assist the international community in taking the necessary practical steps to implement the provisions foreseen in the Code.

# 1. INTRODUCTION

There are 130 species and 84 subspecies/subpopulations of marine mammals distributed across all the world's oceans, grouped under whales, dolphins, and porpoises (cetaceans), seals, sea lions and walrus (pinnipeds), dugong and manatees (sirenians), sea otters and polar bear (IUCN, 2019). Marine mammals are typically large-bodied animals with long lifespans, delayed maturation, and low reproductive output. Many species have a strong influence on the structure and function of ecosystems through top-down effects (e.g. prey removal) and bottom-up processes (see Bowen 1997; Roman *et al*., 2014; Kiszka *et al*., 2015).

For millennia, humans have exploited marine mammals for food and other products. However, in recent decades, owing to population declines and on conservation grounds, many marine mammal species have been designated as protected under international conventions and national level legislations. Not all marine mammal species are under threat from bycatch and fisheries targeting specific marine mammals can be found in some regions. Nevertheless, the catch of marine mammals is not desirable in most fisheries; where marine mammals are considered bycatch, this negatively affects the fishing operations and resulting revenues.

In these guidelines bycatch is defined as, "the catch of organisms that are not targeted", consistent with the existing FAO definition (Perez Roda *et al*., 2019). Furthermore, the definition applied here also includes any animal adversely affected by an interaction that may go unobserved or otherwise not accounted for as part of fishing operations.

It is estimated that more than 500 000 marine mammals (excluding polar bear and walrus) are incidentally captured in a range of fisheries every year (Read *et al*., 2006; Gray and Kennelly, 2018). Such bycatch is generally acknowledged as a principal threat to the persistence and recovery of many marine mammal species (Read *et al*., 2006; Žydelis *et al*., 2009; Reeves *et al*., 2013; Brownell *et al*., 2019).

There are many records of marine mammal bycatch occurring in all types of fishing gears including gillnets and entangling nets, surrounding nets, hook and lines, traps (including pound nets and pots) and trawls (bottom and midwater). For many marine mammals, gillnets pose the greatest risk of bycatch (Read *et al*., 2006; Reeves *et al.*, 2013; Peltier *et al*., 2020), but for mysticetes (baleen whales) the main risk comes from gillnets and the buoy lines of fishing gears used to catch fish and shellfish (Johnson *et al*., 2005;

van der Hoop, 2012). Longline fishery interactions mainly involve toothed cetaceans attracted primarily to the target catch as a feeding opportunity, and trawls have significant interactions with pinnipeds and cetaceans (Werner *et al*., 2015). Abandoned, lost or otherwise discarded fishing gear (ALDFG) also cause mortality to these animals through ghost fishing (Stelfox *et al*., 2016; see also *Voluntary Guidelines on the Marking of Fishing Gear, FAO*, 2019).

Although large-scale industrial fisheries are often identified as major sources of marine mammal bycatch, many of the most threatened populations affected by bycatch occur in small-scale fisheries, which include subsistence and artisanal fisheries. Furthermore, distinguishing between catch and bycatch does not occur in some parts of the world, where marine mammals can be a source of food (Robards and Reeves, 2011), bait (Mintzer *et al*., 2018) and income (see also *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*, FAO, 2015). However, bycatch of marine mammals is often not desired, and prohibited in due consideration of low populations or their protected status. The present guidelines intend to help prevent or reduce the unwanted bycatch of marine mammals. One of the primary motivations is to aid the recovery of threatened and endangered species, which also benefits the health of the ecosystems in which they reside.

Although the problems associated with marine mammal bycatch have been recognized, the issue remains unresolved in many parts of the world. This is especially true in developing countries (Peltier *et al*., 2016), where capacity for bycatch monitoring, surveillance and enforcement of fisheries regulations may be insufficient. The problem is even more acute considering that marine mammal interactions are known to occur in significant numbers (Lewison *et al*., 2014; Teh *et al*., 2015; Temple *et al*., 2019).

From the point of view of fishers in most jurisdictions, interactions and encounters with marine mammals, as well as the resulting bycatch, are undesirable. Encounters can result in:

- lower revenues due to marine mammals stealing bait or their depredations of captured fish;
- additional time spent in trying to free animals captured or entangled in the gear;
- increased operating expenses due to gear damage or loss;
- safety concerns from handling large marine mammals in distress;

- negative public perceptions about the fishery that can result in decreased demand for its products; and
- stricter regulatory measures such as closures and gear modifications, which can increase costs and lost fishing opportunities.

In summary, bycatch in fisheries is an important threat to the persistence, health and recovery of many marine mammal populations. Reducing bycatch of marine mammals aids the recovery of endangered and threatened species and improves ecosystem health, leading to more sustainable fisheries. Furthermore, the interactions of marine mammals with fishing operations can affect the commercial viability of capture fisheries in both large-scale industrial and small-scale fisheries.

**Rationale**

The past few decades have seen a heightened awareness and attention regarding the development of solutions to reduce marine mammal bycatch in fisheries. Yet while there has been a great deal of work on solutions, their implementation has remained slow. Solutions that are suitable for many fisheries have yet to be identified and developed, and more research needs to be carried out to evaluate their potential for reversing the trend of population decline. A number of reviews have focused on particular aspects of marine mammal bycatch mitigation (for example, Dawson *et al*., 2013; Geijer and Read, 2013; Hamer *et al*., 2012; How *et al*., 2015; Laverick *et al*., 2017; Leaper and Calderan, 2018; Werner *et al*., 2006, 2015; Hamilton and Baker, 2019), but there are few readily accessible documents with clear guidelines for effective mitigation methods.

The FAO Code of Conduct for Responsible Fisheries (CCRF) (FAO, 1995) requires that States conduct fishing with due regard for the environment. Article 6.6 of the Code stipulates that "States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species". Similarly, in Article 7.6.9 it goes on to specify that:

States should take appropriate measures to minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and negative impacts on associated or dependent species, in particular endangered species. (FAO, 1995)

Consequently, at the request of its Members FAO developed the International Guidelines on Bycatch Management and Reduction of Discards (FAO, 2011a). These guidelines provided concepts, principles and practical measures ranging from appropriate regulatory frameworks to the components of an efficient and effective data collection programme. They also identified key management considerations and measures necessary to ensuring the conservation of target and non-target species.

At various sessions of the FAO Committee on Fisheries (COFI) Members emphasized the need to increase efforts to reduce bycatch and discards, while more recently specific concerns have been raised concerning the bycatch of marine mammals. At its Thirty-first Session in 2014, the Committee reiterated, *inter alia*, that the bycatch and subsequent mortality of marine mammals was a problem that required greater attention. The subject was raised again during the Thirty-second and Thirty-third sessions of COFI in 2016 and 2018, and FAO was requested to develop technical guidelines to reduce marine mammal bycatch in capture fisheries.

In response to the COFI request, and because marine mammal bycatch in fisheries has become a growing concern for a number of FAO Members, FAO developed these technical guidelines with extensive inputs from relevant experts by way of an Expert Workshop and an Expert Meeting. In both cases the objective was to prevent and/or reduce marine mammal bycatch in capture fisheries so as to reduce their incidental mortality in order to enhance the conservation of marine mammals. FAO Members and relevant international organizations were provided with opportunities to comment on the draft guidelines before publication, with due consideration of FAO's mandate to promote and support the sustainable utilization of living marine resources based on the best available science, thereby contributing to food security, nutrition and livelihoods.

**Scope**

Since 1995 FAO Technical Guidelines have been developed on a wide variety of fisheries subjects, including aquaculture development, fishing operations, fisheries management, responsible fish utilization, and the integration of fisheries into coastal area management.[1] The present *Guidelines to prevent or reduce bycatch of marine mammals in capture fisheries* is Supplement 4 to Volume 1 on Fishing Operations. The first three supplements deal with vessel monitoring systems, incidental bycatch of seabirds, and safety at sea in fisheries.

These guidelines will be promoted globally as a voluntary instrument and are intended to be applicable to capture fisheries in all regions where there are problems of marine mammal bycatch. The guidelines therefore consider a number of interlinked institutional and technical issues in the light of current and changing management perspectives in the fisheries sector. They are directed at decision-makers, planners, and all those involved in developing and implementing policy and technical interventions which relate to the bycatch of marine mammals in capture fisheries.

It is important to note that these guidelines do *not* relate to the targeted harvest of marine mammals, but rather to their incidental interactions during fishing. These guidelines do not include procedures for the safe handling and release of marine mammals from fishing vessels, nor for the disentanglement of marine mammals from fishing gears, or the return and handling of animals stranded on beaches. These guidelines do not deal with the final deposition of marine mammals caught incidentally in fishing gears as bycatch, without prejudice to their possible use for food and/or other purposes. Guidelines and procedures for the handling and release of bycaught marine mammals have been developed by other groups (e.g. Whaley and Borkowski, 2009; Hammer and Minton, 2020). Similarly, this document does not discuss issues related to marine mammal entanglement with aquaculture facilities, beach nets erected to prevent shark attacks on swimmers, and recreational or sports fisheries. These guidelines focus on *preventing or reducing* unwanted marine mammal bycatch in capture fisheries.

[1] FAO Technical Guidelines for Responsible Fisheries can be found at: http://www.fao.org/fishery/publications/en

# 2. DECISION-MAKING PROCESS FOR MARINE MAMMAL BYCATCH REDUCTION

Figure 1 presents a flow chart that can assist stakeholders in identifying steps that may be followed to find solutions and take actions related to marine mammal bycatch. The first question fisheries managers should ask is whether or not marine mammal bycatch is occurring in their fishery. If so, the types of measures they might use will require sustained investment of financial and human resources in data collection on marine mammal distribution, population trends, biology, ecology, bycatch rates, and the fisheries that interact with them (location, seasonality, gear, practices, economic and social aspects, etc.). However, in fisheries where there is documented bycatch of any threatened or potentially threatened marine mammal population, data collection should not delay the implementation of appropriate mitigation measures (see the steps for a 'Priority Situation' in Figure 1 below). Spatio-temporal overlays of critical marine mammal habitats and fishing grounds (co-occurrence) can identify the most critical areas where action may be required (Avila *et al.*, 2018).

When evaluating mitigation options, it is important to carry out testing in local fisheries regarding the modifications to fishing gear and practices. It is possible that while measures to reduce bycatch in one area may appear ineffective, it may produce positive results on another location with only minor modifications to the gear. Results of trials need to be interpreted carefully to ensure that they are truly representative. For example, many trials of acoustic deterrents inadequately characterize how differences in frequencies, power outputs, duty cycles, or spacing along a net affect the results obtained, while also using different experimental designs applied under variable environments and fishing conditions.

Above all, identifying what levels of bycatch (if any) can still allow a local population of marine mammals to persist or recover from past depletion in numbers is paramount. Regrettably, this information is absent for most species and populations. The lack of multiple years of data collection often hinders efforts to ascertain whether fisheries are operating sustainably with regard to marine mammal population management (Reeves *et al.*, 2013).

**Figure 1. Flow chart for developing a Marine Mammal Bycatch Prevention and Reduction Plan under the FAO Code of Conduct for Responsible Fisheries**

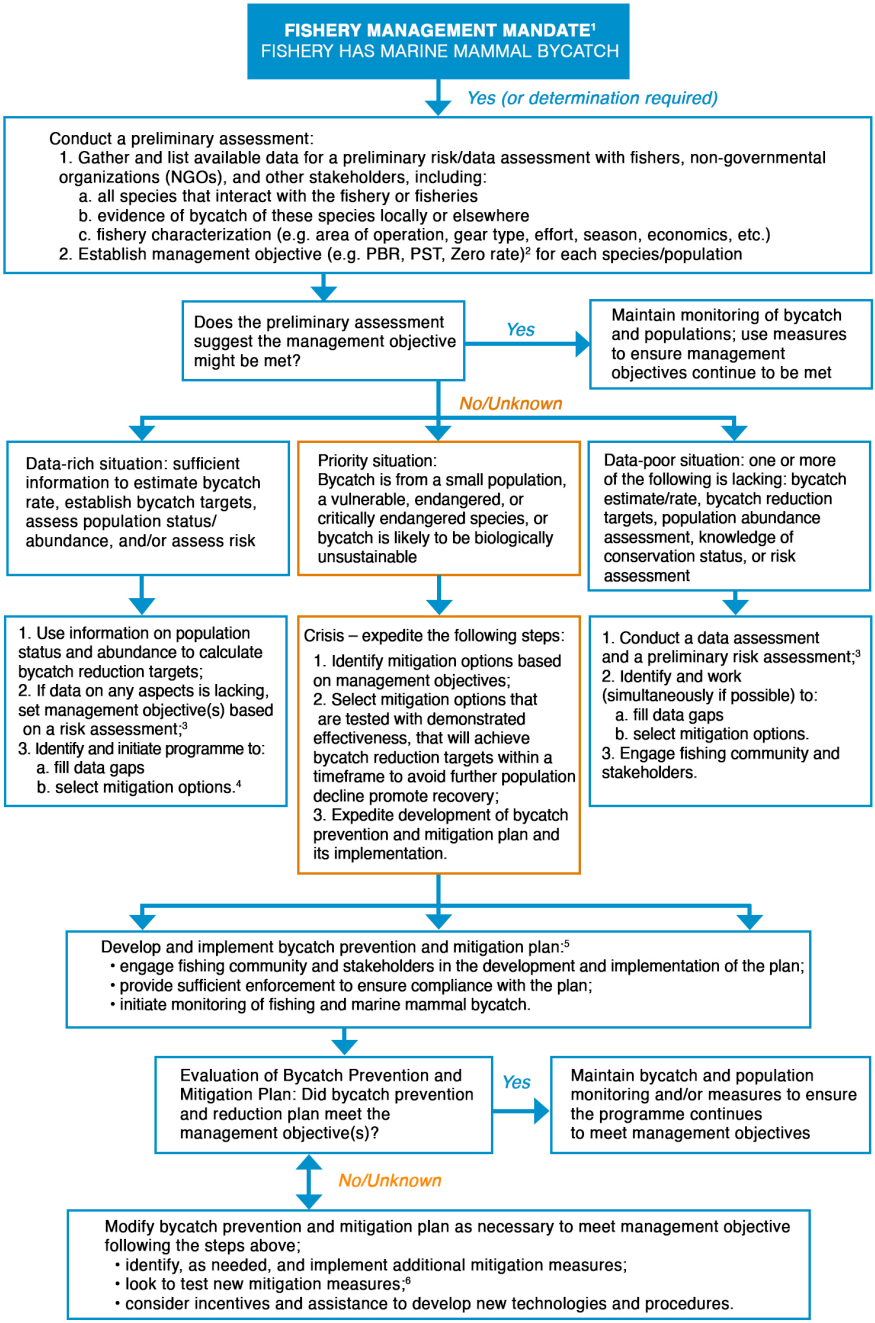

Figure 1 Notes:

[1] As per Article 6 of the FAO Code of Conduct for Responsible Fisheries, States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species (FAO, 1995). States should thus take appropriate measures to minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, and negative impacts on associated or dependent species, in particular endangered species. Where appropriate, such measures may include technical measures related to fish size, mesh size or gear, discards, closed seasons and areas and zones reserved for selected fisheries – particularly artisanal fisheries. Such measures should be applied, where appropriate, to protect juveniles and spawners. States and subregional or regional fisheries management organizations and arrangements should promote, to the extent practicable, the development and use of selective, environmentally safe and cost-effective gear and techniques (Article 7.6.9, FAO, 1995).

[2] These can be qualitative objectives such as: to 'reduce' or 'minimize' bycatch in line with Code of Conduct for Responsible Fisheries, avoid the depletion of marine mammal populations, achieve favourable conservation status, maintain marine mammal population(s) at a level that is determined to be sustainable or recovering, or achieve compliance with seafood import regulations. As per Article 7.2.3 of the Code of Conduct:

> States should assess the impacts of environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks, and assess the relationship among the populations in the ecosystem (FAO, 1995).

[3] To begin with, an analysis of the gears used in the fishery, as well as the marine mammal species known to be present in the area, can be assessed against other similar fisheries to assess the likelihood of bycatch risk. Further risk assessment methodologies could involve running through a simple checklist of data on the fishery and marine mammal population, and engaging relevant experts on what might be needed. Risk assessment methodologies generally involve modelling different population trends for bycatch species, based on the spatial overlap between fishing locations and the use and occurrence of marine mammal habitats; these trends can then be used to estimate the level of risk to those populations.

[4] Mitigation techniques are described throughout Chapter 3 and in the appendices of the *Report of the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations* (FAO, 2018). Techniques can include regulatory and voluntary measures, codes of conduct, gear switching, spatial and temporal closures, dynamic closures, acoustic deterrents and gear modifications.

[5] The bycatch prevention and mitigation plan should include regulatory mitigation measures, voluntary mitigation measures, identification of research needs, and include timelines for implementation and evaluation.

[6] Testing of mitigation methods should comply with the FAO Code of Conduct which states that:

> Catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species are minimized, through measures including, to the extent practicable, the development and use of selective, environmentally safe and cost-effective fishing gear and techniques (Article 7.2.2g, FAO, 1995).

States should require that fishing gear, methods and practices, to the extent practicable, are sufficiently selective so as to minimize waste, discards, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species and that the intent of related regulations is not circumvented by technical devices. In this regard, fishers should cooperate in the development of selective fishing gear and methods. States should ensure that information on new developments and requirements is made available to all fishers (Article 8.5.1, FAO, 1995). In order to improve selectivity, States should, when drawing up their laws and regulations, take into account the range of selective fishing gear, methods and strategies available to the industry. (Article 8.5.2, FAO, 1995).

# 3. TECHNICAL MEASURES

In general, interactions between marine mammals and fishing operations tend to occur either when marine mammals actively seek to prey on fish captured in fishing gears (depredation), or inadvertently become entrapped, hooked or entangled. However, a combination of these factors can also result in their bycatch. Longline catch and bait can attract species of toothed cetaceans such as sperm whales (*Physeter macrocephalus*), killer whales (*Orcinus orca*), pilot whales (Globicephala spp.), and false killer whales (*Pseudorca crassidens*). The catch in purse seines, trawls, and pots/traps can attract pinnipeds and small cetaceans such as killer whales, common dolphins (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*). Catch in pots can also attract otters. In contrast to this depredating behaviour, inadvertent capture or entanglement most typically occurs with large baleen whales and small cetaceans when they become entangled in the buoy ropes of pots or gillnets; small cetaceans and pinnipeds can get caught in gillnet webbing and purse seines, as well as in bottom or midwater trawls. Trawl interactions generally occur when marine mammals exploit them as a feeding opportunity and accidentally become trapped.

The largest proportion of marine mammal bycatch is undoubtedly the result of accidental encounters, and gillnets are considered the riskiest gear to most species (Perrin *et al.*, 1994; Read *et al.*, 2006; Reeves *et al.*, 2013). Sometimes, especially in cases involving depredation, the interactions do not necessarily lead to bycatch and their impact on long-term reductions in population sizes may be negligible. However, they may be more problematic for fishers, due to the economic losses caused by damage, or the removal of catch or gear.

An understanding of the nature of the interaction is important to identify the most appropriate mitigation measures. Generally, the most successful mitigation strategies have emerged from collaborations between fishers, fisheries managers, marine mammal experts and fisheries engineers, each of whom contributes critical expertise in developing, evaluating or implementing bycatch reduction measures.

The techniques for preventing or minimizing bycatch of marine mammals in capture fisheries can be categorized as follows:

- spatial closures (including dynamic or real-time closures)
- acoustic deterrents or alerting devices

- modifications to fishing gear
- changes in fishing operations
- other strategies

The main emphasis of these strategies is on preventing interactions altogether, in order to ensure the long-term survival of the individual animals and their populations while also avoiding potential injury or mortality to the animals involved. In addition, preventing bycatch avoids problems for fishers who may lose gear or time spent fishing, face hazards associated with setting free animals that have become ensnared or entangled in their gear, and experience negative public responses to their operations and products in the marketplace.

Fishing crews who are not trained in proper handling and release techniques may also unintentionally cause further harm to animals as they attempt to set them free, or put themselves in danger by engaging in unsafe practices, such as entering the water with the animals. Good practices related to the safe handling of marine mammals (e.g. Whaley and Borkowski, 2009; Hammer and Minton, 2020) should be promoted and followed as appropriate, while the emphasis should be on the prevention of bycatch and entanglement.

Due to the variability between species, populations, fisheries and local conditions, each fishery must consider the appropriateness of different techniques before their full implementation in a fishery, often through trials. More details on individual techniques and their effects on both marine mammals and target catch can be found in the companion document to these guidelines, the *Report of the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations* (FAO, 2018).

Abandoned, lost or otherwise discarded fishing gear (ALDFG) contributes to marine mammal bycatch. However, it can be difficult to differentiate entanglements that occurred in actively fished gear versus ALDFG, especially when animals such as large whales are capable of carrying off a good portion of the actively fished gear from the site where the initial encounter occurred. These guidelines therefore make very few references to ALDFG, while acknowledging that the problem is given extensive consideration by conservation organizations and fisheries management agencies.

Finally, this document only occasionally refers to how some marine mammal bycatch reduction techniques impact other taxa – such as sea turtles, sea birds, and elasmobranchs – or how techniques developed for those groups might affect

marine mammals. Nevertheless, an inherent assumption of these guidelines is that mitigation techniques should neither increase bycatch of other species nor significantly alter the ecosystem they inhabit.

## 3.1 Spatial closures

Spatial closures (also referred to as time–area closures) can be effective in reducing interactions between marine mammals and fishing gear in areas where they both occur. This applies especially in areas where marine mammals aggregate, such as breeding grounds, areas with seasonal prey abundance, migration corridors, or other critical habitats. Spatial closures ban or restrict fishing within all or a subset of a particular fishing zone, permanently or for a defined period of time (FAO, 2011b). The most restrictive are permanent closures, which are applied to all fisheries (marine protected areas that prohibit fishing and no fishing zones) or to specific gear types. Temporal closures can restrict fishing activity seasonally (seasonal or rolling closures), be triggered when bycatch limits within a zone or region are reached or exceeded, or implemented when certain marine mammal species, usually the most endangered species, are observed in the area (dynamic closures). Both permanent and temporal closures can be applied to entire fleets, specific gear types, and in some cases, individual fishers. The extent of fishing exclusion within and between categories of closure can vary among national and local jurisdictions. Regardless of the type of closure, it needs to be of an appropriate scale to meet management objectives. In other words, it must be located in the right places, or take place at the right times, be effectively managed and enforced to remove the principal threats, avoid introducing new threats, and consider the dynamic nature of the fishery and habitats used by marine mammals over time (FAO, 2018).

