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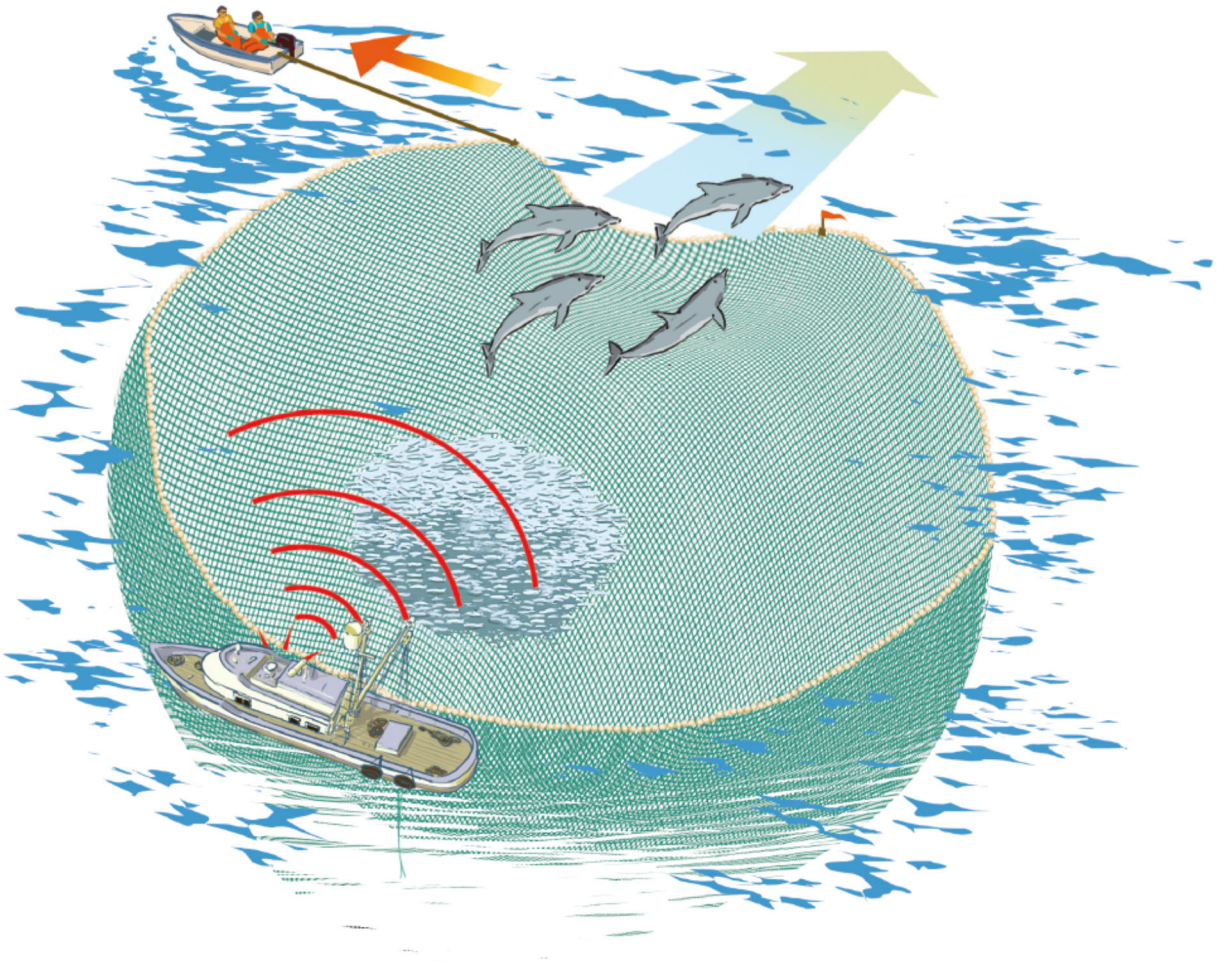
Report of the

EXPERT MEETING TO DEVELOP TECHNICAL GUIDELINES TO REDUCE BYCATCH OF MARINE MAMMALS IN CAPTURE FISHERIES

Rome, Italy, 17–19 September 2019



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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2020

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PREPARATION OF THIS DOCUMENT

This is the Report of the Expert Meeting to "Develop Technical guidelines to reduce bycatch of marine mammals in capture fisheries" which was held at FAO headquarters in Rome on 17–19 September 2019.