Spatial closures to restrict gillnet and pot fishing have been established in several countries in response to concerns about marine mammal bycatch; they include Australia, New Zealand, Mexico, the United States of America and the European Union (FAO, 2018). Some areas may be temporarily closed through a dynamic process, only coming into effect when a particular level of bycatch is reached or exceeded (bycatch quota/trigger limits), or when the presence of bycatch-prone species reaches a certain threshold during fishing

[2] One possible exception may be when the measure assists the conservation and recovery of a highly threatened marine mammal but has a negligible impact on the health and fitness of another population of marine animal that is not threatened.

operations. Such conditional regulations include: the 'consequence closures' to protect harbour porpoise (*Phocoena phocoena*) off the eastern United States of America; banning gillnets when the Potential Biological Removal target is reached (NMFS, 2010); and the 'dynamic closures' that are implemented when North Atlantic right whales (*Eubalaena glacialis*) are observed in, or near to, snow crab fishing grounds in Canada's Gulf of St. Lawrence. In both the United States of America and Canada, seasonally closed areas are also established in this species' critical habitats, mainly to prevent entanglements in pot fishing lines. In the gillnet fisheries off South Australia, a combination of permanent and temporal spatial closures is used to reduce bycatch interactions with Australian sea lions (*Neophoca cinerea*). Permanent spatial closures prevent gillnets from being set in areas of key sea lion habitats and in close proximity (4 to 11 nautical miles) to all breeding sites. The remainder of the fishery is split into seven zones, each of which is subjected to temporal (18-month) spatial closures whenever zone-specific bycatch trigger limits are reached (AFMA, 2014). In this same fishery, management provisions enable fishers to use alternate gears (longlines) inside the permanent gillnet closures, or inside zones that are subject to a temporal gillnet closure (AFMA, 2014).

In two Australian fisheries, spatial closures in particular fishing zones can be implemented with individual fishers where the total number of bycaught dolphins, or bycatch rates within a specified period, exceed management limits (AFMA, 2019a, 2019b). These management arrangements create incentives for fishers to innovate and adopt best practices. All fishing operations are electronically monitored. Fishers sometimes restrict the areas in which they fish voluntarily by using real-time reports on high rates of interactions between marine mammals and fisheries (Gilman *et al.*, 2006).

As a bycatch reduction measure, the objective of spatial closures is generally to avoid extinction and enable the recovery of a population or species. It is therefore important to determine management targets that are quantitatively measurable: for example, monitoring needs to determine whether bycatch is at or below the mortality numbers that do not prevent a population from maintaining or reaching a biologically viable, optimal size. For the most endangered and vulnerable populations, spatial closures are among the preferred management measures because they remove the fishing gear and so prevent direct interactions. However, spatial closures should be implemented proactively, well before populations are so depleted as to hinder the intrinsic rates of species recovery.

Many fisheries closures are static in space and time, whereas geographic distributions of marine mammals and target fish species can be dynamic. Static closures are more effective only when large amounts of bycatch occur consistently in the same areas and seasons (Murray *et al.*, 2000; FAO, 2011b). Moreover, it is often the case that areas used by many marine mammals are geographically broad and dynamic, suggesting that restricted zones should be sufficiently large or flexible to be effective (Kaiser, 2005). Examples of research tools to help optimize the design of closed areas include those used for the Australian sea lion – in which managers used models of biological (and economic) cost–benefit to evaluate different management options (Goldsworthy *et al.*, 2007, 2010; AFMA, 2014) – and Hector's dolphins (*Cephalorhynchus hectori*) in New Zealand (Slooten and Dawson, 2010; Slooten and Davies, 2012). The data needed to assess the optimal location and effectiveness of closed areas in reducing bycatch to sustainable levels includes marine mammal distribution, abundance, survival rates, population viability, year-to-year variability, distribution of fishing effort and level of bycatch. To be effective, spatial closures should have positive impacts not only within the areas themselves but also for the population as a whole.

Only a few studies have quantified the effect of closures on the bycatch species or populations of marine mammals for which they were established. Gormley *et al.* (2012) used tag-recapture data of Hector's dolphins in the vicinity of a small reserve in New Zealand that bans the use of gillnets: they found that the reserve increased the means of survival probability for the resident population, but the size of the reserve was in itself insufficient for the recovery of the overall population. Slooten (2013) modelled the potential for population recovery of this endangered species throughout its entire range under the existing spatial management system, and concluded that the existing scheme (reserve locations, sizes and management regimes) was unlikely to lead to a recovery of the Hector's dolphin population, and nor would it prevent the species from continuing its decline. Rojas-Bracho and Reeves (2013) concluded that protected areas needed to encompass the entire range of the critically endangered vaquita (*Phocoena sinus*) in order to eliminate bycatch completely and give the remaining population a higher probability of recovery.

The consensus from these studies is that adopting spatial closures as a principal management response for the reduction of bycatch of marine mammals did not achieve adequate – or indeed measurable – population recovery. This does not mean that they cannot contribute to achieving population stabilization

or recovery, but rather that their location, design and management require adequate information, monitoring and enforcement to be effective (Table 1). Fisheries managers who are considering spatial closures should also note that fishers generally oppose spatial closures, which typically exclude them from preferred fishing grounds. In addition, many countries, primarily developing ones, lack the capacity to enforce and monitor the closures effectively (Box 1). Finally, closures can lead to redirecting fishing effort to other areas, where concentrated fishing effort in smaller or more densely fished areas may result in even higher bycatch of marine mammals (O'Keefe *et al.*, 2014; Orphanides and Palka, 2013).

**Table 1. Pros and cons of using spatial closures**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Eliminates all or nearly all bycatch within the designated area (when effectively enforced)<br><br>May have other ecosystem benefits during the period the closure is in effect, such as avoiding environmental consequences from fishing or helping to rebuild fish populations | Does not always achieve the ultimate conservation benefit of population recovery<br><br>Requires reliable information on marine mammals (such as foraging areas) and fisheries activity, as well as effective management, monitoring and enforcement<br><br>Benefits limited to the designated area(s)<br><br>Can concentrate fishing effort outside the boundary in a small area, which can increase bycatch<br><br>Generally unpopular with fishers, who become excluded from their preferred fishing grounds | All species and populations that spend substantial time in the area |

## Box 1
## Guidelines for establishing, monitoring, and enforcing spatial closures

1. Provide adequate baseline data on marine mammal habitat use, fishing effort, bycatch rates, and other variables to feed into the location and design of closures.
2. Support fisheries monitoring programmes such as the use of trained and independent observers, and/or adequate electronic monitoring systems.
3. Identify functional mechanisms for collaboration between jurisdictions to enhance the effectiveness of spatial closures across the total range of a population, given that different fisheries pose varying entanglement and bycatch risks to marine mammals in different parts of their range. Instruments such as regional fishery management and intergovernmental agreements and conventions may support transboundary population (or shared resource) conservation efforts.
4. Use good science to ensure spatial closures are of appropriate size, in the right locations and implemented at appropriate times. They should be effectively managed and enforced to mitigate the bycatch threat and avoid introducing new threats, with the potential to be adapted based on changing circumstances in the fishery and/or marine mammal populations, including a shift in preferred fishing areas and marine mammal habitats.
5. Select locations of spatial closures so that they avoid redirecting fishing effort to areas in which the potential risk of bycatch is even greater, or to areas where commercial fish stocks are already overexploited by fisheries.
6. Insist on transparency and full disclosure on the selection process used to establish representative areas and the criteria for no-take/closed areas; engage all stakeholders in the full process from area selection to evaluation and monitoring.
7. Educate decision-makers on all types of spatial closures, and ensure they understand when these and other fisheries management measures may sometimes be more effective than spatial closures.
8. Build or strengthen in-country capacity for carrying out all the needs mentioned above.
9. Implement an effective system of control and enforcement.

During the development and implementation of spatial closures it also vital to apply:

- the ecosystem approach to fisheries (EAF)
- the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO, 2015),
- the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (FAO, 2012), and where appropriate,
- the FAO Technical Guidelines for Responsible Fisheries. No. 4. Fisheries management, Suppl. 4. Marine protected areas and fisheries (FAO, 2011a).

## 3.2 Acoustic alerting or deterrent devices

Acoustic alerting or deterrent devices (primarily pingers), can serve as an effective bycatch reduction measure in certain situations. In some fisheries, data from field research as well as those from fisheries observer monitoring marine mammal bycatch have shown that pingers can exclude certain species of marine mammal within the range of the sound field (Kraus *et al.*, 1997). However, an opposite effect can also occur, whereby some marine mammals become attracted to the devices, while others can suffer serious injury from the use of deterrents with high sound outputs (Dawson *et al.*, 2013).

Acoustic deterrents consist of a range of devices that either emit sounds, using electrical or mechanical means, or acoustically reflect those emitted by echolocating cetaceans. These devices may be deployed on or near fishing gear and include categories referred to as pingers, acoustic harassment devices (including seal-scarer devices), and acoustic alerting devices. Their intended use is to enhance detection of fishing gear by those cetaceans that echolocate for prey detection and other reasons: to do so, they may create an alert or unappealing sound that causes animals to avoid the sound source, or associate it with an obstacle to avoid. The units that actively produce sound span a range of power outputs that are measured in decibels (dB), audio frequency (Hz), sound duration, and the periodicity of sound emission –its duty cycle, which may be regular, random, or triggered by sounds such as those emitted by echolocating cetaceans.

Separating these devices into different categories is somewhat arbitrary, although it helps in understanding of how different units are designed to function.

*Pingers* tend to be relatively small, cylindrical units roughly the size of a soda can. They produce sound at different frequencies, although generally in the 3–70 kHz range, and lower than 180 dB (re 1 pPa @ 1 m). Some devices operate at random frequencies, such as the Dolphin Deterrence Devices produced by STM Products, which has a range of 5–500 kHz. Pingers are most commonly used to avoid the bycatch of small cetaceans in gillnets, harbour porpoise in particular.

*Acoustic Harassment Devices* (*AHDs*) are intended to deter animals from approaching fish traps or aquaculture cages and sea pens, using higher sound outputs that typically inflict pain or discomfort. Devices of 180 dB or higher are sometimes classified as AHDs to distinguish them from pingers (Long *et al.*, 2015). Seal-scarers are a type of AHD intended to keep seals and sea lions from preying on fish raised in aquaculture cages and sea pens.

*Passive acoustic devices* use air-filled or metallic components incorporated into fishing gear to increase their detection by echolocating cetaceans. The logic for using this approach is that marine mammals will avoid gear that they can detect acoustically.

*Predator sounds* mainly include the playback of killer whale calls, with the aim of prompting marine mammal prey species to flee or avoid the area the sound is being emitted from.

The most critical consideration is whether or not these deterrents elicit a behavioural response in a particular species such that bycatch is prevented or substantially reduced. Evidence shows that acoustic deterrents do not necessarily elicit a behavioural response that reduces bycatch for every marine mammal species. In controlled experiments comparing nets with and without pingers, and multi-year monitoring of bycatch levels, pingers have been shown to be effective in reducing bycatch or causing area avoidance for at least the following 7 species (although possibly as many as 12):

- harbour porpoise
- striped dolphin (*Stenella coeruleoalba*)
- franciscana dolphin (*Pontoporia blainvillei*)
- several beaked whales (Ziphiidae family) – Cuvier's, Hubb's, Stejneger's and Baird's beaked whale (see reviews in Dawson *et al.*, 2013; FAO, 2018).

A pinger trial involving Burmeister's porpoise (*Phocoena spinipinnis*) suggested that pingers might also help reduce bycatch of this species (Clay *et al.*, 2019), yet

acoustic deterrents appear ineffective with dugong (*Dugong dugon*) (Hodgson *et al.*, 2007). Similarly, while some North Atlantic right whales (Nowacek, 2004) showed a behavioural response to high frequency sound exposure – just as humpback whales (*Megaptera novaeangliae*) did to pinger sounds (Lien, 1992; Harcourt *et al.*, 2014; Pirotta *et al.*, 2016) – there is no evidence that the type of response will help prevent entanglements in fishing gear. Some species, such as bottlenose dolphin (*Tursiops truncatus*), are attracted to the sound of pingers, presumably because they associate the sound with easy-to-catch fish caught in gillnets (Cox *et al.*, 2004; Leeney *et al.*, 2007). As such, there is no indication that pingers deter bottlenose dolphins from entering trawl nets (Allen *et al.*, 2014). The interactions of both California (*Zalophus californianus*) and South American (*Otaria flavescens*) sea lions with gillnets appear to increase when acoustic deterrents are used; this has been termed the "dinner bell effect" (Barlow and Cameron, 2003; Bordino *et al.*, 2002; Carretta and Barlow, 2011). Increasing the frequency to make pingers less audible to pinnipeds may eliminate this undesirable outcome. A trial in Argentina using a pinger with a higher frequency of 70 kHz, instead of 10 kHz, showed a similar reduction in franciscana dolphin bycatch without increasing the attraction of sea lions (Bordino *et al*., 2004).

Playbacks of predator calls have shown some potential for deterring particular marine mammal species (Werner *et al.*, 2015), but they can also affect the behaviour of target fish, leading to a reduced target catch (Doksæter *et al.*, 2009).

Passive acoustic devices with enhanced reflecting materials have shown to be effective in some studies but not others (Trippel *et al.*, 2003; Bordino *et al.*, 2013), and would be limited to echolocating marine mammals.

Given the insufficient evidence of a bycatch prevention effect with louder devices (AHDs), predator playbacks or passive acoustic deterrents, it can be concluded that of all the devices available pingers are the most appropriate ones to use where they are effective.

In addition to species-specific differences, the effectiveness of acoustic deterrents is also dependent upon their experimental design, the fishery in which they are tested, the sound they create, the ambient noise level, gear type and fishing practices. Tests of the devices should therefore be carried out in local fisheries before widespread implementation. Monitoring the use of pingers is also critical to ensure that bycatch reduction targets are being met, even when they have been shown to reduce bycatch experimentally, as results reported from experiments often show greater reductions than when implemented in a fishery (Dawson *et al.*, 2013).

Introducing unnatural sounds into the environment is far from straightforward. Many variables influence how they are propagated, as well as how the sounds are received by animals, which in turn affects the degree of bycatch deterrence. A partial list of physical factors that influence sound propagation includes depth, bathymetry, temperature, turbulence, density of particulate matter, and refraction (Erbe *et al.*, 2018). Furthermore, acoustic deterrents vary in the strength of their signal and the directionality of sound waves. Pingers also have a range of duty cycles (i.e. the periodicity and duration of signal output, including how it is activated). The spacing of multiple units and whether or not they are all in working condition can also affect how effective they may act as a deterrent, with different sound frequencies attenuating at different distances from the source. Some guidelines for deploying pingers are provided in Box 2.

The costs of purchasing pingers and maintaining them can be a significant barrier to their use. Gillnets require several pingers along a net string at varying intervals, meaning that fishers must acquire and maintain numerous units. Based on anecdotal reports of injury when hauling solid objects, some models may also have safety issues, while some units can rupture when the battery becomes exposed to water after deployment in deep waters.

**Table 2. Pros and cons of using acoustic deterrents in gillnet fisheries**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Have demonstrated reduction in marine mammal bycatch for some species, and in some cases over many fishing seasons<br><br>Do not tend to affect target catch<br><br>Supported by a range of studies involving field trials, behavioural responses, and fisheries monitoring | Do not work for all species<br><br>Effect may be nullified or reduced depending on where they are deployed<br><br>In a few cases, species or populations may habituate, in which case the deterrent effect no longer works without adjustments (e.g. change in sound frequency) | Pinger trials report bycatch reduction or increased area avoidance for at least 7 (but possibly up to 12) species: harbour porpoise, striped dolphin, franciscana dolphin, and several beaked whales (Ziphiidae) – Cuvier's, Hubb's, Stejneger's, and Baird's beaked whale |

| Pros | Cons | Marine mammal species |
|---|---|---|
| Produced by a number of manufacturers with different models, some of which continue to receive upgrades to battery life, LED indicators that confirm proper function, modified duty cycles, and other features<br><br>Help reduce depredation by pinnipeds with increased sound frequency | May overly ensonify an environment and exclude some marine mammals from critical habitats when used at a large scale<br><br>Requires units that are functioning properly and spaced correctly to avoid the risk of increased bycatch<br><br>Some units emit high power outputs that can cause hearing impairment and other adverse health effects to marine mammals<br>When implemented, the level of bycatch reduction generally tends to be lower than that recorded in scientific trials; the use of acoustic deterrents is therefore a less suitable option for highly endangered species<br><br>When implemented, the level of bycatch reduction generally tends to be lower than that recorded in scientific trials; the use of acoustic deterrents is therefore a less suitable option for highly endangered species<br><br>There are reports that pingers can pose risks to fishermen, as devices have been known to explode during hauling, owing to increased gear weight<br><br>At certain frequencies, pingers may lead to increased depredation and bycatch through the “dinner bell effect” | Possibly effective for Burmeister’s porpoise<br><br>They do not appear effective for dugong, North Atlantic right whales, humpback whales and, in many instances, for bottlenose dolphins<br><br>In both California and South America, sea lion interactions with fishing nets appear to increase when acoustic deterrents are used; however, this can be managed by increasing pinger frequency |

**Box 2**
**Guidelines for deploying pingers**

1. Pingers should be used only when there is evidence for an area displacement effect, or the population is large enough and has adequate observer coverage for evaluating the long-term effects of using pingers.
2. The type of gear should be considered and fully assessed.
3. A minimum number of pingers is required to ensure adequate coverage of the sound field for producing the bycatch deterrence effect, which can be informed by guidelines from other fisheries but especially from local field trials.
4. Review the range of acoustic deterrents and select the one with sound characteristics and duty cycle that best meets the focal species, fishery and environment.
5. Engage fishers, gear engineers, marine mammologists, fisheries managers and other stakeholders in evaluating and deploying pingers.
6. Calculate an acceptable bycatch level or reduction effect and ensure adequate monitoring and enforcement of pingers in the fishery.
7. Identify any unintended consequences on other species and the environment exposed to the sound source.
8. Maintain the operating condition of pingers (e.g. sufficient battery charge, no leakage).

The use of acoustic deterrents without a carefully considered plan of deployment and appropriate monitoring can cause more harm than good. The improper or unmanaged uses of acoustic deterrents can create an assumption that the marine mammal bycatch problem has been solved when this is not the case, with potentially negative consequences for fishers, marine mammals and the environment. These may include habitat exclusion (if the units are deployed in a dense fishery that is also a major critical habitat for marine mammals), excessive sonification (saturating an area with an introduced source of sound), habituation, physical harm (such as long-term hearing impairment when using AHDs), and operational safety concerns. Encouragingly, habituation has not been reported from fisheries on the east- (multi-species gillnet) and west-coast (driftnet) fisheries of the United States of America, which have long-term monitoring data (FAO, 2018). Nevertheless, all of the concerns mentioned

above need to be considered prior to implementing acoustic deterrents in a fishery. The pros and cons of using acoustic deterrents in gillnet (and possible trawl) fisheries are presented in Table 2.

In summary, there is much evidence to support the contention that pingers are one of the best technical measures available to mitigate bycatch of some species, predominantly in gillnet fisheries. However, many factors can influence their effectiveness, suitability and/or practicality as a deterrent. They therefore require scientific evaluation within a fishery prior to their widespread implementation, and their use should be subject to ongoing monitoring.

## 3.3 Modifications to fishing gear

Fishing gear may be modified to reduce interactions with marine mammals or to facilitate animals to self-release when they become hooked or entrapped. There are many physical modifications, some of which have been tested and others are used but not adequately studied.

*Excluder devices*

Trawl fisheries that are prone to marine mammal bycatch should consider using excluder devices with escape openings (holes) through which these animals can exit the net after becoming entrapped.

Marine mammal excluder devices follow the same principle as turtle excluder devices (TEDs). An excluder device usually consists of a grid that allows the target catch to pass through to the codend but blocks the marine mammal from doing so because of its size. The grid is placed inside the net, before the codend, at an angle, so the mammal is directed towards an escape opening (Dotson *et al.*, 2010; Baker *et al.*, 2014). The escape opening is placed on the top or bottom of the net, but the top placement has proven the most effective for pinnipeds, perhaps because of their need to swim upwards for air (CCAMLR, 2017; Hamilton and Baker, 2015a; Tilzey *et al.*, 2006). However, in order for such devices to be effective, the escape responses and other behaviours of marine mammal species must be known, as well as the size and shape differences between target and bycatch animals. Similarly, towing speed, depth, gear characteristics, vessel size and the space available for hauling and stowing gear must be taken into account for each fishery when designing or implementing a marine mammal excluder device (Baker *et al.*, 2014; Hamilton and Baker, 2019).

Midwater trawls pose a greater risk to marine mammals than bottom trawls (Read, 1994) as they are usually large in size and towed at higher speeds; moreover, they target small, schooling species such as squid and herring, which are common prey species for marine mammals.

Video monitoring reveals that dolphins swim out of the mouth of the net (Wakefield *et al.*, 2017), as well as through the escape opening. As reported in the aforementioned study, the escape holes for bottlenose dolphins led to some dolphin escapes but also some mortality, and often the tail became lodged in the excluder device. The results from another study in a demersal trawl similarly produced mixed results, with a mixture of escapes and mortality (Santana-Garcon *et al.*, 2018). However, the result was based on observations of only four individuals. Morizur *et al.* (1999) found that dolphins were mostly caught in trawls at night or close to dawn, presumably as a result of their inability to see the netting and the direction of its progression.

Studies have shown conflicting results on the effectiveness of excluder devices in reducing bycatch for common bottlenose dolphins, common dolphins, Antarctic fur seal (*Arctocephalus gazella*), and South American sea lions, with minimal effects on target catch; however, the fate of escaped or excluded animals was not adequately evaluated. Observations of Australia's midwater trawls targeting small pelagics showed that most seals that entered the net exited through the escape opening in apparently good condition, and that large openings were more efficient in reducing lethal interactions (Lyle *et al.*, 2016). However, dead seals were also observed falling out of the net equipped with a bottom-opening seal exclusion device (SED). Based on recent research, the most advisable approach is to decrease the chances of these fallouts by attaching a hood or kite to the escape opening located at the top of the net, which includes a hard grid (Baker *et al.*, 2014; Hamilton and Baker, 2015a; Robertson 2015; and subsequent response by Hamilton and Baker, 2015b). Significant target fish loss out of the top escape opening with a backward-facing cover has been reported (Tilzey *et al.*, 2006). Some fishers may find the use of excluder devices appealing not necessarily from a mammal conservation perspective, but because the device can exclude live and/or dead animals which could affect its operation, and possibly also result in less catch being preyed upon or damaged.

Excluder devices are typically tailored to individual fisheries, fishing vessels and bycatch species because a single design is not suitable for all circumstances. One minor disadvantage of excluder devices is that they effectively render onboard observers blind to the true extent of marine mammal interactions.

Underwater video monitoring is essential to monitor interaction levels, detect cryptic mortality and optimize excluder design.

A semi-flexible grid angled to a bottom escape opening has been used in a multispecies trawl fishery, with a decline in target catch (Stephenson and Wells, 2006; Zeeberg *et al.*, 2006). Barriers located further forward in the net – between the large mesh and small mesh sections – caused unacceptably high levels of gear drag and a large reduction in fish catch (Bord Iascaigh Mhara and University of St. Andrews, 2010; Northridge *et al.*, 2005; van Marlen, 2007). Further research is needed to redesign and test devices for reducing dolphin bycatch, including whether or not a top escape opening would be effective in reducing cetacean bycatch and mortality (de Haan, 2014). Such research may include the optimal location for devices, size and visibility of escape opening, all of which would be informed by a better understanding dolphin behaviour inside the net and the factors that contribute to dolphin mortality (van Marlen, 2007). Apart from trawl fisheries, preliminary results have indicated that the use of excluder devices in stow nets off the coast of the Republic of Korea can reduce finless porpoise bycatch (IWC, 2016).

In summary, bycatch of pinnipeds in trawl fisheries can be reduced by the use of a top-opening excluder device to facilitate the escape of animals from the top of the net. The pros and cons of using excluder devices in trawl nets for reducing marine mammal bycatch are presented in Table 3. Nevertheless, certain operational parameters and species-specific design characteristics need to be met in order for them to function properly. For cetaceans, the effectiveness of these excluder devices appears more variable, and requires further research. In some cases, the use of excluder devices may result in reductions of target catch; this should be minimized through net design and further modification.

**Table 3. Pros and cons of using excluder devices in trawl fisheries**

| Pros | Cons | Marine mammal species |
|---|---|---|
| When properly designed for the concerned species, they tend to function adequately, at least in bottom trawls | Post-release survival requires more documentation<br><br>Many interactions go unobserved and may result in unaccounted mortality<br><br>Appear generally more effective with pinnipeds than cetaceans<br><br>May reduce target catch | Bottlenose dolphins, common dolphins, and potentially other small cetaceans; Australian, South American and Antarctic fur seals; other pinnipeds |

*Weak ropes/links – pots and gillnets*

Weak ropes in pot and gillnets, as well as weak gillnet webbing, may help entangled baleen whales shed gear, thereby reducing mortality and serious injury.

In the United States of America, regulatory measures under the Atlantic Large Whale Take Reduction Plan require that weak links with a maximum breaking strength of 500 kgf (kilogram-force)[3] are placed just below the buoy in gillnet and pots, at the uppermost portion of the vertical line (NMFS, 2010). Weak links are also required in other parts of gillnets. Depending on the area fished, the load threshold generally ranges between 90–900 and 270–680 kgf. However, there is no evidence to support that the incorporation of weak links below the buoy in pots (or gillnets) have reduced either the incidence or severity of large whale entanglements off the east coast of the United States of America (Pace *et al.*, 2014), and a lot of gear retrieved from entangled whales still has these links attached (see Large Whale Entanglement Reports from the NOAA Greater Atlantic Regional Fisheries Office).[4]

[3] 1 kgf = 9.806 N in SI unit

[4] https://www.greateratlantic.fisheries.noaa.gov/protected/whaletrp/reports/index.html

Knowlton *et al.* (2016) concluded that whales would be more likely to break free from ropes with breaking strengths of 771 kgf or less. Instead of using a single weak link placed immediately below the buoy, using the design specifications allowed in the American lobster fishery, alternative designs would distribute lower breaking strength along the length of the rope. Based on at-sea testing in the American lobster fishery and computer modelling studies, ropes with 771 kgf braided sleeves represent a suitable option, at least in inshore waters, providing whales with a better chance of freeing themselves from the ropes (Knowlton *et al.*, 2018). Two design options are currently available: the first involves constructing the entire rope with this breaking strength, and the other is to incorporate braided sleeves in which the bitter ends of cut vertical line can be inserted to make a rope with multiple weak links.

Thinner twines in gillnets might facilitate marine mammals breaking free from them, however net damage and other concerns mean this technique requires further evaluation (FAO, 2018).

*Weak hooks – longlines*

The use of weak hooks can reduce the bycatch of toothed whales (odontocetes) in longlines but can also result in significant reductions in the catch volume and preferred sizes of the target species in some circumstances.

Weak hooks in pelagic longline fisheries involve decreasing the hooks' bending strength to such a degree that they can be straightened when marine mammals remove catch or bait from them, while remaining strong enough to retain target catch, thus facilitating release of marine mammals (Bayse and Kerstetter, 2010; Bigelow *et al.*, 2012). Kerstetter (2012) found comparable catch rates of tuna and swordfish using weaker hooks, although the size of swordfish may have decreased compared to when stronger hooks were used. Only weaker hooks showed straightening as observed after hauling. A trial of weak hooks off Hawaii showed no statistical difference in tuna catch between weak and strong hooks, with the majority of straightened hooks occurring in weak hooks (Bigelow *et al.*, 2012). However, the study was not carried out during the season when the largest tuna tend to be caught. Weak hooks involve minimal change and expense to current practices, and require no knowledge of how animals cue into gear or fishing operations. While this technique may reduce bycatch, it does not address catch loss from depredation. In addition, hook construction and the material used in its fabrication can affect these results (McLellan *et al.*, 2015).

The pros and cons of using gear with lower breaking or bending strength in pots, longlines and gillnet fisheries are presented in Table 4.

**Table 4. Pros and cons of using gear with lower breaking or bending strength**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Ropes with reduced breaking strength can lower the incidence and severity of larger baleen whale (mysticete) entanglements | Weaker ropes in pot fisheries may not work with heavier offshore gear, and do not entirely eliminate entanglements | Pilot whales (*Globicephala* spp.), false killer whales, pelagic toothed whales (odontocetes), North Atlantic right whales and other baleen whales (mysticetes) |
| In some fisheries, there is a comparable catch between traditional and modified gear | Weaker longline hooks may lead to a reduced catch of larger size classes of the target species | |
| Weak hooks can be straightened by marine mammals, which facilitates their escape and reduces injury | Post-hooking survival remains undocumented | |

*Tie-downs/lowered net profile – gillnets*

Tie-downs may be used to reduce the bycatch of small cetaceans caught in bottom-set, midwater or driftnet gillnet fisheries.

Tie-downs are lines that are shorter than the height of the fishing net, with terminal ends that are attached to the float line and lead line along the net, at equal horizontal distances. Tie-downs reduce the profile of the gillnet and create a more vertically curved shape to the net. One trial examined the effect of tie-downs on the bycatch of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in a sink gillnet fishery for monkfish (*Lophius americanus*) off the eastern coast of the United States of America. The results showed no bycatch of common dolphins in gillnets with tie-downs, while six were caught in gillnets without tie-downs (as well as an additional three unidentified species of dolphins) (Fox *et al*., 2011). The trial involved a total of 120 hauls of combined net types. Elsewhere, an analysis of American observer data found the use of tie-downs was associated with lower bycatch rates of harbour porpoise in gillnets (Palka, 2000).

Other methods for reducing a gillnet's vertical profile in the water column have been tested. The rationale of this approach is to deploy the net in such a way that its vertical profile occupies an area of the water column that optimizes the catch of target species but excludes marine mammals. Hembree and Harwood (1987) recorded a 50 percent reduction in small cetacean bycatch by lowering the depth of a gillnet headline in a subsurface set. However, they also reported a reduced target catch. However, an experiment to test gillnets without floats but with a floating headline, compared to gillnets with regular polypropylene floats, found that bycatch rates for harbour porpoise were significantly higher in nets without floats (SMRU, 2001). Even though these nets probably had a lower vertical profile, the elimination of floats probably made the net acoustically less "visible" to the porpoise. In addition, any evaluation of these techniques needs to record the impact on target catch to ensure that a net with a lower vertical profile is not simply reducing both target catch and bycatch because of the net's reduced fishing area.

**Table 5. Pros and cons of using tie-downs and nets with lower profile in (bottom, midwater, and surface/drift) gillnet fisheries**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Reduces bycatch of some small marine mammals | May reduce target catch<br><br>Can increase bycatch of other species such as sea turtles | Harbour porpoise, common dolphin, other cetaceans |

*Ropeless fishing – pots*

Removing vertical lines from the water column is probably one of the most effective ways to ensure that large whales do not become entangled in them. Companies in Australia, Canada and the United States of America are involved in evaluating different ropeless fishing systems to reduce whale entanglements. Given the high entanglement risk that ropes pose to baleen whales worldwide and the danger to disentanglement teams when attempting to remove ropes from these large animals in distress, these efforts should continue.

Ropeless fishing involves the retention of buoy lines on or near the seafloor, except during setting and hauling. Haul lines can be recalled to the surface by releasing bottom-stowed ropes and floats using mechanical, acoustic or

galvanic timed releases (GTRs). Release mechanisms other than GTRs can consist of a solenoid, burn wire or mechanical motor that secures vertical line systems at depth, which can be triggered by a digital timer or an acoustic release. If groundlines are used to attach pots together on the seafloor, the use of a grappling hook is another retrieval option. Individual pots might also use inflatable bags to bring them to the surface.

The New South Wales rock lobster pot fishery in Australia has used bottom-stowed vertical lines for more than a decade (Liggins, 2013). Researchers and fishers in the eastern United States of America have carried out three separate trials of prototype units that contained buoys and buoy lines near the ocean floor, except when hauling, in which they demonstrated the technology's viability (DeAlteris, 1999; Hopkins and Hoggard, 2006; Allen and DeAlteris, 2007). Challenges remain however, including the following:

- Surface buoys provide visual markers to all fishers and other boaters of the presence of underwater gear. Eliminating them could lead to a higher incidence of gear conflicts because other fishers are unaware about the location of gear underneath.
- Acoustic releases, which give fishers the greatest flexibility as to when to retrieve the gear, can be expensive, requiring at least one transponder, mechanical release, and a containment system for at least one vertical line per gear set, as well as a deck-based acoustic signal transmitter. However, the high cost of prototypes would certainly come down with technological refinements and economy of scale through higher sales.
- Depending on how the rope is contained, as well as how it is released, there may be a higher incidence of the rope becoming tangled or snarled during retrieval.
- Regulators have expressed concerns that the inability to monitor gear from the ocean surface might obscure unregulated fishing. Monitoring subsurface gear sets relies on the ability to detect a surface buoy visually.

None of these challenges seem insurmountable, but they do require investment in their research and development. Some pros and cons of ropeless fishing in pot fisheries are presented in Table 6.

**Table 6. Pros and cons of using ropeless fishing**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Should eliminate or significantly reduce entanglements of whales (as well as leatherback sea turtles and basking sharks); no significant effect on target catch anticipated. | Requires considerable evaluation of appropriate gear designs for different fisheries, including the development of a system for visualizing ropeless gear at depth<br><br>Relatively expensive<br><br>Possibility of gear loss | Baleen whales (mysticetes). |

*Sinking or neutrally buoyant groundline – pots*

Making groundlines negatively or neutrally buoyant is intended to remove them from the water column so that they have a lower probability of entangling mysticete whales. It is a technique only applicable when two or more pots are rigged together along the seafloor. Although this measure should lead to reduced entanglement probability, the risk would not necessarily be eliminated. For example, Critically Endangered North Atlantic right whales feed at, or very close to, the seabed (Hamilton and Kraus, 2019). Lobster pot fishers in the U.S. northeast also report a number of operational challenges (FAO, 2018), but have largely adapted to operating under this regulatory change.

**Table 7. Pros and cons of using sinking groundline in pot fisheries using strings of multiple pots**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Removes entangling groundline ropes from the water column which likely reduces risk | Decreases the operational life of groundlines due to increased chafing and siltation through contact with the seafloor<br><br>May increase 'hang-downs', in which ropes become lodged under rocks or other fishing gear and therefore make hauling more difficult<br><br>Does not entirely eliminate entanglement risk because some whales come into contact with the seabed | Mysticete whales |

*Entrance and bait well barriers – pots*

Fish and shellfish pots can incorporate physical barriers or modified entrances that allow target species to enter while preventing or deterring predatory marine mammals – most notably pinnipeds and sea otters – from becoming trapped.

This technique makes it more difficult for marine mammals to prey on bait or catch by reaching into the pot, thus avoiding entrapment which can result in drowning, injury or lower target catch. To prevent pinnipeds, cetaceans or otters from reaching their heads into a pot and removing target catch or bait, a pole or spike can be inserted inside a pot so that its other end extends out towards the pot opening. When designed properly, these poles effectively deter depredation and prevent entrapment in lobster pots by Australian sea lions (Campbell *et al.*, 2008; Goldsworthy *et al.*, 2010; Mackay and Goldsworthy, 2017). Furthermore, Goldsworthy *et al.* (2010) found that where a pole extends to the base of the pot-collar this had no impact on catch rates or lobster size. Another technique modifies the size and/or composition of the innermost opening of the pot entrance to prevent entry by marine mammals. Solid rings of steel prevent seals in the Baltic Sea from gaining entry into cod pots (Königson *et al.*, 2015a). Hatfield et al. (2011) found during laboratory experiments that decreasing the diameter of entrance of crab and other shellfish pots would

reduce the entry rate of sea otters (*Enhydra lutris*) in the pot fisheries off the west coast of the United States of America. Finally, changing how bait bag openings were secured by using bungee cords in Florida's blue crab pot fishery eliminated nearly all interactions with bottlenose dolphins (Noke and Odell, 2002). While few concerns appear associated with these techniques which are relatively simple to implement, they require careful design considerations to have the desired effect on bycatch without affecting target catch.

**Table 8. Pros and cons of using entrance and bait barriers in pot fisheries**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Prevents the heads of marine mammals from entering the gear and becoming entrapped by preying on target catch | None reported | Pinnipeds, otters, small cetaceans (at least bottlenose dolphins) |

*Catch-protecting gear – Longlines*

The purpose of catch-protecting gear is to envelop longline catch in metal chains, nylon filaments, or a conical net sleeve before and during hauling to deter marine mammals from removing or partially consuming the hooked catch. Moreno *et al.* (2008) reported reduced depredation rates by sperm whales and South American sea lion in surface waters on demersal longlines when using a conical net that surrounds the target catch during hauling; over time, they also recorded fewer observations of sperm whales in the vicinity of longline fishing. These authors assumed that eliminating the opportunity to prey on target catch may decrease the extent to which the population associates this gear with a feeding opportunity. Other studies of catch-protecting devices have shown limited success or had sample sizes too small to determine their effectiveness. These trials are summarized in the FAO (2018) report.

**Table 9. Pros and cons of using catch-protecting gear in demersal longline fisheries**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Some evidence shows reduced depredation rates<br><br>The cost of new equipment may be at least partially offset by an increase of retained catch (neither removed nor partially eaten through depredation)<br><br>Continued and persistent use of these devices possibly alters depredation behaviour in marine mammal populations<br><br>Better catch quality and higher catch retention rate | Units can sometimes fail to release components that encapsulate target catch, or become tangled<br><br>Deployment takes additional time and results in increased labour time and operating costs | Killer whales, sperm whales and South American sea lion |

*Other gear modifications*

A more detailed discussion of these and other measures can be found in FAO (2018), which describes additional techniques that may be worth considering but which have not as yet been sufficiently developed to suggest effectiveness or promise, or which may result in catch levels that are too low to support viable fisheries. These techniques include:

- camouflage of target catch in pelagic longlines;
- increasing the vertical tension or stiffness of gillnets and buoy lines;
- decreasing gillnet mesh size;
- the deployment of decoy sets in pelagic longlines;
- using a “dolphin gate/weighted cork line” in purse seines;
- electric barriers in gillnets;
- noxious bait;
- devices attached to pot ropes that cause them to sever after a set time; and
- dampening vessel noise to eliminate an acoustic cue that attracts depredating cetaceans.

## 3.4 Changes to fishing operations

Changes in the way fishing operations are conducted may reduce bycatch of marine mammals. However, many measures outlined in guidelines and codes of practice are difficult to enforce and often rely heavily on voluntary adoption by the fishing industry.

*Backdown and other net deployment procedures – Purse seines*

With the Agreement on the International Dolphin Conservation Programme (AIDCP), dolphin mortality in eastern tropical Pacific tuna purse seine fishery has been significantly reduced. While "set on dolphin" practice has not been banned in the AIDCP area, the practice has been drastically curtailed as a result of the implementation of dolphin mortality limits (DML) and a shift to sets around fish aggregation devices (FADs). Relevant management measures and agreements regarding the banning or prohibiting of setting on cetaceans while purse seining for tuna is described later on in this section. When marine mammals occur in a purse seine net, prior to completing the hauling procedure a fishing vessel should endeavour to release them with minimal harm.

One specific fishing method, the backdown procedure, has greatly contributed to the reduction of bycatch of small cetaceans in purse seine fisheries in the eastern tropical Pacific (Hall and Roman, 2013). This solution was developed as a mitigation measure for the well-documented tuna dolphin problem and is widely used (and required) in that region's purse seine tuna fishery. The backdown procedure is effective when combined with the use of dolphin-safe techniques or rescue methods, in addition to the Medina Panel (dolphin safety panel). The backdown occurs after the majority of the net is on board. At this point net retrieval is stopped, the net is tied to the vessel and the engine is put into reverse. This creates a water current that causes the remaining net to form a long channel in the water. The water current pulls the end of the channel underwater, thereby providing an area for dolphins to escape (Bratten and Hall, 1996), which is facilitated by herding dolphins using rafts, swimmers and skiffs to maintain the shape of the seine net (NRC, 1992). Together with the use of the Medina Panel, a small-mesh net liner at the apex of the net, this technique has resulted in significant reductions in mortality for several species of dolphins in the eastern tropical Pacific (Hall and Roman, 2013).

**Table 10. Pros and cons of using backdown/net deployment procedures in purse seine fishing**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Facilitates the escape of dolphins trapped in nets during hauling | Requires additional crew to assist in dolphin escape and the use of a Medina panel | Small cetaceans |

*Gear rigging*

For pot, gillnet, longline, and other similar static gear types, in which multi-gear strings are used, reducing the ratio of vertical lines to units of gear would limit the number of vertical lines and probability of encounter with marine mammals (NMFS, 2015). However, in response to this measure some fishers have reported increasing the diameter of buoy lines to support heavier bottom-set gear, which likely decreases the probability that marine mammals can break free of it (Knowlton *et al.*, 2016). Increasing the number of pots per string will also increase groundline length, which in turns causes the entanglement of marine mammals. It is therefore important to note that any potentially beneficial change must also account for unintended consequences.

*Gear switching*

Where no strategies appear viable and solutions to marine mammal bycatch seem limited – or the challenges of implementing them look extremely daunting – fisheries managers should consider changing the type of gear used in a fishery to one that maintains commercial viability but poses a lower risk to marine mammals. Table 11 summarizes the results of studies that assessed the effectiveness of three alternatives to gillnets, pots, longlines or trawls. The table focuses primarily on the study results with respect to comparing target catch efficiency and size selectivity with assumptions about the reduction of marine mammal bycatch for the alternative gear or with recorded comparisons of both gillnet and the alternative gear.

**Table 11. Gear-switching trials undertaken to determine the potential of gillnet alternatives for reducing bycatch or the interactions of marine mammals (Source: FAO, 2018)**

| Location | Target catch | Marine mammal species | Alternative gear wwtested | Result | Reference |
|---|---|---|---|---|---|
| Baltic Sea (Sweden) | Cod (*Gadus morhua*) | Seals | Longline | Comparable catch levels; reduced seal interactions | Vetemaa and Ložys, 2009 |
| Baltic Sea (Sweden) | Cod | Harbour porpoise | Longline | Comparable catch levels based on logbook data; seasonally dependent | Königson and Hagberg, 2007 |
| Iceland | Cod | Harbour porpoise | Longline | Gear change occurred to meet market demand for fresher product; longlining has increased while gillnetting has decreased, resulting in reduced porpoise bycatch | Pálsson *et al.*, 2015 |
| Baltic Sea (Sweden) | Cod | Grey seals/ harbour seals | Pots | Comparable catch levels but with seasonal variability; no bycatch of seals when using a SED (Seal Excluder Device) | Königson *et al.*, 2015b |
| Baltic Sea (Germany) | Cod and other species | Harbour porpoise | Longline | Higher species selectivity (cod) in pots, but catch per unit of effort (CPUE) is higher with gillnets; no bycatch of porpoise in either gillnets or pots, but seabirds caught only in gillnets | Pusch, 2011 |

| Location | Target catch | Marine mammal species | Alternative gear wwtested | Result | Reference |
|---|---|---|---|---|---|
| Baltic Sea (Sweden) | Cod | Seals | Longline | The focus of the experiment was on evaluating catchability of cod in pots with different mesh sizes; seal exclusion from pots was inconclusive | Ovegård *et al.*, 2011 |
| Gulf of California (Mexico) | Shrimp (*Penaeus stylirostris / P. californiensis*) | Vaquita | Longline | First study was inconclusive with no shrimp caught; a more recent trial showed that the gear had commercial potential | Walsh *et al.*, 2004; Villadsen, 2018 |
| Gulf of California (Mexico) | Shrimp (*Penaeus stylirostris/P. californiensis*) | Vaquita | Trawls | Several trials conducted over multiple years indicated that experimental trawls did continue to catch shrimp | Aguilar-Ramirez and Rodriguez-Valencia, 2012 |
| Great Australian Bight (Australia) | Gummy shark (*Mustelus antarcticus*) | Australian sea lion/ common dolphin | Longline | Longlines can be used successfully to target gummy shark, comprising 60 percent of catch; some increase in seabird bycatch | Knuckey *et al.*, 2014 |

Longline vs. gillnet. Generally, differences in catch amount, species composition and size selectivity occur between gillnets and longlines (Santos *et al.*, 2002; Stergiou and Erzini, 2002; Erzini *et al.*, 2003), and these are among the issues to examine when considering switching from gillnets to longlines. Longlines have a greater chance of hauling in live or much fresher catch than

gillnets, which generally require longer soak times. This can in turn increase the quality of catch and price in the market. The gear shift is market-driven, as the market has revealed a greater demand for fresh products instead of the traditional salt cod in the Icelandic cod fishery. In 1989, around 25 percent of the landed catch of cod was caught in gillnets, while 13 percent was caught on longlines; in 2017, 7 percent was caught in gillnets, but 31 percent on longlines (MFRI, 2019). The number of boats active in the gillnet fishery (boats that land more than 1 tonne) has also dropped from over 240 in 1994 to around 60 vessels in 2016–2018 (MFRI, 2019). Demersal longlines offer an alternative to bottom-set gillnets, with comparable catch for target species, but may be appropriate only at certain times of the year and in certain locations (Königson *et al.*, 2015b).