The Expert Meeting was organized by the Food and Agriculture Organization of the United Nations (FAO). The meeting served to prepare "Technical guidelines to reduce bycatch of marine mammals in capture fisheries" that are directed at decision-makers, planners, managers, and all those involved in developing and implementing policy and technical interventions relevant to the bycatch of marine mammals in fisheries.

The meeting was organized in response to the request from the Committee on Fisheries (COFI) at its 33rd Session in 2018 to develop technical guidelines on this subject. In line with the recommendations of COFI draft guidelines were prepared by Mr Tim Werner and Mr Steven Kennelly, with technical assistance from FAO's Fishing Operations and Technology branch (FIAO) staff and consultants, Raymon van Anrooy, Pingguo He and Ingrid Giskes.

The Expert Meeting reviewed the draft Guidelines for completeness, scope, aim and relevance of the guidance provided. Following the meeting, the authors prepared in October – November 2019 a near-final draft of the guidelines, which is included as annex to this meeting report.

The guidelines development process and Expert Meeting were supported by the Government of the United States of America, Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) – FAO collaborative Trust Fund project "Cooperative Agreement on the United States of America Support for Fisheries and Aquaculture Department Activities" (GCP/GLO/576/USA).

FAO technical assistance to the Expert Meeting and its preparations was provided by Mr Raymon van Anrooy, Ms Ingrid Giskes, Ms Duygu Maktav and Mr Pingguo He. Resource persons to the meeting were Mr Tim Werner and Mr Steven Kennelly. Formatting and publishing assistance was provided by Ms Estefanía Burgos, Ms Marianne Guyonnet and Ms Chorouk Benkabbour of FAO

This report contains a record of the Expert Meeting, including short summaries of presentations and discussions.

ABSTRACT

The Expert Meeting to "Develop Technical guidelines to reduce bycatch of marine mammals in capture fisheries" was held in Rome, Italy, on 17–19 September 2019. Twenty-nine fisheries and bycatch experts and observers from FAO Members participated in the meeting: Argentina, Australia, Brazil, Canada, Chile, Denmark, Iceland, Japan, Norway, Russian Federation, Sweden, and the United States of America. The meeting was also attended by experts from various regional and international organizations, including the Convention on the Conservation of Migratory Species of Wild Animals (CMS), International Council for the Exploration of the Seas (ICES), International Whaling Commission (IWC), North Atlantic Marine Mammal Commission (NAMMCO), and NGOs, including Marine Stewardship Council (MSC), Whale and Dolphin Conservation (WDC), and the World Wildlife Fund (WWF).

The meeting aimed to prepare "Technical guidelines to reduce bycatch of marine mammals in capture fisheries" that are directed at decision-makers, planners, managers, and all those involved in developing and implementing policy and technical interventions relevant to the bycatch of marine mammals in fisheries.

The meeting was organized by FAO in response to the request from the Committee on Fisheries at its 33rd Session in 2018 to develop technical guidelines on this subject. At the meeting the experts reviewed and discussed technical measures that can be applied for the reduction of bycatch of marine mammals in fisheries, including: time-area closures, acoustic deterrents, modifications to fishing gears and changes in fishing operations. The meeting discussed research and development needs for reducing bycatch of marine mammals and drivers of change.

The meeting also discussed the roles of various stakeholders (national governments, regional and international organizations, fishers and their organizations and non-governmental organizations) in terms of development and implementation of the technical measures proposed, and with respect to awareness raising, communication and capacity building. Moreover, the meeting reviewed a draft decision tree that aims to facilitate fisheries managers on the process to follow in the management of bycatch of marine mammals in fisheries.