Pot vs. gillnet. Where entanglements of large whales or other endangered groups of non-target species is unlikely or minimal, fishing with pots occasionally has the potential to eliminate bycatch, especially where porpoises and dolphins are frequently caught in gillnets.

Trawl vs. gillnet. Although trawl nets do catch cetaceans in various parts of the world (Northridge *et al.*, 2003; Zollett, 2009; Reeves *et al.*, 2013), the levels of bycatch and mortality are generally much lower than in gillnets (Read, 2006). In cases where the risk of bycatch mortality in trawls is relatively low, trials conducted often focus more on comparing the effect on target catch and less on monitoring the bycatch of marine mammals.

Summary – gear switching. Several gear-switching trials undertaken to date have produced encouraging results, indicating significant potential for this strategy to help reduce marine mammal bycatch in gillnets. Justification for considering the use of alternative gear types should be based on adequate scientific evidence, namely:

- the bycatch of the animals of concern is significantly reduced;
- catches of target species are comparable to gillnets or the fishing gear in question; and
- the switch does not result in negative consequences for other species, habitats or ecosystems in general.

**Table 12. Pros and cons of switching from gillnets to other gears in terms of effects on marine mammal bycatch in fisheries**

| Pros | Cons | Marine mammal species |
|---|---|---|
| Often provides comparable catch using entirely different gear that is less risky to marine mammals in particular locations | Transitioning from successful trials to fishery implementation has rarely occurred and faces several challenges | Small cetaceans, pinnipeds |
| Can provide catch of higher quality and thus of higher value to fishers and consumers | Catches of target species can be slightly lower | |

*Binding measures and codes of conduct/practice*

Regional bodies may adopt binding measures to prevent and reduce marine mammal bycatch. One example is provided in the Indian Ocean Tuna Commission (IOTC) Resolution 13/04 on the conservation of cetaceans. Paragraph 2 of this resolution states that Contracting Parties and Cooperating Non-Contracting Parties shall prohibit their flagged vessels from intentionally setting a purse seine net around a cetacean in the IOTC area of competence, if the animal is sighted prior to the commencement of the set.

Some fisheries adopt voluntary codes of conduct in order to mitigate marine mammal bycatch, including the following examples:

- Under the South Australia Sardine Association 2015 Code of Practice, fishing vessels are to adopt several operational procedures including:
  - avoiding known areas of dolphin aggregation;
  - notifying the skipper of the presence or absence of dolphins before setting gear;
  - delaying or relocating fishing activity if dolphins are detected;
  - initiating release procedures without delay when encircled dolphin(s) are detected, including stopping the net roll, dropping one end of the net and guiding the animal out of it; and
  - aborting fishing altogether if attempts to release encircled dolphins fail.
- Under the Elements of the Code of Fishing Practice for the Australia blue grenadier (*Macruronus novaezelandiae*) fishery (Tilzey *et al.*,

2006), New Zealand deep-water trawl fisheries (Deepwater Group, 2017), and the Southeast Trawl Fishing Industry Association (SETFIA, 2007), which outline operational measures to reduce bycatch of marine mammals. Tilzey *et al.* (2006) indicate that implementing this code reduced seal bycatch by half. Measures in the code include:

- rapid hauling, delaying deployment if seals are sighted;
- release of animals that are caught, closure of net during recovery;
- not dumping offal;
- actively steaming away from seals before deploying nets;
- undertake gear deployment and trawling as quickly as possible;
- removal of meshed fish (stickers) prior to use;
- no discarding of unwanted fish or offal on fishing grounds;
- where possible, adopting techniques to close trawl opening during recovery to minimize opportunities for seals to enter the net;
- not executing turns or changes of direction with doors deployed and net mouth open near surface; and
- if, after the gantry lights are switched off during night trawling, large numbers of marine mammals (more than five) congregate around the vessel when the gear is hauled, the vessel should steam away from them before setting gear again.

*Conclusions regarding technical measures*

Many options exist for reducing bycatch of marine mammals. However, they generally require evaluation within a local fishery to determine whether they are as effective as tests or experiments conducted in another fishery may suggest. Significant variability exists in fishing practices between different locations, as well as differences in marine mammal population characteristics, oceanographic conditions, local scientific and management capacities. Social, cultural and economic circumstances also make it difficult to simply apply an existing technique "off the shelf".

When the use of bycatch reduction measures lacks solid scientific justification for adopting them, promoting their use risks providing a false sense of security and a misplaced perception that the problem is being solved. In the absence of solid scientific justification, economic impact assessments may be an effective approach to achieving acceptance and adoption of bycatch measures by the fishing industry. Several fishing groups promote best practices that may sound like good ideas from a common-sense standpoint, however for some there is no evidence that they are effective. For example, some pot fisheries

recommend using negatively buoyant ropes that connect pots to avoid whale entanglement. The assumption underlying this practice is that whales are less likely to become entangled in a rope that is lying on the seabed rather than floating in the water column. Even though removing ropes from the water column has likely benefits, the North Atlantic right whale feed at multiple depths (Baumgartner *et al.*, 2017), including coming into contact with the seafloor (Hamilton and Kraus, 2019).

There is no quick fix to marine mammal bycatch, and what may work for marine mammal bycatch reduction must also avoid unintended threats to them and their habitats, minimize reductions in target catch, and not increase bycatch of other protected species. As some modifications may render a measure effective when previous trials showed no or insufficient bycatch reduction, the collective results should guide the selection of techniques to evaluate the most promising, while appreciating that even minor modifications (e.g. slight changes in hook curvature) can produce different results.

Involving fishers in identifying solutions from the outset should be a component of any initiative to identify sustainable marine mammal bycatch solutions. They have the best understanding of what fishing techniques are the most practical, how innovations might best be incorporated into existing gear, vessels and fishing grounds, provide essential buy-in to modified fishing practices, and have a critical role in the design and testing of gear modifications.

## 3.5 Other strategies

Other strategies have been put forward as potential tools for reducing bycatch. However, based on the information available, only some of these other tools have been used, and only in combination with one or more of the mitigation techniques discussed above.

*Improving fishing efficiency*

Bycatch can essentially be regarded as an inefficiency related to the catching of target species, at least when the target catch is specifically identified. Greater efficiency and precision in catching target species can therefore reduce fishing effort in output-controlled fisheries, and thus help reduce the bycatch of marine mammals. This can include decreasing soak time, or the number of gear units used in static gear fisheries, or operating time in mobile gear fisheries.

*Conservation offsets/Compensatory mitigation*

This concept would identify alternative off-setting conservation measures for the bycatch of marine mammals, which would be funded by the fishery causing that bycatch (Wilcox and Donlon, 2017; Finkelstein *et al.*, 2008). For example, bycatch of seals might be offset by supporting projects that reverse population loss within their breeding or haul-out sites on land. This approach does not appear to have been implemented to date, at least for marine mammals, and several studies have suggested that it may be unworkable or involve too many limitations (See for example, Finkelstein *et al.*, 2008; Žydelis *et al.*, 2009).

*Economic strategies*

Even when fishing trials indicate the potential to use alternative gear to reduce the bycatch of marine mammals, rarely do they also include complementary studies (economic, political, social, cultural, etc.) that can facilitate uptake of this new gear by fishers, and move forward from a research to an implementation phase. There is a need to build on encouraging results from trials by conducting supporting studies that assess and remove social, cultural and economic barriers towards implementing fishing gear or operational changes. Furthermore, because there is often resistance to change within fisheries, the science–policy interface should be developed; persistence on the part of scientists and fisheries managers is also needed to help address barriers and provide incentives for the uptake of more sustainable practices. Critical to the success of transforming fishing practices is a focus on the following incentives to change.

Fisheries buybacks. There are examples of public and private funding designated for fishers to curtail fishing or compensate them to cease practices that do not support biodiversity conservation goals (Squires, 2010). In Mexico, three types of funding to curb the use of gillnets entangling the critically endangered vaquita porpoise were provided under the Species Conservation Action Plan for the Vaquita: An Integrated Strategy of Management and Sustainable Use of Marine and Coastal Resources in the Upper Gulf of California (PACE-Vaquita) (Rojas-Bracho and Reeves, 2013):

- buyouts that enabled fishers to change their livelihood from fishing to other business;
- switch-outs that supported fishers to replace gillnets and trammel nets with another gear type that would not cause vaquita bycatch; and

- rent-outs that compensated fishers to only fish outside of a refuge established to conserve the vaquita.

Studies concluded that the benefits of the programme had mixed results, in part because of insufficient monitoring and enforcement; ultimately the species has declined to such a degree that only an estimated ten individuals remain (CIRVA, 2019).

*Individual transferable quotas (ITQs)*

ITQs are commonly used to allocate catch limits among fleets or individual fishing vessels but are less commonly used for bycatch. Quotas can be applied either individually or fleet-wide and allow for their transfer, purchase and lease (Alverson *et al.*, 1994, O'Keefe *et al.*, 2013). A study using a Bayesian analysis applied to a squid fishery in New Zealand with bycatch of Hooker's sea lion (*Phocarctos hookeri*), concluded that any gains in the population of sea lions was far less than what was lost in squid catch (Maunder *et al.*, 2000).

The Inter-American Tropical Tuna Commission (IATTC) allocates an annual quota of 5 000 dolphin mortalities in Eastern Tropical Pacific purse seine fisheries under the Agreement on the International Dolphin Conservation Programme (AIDCP), a legally binding, multilateral agreement administered by the IATTC (IATTC 2007a, IATTC 2007b). In the event that the mortality of any single species is exceeded (as recorded by fisheries observers), all sets on dolphins become prohibited for the remainder of the year and annual mortality caps are established for individual dolphin stocks – which equate to 0.1 percent of each stock's minimum estimated abundance (IATTC 2007a, IATTC 2007b). This quota acts in combination with other mitigation measures described above and has resulted in significant reductions of marine mammal bycatch from hundreds of thousands to fewer than 1 000 in recent years (IATTC, 2017, 2018, 2019).

In two Australian fisheries, spatial closures can be applied to individual fishers in particular fishing zones when the total number of bycaught dolphins, or bycatch rates within a specified period, exceed management limits (AFMA, 2019a, 2019b). The objective of this approach is to create incentives for fishers to innovate and prevent marine mammal bycatch. It also avoids unfairly penalizing fishers who have already minimized bycatch interactions.

Squires and Garcia (2018) summarize the use of ITQs in the American groundfish fishery, and how quotas on bycatch, as well as target catch, create

an incentive to minimize bycatch for the fisher holding an ITQ. This permits the fishers to continue fishing and adopt techniques that seek to avoid bycatch. Bisack and Sutinen (2006) modelled the benefits of ITQs versus spatial closures for harbour porpoise bycatch in the New England sink gillnet fishery. The model incorporated spatial and temporal patterns of fish species and marine mammals over several seasons and years. The results showed that the ITQs were less costly to the industry compared to the season-port closures. The difference between the two changed depending on the bycatch limit, although ITQs incurred the lowest cost to the fishery in all cases.

*Credit systems or Penalty-and-Reward systems*

No examples exist yet for these types of market-based programmes for marine mammal bycatch. The concept involves rewarding vessels that satisfy a bycatch limit by adopting recommended bycatch-reducing gear or operating techniques, refraining from fishing in an undesired area or time, or adopting some other bycatch reduction measures. The reward (credit) targets an individual fishery, and can include, for example, additional days at sea in an effort-regulated fishery, target catch, or ITQ allocation in a catch-regulated fishery. The reward or credit incentivizes bycatch reduction by offsetting any foregone catch and revenue, the costs of new bycatch-reducing gear, or any direct or indirect costs associated with implementation of another bycatch reduction measure. These schemes might also penalize a fishery by reducing days at sea, market access, or area fished. The programme requires some form of monitoring, control, and surveillance (MCS), and can be combined with other bycatch reducing measures such as move-on rules.

# 4. RESEARCH AND DEVELOPMENT: ISSUES AND FUTURE DIRECTIONS

The previous chapters demonstrated several technologies and methods that have been trialed and occasionally implemented to reduce the bycatch of marine mammals in capture fisheries. They have also shown that further research, trials, development and dissemination of successes and failures are highly needed. As the field continues to evolve, additional strategies currently undergoing evaluation are summarized in this section.

## 4.1 Modelling bycatch probabilities

For the most endangered species of marine mammals, reliance on a multi-year process of trial and error in examining potential mitigation techniques may take too long before they become extinct or severely depleted. Furthermore, meaningful conclusions cannot be drawn from experiments involving inadequate sample sizes. Small populations make bycatch events relatively rare, but only because of the small sample size. In these populations each mortality from bycatch is catastrophic and must be avoided at all costs. A good example is the Baltic harbour porpoise which numbers no more than 500 and for which an annual bycatch of even a single animal exceeds the potential biological removal (PBR) (NAMMCO/IMR, 2019). For these species and populations, emergency measures are required that completely eliminate bycatch, at least until the population achieves significant recovery.

When small population sizes preclude carrying out field tests of bycatch deterrents, other strategies need to be followed. For the North Atlantic right whale, researchers are using a computerized model that simulates encounters between whales and ropes with different physical characteristics (Howle *et al.*, 2018). Although not equivalent to field trials, which compare standard to modified ropes, this approach offers an insightful alternative for a small population, and can produce statistically robust results within a matter of hours that would otherwise take several years of fieldwork.

Researchers are increasingly using predictive models that identify where marine mammal-fishery interactions are most likely to occur and therefore be avoided (Breivik *et al.*, 2016; Dunn *et al.*, 2016; Goldsworthy *et al.*, 2007, 2010; Hazen *et al.*, 2018; Kindt-Larsen *et al.*, 2016; Lewison *et al.*, 2015; Passadore *et al.*, 2012; 2015a; 2015b; Peterson and Carothers, 2013; Roberts *et al.*, 2019). Some of these models have also been used to identify locations where any level of

bycatch may have a disproportionate effect on small/vulnerable populations. These methodologies require a long-term commitment to data collection and analysis, as well as testing in field trials, including recording actual bycatch to determine correspondence with what the models show. However, while this approach uses historical or real-time information appropriate for fishing in the present day, it does not factor in the effects of dynamic shifts in prey availability, fishing occurrence and other changes in oceanographic conditions (e.g. Waggitt *et al.*, 2000). This lessens the utility of this mitigation strategy with regard to future planning, but sustained data collection can eventually improve its ability to predict areas of greatest bycatch probability.

## 4.2 Marine mammal and target catch sensory biology and behaviour

A modification to fishing gear that prevents the bycatch of marine mammals while having no effect on target catch is the optimal outcome. Identifying differences in the sensory systems or behaviour between marine mammals and target species thus provides a promising field of research, although it does require a good understanding of how marine mammals and target species respond to introduced stimuli such as sound and visual cues. Few of the techniques described above originated from a basic understanding of differences in how marine mammals and target species perceive their environment or introduced stimuli. Some promising bycatch prevention measures may well emerge from exploiting these differences, and this will require basic scientific research on sensory biology and behaviour of target and non-target animals.

*Visual deterrents*

This technique involves altering the colour, luminosity or appearance of fishing gear to make them more visually detectable by large whales or small cetaceans. Preliminary fieldwork on rope colouration indicates that, for North Atlantic right whales, red and orange ropes are detectable near the surface during daylight hours at nearly twice the distance of green ropes (Kraus *et al.*, 2014). Another experiment showed the importance of vision in navigating through objects such as ropes where a blindfolded humpback whale failed to navigate a “maze” while the whale without a blindfold successfully navigated its way through it, even at night (Beamish, 1978). Taken together, the two studies clearly show the importance of vision to mysticete whales.

Studies have shown that in the Peruvian small-scale gillnet fishery net illumination using light emitting diodes (LEDs) fixed on the headline as a visual deterrent reduced bycatch of small cetaceans without negatively affecting the catch of the target species (Bielli *et al.*, 2020).

Altering rope colour is an attractive option for whale entanglement prevention because it is relatively easy to do and should not increase the cost of fishing gear if a phased-in period accommodates the natural replacement regime of gear by fishers. Furthermore, altering gear colour could be widely applicable to a variety of gear types, including aquaculture systems. On the other hand, concerns have been raised about the effects of making gear more detectable, and the possibility of eliciting curiosity or another attractant response from some species. Apart from colour and luminosity, vertical buoy lines with short (20 cm) flexible rope whiskers attached at 1 m intervals are more readily detectable by minke whales (Kot *et al.*, 2012).

There is a lack of studies on behavioural responses at night and at greater depths where mysticetes also occur and engage in feeding. Different levels of entanglement risk are likely based on swimming depth, behaviour at night, whether an animal is alone or in a group, as well as how colour or luminosity is detected deeper in the water. Differences in behavioural responses between species, populations and even individuals are also possible. All of these require further investigation.

*Circadian/feeding cycles*

A largely uninvestigated technique involves altering the time of day in which fishing occurs, which might produce adequate catch while reducing marine mammal bycatch. For example, in the French midwater pair trawl fishery for sea bass, which takes place in the Bay of Biscay, night-time fishing has been shown to result in particularly high bycatch (Morizur *et al.*, 1999). Obviously, this strategy is not feasible for some fisheries if the target species and marine mammals always co-occur in space and time.

*Acoustic startle response*

Acoustic techniques are one of the most tested measures for reducing marine mammal bycatch. Newer devices might produce fewer prolonged effects, such as by evoking an alert response of shorter duration. This alert might warn a marine mammal of the presence of fishing gear so that it avoids the gear without disrupting its continued use of the specific habitat in which the acoustic deterrents are deployed, and without creating other negative health

effects. One ongoing research area seeks to identify how to elicit such a startle response (Culik *et al.*, 2015; Götz and Janik, 2014). The PAL (programmable warning device) system developed by Culik *et al.* (2017) has had some success in reducing bycatch during trials in the Baltic Sea, although it was much less successful in the North Sea and in Iceland (ICES WGBYC, 2017, 2018).

# 5. POLICY INSTRUMENTS AND INSTITUTIONAL FRAMEWORKS SUPPORTING THE CONSERVATION OF MARINE MAMMALS FROM BYCATCH IN CAPTURE FISHERIES

## 5.1 National instruments

Many guidelines and codes of practice regarding marine mammal protection are national in scope and/or involve instruments at the local level. As national governments are responsible for managing most of the world's fisheries, national instruments are designed to meet a nation's obligations to international or regional agreements. Such policy, management and legislative instruments are therefore among the most important for directly implementing measures to reduce the bycatch of marine mammals.

Common elements of effective legislation at a national level involve marine mammal population and bycatch assessment, mitigation and enforcement. This includes regular surveillance and monitoring of the fishery to assess or estimate the level of bycatch and its risk to the population. In addition, regulatory frameworks outline processes for implementing and evaluating the effectiveness of bycatch prevention and mitigation measures. Other essential elements include the need for adequate enforcement efforts to ensure compliance with regulatory measures, and the inclusion of a range of key stakeholders in decision-making processes. Finally, for national regulation to be effective, sufficient long-term funding is required.

## 5.2 International instruments

At the international level, there are a wide range of policy instruments and frameworks that support the conservation of marine mammals. Many are directly or indirectly relevant to prevention and reduction of bycatch in capture fisheries. The most important global instruments are listed below, details of which are provided in the Appendix.

- United Nations Convention on the Law of the Sea
- FAO Code of Conduct for Responsible Fisheries
- FAO International Guidelines on Bycatch Management and Reduction of Discards
- Convention on International Trade in Endangered Species of Wild Fauna and Flora

- Convention on the Conservation of Migratory Species of Wild Animals
- International Whaling Commission
- Convention on Biological Diversity
- UN Driftnetting Resolution (Global moratorium on all large-scale pelagic drift-net fishing on the high seas of the world's oceans and seas, including enclosed seas and semi-enclosed seas)

## 5.3 Regional instruments

At a regional scale, there exist many codes, conventions, agreements, Memorandums of Understanding (MoUs), and guidelines for the conservation of marine mammals in fisheries. The following are some of the most important instruments, details of which are provided in the Appendix.

- Regional instrument under the Convention on the Conservation of Migratory Species of Wild Animals (CMS)
  - The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish, and North Seas (ASCOBANS, 1994)
  - The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS, 1996)
  - The Trilateral Agreement between Denmark, Germany, and the Netherlands on the Conservation of Seals in the Wadden Sea (1991)
  - The Memorandum of Understanding on the Conservation and Management of Dugongs (*Dugong dugon*) (2007)
  - The Memorandum of Understanding concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (2007)
  - The Memorandum of Understanding for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (2006)
  - The Memorandum of Understanding concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (2008)
- United Nations Environment Programme Action Plan for the conservation of Cetaceans in the Mediterranean Sea (2017)
- Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
- The North Atlantic Marine Mammal Commission (NAMMCO)

  - NAMMCO Working Group on Bycatch, Entanglements and Live Strandings (BYCELS) (2017)
- Regional Fisheries Management Organizations/Arrangements (RFMO/As)
- Indian Ocean Tuna Commission (IOTC) Resolution 13/04 on the Conservation of Cetaceans,
- Western and Central Pacific Fisheries Commission (WCPFC)'s Conservation and Management Measure 2011-03.
- The Indian Ocean Tuna Commission (IOTC)
- The Commission for the Conservation of Southern Bluefin Tuna (CCSBT)
- The Inter-American Tropical Tuna Commission (IATTC)
- The Agreement on the International Dolphin Conservation Programme (AIDCP)
- The Western and Central Pacific Fisheries Commission (WCPFC)
- The General Fisheries Commission for the Mediterranean (GFCM).

# 6. IMPLEMENTATION OF THESE GUIDELINES

## 6.1 Driving change to prevent and reduce marine mammal bycatch

Change in fishing practices ultimately depends on fishers themselves, but it occurs in the context of market forces, government policies and legislation, public perception, and in response to seemingly complex political, social, cultural, economic and even psychological factors. Arguably the greatest need for altering fishing practices, including the reduction of marine mammal bycatch, is to have an effective process that gets fishers to change how they fish. Even when economic incentives exist for the adoption of new fishing gear or methods, fishers generally do not make the transition voluntarily (Eayrs and Pol, 2018). In developed countries, new fisheries regulations are generally the main drivers for change. However, much of the world's fishing sector is located – and operates in – developing countries, where many endangered and threatened marine mammals also live, and in which there may be limited focus on bycatch reduction. Even where there may be interest among, and options for, fishers to reduce bycatch, the high cost of new gear may make it inaccessible to them. Furthermore, in the absence of regulatory measures, oversight, and adequate penalization for a lack of compliance, there is little incentive for them to modify fishing techniques.

For developing countries, there are many challenges for implementing measures to prevent/reduce marine mammal bycatch. Small-scale fisheries are prominent in these countries, and governance and surveillance of fishing activities is either lacking or challenging. In fact, many vessels and fisheries are unregistered, insufficiently documented, and monitoring is mostly land-based (Teh *et al.*, 2015). Moreover, the incidental catch of marine mammals sometimes represents a source of income and food supply. In such cases, consideration could be given to conducting assessments of the socio-economic effects of implementing measures so that the potential impact on livelihoods and food security may be minimized.

Despite examples of self-motivated fishers implementing bycatch solutions to improve their catch of target species (Werner *et al.*, 2006), nearly all measures that reduce bycatch of marine mammals have been the result of regulations. Governments and other fisheries management organizations therefore have important roles to play in creating informed regulatory changes to fishing practices.

There are a lot of competing priorities in fisheries management, and funds and human resources are generally inadequate to address them within the range of all government funding needs. Consequently, marine mammal bycatch reduction often fails to emerge as one of the top priorities in fishery management. In this respect, it may be easier to introduce marine mammal bycatch reduction measures in fisheries that already have relatively good management capacity. Such fisheries are subject to negotiated management measures (such as quotas) and benefit from considerable engagement from governments, regional fisheries management bodies, fisher organizations, NGOs and researchers. On the other hand, when the investment of time and resources yields little financial benefits it is more difficult to garner the commitment of political entities and fishers to support them.

In the case of bycatch, national laws that protect marine mammals can help justify and promote the engagement of management agencies in both bycatch reduction and other conservation challenges. However, these legal measures need to be combined with the allocation of financial resources for their implementation. This likely explains why most of the examples of effective bycatch mitigation occur in countries that have both a proper legal framework for fisheries and financial resources, in addition to a commitment to addressing the problem of bycatch of marine mammals.

Often, because many marine mammals are highly migratory and occur within the jurisdictions of more than one nation, regional and global coordination is critical. This highlights the importance of regional fisheries management organizations that have transboundary management and conservation mandates, including those that relate to the development and implementation of marine mammal bycatch reduction programmes.

Some overarching approaches that deserve attention when promoting the prevention and reduction of marine mammal bycatch in fisheries include:

- more detailed region-by-region strategies to identify and prioritize high-risk fisheries and vulnerable populations, while generally increasing the level of bycatch monitoring at the same time;
- supporting the local evaluation of appropriate fishing techniques that reduce marine mammal bycatch and could realistically be implemented;
- transferring knowledge from countries with proven fisheries solutions for marine mammal bycatch to countries where such information is lacking;

- building local capacity for marine mammal population assessments, fisheries surveys, field trials of potential deterrents and monitoring any tangential impacts, as well as the long-term consequences of measures;
- fisher-to-fisher capacity building, in which they share experiences and information on how well different techniques work;
- building a greater commitment to collecting data on marine mammal populations, fishing grounds and effort, fishing practices (e.g. gear configurations), physical and biological oceanographic characteristics, the scale of marine mammal bycatch, economic information, and other relevant factors to help assess and manage the problem;
- a strong engagement with the fishing sector in all aspects of marine mammal bycatch prevention/reduction;
- supporting the collaborative efforts of sociologists, economists and change management experts in bycatch mitigation programmes to identify paths that can lead from scientific success to the implementation of changes, while reinforcing the importance of social engagement, and community and bottom up approaches;
- developing public outreach programmes regarding the scale and extent of the problem, including articulating the potential ecological and economic losses that can arise from marine mammal population declines, and emphasizing the role of marine mammals in ecosystem functioning and services; and
- addressing the local concerns of fishers, such as dwindling target stocks and relatively low political influence, to put marine mammal bycatch in an appropriate and meaningful context.

## 6.2 Roles of various entities

There are many entities that should be engaged in the implementation of these guidelines and assist with driving change in the prevention/reduction of marine mammal bycatch. These include:

- national and local governments and agencies (dedicated to fisheries and to marine environmental conservation);
- regional organizations, such as the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the WCPO; the Convention on the Conservation of Antarctic Marine Living Resources;

the various RFMO/As and signatories to the various agreements and MoUs described in the Appendix to these guidelines;
- global organizations such as FAO and the International Whaling Commission;
- non-government organizations, including environmental groups;
- fisher organizations, individual fishing companies, owners, captains and crews; and
- scientific organizations.

The extent to which each entity implements these guidelines, and the manner in which they do so, will depend on their particular mandate(s), legal framework(s), circumstances, interests and responsibilities.

*National and local governments*

The main agencies with the mandate to manage and conserve marine mammals are national and local governments. These jurisdictions are responsible for enacting policy, ensuring compliance, managing fisheries, collecting data and conducting research in support of their missions. Moreover, the majority of fishing operations and associated interactions with marine mammals occur in the territorial waters and EEZs of States. National government agencies also typically represent their interests in international organizations (e.g., FAO, UNEP, IWC) and regional fisheries management organizations. These characteristics mean government agencies are assigned the most important roles for implementing these guidelines, and national governments can work within the regional bodies of which they are members to propose the adoption of relevant measures contained herein. Similarly, national and local governments can ensure they fulfil the obligation to comply with any measures adopted by said regional bodies, which may include bycatch data collection, data reporting and implementation of bycatch mitigation measures.

Specific examples of the roles that national government agencies could play in the implementation of these guidelines include:

- using these guidelines to draft particular management measures to prevent or reduce marine mammal bycatch, and incorporate the associated enabling legislation or the appropriate text into regional agreements;
- integrating these guidelines in routine fisheries management decision-making processes within their jurisdictions and regionally;

- establishing collaborative mechanisms among their component agencies or Member States to develop compatible standards, monitoring tools, mitigation measures and regulatory regimes aimed at preventing/reducing marine mammal bycatch;
- standardizing monitoring and reporting procedures regarding marine mammal bycatch;
- ensuring appropriate levels of monitoring and reporting regarding marine mammal bycatch throughout their region;
- developing long-term capacity to coordinate data collection, assessments and mitigation measures;
- sharing information about measures that prevent or reduce marine mammal bycatch among their component jurisdictions, Member States, and throughout their region;
- considering measures to evaluate accountability, adaptability, effectiveness, practicability, socio economic aspects, timeliness and transparency in implementing these guidelines;
- participating in appropriate regional fisheries bodies to assess, share and evaluate measures that prevent/reduce marine mammal bycatch;
- implementing cooperation and integration programmes with other organizations and entities within their country and regionally to further these guidelines across states, nations and regions;
- using these guidelines as a resource when developing certification schemes for sustainable fisheries;
- supporting research and management activities financially within their country that are designed to assist in marine mammal bycatch prevention/reduction;
- encouraging and financially supporting research and management activities to evaluate the effectiveness of, and investigate new, marine mammal bycatch mitigation measures;
- adopting principles of adaptive management when implementing and assessing various measures to prevent/reduce marine mammal bycatch; and
- using the guidelines to elaborate and incorporate objectives and actions in specific National Action Plans to reduce the interaction of marine mammals with fisheries.

*Regional bodies*

Regional bodies such as RFMO/As and regional environment organizations can play a strong role in the implementation of these guidelines. Potential roles of regional bodies in the implementation of these guidelines include:

- Where appropriate, adopting binding measures to prevent and reduce marine mammal bycatch and incorporating the appropriate text into other regional agreements.
- sharing information about measures that prevent or reduce marine mammal bycatch with their component States;
- using their collaboration mechanisms to address common issues, notably through the development of compatible standards, tools and information aimed at marine mammal bycatch prevention/reduction;
- developing and implementing standards and harmonized measures to reduce bycatch of marine mammals in their fisheries, where appropriate;
- requiring appropriate levels of monitoring and reporting regarding marine mammal bycatch throughout their region;
- developing long-term capacity to coordinate data collection, assessments and mitigation measures throughout their region;
- considering appropriate levels of accountability, adaptability, effectiveness, practicability, socio economic aspects, timeliness and transparency;
- establishing and supporting working groups to provide scientific advice on bycatch management in fisheries, and ensuring that marine mammals get adequate attention in such working groups;
- encouraging the participation of scientists and managers with expertise on marine mammal bycatch prevention and reduction in appropriate scientific committees and working groups;
- implementing cooperation and integration programmes throughout their region to further these guidelines across Member States and neighbouring regions;
- where appropriate, considering consistent management approaches within the region;
- ensuring compliance with marine mammal bycatch prevention and reduction measures;
- encouraging and financially supporting research and management activities to evaluate the effectiveness of marine mammal bycatch mitigation measures, and investigating new measures; and
- adopting principles of adaptive management when implementing and assessing various measures to prevent/reduce marine mammal bycatch.

*International organizations*

While often not directly involved in day-to-day fisheries management and marine mammal bycatch prevention and mitigation, global organizations such as FAO and IWC nevertheless have a variety of tools to support the implementation of these guidelines, including:

- distributing these guidelines to all Member States, posting them on appropriate websites and social media platforms and promoting them at relevant conferences and events;
- developing collaborative mechanisms to address common issues, such as through the development of compatible standards, tools and information for dissemination to member entities;
- encouraging the standardization of monitoring and reporting procedures regarding marine mammal bycatch;
- encouraging the development of long-term capacity to coordinate data collection, assessments and mitigation measures;
- cooperating with other organizations and entities to build capacity for the implementation and monitoring of these guidelines across Member States;
- sharing information about measures that prevent or reduce marine mammal bycatch at international for a;
- informing other stakeholders and the public of actions taken to monitor, prevent and reduce the bycatch of marine mammals; and
- monitoring the progress made in the implementation of the guidelines using the existing biennial CCRF questionnaires produced by FAO and the Organization's reports to COFI.

*Non-governmental organizations (NGOs)*

A broad range of NGOs are involved in the conservation of marine mammals: from large international NGOs to small-scale, local, whale-watching and rescue groups. Their role is usually to facilitate the exchange of information about marine mammal biology, ecology, their interactions with various fishing methods, measures available to ameliorate interactions, citizen science and monitoring. They also conduct fundraising to support marine mammal protection and rescue, and advocacy for general protection and/or particular management measures. As such, these groups have an important role to play in the implementation of these guidelines. Specific examples include:

- working with national and local authorities, fisheries organizations and the general public to obtain and disseminate accurate information regarding the bycatch of marine mammals, as well as ways to mitigate such interactions, and the success (or otherwise) of attempts to do so;
- using these guidelines as a roadmap for advocating relevant fisheries management decisions regarding measures to protect marine mammals;
- using these guidelines as an information source for lobbying and advocacy;
- encouraging fishing industry organizations to work with their members to ensure that innovations in fishing gear and practices are consistent with these guidelines;
- mobilizing resources to support various initiatives including those listed above;
- urging changes in fisheries that pose the greatest risk to marine mammals; and
- educating companies (and their consumers) that buy and sell seafood on the origins of their products, allowing them to avoid those which cause excessive marine mammal bycatch.

*Fishers, their representative bodies and certification programmes*

At the core of the interaction between the fishing sector and marine mammals are fishers themselves: in other words, the captains, crews, vessel owners and organizations of fishing fleets whose gears catch, kill, release or otherwise interact with marine mammals. This is the main group of stakeholders these guidelines will affect, and their implementation of these guidelines will be key to preventing and reducing the bycatch of marine mammals throughout the world.

Several fishing industry groups have developed codes of conduct for their fisheries that address the prevention/reduction of marine mammal bycatch. Examples include the South Australia Sardine Association 2015 Code of Practice (Hamer *et al.*, 2008), the Australian blue grenadier (*Macruronus novaezelandiae*) fishery (Tilzey *et al.*, 2006), the New Zealand deepwater trawl fisheries (Deepwater Group, 2017) and the Southeast Trawl Fishing Industry Association (SETFIA, 2007).

Fisherfolk organizations play an important role in fisheries management decision-making processes, particularly when an EAF is applied. These organizations have a mandate to represent their members and have a role to facilitate exchange of information on a wide range of subjects, including marine mammal bycatch

reduction. Specific examples of how fishers and their representative bodies can implement these guidelines include:

- embracing these guidelines and relevant codes of conduct that deal with marine mammal protection;
- developing and adopting responsible fishing codes/practices consistent with these guidelines;
- participating in fisheries research, management and decision-making processes that relate to marine mammal bycatch prevention/reduction;
- maintaining an awareness of the concerns regarding marine mammal bycatch and ways to prevent/reduce it or, if caught, measures to mitigate any mortality associated with such capture and subsequent release of animals;
- reporting bycatch of and interactions with marine mammals promptly to competent authorities as required to contribute to data collection and scientific assessment;
- ensuring that crew members are trained on marine mammal bycatch issues and the measures in place to mitigate its impacts;
- working together to share information and educate others regarding the content of these guidelines, as well as offering suggestions for the development and testing of measures to prevent or reduce marine mammal bycatch;
- lobbying, advocating and engaging management bodies on topics related to marine mammal protection;
- developing and using outreach, education and awareness materials;
- recognizing that they are important players in marine mammal stewardship, ensuring that they contribute to formulating objectives and marine mammal protection measures suitable to their operations and implementing them swiftly;
- contributing to the generation of new knowledge and collection of data about marine mammal interactions that will be essential for developing new ways to prevent/reduce interactions; and
- providing insight on the value chain to help identify stakeholders who have financial capacity and incentives to financially support research and management activities.

Fisheries certification programmes play an increasing role in promoting sustainable fisheries. Such programmes may provide a market advantage to those fisheries that make changes resulting in more sustainable outcomes,

which may include maintaining stocks of target species and non-target bycatch species, reducing or eliminating bycatch of endangered, threatened and protected species, avoiding severe adverse impacts on marine habitats, and promoting effective fisheries management. The largest and most well-known certification body is the Marine Stewardship Council (MSC), but there are many other international, regional and national certification programmes.

Fisheries improvement projects (FIPs) are often an important step towards the certification of a fishery. In FIPs the fishing industry collectively introduces environmental or management improvements. These projects can involve practices that reduce marine mammal bycatch and may appeal to companies that only source seafood from them or certified fisheries. FIPs can be ‘basic’ or ‘comprehensive’, the latter involving more rigorous verification and a commitment to enter assessment data for certification after some years.

# 7. AWARENESS, COMMUNICATION AND CAPACITY-BUILDING MEASURES

There are many entities that should be engaged in raising awareness, improving communication and enhancing capacity for protecting marine mammals. These include the aforementioned global organizations, regional organizations, national governments, NGOs, fishing companies, owners, fisherfolk organizations, captains and their fishing crews. Although not analysed in detail in this section, some other consideration should be given to the potential role and contribution of other entities that profit from fisheries and are included in the value chain (such as wholesalers and processing companies).

*National and local governments*

Specific examples of the role national government agencies can play in awareness raising, communication and capacity building, as these relate to the reduction of bycatch of marine mammals in fisheries, include:

- ensuring that all information used for communication and awareness-building is accurate, up-to-date and appropriate for the target audience(s);
- providing and sharing such information, and raising the level of awareness of marine mammal bycatch issues and measures needed to address them to fishers, other governments and jurisdictions, policymakers, other relevant stakeholders and the general public;
- developing outreach, education and awareness materials in appropriate formats and local languages for appropriate platforms (including websites and social media outlets such as Twitter, Facebook and Instagram), which can be used to disseminate information within and beyond their agency;
- identifying and ensuring the appropriate training needs are met for managers, technologists and particularly fishers in regard to measures to reduce marine mammal interactions and mortalities;
- developing frameworks for long-term cooperative working relationships on marine mammal bycatch reduction with all stakeholders, management authorities at all levels, NGOs and fishers, including the provision of accurate and timely information on marine mammal bycatch-related issues, regulations and activities;

- identifying opportunities for cooperative planning to reduce inconsistencies between management frameworks at all levels;
- collating and sharing best practice methods for:
  - monitoring, estimating and reducing marine mammal bycatch,
  - reducing impacts on animals that are caught and released,
  - preparing appropriate legislation and/or regulations, and
  - effective communication and training;
- providing opportunities for fisheries managers and policymakers to increase their knowledge of marine mammal bycatch and potential solutions, i.e. providing them with up-to-date information, advice and options regarding marine mammal bycatch, its socio-economic impacts and potential solutions;
- ensuring that fishing gear technologists and other scientists receive specialized training in technical measures which may be used to mitigate marine mammal bycatch and impacts on animals that are caught and released;
- taking fishers' opinions and suggestions on effective measures to reduce marine mammal interactions into account;
- providing clear explanations to fishers as to why it is necessary to manage marine mammal bycatch in their fisheries, the consequences of failing to do so and the benefits of adopting such measures;
- communicating regularly with fishers on:
  - the causes and conditions that lead to marine mammal bycatch,
  - the evolution of bycatch reduction programmes,
  - the results of research and bycatch management measures
  - the status of marine mammal species of particular interest;
- coordinating and strengthening the activities and programmes of fishers' cooperatives, companies and similar organizations to mitigate marine mammal bycatch;
- providing adequate training to fishers on:
  - the use and maintenance of appropriate technology and practices to reduce marine mammal bycatch,
  - mechanisms that allow fishers to develop their own solutions,
  - the best ways to handle, recover and release marine mammal species captured alive,
  - basic legislation and policies, and
  - communication techniques to allow their mitigation work to be elucidated to appropriate target audiences;

- providing appropriate funding for programmes designed to improve awareness, communication, training and capacity building across all issues concerning marine mammal protection from fishing in their jurisdiction; and
- incorporating issues of particular relevance to their jurisdiction and stakeholders regarding the cultural use of marine mammals and indigenous rights/issues.

*Regional bodies*

Regional bodies are well placed to facilitate awareness, communication and capacity-building measures to assist in the protection of marine mammals across their mandated areas, as they involve – and regularly liaise with – multiple jurisdictions.

Specific examples of the role regional bodies should play in awareness raising, communication and capacity-building measures related to the reduction of bycatch of marine mammals in fisheries include:

- collecting and sharing data and information on the bycatch of marine mammals;
- pooling resources to fund the collection of baseline information on marine mammal population status/abundance and risk assessments;
- establishing and supporting working groups to provide scientific advice on bycatch management in fisheries and ensuring that marine mammals get adequate attention in such working groups;
- developing standards and harmonized measures to reduce the bycatch of marine mammals in fisheries;
- building capacity for the implementation of marine mammal protection measures by members including the relevant legal, policy, management and enforcement aspects.

*International organizations*

International organizations like FAO and the IWC also have a role to play in facilitating awareness raising, communication and capacity building related to the reduction of bycatch of marine mammals in fisheries. Specific examples include:

- facilitating the development of international guidelines and best-practice approaches;
- promoting these guidelines on various high-level platforms and venues to raise awareness of the issue, and support capacity-building programmes, especially in developing States;
- collecting and sharing information and raising the general level of awareness of Member States on marine mammal bycatch issues, and the measures needed to address such issues –platforms used for the sharing of information and the raising of awareness could include websites and social media;
- producing factsheets and other materials for stakeholders in multiple languages;
- developing frameworks for long-term cooperative relationships with Member States, regional bodies and NGOs;
- identifying opportunities for cooperative planning to harmonize standards and measures and reduce inconsistencies between management frameworks at a global level; and
- collating and sharing best practice methods for monitoring, estimating and reducing marine mammal bycatch.

*Non-governmental organizations (NGOs)*

NGOs also have a role to play in facilitating effective awareness raising, communication and capacity building related to the reduction of bycatch of marine mammals in fisheries. Specific examples include:

- ensuring that all information used for communication and awareness-raising is accurate, up to date and appropriate for the target audience(s);
- providing and sharing such information and raising the level of awareness of marine mammal bycatch issues, as well as the measures needed to address them, to fishers, governments and jurisdictions, policy makers, other NGOs and the general public;
- developing outreach, education and awareness materials in appropriate formats that can be used to disseminate information within and beyond their organization;
- developing platforms for sharing information and raising awareness, including websites and social media;

- developing frameworks for long-term cooperative working relationships on marine mammal bycatch reduction with all stakeholders, management authorities at all levels, other NGOs and fishers;
- collating and sharing best practice methods for:
  - reducing impacts on animals that are caught and released, and
  - effective communication and training;
- taking fishers' opinions and suggestions on effective measures to reduce marine mammal interactions into account; and
- supporting, advocating, lobbying for, and providing appropriate funding for programmes designed to improve awareness, communication, training and capacity building across all issues concerning marine mammal protection from fishing.

*Fishers, their representative bodies and gear manufacturers*

As the recipients of many of the initiatives to improve effective awareness raising, communication and capacity building, the captains, crews, vessel owners and organizations whose fishing operations and gears catch, kill, release or otherwise interact with marine mammals have a key role to play in such areas. Specific examples include:

- sharing information about marine mammal bycatch issues amongst themselves and other stakeholders in order to raise the level of awareness of such issues, and those measures that are implemented to address them.
- contributing to the development of outreach, education and awareness materials that are in formats appropriate for captains, crews, etc.;
- participating in needs assessments and trainings that are focused on captains and crews with regard to measures to reduce marine mammal interactions and mortalities in fisheries;
- sharing amongst each other best practice methods for:
  - recording interactions, catch and release information related to marine mammal bycatch,
  - reducing impacts on animals that are caught and released;
- providing their own opinions, observations and suggestions on effective measures to reduce marine mammal interactions to each other and management agencies;
- communicating amongst each other on issues related to marine mammal bycatch;

- coordinating and strengthening the activities and programmes of fishers' cooperatives, companies and similar organizations to mitigate marine mammal bycatch;
- actively participating in training in:
  - the use and maintenance of appropriate technology and practices to reduce marine mammal bycatch,
  - techniques that allow them to develop their own solutions,
  - best ways to handle, recover and release marine mammal species captured alive,
  - communication techniques to allow their own mitigation work to be elucidated to appropriate target audiences.

# 8. SPECIAL REQUIREMENTS OF DEVELOPING STATES

States should fully recognize the special requirements of developing States – notably the least developed and small island developing States – together with small–scale fisheries. Such requirements should be understood in terms of te capacity of these States to implement marine mammal bycatch reduction measures consistent with these guidelines, including the assessment of risk and feasibility.

Small-scale, non-industrial fisheries constitute a particularly difficult challenge. They impact many of the world's most endangered marine mammals, yet solutions are largely absent. Looking ahead, a greater emphasis on identifying practical approaches in these fisheries is critical if we are to succeed in overcoming this major threat to marine mammals.

In particular, States, international and regional organizations, international financial institutions and other entities should consider offering financial and technical assistance to enhance the capacity of developing States to reduce marine mammal bycatch in their fisheries. This assistance should be provided on voluntary and mutually agreed terms, in conformity with relevant international law, the FAO Code of Conduct for Responsible Fisheries and related instruments. Particular focus areas may include the following:

- the development of management, legal and regulatory frameworks and infrastructure for marine mammal bycatch reduction;
- development of effective marine mammal bycatch management planning, including at a regional scale;
- data collection and assessment of marine mammal bycatch;
- marine mammal bycatch monitoring and reporting;
- development and implementation of low-cost, low-tech measures to prevent/reduce marine mammal bycatch;
- development of effective Monitoring, Control and Surveillance (MCS);
- research and development;
- carrying out socio-economic studies on the effects of marine mammal bycatch reduction measures;
- technology transfer and training;
- awareness raising, communication and capacity-building measures;

- providing support to prevent, deter and eliminate illegal, unreported and unregulated (IUU) fishing, particularly as it pertains to marine mammal interactions; and
- developing social engagement and joint management initiatives.

# REFERENCES

**Aguilar-Ramirez, D. & Rodriguez-Valencia, A**. 2012. *Eficiencia y Selectividad de Dos Diseños de Redes de Arrastre para Pescar Camarón Azul* (Litopenaeus Stylirostris) e*n la Pesquería Artesanal del Alto Golfo de California.* INAPESCA. Disponible en. 13 pp.

**Allen, R.B. & DeAlteris, J.** 2007. *Use of pop-up buoys in fixed gear commercial fisheries. A demonstration.* National Fish and Wildlife Foundation Project No. 2005-0327-002, Washington, DC, 21 pp.

**Allen, S.J., Tyne, J.A., Kobryn, H.T., Bejder, L., Pollock, K.H. & Lonergan. N.R.** 2014. Patterns of Dolphin Bycatch in a North-Western Australian Trawl Fishery. *PLOS ONE,* 9(4). e93178. https://doi.10.1371/journal.pone.0093178

**Alverson, D. L., Freeberg, M. H., Pope, J. G. & Murawski, S. A.** 1994. *A global assessment of fisheries bycatch and discards.* FAO Fisheries Technical Paper No. 339. Rome, FAO. 233 pp. (also available at http://www.fao.org/3/T4890E/T4890E00.htm).

**Australian Fisheries Management Authority (AFMA).** 2014. *Dolphin Strategy. Minimising Gillnet Bycatch.* Canberra, Australia. 14 pp.

**Australian Fisheries Management Authority (AFMA).** 2019a. *Gillnet Dolphin Mitigation Strategy. Minimising dolphin interactions with gillnets in the Southern and Eastern Scalefish and Shark Fishery. September 2019.* Canberra, Australia. 24 pp. (also available at https.//www.afma.gov.au/sites/default/files/gillnet_dolphin_mitigation_strategy_updated_aug_2019_accessible.pdf).

**Australian Fisheries Management Authority (AFMA).** 2019b. *Small Pelagic Fishery Dolphin Strategy. Minimising dolphin interactions in the Small Pelagic Fishery. September 2019.* Canberra, Australia. 17 pp. (also available at https.//www.afma.gov.au/sites/default/files/spf_dolphin_strategy_2019_updated_accessible.pdf).

**Avila, I.C., Kaschner, K. & Dormann, C.F.** 2018. Current global risks to marine mammals: Taking stock of the threats. *Biological Conservation*, 221: 44–58.

**Baker, B., Hamilton, S., McIntosh, R. & Finley, L.** 2014. *Technical Review. Development and Application of Bycatch Mitigation Devices for Marine*

*Mammals in Mid-Water Trawl Gear. Report prepared for the Department of the Environment (on behalf of the expert panel), 12 May 2014.*

**Barlow, J. & Cameron, G.A.** 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gill net fishery. *Marine Mammal Science*, 19(2): 265–283.

**Baumgartner, M.F., Wenzel, F.W., Lysiak, N.S.J. & Patrician, M.R.** 2017. North Atlantic right whale foraging ecology and its role in human-caused mortality. *Marine Ecology Progress Series*, 581: 165–181.

**Bayse, S. M. & Kerstetter, D. W.** 2010. Assessing bycatch reduction potential of variable strength hooks for pilot whales in a western North Atlantic pelagic longline fishery. *Journal of the North Carolina Academy of Science*, 126(1): 6–14.

**Beamish, P.** 1978. Evidence that a captive humpback whale (*Megaptera novaeangliae*) does not use sonar. *Deep-Sea Research*, 25: 469–472.

**Bielli, A., Alfaro-Shigueto. J., Doherty, P.D., Godley, B.J., Ortiz, C., Pasara, A., Wang, J.H. & Mangel, J. C.** 2020. An illuminating idea to reduce bycatch in the Peruvian small-scale gillnet fishery. *Biological Conservation*, 241: 108–277.

**Bigelow, K.A., Kerstetter, D.W., Dancho, M. G. & Marchetti, J.A.** 2012. Catch rates with variable strength circle hooks in the Hawaii-based tuna longline fishery. *Bulletin of Marine Science*, 88(3): 424–427.

**Bisack, K.D. & Sutinen, J.G.** 2006. Harbor porpoise bycatch. ITQs or time/area closures in the New England gillnet fishery. *Land Economics*, 82 (1): 85–102.

**Bord Iascaigh Mhara & University of St Andrews**. 2010. *Mitigation of incidental catches of cetaceans in EU waters. Report to European Parliament's Committee on Fisheries*. [Cited 1 June 2017]. (also available at http.//www.ascobans.org/sites/default/files/document/DGIPOL_final-report-mitigationBYC-EUwaters_2010.pdf).

**Bordino, P., Kraus, S., Albareda, D. & Baldwin, K.** 2004. *Acoustic devices help to reduce incidental mortality of the Franciscana dolphin* (Pontoporia blainvillei) *in coastal gillnets. Report to the Scientific Committee of the International Whaling Commission* SC/56/SM12: 10 pp.

**Bordino, P., Kraus, S., Albareda, D., Fazio, A., Mendez, M. & Botta, S.** 2002. Reducing incidental mortality of Franciscana dolphin *Pontoporia blainvillei* with acoustic warning devices attached to fishing nets. *Marine Mammal Science*, 18(4): 833–842.

**Bordino, P., Mackay, A.I., Werner, T.B., Northridge, S.P. & Read, A.J.** 2013. Franciscana bycatch is not reduced by acoustically reflective or physically stiffened gillnets. *Endangered Species Research*, 21:1-12. (also available at https://doi.org/10.3354/esr00503).

**Bowen, W.D.** 1997. Role of marine mammals in aquatic ecosystems. *Marine Ecology Progress Series*, 158: 267–274.

**Bratten, D. & Hall, M.** 1996. Working with fishers to reduce bycatch. The tuna-dolphin problem in the eastern Pacific Ocean. In *Fisheries bycatch – consequences & management*. pp. 97-100. Alaska Sea grant Program Report No. 97-02, Fairbanks, AK, USA, University of Alaska Fairbanks.

**Breivik, O. N., Storvik, G. & Nedreaas, K.** 2016. Latent Gaussian models to decide on spatial closures for bycatch management in the Barents Sea shrimp fishery. *Canadian Journal of Fisheries and Aquatic Sciences*, 73(8): 1271–1280.

**Brownell, Jr R.L., Reeves, R.R., Read, A.J., Smith, B.D., Thomas, P.O., Ralls, K., Amano, M., Berggren, P., Chit, A.M., Collins, T., *et al.*** 2019. Bycatch in gillnet fisheries threatens Critically Endangered small cetaceans and other aquatic megafauna. *Endangered Species Research*, 40: 285–296.

**Campbell, R., Holley, D., Christianopoulos, D., Caputi, N. & Gales, N.** 2008. Mitigation of incidental mortality of Australian sea lions in the west coast rock lobster fishery. *Endangered Species Research*, 5: 345–358.

**Carretta, J.V. & Barlow, J.** 2011. Long-term effectiveness, failure rate, and "dinner bell" properties of acoustic pingers in a gillnet fishery. *Marine Technology Society Journal* 45(5): 7–19.

**CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources).** 2017. *Krill – biology, ecology and fishing*. [online]. Hobart, Australia. [Cited 1 June 2017]. www.ccamlr.org/en/fisheries/krill-%E2%80%93-biology-ecology-and-fishing

**CIRVA (Comité Internacional para la Recuperación de la Vaquita).** 2019. *Report of the Eleventh meeting*, 19–21 February 2019, La Jolla, CA, USA. Southwest Fisheries Science Center (SWFSC). (also available at http://www.iucn-csg.org/wp-content/uploads/2019/03/CIRVA-11-Final-Report-6-March.pdf)

**Clay, T.A., Alfaro-Shiqueto, J., Godley, B.J., Tregenza, N. & Mangel, J.C.** 2019. Pingers reduce the activity of Burmeister's porpoise around small-scale gillnet vessels. *Marine Ecology Progress Series*, 626: 197–208.

**Cox, T. M., Andrew, J.R., Swanner, D., Urian, K. & Waples, D.** 2004. Behavioural responses of bottlenose dolphins, *Tursiops truncatus*, to gillnets and acoustic alarms. *Biological Conservation*, 115(2): 203–212.

**Culik, B., Conrad, M., and Chladek, J.** 2017. *Acoustic protection for marine mammals: new warning device PAL*. DAGA Proceedings, Kiel 2017: pp. 387–390. (also available at http://www.f3mt.net/uploads/7/5/1/8/75189669/daga-english_jc.pdf)

**Culik, B., von Dorrien, C., Müller, V. and Conrad, M.** 2015. Synthetic communication signals influence wild harbour porpoise (*Phocoena phocoena*) behaviour. *Bioacoustics*, 24(3): 201–221.

**Dawson, S.M., Northridge, S., Waples, D. & Read, A.J.** 2013. To ping or not to ping. The use of active acoustic devices in mitigating interactions between small cetaceans and gillnet fisheries. *Endangered Species Research*, 19: 201–221.

**de Haan, D.** 2014. *Large Animal Reduction Device (LARD) to reduce non-target fish in gears operating in EU-waters*. Research Report, Institute for Marine Resources and Ecosystem Studies, IMARES (now Wageningen Marine Research). Wageningen University and Research.

**DeAlteris, J.** 1999. *Design, testing, and evaluation of an acoustic release system for offshore lobster pot buoy lines.* NMFS Project No. 40EANF800065, submitted to Al Blot of the NMFS Fisheries Engineering Goup, Kingston, RI. 16 pp.

**Deepwater Group.** 2017. *Marine Mammal Operating Procedures* [online]. Auckland, New Zealand. [Cited 20 December 2017]. www.deepwatergroup.org/wp-content/uploads/2018/03/Marine-Mammal-OP-2017.pdf

**Doksæter, L., Godø, O.R., Handegard, N.O., Kvadsheim, P.H., Lam, F.-P.A., Donovan, C. & Miller, P.J.O.** 2009. Behavioral responses of herring (*Clupea harengus*) to 1–2 and 6–7 kHz sonar signals and killer whale feeding sounds. *Journal of the Acoustic Society of America*, 125(1): 554–564.

**Dotson, R.C., Griffith, D.A., King, D.L. & Emmett, R.L.** 2010. *Evaluation of a Marine Mammal Excluder Device (MMED) for a Nordic 264 Midwater Rope Trawl.* NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-455. 19 pp.

**Dunn, D.C., Maxwell, S.M., Boustany, A.M. & Halpin, P.N.** 2016. Dynamic ocean management increases the efficiency and efficacy of fisheries management. *Proceedings of National Academy of Science*, 113(3): 668–673.

**Eayrs, S. & Pol, M.** 2018. The myth of voluntary uptake of proven fishing gear. Investigations into the challenges inspiring change in fisheries. *ICES Journal of Marine Science*, 76(2): 392–401.

**Erbe, C., Dunlap, R. & Dolman, S.** 2018. Effects of noise on marine mammals. In H. Slabbekoorn, R. J. Dooling, A. N. Popper & R. R. Fay, eds. *Effects of Anthropogenic Noise on Animals* (Vol. 66), pp. 277–309). New York, NY, Springer Science-Business Media.

**Erzini, K., Gonçalves, J.M.S., Bentes, L., Lino, P.G., Ribeiro, J. & Stergiou, K.I.** 2003. Quantifying the roles of competing static gears. Comparative selectivity of longlines and monofilament gill nets in a multi-species fishery off the Algarve (southern Portugal). *Scientia Marina*, 67(3): 341–252.

**FAO.** 1995. *Code of Conduct for Responsible Fisheries*. Rome, FAO. 46 pp. (http://www.fao.org/3/v9878e/V9878E.pdf)

**FAO.** 2011a. *International Guidelines on Bycatch Management and Reduction of Discards.* Rome, FAO. 73 pp. (www.fao.org/3/a-ba0022t.pdf)

**FAO.** 2011b. Fisheries management. 4. Marine protected areas and fisheries. *FAO Technical Guidelines for Responsible Fisheries*. No. 4, Suppl. 4. Rome, FAO. 198 pp. (www.fao.org/3/i2090e/i2090e00.htm)

**FAO.** 2012. *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests in the context of national food security*. Rome, FAO. (http://www.fao.org/3/i2801e/i2801e.pdf)

**FAO.** 2015. *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*. Rome, FAO. (www.fao.org/3/a-i4356en.pdf)

**FAO.** 2018. *Report of the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations*. Rome, 20–23 March 2018. FAO Fisheries and Aquaculture Report No.1231. Rome, FAO. (http://www.fao.org/3/I9993EN/i9993en.pdf)

**FAO.** 2019. *Voluntary Guidelines on the Marking of Fishing Gear. Directives volontaires sur le marquage des engins de pêche. Directrices voluntarias sobre el marcado de las artes de pesca*. Rome, FAO. 88 pp. (http://www.fao.org/3/ca3546t/ca3546t.pdf)

**Finkelstein, M., Bakker, V., Doak, D.F., Sullivan, B., Lewison, R., Satterthwaite, W.H. & Croxall, J.** 2008. Evaluating the potential effectiveness of compensatory mitigation strategies for marine bycatch. *PLOS ONE*, https.//doi.org/10.1371/journal.pone.0002480

**Fox, DA., Wark, K., Armstrong, J.L. & Brown, L.M.** 2011. *Gillnet configurations and their impact on Atlantic sturgeon and marine mammal bycatch in the New Jersey Monkfish fishery.* Year 1. Final Report to NOAA under Contract #EA133F-10-RQ-1160, Endeavor Fisheries, Inc. 30 pp.

**Geijer, C.K.A & Read A.J.** 2013. Mitigation of marine mammal bycatch in U.S. fisheries since 1994. *Biological Conservation*, 159: 54–60

**Gilman, E., Brothers, N., McPherson, G. & Dalzell, P.** 2006. A review of cetacean interactions with longline gear. *Journal of Cetacean Research and Management*, 8(2): 215–223.

**Goldsworthy, S. D. & Page, B.** 2007. A risk-assessment approach to evaluating the significance of seal bycatch in two Australian fisheries. *Biological Conservation*, 139: 262–285.

**Goldsworthy, S.D., Page, B., Shaughnessy, P.D. & Linnane, A.** 2010. *Mitigating Seal Interactions in the SRLF and the Gillnet Sector SESSF in South Australia. Report to the Fisheries Research and Development Institute.* South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2009/000613-1, SARDI Research Report Series No. 405.

**Gormley, A.M., Slooten, E., Dawson, S., Barker, R.J., Rayment, W., du Fresne, S. & Bräger, S.** 2012. First evidence that marine protected areas can work for marine mammals. *Journal of Applied Ecology*, 49: 474–480.

**Götz, T. & Janik, V.M.** 2014. Target-specific acoustic predator deterrence in the marine environment. *Animal Conservation*, 18: 102–111.

**Gray, C.A & S.J. Kennelly.** 2018. Bycatches of endangered, threatened and protected species in marine fisheries. *Reviews in Fish Biology and Fisheries*, 28(3): 521–541. (also available at https://doi.org/10.1007/s11160-018-9520-7).

**Hall, M. & Roman, M.** 2013. *Bycatch and non-tuna catch in the tropical tuna purse seine fisheries of the world*. FAO Fisheries and Aquaculture Technical Paper No. 568. Rome, FAO. 249 pp. (also available at www.fao.org/docrep/018/i2743e/i2743e.pdf).

**Hamer, D.J., Childerhouse, S.J. & Gales, N.J.** 2012. Odontocete bycatch and depredation in longline fisheries. A review of available literature and potential solutions. *Marine Mammal Science*, 28(4): E345–E374.

**Hamer, D.J. & Minton, G.** 2020. *Guidelines for the safe and humane handling and release of bycaught small cetaceans from fishing gear*. UNEP/CMS Secretariat. Bonn, Germany. CMS Technical Series No. 43.

**Hamer, D.J., Ward, T.W. & McGarvey, R.** 2008. Measurement, management and mitigation of operational interactions between the South Australian sardine fishery and short-beaked common dolphins (*Delphinus delphis*). *Biological Conservation*, 141: 2865–2878.

**Hamilton, P.K. & Kraus, S.D.** 2019. Frequent encounters with the seafloor increase right whales' risk of entanglement in fishing groundlines. *Endangered Species Research*, 39: 235–246.

**Hamilton, S. & Baker, G.B.** 2015a. Review of research and assessments on the efficacy of sea lion exclusion devices in reducing the incidental mortality of New Zealand sea lions *Phocarctos hookeri* in the Auckland Islands squid trawl fishery. *Fisheries Research*, 161: 200–206.

**Hamilton, S. & Baker, G.B.** 2015b. Review of research and assessments on the efficacy of Sea Lion Exclusion Devices in reducing the incidental mortality of New Zealand sea lions *Phocarctos hookeri* in the Auckland Islands squid trawl fishery. Reply to Robertson (2015). Fisheries Research, 165: 130–132.

**Hamilton, S. & Baker, G.B.** 2019. Technical mitigation to reduce marine mammal bycatch and entanglement in commercial fishing gear. lessons learnt and future directions. *Review in Fish Biology and Fisheries*, 29(2): 223-247 (also available at https://doi.org/10.1007/s11160-019-09550-6).

**Harcourt, R., Pirotta, V., Heller, G., Peddemors, V. & Slip, D.** 2014. A whale alarm fails to deter migrating humpback whales. An empirical test. *Endangered Species Research*, 25: 35–42.

**Hatfield, B.B., Ames, J.A., Estes, J.A., Tinker, M.T., Johnson, A.B., Staedler, M.N. & Harris, M.D.** 2011. Sea otter mortality in fish and shellfish traps. estimating potential impacts and exploring possible solutions. *Endangered Species Research*, 13: 219–229.

**Hazen, E.L., Scales, K.L., Maxwell, S., Briscoe, D., Welch, H., Bograd, S.J. & Lewsion, R.L.** 2018. A dynamic ocean management tool to reduce bycatch and support sustainable fisheries. *Science Advances*, 4(5): 1-7.

**Hembree, D. & Harwood, M.B.** 1987. Pelagic gillnet modification trials in northern Australian seas. *Reports of the International Whaling Commission*, 37: 369–373.

**Hodgson, A.J., Marsh, H., Delean, S. & Marcus, L.** 2007. Is attempting to change marine mammal behaviour a generic solution to the bycatch problem? A dugong case study. *Animal Conservation*, 10: 263–273.

**Hopkins, N. & Hoggard, W.** 2006. A pilot study to investigate possible alternatives to reducing Vertical line entanglements by marine mammals. Report by the Harvesting Systems Gear Team of NOAA's Southeast Fisheries Science Center. In. Salvador, G., J. Kenney, and J. Higgins, eds. *Large Whale Gear Research Summary*, NOAA/Fisheries.

**How, J., Coughran, D., Smith, J., Double, M.C., Harrison, J., McMath, J., Hebiton, B., Denham, A.** 2015. *Effectiveness of mitigation measures to reduce interactions between commercial fishing gear and whales.* FRDC Project No 2013/03. Fisheries Research Report No. 267. Department of Fisheries, Western Australia. (also available at https://www.fish.wa.gov.au/Documents/research_reports/frr267.pdf).

**Howle, L.E., S.D. Kraus, T.B. Werner & D.P. Nowacek.** 2018. Simulation of the entanglement of a North Atlantic Right whale (*Eubalaena glacialis*) with fixed fishing gear. *Marine Mammal Science*, 35(3): 760–778

**IATTC.** 2007a. *Agreement on the International Dolphin Conservation Program*. Executive Report on the Functioning of the AIDCP in 2006. La Jolla, USA. Inter-American Tropical Tuna Commission.

**IATTC.** 2007b. *Agreement on the International Dolphin Conservation Program* (as amended October 2007). Inter-American Tropical Tuna Commission, La Jolla, USA.

**IATTC.** 2017.IRP-62-06a *Dolphin Mortality Limits 2017*. [online] La Jolla, USA. [Cited 18 July 2019] iattc.org/Meetings/Meetings2017/AIDCP-36/PDFs/Docs/_English/IRP-62-06a_Dolphin-Mortality-Limits-2017.pdf

**IATTC.** 2018. IRP-63-01 *Review of Dolphin Mortality Limits for 2017 and 2018*. [online] La Jolla, USA. [Cited 18 July 2019] iattc.org/Meetings/Meetings2018/IATTC-93/Docs/_English/IRP-63-01_Dolphin-Mortality-Limits-2017-2018.pdf.

**IATTC.** 2019. IRP-65-01 *Review of Dolphin Mortality Limits for 2018 and 2019*. [online] La Jolla, USA. [Cited 18 July 2019] iattc.org/Meetings/Meetings2019/IATTC-94/AIDCP-39/Docs/_English/IRP-65-01-REV-14-Jul-19_Review_of_Dolphin_Mortality_Limits_for_2018_and_2019.pdf.

**ICES WGBYC.** 2017. *Report of the Working Group on Bycatch of Protected Species (WGBYC)*, 12–15 June 2017.Woods Hole, Massachusetts, USA. ICES CM 2017/ACOM: 24. 80 pp.

**ICES WGBYC.** 2018. *Report of the Working Group on Bycatch of Protected Species (WGBYC)*, 1–4 May 2018. Reyjkavik, Iceland. ICES CM 2018/ACOM: 25. 128 pp.

**IUCN.** 2019. *The IUCN Red List of Threatened Species.* Version 2019-2. [online] Cambridge, UK. [Cited 18 July 2019]. http://www.iucnredlist.org.

**IWC.** 2016. *Report of the Scientific Committee 2016*. Annex J: Report of the Working Group on Non-deliberate Human-induced Mortality of cetaceans, 7–19 June, Bled, Slovenia.

**IWC.** 2019. *Report of the IWC Workshop on Bycatch Mitigation Opportunities in the Western Indian Ocean and Arabian Sea*, 8–9 May 2019, Nairobi, Kenya. (also available at https.//archive.iwc.int/pages/view.php?ref=9612&k=).

**Johnson, A., Salvador, G., Kenney, J., Robbins, J., Kraus, S., Landry, S. & Clapham, P.** 2005. Fishing gear involved in entanglements of right and humpback whales. *Marine Mammal Science*, 21: 635–645. (also available at doi. 10.1111/j.1748-7692.2005.tb01256.x).

**Kaiser, M.J.** 2005. Are marine protected areas a red herring or fishing panacea? *Canadian Journal of Fisheries and Aquatic Science*, 62: 1194–1199.

**Kerstetter, D.** 2012. *Evaluation of Variable Strength Hooks to Reduce Serious Injury Pilot Whale Interactions with the North Carolina-Based Pelagic Longline Fishery.* Final Report to the Consortium for Wildlife Bycatch Reduction, under NOAA Award # NA09NMF4520413 to the New England Aquarium, Boston: 22 pp.

**Kindt-Larsen, L., Berg, C.W., Tougaard, J., Sørensen, T.K., Geitner, K., Northridge, S. & Larsen, F.** 2016. Identification of high-risk areas for harbour porpoise *Phocoena phocoena* bycatch using remote electronic monitoring and satellite telemetry data. *Marine Ecology Progress Series*, 555: 261–271.

**Kiszka, J.J., Heithaus, M.R. & Wirsing, A.J.**, 2015. Behavioural drivers of the ecological roles and importance of marine mammals. *Marine Ecology Progress Series*, 523:267–281.

**Knowlton, A.R., Richard Malloy, J., Kraus, S.D. & Werner, T.B.** 2018. *Development and evaluation of reduced breaking strength rope to reduce large whale entanglement severity*. Final Report to the Office of Energy and Environmental Affairs, State of Massachusetts, under MMARS# CT EVN 0607160000 000 000 3938, 66 pp.

**Knowlton, A.R., Robbins, J., Landry, S., McKenna, H.A., Kraus, S.D. & Werner, T.B.** 2016. Implications of fishing rope strength on the severity of large whale entanglements. *Conservation Biology*, 30(2): 318–328.

**Knuckey, I., Ciconte, A., Koopman, M., Judson, R. & Rogers, P.** 2014. *Trials of longlines to target Gummy shark in SESSF waters off South Australia.* Fishwell Consulting.

**Königson, S. & Hagberg, J.** 2007. *The Swedish hook fishery in the South Baltic. An analysis of logbook data.* Report to ASCOBANS. Göteborg, Sweden, Swedish Board of Fisheries.

**Königson, S. J., Fredriksson, R. E., Lunneryd, S.-G., Strömberg, P. & Bergström, U. M.** 2015b. Cod pots in a Baltic fishery. Are they efficient and what affects their efficiency? *ICES Journal of Marine Science*, 72(5): 1545–1554.

**Königson, S., Lövgren, J., Hjelm, J., Ovegård, M., Ljunghager, F. & Lunneryd, S.-G.** 2015a. Seal exclusion devices in cod pots prevent seal bycatch and affect their catchability of cod. *Fisheries Research*, 167: 114–122.

**Kot, B.W., Sears, R., Anis, A., Nowacek, D.P., Gedamke, J. & Marshall, C.D.** 2012. Behavioural responses of minke whales (*Balaenoptera acutorostrata*) to experimental fishing gear in a coastal environment. *Journal of Experimental Marine Biology and Ecology*, 413. 13–20.

**Kraus, S., Read, A., Anderson, E., Baldwin, K., Solow, A., Spradlin, T. & Williamson, J.** 1997. Acoustic alarms reduce incidental mortality of porpoises in gill nets. *Nature*, 388:525.

**Kraus, S.D., Fasick, J., Werner, T. & McCarron, P.** 2014. *Enhancing the Visibility of Fishing Ropes to Reduce Right Whale Entanglements.* Final Report under NOAA Contract Number NA12NMF4720254, from the Bycatch Reduction and Engineering Program of NMFS/NOAA.

**Laverick S, Douglas L, Childerhouse S & Burns D.** 2017. *Entanglement of cetaceans in pot/trap lines and set nets and a review of potential mitigation methods*. Blue Planet Marine report to Department of Conservation, New Zealand. (also available at http.//www.doc.govt.nz/our-work/conservationservices-programme/csp-reports/2016-17/entanglementof-cetaceans-in-pot-trap-lines-and-set-nets-and-a-reviewof-potential-mitigation-methods/)

**Leaper RC, Calderan S.** 2018 *Review of methods used to reduce risks of cetacean bycatch and entanglements*. UNEP/Convention on the Conservation of Migratory Species of Wild Animals (CMS) Secretariat, Bonn, Germany. CMS Technical Series Publication No. 38. 76 pp.

**Leeney, R.H., Berrow, S., Mcgrath, D., O'Brien, J., Cosgrove, R., and Godley, B.J.** 2007. Effects of pingers on the behaviour of bottlenose dolphins. *Journal of the Marine Biological Association UK,* 87: 129–133.

**Lewison R.L., Crowder, L.B., Wallace, B.P., Moore, J.E., Cox, T., Zydelis, R., McDonald, S., Di Matteo A., Dunn, D.C. & Kot, C.Y.** 2014. Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. *Proceedings of the National Academy of Sciences*, 111: 5271–5276.

**Lewison, R., Hobday, A.J., Maxwell, S., Hazen, E., Hartog, J.R., Dunn, D. C., Crowder, L.B.** 2015. Dynamic ocean management. Identifying the critical ingredients of dynamic approaches to ocean resource management. *BioScience*, 65(5): 486–498.

**Lien J., Barney W., Todd S., Seton R., Guzzwell J.** 1992. Effects of Adding Sounds to Cod traps on the Probability of Collisions by Humpback Whales. In Thomas J.A., Kastelein R.A., Supin A.Y., eds. *Marine Mammal Sensory Systems*, pp. 701–708. Springer, Boston, MA.

**Liggins, G.** 2013. "At call" release of submerged head-gear. Application and benefits of an acoustic release system for the NSW deep-water lobster fishery. (Powerpoint presentation). NSW Department of Primary Industry. 32 pp.

**Long, K. J., DeAngelis, M.L., Engelby, L. K., Fauquier, D.A., Johnson, A. J., Kraus, S.D. & Northridge, S.P.** 2015. Marine Mammal Non-Lethal Deterrents. Summary of the Technical Expert Workshop on Marine Mammal Non-Lethal Deterrents, 10–12 February 2015, Seattle, Washington. U.S. Department of Commerce, *NOAA Technical Memorandum* NMFS-OPR-50: 38 pp.

**Lyle, J.M., Wilcox, S.T. & Hartmann, K.** 2016. Underwater observations of seal-fishery interactions and the effectiveness of an exclusion device in reducing bycatch in a midwater trawl fishery. *Canadian Journal of Fisheries and Aquatic Science*, 73: 436–444.

**Mackay, A. & Goldsworthy, S.** 2017. *Experimental field trials to test if alternative sea lion excluder devices (SLEDs) adequately prevent Australian sea lions from entering rock lobster pots.* Fisheries Research and Development Corporation and South Australian Research and Development Institute. 19 pp.

**Marine and Freshwater Research Institute (MFRI).** 2019. *Advice for Cod* (Gadus morhua) *for the 2019/2020 fishing year*. Hafnarfjörður, Iceland. (also available at https://www.hafogvatn.is/en/harvesting-advice/cod)

**Maunder, M.N., Starr, P.J., Hilborn, R.** 2000. A Bayesian analysis to estimate loss in squid catch due to the implementation of a sea lion population management plan. *Marine Mammal Science*, 16 (2): 413–426.

**McLellan, W.A., Arthur, L.H., Mallette, S.D., Thornton, S.W., McAlarney, R.J., Read, A.J. & Pabst, D.A.** 2015. Longline hook testing in the mouths of pelagic odontocetes. *ICES Journal of Marine Science, 72*(5): 1706–1713.

**Mintzer, V.J., Diniz, K. & Frazer, T.K.** 2018. The use of aquatic mammals for bait in global fisheries. *Frontiers in Marine Science*, 5: Article 191, 26 pp. (also available at doi. 10.3389/fmars.2018.00191).

**Moreno, C.A., Castro, R., Mújica, L.J. & Reyes, P.** 2008. Significant conservation benefits obtained from the use of a new fishing gear in the Chilean Patagonian toothfish fishery. *CCAMLR Science*, 15: 79–91.

**Morizur, Y., Berrow, S.D, Tregenza, N.J.C., Couperus, A.S. & Pouvreau, S.** 1999. Incidental catches of marine mammals in pelagic trawl fisheries of the north-east Atlantic. *Fisheries Research*, 41(3): 297–307

**Murray, K.T., Read, A.J. & Solow, A.R.** 2000. The use of time/area closures to reduce bycatch of harbour porpoises: lessons from the Gulf of Maine sink gillnet fishery. *Journal of Cetacean Research and Management*, 2(2): 135–141

**National Marine Fisheries Service (NMFS).** 2010. *Guide to the Atlantic Large Whale Take Reduction Plan. An evolving plan to reduce the risk to North Atlantic large whales (right, humpback, and fin) posed by commercial trap/pot and gillnet fishing gear in the U.S Atlantic Ocean.* NOAA Fisheries Service, Protected Species Division, 70 pp.

**National Marine Fisheries Service (NMFS).** 2015. *False Killer Whale Take Reduction Team Meeting 29 April–1 May 2015*, Honolulu, Hawaii (Key Outcomes Memorandum).

**National Research Council (NRC).** 1992. *Dolphins and the Tuna Industry.* Washington, D.C. National Academy Press.

**NOAA Fisheries.** 2020. New England/Mid-Atlantic. In: *NOAA Fisheries* [online]. Silver Spring, MD. [Cited 2 December 2020]. (http://www.fisheries.noaa.gov/region/new-england-mid-atlantic).

**Noke, W.D. & Odell, D.K.** 2002. Interactions between the Indian River lagoon blue crab fishery and the bottlenose dolphin, *Tursiops truncatus. Marine Mammal Science*, 18(4), 819–832.

**North Atlantic Marine Mammal Commission (NAMMCO) & the Norwegian Institute of Marine Research (IMR).** 2019 *Report of Joint IMR/NAMMCO International Workshop on the Status of Harbour Porpoises in the North Atlantic.* Tromsø, Norway.

**Northridge, S., Mackay, A. I. & Cross, T.** 2005. *Dolphin bycatch. observations and mitigation work in the UK bass pair trawl fishery 2004–2005 season.* [online] London, UK. [Cited 20 February 2017]. (randd.defra.gov.uk/Document.aspx?Document=MF0736_2978_OTH.doc).

**Northridge, S., Vernicos, D. & Raitsos-Exarchpolous, D.**, 2003. *Net depredation by bottlenose dolphins in the Aegean: First attempt to quantify and to minimise the problem.* Paper SC/55./SM25 presented to the IWC Scientific Committee Meeting 2003

**Nowacek, D. P., Johnson, M. P. & Tyack, P. L.** 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London. B*, 271: 227–231.

**O'Keefe, C.E., Cadrin, S.X. & Stokesbury, K.D.E.** 2013. Evaluating effectiveness of time/area closures, quotas/caps, and fleet communications to reduce fisheries bycatch. *ICES Journal of Marine Science*, 71(5):1286-1297 (also available at doi.10.1093/icesjms/fst063).

**Orphanides, C.D. & Palka, D.L.** 2013. Analysis of harbor porpoise gillnet bycatch, compliance, and enforcement trends in the US northwestern Atlantic, January 1999 to May 2010. *Endangered Species Research*, 20: 251–269.

**Ovegård, M., Königson, S., Persson, A. & Lunneryd, S. G.** 2011. Size selective capture of Atlantic cod (*Gadus morhua*) in floating pots. *Fisheries Research*, 107: 239–244.

**Pace III, R.M., Cole, T.V.N. & Henry, A.G.** 2014. Incremental fishing gear modifications fail to significantly reduce large whale serious injury rates. *Endangered Species Research*, 26: 115–126.

**Palka, D.L.** 2000. *Effectiveness of gear modification as a harbour porpoise bycatch reduction strategy off the mid-Atlantic coast of the US.* Paper presented to the Scientific Committee of the International Whaling Commission, June 2000, Adelaide.

**Pálsson, Ó.K., Gunnlaugsson, Þ. & Ólafsdóttir, D.** 2015. *Meðafli sjófugla og sjávarspendýra í fiskveiðum á Íslandsmiðum* [Bycatch of sea birds and marine mammals in Icelandic fisheries]. Hafrannsóknir nr. 178, Reykjavik. (Icelandic with English summary).

**Passadore, C., Domingo, A. & Secchi, E.R.** 2015a. Analysis of marine mammal bycatch in the Uruguayan pelagic longline fishery operating in the Southwestern Atlantic Ocean. *ICES Journal of Marine Science*, 72(5): 1637–1652.

**Passadore, C., Domingo, A. & Secchi, E.R.** 2015b. Depredation by killer whale (*Orcinus orca*) and false killer whale (*Pseudorca crassidens*) on the catch of the Uruguayan pelagic longline fishery in the Southwestern Atlantic Ocean. *ICES Journal of Marine Science*, 72(5): 1653–1666.

**Passadore, C., Domingo, A., Szephegyi, M. & Secchi, E.** 2012. Influence of environmental and longline fishing operational variables on the presence of killer whales (*Orcinus orca*) in south-Western Atlantic. *Journal of the Marine Biological Association of the United Kingdom.*

**Peltier, H., Authier, M., Dabin, W., Dars, C., Demaret, F., Doremus, G., Van Canneyt, O., Laran, S., Mendez-Fernandez, P., Spitz, J., Daniel, P., & Ridoux. V.** 2020. Can modelling the drift of bycaught dolphin stranded carcasses help identify involved fisheries? An exploratory study. *Global Ecology and Conservation*, 21: e00843

**Peltier, H., Authier, M., Deaville, R., Dabin, W., Jepson, P.D., van Canneyt, O., Daniel, P. & Ridoux, V.** 2016. Small cetacean bycatch as estimated from stranding schemes: the common dolphin case in the northeast Atlantic. *Environmental Science & Policy*, 63: 7–18

**Pérez Roda, M.A., Gilman, E., Huntington, T., Kennelly, S.J., Suuronen, P., Chaloupka, M. & Medley, P.** 2019. *A third assessment of global marine fisheries discards.* FAO Fisheries and Aquaculture Technical Paper No. 633. Rome, FAO. 78 pp

**Perrin, W.F., Donovan, G.P. & Barlow, J. (Editors).** 1994. *Gillnets and Cetaceans, Special Issue 15.* International Whaling Commission, i–ix + 629 pp.

**Peterson, M.J. & Carothers, C.** 2013. Whale interactions with Alaska sablefish and Pacific halibut fisheries. Surveying fishermen perception, changing fishing practices and mitigation. *Marine Policy*, 42: 315–324.

**Pirotta, V., Slip, D., Jonsen, I.D., Peddemors, V.M., Cato, D.H., Ross, G. & Harcourt, R.** 2016. Migrating humpback whales show no detectable response to whale alarms off Sydney, Australia. *Endangered Species Research*, 29: 201–209.

**Pusch, C.** 2011. *Cod traps as an ecological sound fishing gear in German waters. International Marine Mammal-Gillnet Bycatch Workshop.* 17-20 October 2011, Woods Hole, MA, USA.

**Read, A.** 1994. Interactions between cetaceans and gillnet and trap fisheries in the Northwest Atlantic. In Perrin, W. F., Donovan, G. & Barlow, J., eds. *Gillnets and Cetaceans. Reports of the International Whaling Commission* (Special Issue), 15: 133–148.

**Read, A.J., Drinker, P. & Northridge, S.** 2006. Bycatch of marine mammals in U.S. and global fisheries. *Conservation Biology*, 20: 163–169.

**Reeves, R.R., McClellan, K. & Werner, T.B.** 2013. Marine mammal bycatch in gillnet and other entangling net fisheries, 1990 to 2011. *Endangered Species Research*, 20: 71–97.

**Robards, M.D. & Reeves, R.R.** 2011. The global extent and character of marine mammal consumption by humans. 1970–2009. *Biological Conservation*, 144: 2770–2786

**Roberts, J.O., Webber, D.N., Roe, W.T., Edwards, C.T.T. & Doonan, I.J.** 2019. *Spatial risk assessment of threats to Hector's/Māui dolphins* (Cephalorhynchus hectori). New Zealand Aquatic Environment and Biodiversity Report No. 214: 168 pp.

**Robertson, B. C.** 2015. Comment on "Review of research and assessments on the efficacy of sea lion exclusion devices in reducing the incidental mortality of New Zealand sea lions *Phocarctos hookeri* in the Auckland Islands squid trawl fishery". *Fisheries Research*, 165: 127–129.

**Rojas-Bracho, L. & Reeves, R.R.** 2013. Vaquitas and gillnets. Mexico's ultimate cetacean conservation challenge. *Endangered Species Research,* 21: 77–87.

**Roman, J., Estes, J.A., Morissette, L., Smith, C., Costa, D., McCarthy, J., Nation, J.B., Nicol, S., Pershing, A. & Smetacek, V.** 2014. Whales as marine ecosystem engineers. *Frontiers in Ecology and the Environment*, 12(7): 377–385.

**Santana-Garcon, J., Wakefield, C.B., Dorman, S.R., Denham, A., Blight, S., Molony, B.W. & Newman, S.J.** 2018. Risk versus reward. interactions, depredation rates, and bycatch mitigation of dolphins in demersal fush trawls. *Canadian Journal of Fisheries and Aquatic Sciences*, 75: 2233–2240.

**Santos, M.N., Gaspar, M.B., Monteiro, C.C. & Vasconcelos, P.** 2002. Gill net and long-line catch comparisons in a hake fishery. The case of southern Portugal. *Scientia Marina*, 66(4): 433–441.

**Sea Mammal Research Unit (SMRU), University College Cork, Cornish Fish Producers' Organization, and Irish South & West Fishermen's Organization.** 2001. *Reduction of porpoise bycatch in bottom set gillnet fisheries.* Study Contract 97/095, Report to the European Commission, DG Fisheries. 38 pp.

**Slooten, E.** 2013. Effectiveness of area-based management in reducing bycatch of the New Zealand dolphin. *Endangered Species Research*, 20: 121–130.

**Slooten, E. & Davies, N.** 2012. Hector's dolphin risk assessments: old and new analyses show consistent results. *Journal of the Royal Society of New Zealand*, 42: 49–60. (also available at https://doi.org/10.1080/03036758.2011.606820).

**Slooten, E. & Dawson, S.M.** 2010. Assessing the effectiveness of conservation management decisions: likely effects of new protection measures for Hector's dolphin. Aquatic Conservation. *Marine and Freshwater Ecosystems*, 20: 334–347.

**South East Trawl Fishing Industry Association (SETFIA).** 2007. *Industry Code of Practice to Minimise Interactions with Seals.* South East Trawl Fishing Industry Association, Tasmania, Australia. 11 pp.

**Squires, D.** 2010. Fisheries buybacks. A review and guidelines. *Fish and Fisheries*, 11: 366–387.

**Squires, D. & Garcia, S.** 2018. The least-cost biodiversity impact mitigation hierarchy with a focus on marine fisheries and bycatch issues. *Conservation Biology*, 32(5): 989–997.

**Stelfox M., Hudgins J. & Sweet M.** 2016. A review of ghost gear entanglement amongst marine mammals, reptiles and elasmobranchs. *Marine Pollution Bulletin*, 111 (1–2): 6–17.

**Stephenson, P.C. & Wells, S.** 2006. *Evaluation of the effectiveness of reducing dolphin catches with pingers and exclusion grids in the Pilbara trawl fishery.* Fisheries Research and Development Corporation (FRDC), Fisheries Research Report No. 173, Department of Fisheries, Western Australia, 44 pp. (also available at http://frdc.com.au/Archived-Reports/FRDC%20Projects/2004-068-DLD.PDF)

**Stergiou, K.I. & Erzini, K.** 2002. Comparative fixed gear studies in the Cyclades (Aegean Sea). Size selectivity of small-hook longlines and monofilament gill nets. *Fisheries Research*, 58: 25–40.

**Teh, L., Zeller, D. & Pauly, D.** 2015. *Preliminary reconstruction of Thailand's fisheries catches. 1950–2010*. Fisheries Centre Working Paper #2015–01. Vancouver, BC. Fisheries Centre; University of British Columbia.

**Temple, A.J., Kiszka, J.J., Stead, S.M., Wambiji, N., Brito, A., Poonian, C.N.S., Amir, O.A., Jiddawi, N., Fennessy, S.T., Pérez-Jorge, S. & Berggren, P.** 2018. Marine megafauna interactions with small-scale fisheries in the southwestern Indian Ocean. A review of status and challenges for research and management. Reviews in *Fish Biology and Fisheries*, 28(1): 89–115.

**Tilzey, R., Goldsworthy, S.D., Cawthorn, M., Calvert, N., Hamer, D., Russell, S., Shaughnessy, P., Wise, B., and Stewardson, C.** 2006. *Assessment of seal-fishery interactions in the winter blue grenadier fishery off west Tasmania and the development of fishing practices and Seal Exclusion Devices to mitigate seal bycatch by factory trawlers*. Australian Government, Fisheries Research and Development Corporation, Bureau of Rural Sciences. Final Report to FRDC, Project no. 2001/008. (also available at http://www.frdc.com.au/Archived-Reports/FRDC%20Projects/2001-008-DLD.pdf)

**Trippel, E.A., Holy, N.L., Palka, D.L., Shepherd, T.D., Melvin, G.D., Terhune. J.M.** 2006. Nylon Barium Sulphate Gillnet Reduces Porpoise and Seabird Mortality. *Marine Mammal Science*, 19(1): 240–243

**United Nations (UN)**. 1990. *Large-scale pelagic driftnet fishing and its impact on the living marine resources of the world's oceans and seas: resolution 44/225 adopted by the General Assembly.* New York. (also available at digitallibrary.un.org/record/82553?ln=en).

**van der Hoop, J.M., Moore, M.J., Barco, S.G., Cole, T.V.N., Daoust, P.Y., Henry, A.G. & Solow, A.R.** 2012. Assessment of management to mitigate anthropogenic effects on large whales. *Conservation Biology*, 27(1): 121–133.

**van Marlen, B.** 2007. NECESSITY Final Publishable Activity Report. Contract 501605. Nephrops and Cetacean Species Selection Information and Technology Scientific Support to Policy (SSP). [Cited April 14, 2008]. http://www.researchgate.net/publication/268816350_NEphrops_and_CEtacean_Species_Selection_Information_and_TechnologY_NECESSITY_NECESSITY_Final_Publishable_Activity_Report_FPAR_SSP8-CT-2003-501605_62_pp.

**Vetemaa, M. & Ložys, L.** 2009. *Action D1 - Use of bycatch safe fishing gear in pilot protected areas. LIFE Nature project.* Marine Protected Areas in the Eastern Baltic Sea Reference number. LIFE 05 NAT/LV/000100, Estonia Marine Institute, Universtiy of Tartu.

**Villadsen, M.K.** 2018. *Fishing for alternatives. Bait and pot trials in the upper Gulf of California*. DTU Aqua, Denmark Technical University. (Master's thesis)

**Waggitt, J.J., Evans, P.G.H., Andrade, J., Banks, A.N, Boisseau, O., Bolton, M., Bradbury, G., *et al.*** 2020. Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology*, 57: 253–269 (also available at DOI: 10.1111/1365-2664.13525).

**Wakefield C.B., Santana-Garcon J., Dorman S.R., Blight, S., Denham, A., Wakeford, J., Molony, B.W., Newman, S.J.** 2017. Performance of bycatch reduction devices varies for chondrichthyan, reptile, and cetacean mitigation in demersal fish trawls: Assimilating subsurface interactions and unaccounted mortality. *ICES J Mar Sci*, 74: 343–358.

**Walsh, P., Grant, S., Winger, P., Blackwood, G., Balmori-Ramirez, A. & Silva-Ramírez, T.** 2004. *An investigation of alternative harvesting methods to reduce the by-catch of vaquita porpoise in the Upper Gulf of California shrimp gillnet fishery.* St. Johns, NL, Canada, Center for Sustainable Aquatic Resources, Fisheries and Marine Institute of Memorial University. 89 pp.

**Werner, T., Kraus, S., Read, A. & Zollett, E.** 2006. Fishing techniques to reduce the bycatch of threatened marine animals. *Marine Technology Society Journal*, 40(3): 50–68.

**Werner, T.B., Northridge, S., Press, K.M. & Young, N.** 2015. Mitigating bycatch and depredation of marine mammals in longline fisheries. *ICES Journal of Marine Science*, 72 (5):1576–1586.

**Whaley, J.E & R. Borkowski.** 2009. *Policies and best practices, Marine mammal stranding response, Rehabilitation, and release.* Standards for release. NOAA National Marine Fisheries Service. 114 pp.

**Wilcox, C. & Donlan, C.J.** 2007. Compensatory mitigation as a solution to fisheries bycatch-biodiversity and conservation conflicts. *Frontiers in Ecology and the Environment*, 5(6): 325–331.

**Zeeberg, J., Corten, A. & De Graaf, E.** 2006. Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. *Fisheries Research*, 78: 186–195.

**Zollett, E.A.** 2009. Bycatch of protected species and other species of concern in US east coast commercial fisheries. *Endangered Species Research*, 9: 49–59.

**Žydelis, R., Wallace, B.P., Gilman, E.L. & Werner, T.B.** 2009. Conservation of marine megafauna through minimization of fisheries bycatch. *Conservation Biology*, 23(3): 608–616.

# APPENDIX

International and regional policy instruments and institutional frameworks that support the conservation of marine mammals and reduce their bycatch in capture fisheries

There are a large number and variety of policy instruments and frameworks that support the conservation of marine mammals, many of which are directly or indirectly relevant to the impacts caused by fisheries bycatch. These instruments may be relevant and applicable at a global, regional and/or national scale.

## International instruments

United Nations Convention on the Law of the Sea

The **United Nations Convention on the Law of the Sea** (UNCLOS, 1982), outlines the rights and obligations of Member States and provides the international basis for pursuing the protection and sustainable development of the marine and coastal resources. Sustainable use and conservation of marine living resources of the high seas, strengthening international, including regional, cooperation and coordination are highly applicable to marine mammals and their management (U.N. 1992).

Obligations for parties include assessing, monitoring, managing, protecting and conserving resources, as well as minimizing bycatch and waste through means such as selective fishing gear and techniques.

UNCLOS Article 65 states that "States shall cooperate with a view to the conservation of marine mammals and in the case of cetaceans shall in particular work through the appropriate international organizations for their conservation, management and study."

One international agreement under UNCLOS is the agreement related to the **Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks** (UNFSA, 2011). Under this agreement, Member States and other signatories are committed to conserving straddling and highly migratory fish stocks to ensure their sustainable use. While not referring to marine mammals specifically, the UNFSA does require signatories to assess the impacts of fishing on species belonging to the same ecosystem (which would include marine mammals). Signatories must adopt conservation and management measures to maintain or restore populations above levels at which

their reproduction may become seriously threatened, minimize catch by lost or abandoned gear, and minimize the catch of non-target species, in particular endangered species, through measures that include selective, environmentally safe and cost-effective fishing gear and techniques.

FAO Code of Conduct for Responsible Fisheries

The FAO **Code of Conduct for Responsible Fisheries** (FAO, 1995) requires protection of endangered species (including marine mammals) through the adoption of appropriate scientific evidence-based measures.

FAO International Guidelines on Bycatch Management and Reduction of Discards

The **International Guidelines on Bycatch Management and Reduction of Discards** (FAO, 2011a) identify endangered, threatened, and protected species (including marine mammals) as a bycatch problem and recommend that Member States assess fisheries and identify bycatch of any endangered and protected species, including where bycatch species may overlap with fishing operations through use of seabed maps, and/or species distributions and ranges. Furthermore, in order to reduce interactions with these types of species, Member States should identify and establish areas where use of all or some fishing gears is limited or prohibited using the best available scientific information.

Convention on International Trade in Endangered Species of Wild Fauna and Flora

The **Convention on International Trade in Endangered Species of Wild Fauna and Flora** (CITES) is an international agreement between governments to ensure that international trade in wild animals and plants does not threaten their survival (CITES, 2018). This is a legally binding agreement. Over 40 marine mammal species are listed under Appendix I (species threatened with extinction) of CITES and many more are listed under Appendix II (species for which trade must be controlled to maintain their populations).

Convention on the Conservation of Migratory Species of Wild Animals

The **Convention on the Conservation of Migratory Species of Wild Animals** (CMS) is a treaty under the United Nations Environment Programme. It provides a legal framework to coordinate conservation measures internationally throughout the range of migratory species, including marine mammals (CMS 2018). Appendix I of the CMS lists migratory species threatened with extinction.

Appendix II lists migratory species that may need or would benefit from international cooperative measures. The CMS strongly encourages entities to work together through international agreements to conserve these species and their habitats. To date, three regional agreements and four memoranda of understanding have been created in relation to marine mammals under this framework and are listed under the Regional Instruments below.

International Whaling Commission

The **International Whaling Commission** (IWC) is the global body charged with the conservation of whales and the management of whaling. The Commission's role has expanded since its establishment in 1946 such that, in addition to regulating whaling, the IWC works to address a wide range of conservation issues including bycatch and entanglement of whales.

In 2016, the IWC endorsed the establishment of the Bycatch Mitigation Initiative (BMI). In collaboration with other organizations, national governments and fishing communities, this aims to develop, assess and promote effective bycatch prevention and mitigation measures worldwide. It is comprised of: a Bycatch Coordinator in the IWC Secretariat; the Standing Working Group (SWG) on Bycatch under the IWC Conservation Committee; and a multidisciplinary Expert Panel to advise the Coordinator and the SWG. The BMI works closely with the Global Whale Entanglement Response Network (GWERN), which addresses the welfare, conservation and human safety impacts of large whale entanglement in fishing gear and marine debris. The GWERN provides trainings to countries on whale migration routes to help response teams safely disentangle whales in distress. The IWC Scientific Committee has a specific sub-committee (Working Group on Non-Deliberate Human-Induced Mortality of Cetaceans) which focuses much of its work on reviewing technical information on bycatch estimates and mitigation.

The IWC also has many different resolutions and recommendations relating to cetacean bycatch. One resolution encourages the sharing of data on whale entanglements with the Global Ghost Gear Initiative’s global data portal. This resolution will also promote better practices and provide ongoing support for practical protection and prevention initiatives.

Convention on Biological Diversity

The **Convention on Biological Diversity** (CBD, 1993) aims to conserve biological diversity, promote sustainable use of natural resources, and share the benefits fairly and equitably that stem from using genetic resources (CBD,

2018). Bycatch species that are vulnerable, endangered or threatened with extinction all fall under this agreement.

UN Driftnetting Resolution

As a measure to protect, *inter alia*, marine mammals from bycatch in large-scale drift netting, the **UN General Assembly** unanimously adopted Resolution 44/225[5] recommending that all members of the United Nations agree to moratoria on all large-scale pelagic driftnet fishing on the high seas by 30 June 1992.

**Regional instruments**

There are many codes, conventions, agreements, MoUs and guidelines for the conservation of marine mammals in fisheries at the regional scale.

Regional instrument under Convention on the Conservation of Migratory Species of Wild Animals (CMS)

- The **Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish, and North Seas** (ASCOBANS, 1994) aims to maintain populations of small toothed cetaceans (over 20 species) in the Agreement area. The area was expanded in 2008, with the addition of the North East Atlantic and Irish Seas. Entanglement in fishing gear is considered the greatest threat to these species in the agreement area.
- The **Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area** (ACCOBAMS, 1996), specifically protects all cetacean species in the Mediterranean and Black Sea areas where entanglement in fishing gear remains a significant threat.
- The Trilateral Agreement between Denmark, Germany and Netherlands (the) on the **Conservation of Seals in the Wadden Sea** (1991) prohibits the killing or harassment of seals in the Wadden Sea, specifically for the harbour seal population. This agreement also focuses on research and monitoring takes, habitat protection and raising awareness.
- The **Memorandum of Understanding on the Conservation and Management of Dugongs** (*Dugong dugon*) (2007) and their habitats throughout their range was made to ensure the long-term survival of dugongs.

- The **Memorandum of Understanding concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal** (*Monachus monachus*) (2007) aims to improve the conservation status and habitats for monk seals in the Eastern Atlantic, where entanglement in fishing gear remains a significant threat.
- The **Memorandum of Understanding for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region** (2006) covers the cooperative conservation of 48 species of marine mammals in this region.
- The **Memorandum of Understanding concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia** (2008) provides a platform to implement research and conservation for the 32 species listed; as one of the few relevant instruments from the African region, it is covered in greater detail below.

UNEP Action Plan for Conservation of Cetaceans in the Mediterranean Sea

The **United Nations Environment Programme's Action Plan for Conservation of Cetaceans in the Mediterranean Sea** (2017) has the following objectives: a) the protection and conservation of cetacean habitats including feeding, breeding and calving grounds, and b) the protection, conservation and the recovery of cetacean populations in the Mediterranean Sea area.

Convention on the Conservation of Antarctic Marine Living Resources

The **Commission for the Conservation of Antarctic Marine Living Resources** (CCAMLR) takes action to, *inter alia*, prevent the harvest of krill and finfish at a rate that is detrimental to the ecosystems, or to dependent and related populations of Antarctic marine living resources such as seabirds, seals, whales and fish. Several conservation measures have been adopted by CCAMLR to reduce the incidental mortality of, or injury to, marine mammals during trawl fishing, including the mandatory use of marine mammal exclusion devices on trawls used in krill fisheries. The Convention has also prohibited the use of plastic packaging bands to secure bait boxes, to prevent entangling and mortality of seals from such bands.

[5] See https://digitallibrary.un.org/record/82553?ln=en

The numbers of marine mammals of each species caught and released or killed for trawl, longline and pot fisheries is required by CCAMLR, and scientific observers must record entanglement and incidental mortality of marine mammals and report on the measures taken to avoid incidental mortality.

North Atlantic Marine Mammal Commission

The North Atlantic Marine Mammal Commission (NAMMCO), established by an international agreement in 1992, contributes to the conservation, management and study of cetaceans (whales, dolphins and porpoises) and pinnipeds (seals and walruses) in the North Atlantic through regional consultation and cooperation. Its four members – the Faroe Islands, Greenland, Iceland and Norway – have committed to the sustainable and responsible use of marine mammals. This also includes a focus on animal welfare and minimizing animal suffering related to both hunting and bycatch. With regard to bycatch, direct cooperation began in 1998 through a working group that addressed conservation, management and animal welfare. In 2014, the NAMMCO Scientific Committee established another working group on bycatch with the aim of identifying all fisheries that have potential bycatch of marine mammals. Its role is to review and evaluate current bycatch estimates and provide advice on improved data collection, as well methods to obtain best estimates of bycatch over time, for use in stock assessments. In 2017 NAMMCO also established a Working Group on Bycatch, Entanglements and Live Strandings (BYCELS) to provide advice on such issues. This ensures that advice is based on the best available scientific findings, technological developments and traditional knowledge, with due consideration given to safety requirements for humans.

Regional Fisheries Management Organizations/Arrangements (RFMO/As)

There are a number of regional fishery management organizations and arrangements that support marine mammal bycatch prevention and reduction. These include specific conservation and management measures targeting marine mammal bycatch including the Indian Ocean Tuna Commission (IOTC) Resolution 13/04 on the Conservation of Cetaceans (which includes several binding measures), the Western and Central Pacific Fisheries Commission (WCPFC) Conservation and Management Measure 2011-03: Cetaceans, Guidelines for the Protection of Cetaceans from Purse Seine Fishing, and the General Fisheries Commission for the Mediterranean and Black Sea (GFCM), which works specifically on data collection to monitor the incidental catch of vulnerable species in the Mediterranean and Black Sea fisheries .[6]

Indian Ocean Tuna Commission

In 2013 the **Indian Ocean Tuna Commission** (IOTC) issued its Resolution 13/04 on the Conservation of Cetaceans, which includes several binding measures, namely:

- Contracting Parties and Cooperating Non-Contracting Parties (collectively, CPCs) shall prohibit their flagged vessels from intentionally setting a purse seine net around a cetacean in the IOTC area, if the animal is sighted prior to the commencement of the set.
- CPCs shall require that, in the event that a cetacean is unintentionally encircled in a purse seine net, the master of the vessels takes all reasonable steps to ensure the safe release of the cetacean, while taking the safety of the crew into consideration and following the best practice guidelines for the safe release and handling of cetaceans developed by the IOTC Scientific Committee. The master of the vessels shall report the incident to the relevant authority of the flag State, with the following information:
  - the species (if known)
  - the number of individuals
  - a short description of the interaction, including details of how and why the interaction occurred, if possible
  - the location of the encirclement
  - the steps taken to ensure safe release
  - an assessment of the life status of the animal on release, including whether the cetacean was released alive but subsequently died.
- CPCs using other gear types fishing for tuna and tuna-like species associated with cetaceans shall report all interactions with cetaceans to the relevant authority of the flag State and include all the information outlined above.
- CPCs shall adopt fish aggregating device (FAD) designs that reduce the incidence of entanglement, according to Annex III of Resolution 13/08 (or any subsequent revision).
- The Commission requests that the IOTC Scientific Committee develops best practice guidelines for the safe release and handling of encircled cetaceans, taking into account those developed in other RFMOs.
- CPCs shall report, in accordance with Article X of the IOTC Agreement, any instances in which cetaceans have been encircled by the purse seine nets of their flagged vessels.

Commission for the Conservation of Southern Bluefin Tuna

The **Commission for the Conservation of Southern Bluefin Tuna** (CCSBT) adopted the above measures of IOTC for Ecologically Related Species in its managed areas. The measures are now binding on all Members of the CCSBT when fishing within the relevant area.

Inter-American Tropical Tuna Commission

The **Inter-American Tropical Tuna Commission** (IATTC) members adopted the **Agreement on the International Dolphin Conservation Programme** (AIDCP) which aims to reduce incidental mortalities of dolphins in the tuna purse seine fishery in the Eastern Pacific Ocean. It became legally binding in 1999, succeeding the 1992 Agreement on the Conservation of Dolphins (AIDCP), and has the following objectives:

- to progressively reduce incidental dolphin mortalities in the tuna purse-seine fishery in the Agreement Area to levels approaching zero, through the setting of annual limits;
- to eliminate dolphin mortality in this fishery and to seek ecologically sound means of capturing large yellowfin tunas not in association with dolphins; and
- to ensure the long-term sustainability of the tuna stocks in the Agreement Area, as well as that of the marine resources related to this fishery, taking into consideration the interrelationship among species in the ecosystem, with special emphasis on, *inter alia*, avoiding, reducing and minimizing bycatch and discards of juvenile tunas and non-target species.

One of the specific measures is to establish per-stock per-year dolphin mortality caps, and to review and assess the effects of these caps. The current measure is to limit total incidental dolphin mortality in the purse-seine tuna fishery in the Agreement Area to no more than 5 000 annually, through the adoption and implementation of the following:

[6] See: http://www.fao.org/fishery/rfb/en for details

- the establishment of a system that provides incentives to vessel captains to continue to reduce incidental dolphin mortality, with the goal of eliminating dolphin mortality in this fishery;
- the establishment, within the framework of the IATTC, of a system of technical training and certification for fishing captains and crews on the gear and its use, as well as the techniques for the rescue and safety of dolphins;
- the promotion and support of research to improve gear, equipment and fishing techniques within the framework of the IATTC, including those used in the fishery for tunas associated with dolphins;
- the establishment of an equitable system for the assignment of dolphin mortality limits (DMLs), consistent with the per-year dolphin mortality caps, in accordance with Annexes III and IV;
- the requirement for the vessels that have been assigned a DML, or that otherwise operate in the Agreement Area, to comply with the operational requirements set forth in Annex VIII;
- the establishment of a system for the tracking and verification of tuna harvested with and without mortality or serious injury of dolphins;
- the exchange of scientific research data collected by the Parties pursuant to this Agreement on a full and timely basis; and
- the conduct of research for the purpose of seeking ecologically sound means of capturing large yellowfin tunas not in association with dolphins.

Western and Central Pacific Fisheries Commission

In 2011 the **Western and Central Pacific Fisheries Commission** (WCPFC) adopted the Conservation and Management Measure 2011-03: Cetaceans, Guidelines for the Protection of Cetaceans from Purse Seine Fishing, which includes the following specific requirements:

- do not set purse seine net on school of tuna associated with a cetacean in the high seas and exclusive economic zones if the animal is sighted prior to commencement of the set;
- if a cetacean is unintentionally encircled by a purse seine net, ensure its safe release, i.e. stop net roll and do not recommence fishing until the animal is released and is no longer at risk of recapture;
- call the attention of the observers for any interaction on cetaceans; and
- record any catch of cetaceans on the catch logsheet.

General Fisheries Commission for the Mediterranean

The **General Fisheries Commission for the Mediterranean** (GFCM) adopted two binding recommendations addressing the conservation of cetaceans (Rec. GFCM/36/2012/2 on mitigation of incidental catches of cetaceans in the GFCM area; and Rec. GFCM/37/2013/2 on the establishment of a set of minimum standards for bottom-set gillnet fisheries for turbot and conservation of cetaceans in the Black Sea). According to these all GFCM parties shall:

- take actions to study, monitor, prevent, mitigate and, to the extent possible, eliminate incidental catch of cetaceans during fishing operations;
- prohibit gillnet fisheries using monofilament greater than 0.5 mm;
- require vessels flying their flag to promptly release alive/unharmed cetaceans that have been incidentally caught and brought alongside the vessel, to the extent practicable;
- collect and forward to the GFCM Secretariat information on incidental catch rates of cetaceans, including relevant information on the fisheries concerned, the characteristics of the type of gear, times, locations (either by geographical subarea [GSA] or by GFCM statistical rectangles) and affected cetacean species.

In 2019, Resolution GFCM/43/2019/2 on enhancing the conservation of cetaceans in the GFCM area was adopted to encourage further commitment from GFCM parties towards improving cetacean conservation.

In 2011, Recommendation GFCM/35/2011/5 on fisheries measures for the conservation of the Mediterranean monk seal (*Monachus monachus*) in the GFCM area of application states that:

- parties shall ensure the implementation of fisheries management measures that strongly mitigate the risk of incidental catch of monk seal during fishing operations;
- fishing vessels are prohibited to take on board, transship and land monk seals in the GFCM area of application unless otherwise required to rescue and to secure assistance for the recovery of harmed individual animals and provided that the competent national authorities concerned have been duly and officially informed in advance;
- specimens of monk seals accidentally caught in fishing gear shall be released unharmed and alive;

- any event of incidental catch and release shall be recorded by the vessel owner/master in the logbook and reported to the respective national authorities for notification to the GFCM Secretariat;
- parties shall adopt fisheries management measures based on scientific studies under their responsibility and designed, whenever appropriate, in order to have very low and close to zero risk of monk seal incidental catch and mortality in fishing activities/operations.

The GFCM has produced technical manuals, reviews and illustrated guides to assist countries in data collection on incidental catches and strandings, with a view to monitoring bycatch, handling bycaught species and working towards overall mitigation:

**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, FAO.

**FAO.** 2019. *Monitoring discards in Mediterranean and Black Sea fisheries: Methodology for data collection.* FAO Fisheries and Aquaculture Technical Paper No. 639. Rome, FAO.

**FAO & ACCOBAMS.** 2018. *Good practice guide for the handling of cetaceans caught incidentally in Mediterranean fisheries*. (available in several languages at www.fao.org/gfcm/data/good-practice-guides).

**Sacchi J.** 2020. *Review of mitigation measures for protected species in fisheries.* Studies and Reviews n. 100. Rome, FAO.

The Guidelines to Prevent and Reduce Bycatch of Marine Mammals in Capture Fisheries were produced by FAO in response to the request from the Committee on Fisheries at its Thirty-third Session in 2018 to develop technical guidelines on this subject, and are directed at decision-makers, planners, managers and all those involved in developing and implementing policy and technical interventions which relate to the bycatch of marine mammals in fisheries.

The guidelines were drafted and developed through a series of activities undertaken by FAO, including the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations and the Expert Meeting to Develop Technical Guidelines to Reduce Bycatch of Marine Mammals in Capture Fisheries. They outline options for marine mammal bycatch reduction through the application of technical measures, including: spatial closures, the use of acoustic deterrents or alerting devices, modifications to fishing gear, changes in fishing operations and other strategies. The document refers to policy instruments and institutional frameworks that support the implementation of the guidelines and the conservation of marine mammals, in addition to awareness raising, communication and capacity-building actions, together with the special requirements of developing States.

Finally, the guidelines address the future research and development needs for the prevention and reduction of marine mammal bycatch in capture fisheries.

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