CONTENTS

INTRODUCTION

1. The Expert Meeting to "Develop Technical Guidelines to Reduce Bycatch of Marine Mammals in Capture Fisheries" was held at FAO headquarters in Rome, Italy from 17 to 19 September 2019. Twenty-nine fisheries and bycatch experts and observers from FAO Members participated in the Meeting: Argentina, Australia, Brazil, Canada, Chile, Denmark, Iceland, Japan, Norway, Russian Federation, Sweden, and the United States of America. The meeting was also attended by experts from various regional and international organizations (Convention on the Conservation of Migratory Species of Wild Animals (CMS), International Council for the Exploration of the Seas (ICES), International Whaling Commission (IWC), North Atlantic Marine Mammal Commission (NAMMCO), and NGOs, including Marine Stewardship Council (MSC), Whale and Dolphin Conservation (WDC), and the World Wildlife Fund (WWF).

2. The overall objective of the Expert Meeting was to prepare "Technical guidelines to reduce bycatch of marine mammals in capture fisheries" that are directed at decision-makers, planners, managers, and all those involved in developing and implementing policy and technical interventions relevant to the bycatch of marine mammals in fisheries.

3. The Expert Meeting was specifically tasked to:

- Review available draft chapters of the "FAO Technical Guidelines for Responsible Fisheries: Guidelines to reduce bycatch of marine mammals in capture fisheries" on completeness, scope, aim and relevance of the guidance provided;
- Summarize regional and global institutional arrangements and mechanisms for advising on marine mammal bycatch reduction in fisheries policy and management, and make practical recommendations on how these can be strengthened; and
- Prepare a near final draft of the FAO Technical Guidelines to supplement the Technical Guidelines No. 1. Fishing Operations under the FAO Code of Conduct for Responsible Fisheries on this subject.

4. The agenda of the Expert Meeting and the List of Participants are provided in Appendices A and B.

OPENING OF THE MEETING

5. The participants of the Expert Meeting were welcomed by Mr Matthew Camilleri, branch head of the FAO Fishing Operations and Technology Branch (FIAO). Mr Camilleri stressed the importance of the Code of Conduct for Responsible Fisheries (CCRF) in the promotion of sustainable fisheries world-wide, and to the duties of states 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. He mentioned that the attention of FAO on bycatch of marine mammals was raised at the FAO Committee on Fisheries (COFI) at 32nd Session in 2016. Reference was made as well to the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations, which was held in Rome by FAO in March 2018, and to the request of the 33rd Session of COFI in 2018, to develop the best practices for the reduction of bycatch of marine mammals in the form of technical guidelines. He emphasized that many FAO Members use the technical guidelines and that the process of development of these specific guidelines, through the inputs from an expert workshop and Expert Meeting, contributes to the final product and its value for the stakeholders. Mr Camilleri thanked Mr Tim Werner and Mr Steve Kennelly for preparing the draft document of technical guidelines, as well as all experts and observers for dedicating time to this important effort. He also acknowledged the important financial contribution from the National Oceanic and Atmospheric Administration (NOAA) of the United States of America, to the Expert Meeting and to the FAO work on reducing bycatch of marine mammals in fisheries.

6. Following the welcome remarks, participants introduced themselves and their area of work.

7. Mr Haraldur Einarsson (ICES) and Ms Cheri McCarty (NOAA) were elected as co-chairpersons of the Expert Meeting. FAO provided the secretariat for the Meeting.

8. The provisional Agenda was introduced and adopted.

9. Mr Raymon van Anrooy and Mr Pingguo He (FAO) presented on behalf of the Secretariat an introduction of the FAO Code of Conduct for Responsible Fisheries (CCRF), its technical guidelines and the outcomes of the 2018 Marine Mammals Expert Workshop. The presentation included a summary overview of the process that led to the preparation of the CCRF, the elaboration process, objectives of the CCRF, its structure and what is being done in support of its implementation. The Secretariat also emphasized the importance of the technical guidelines for responsible fisheries under the CCRF to guide FAO member countries and stakeholders on implementation of specific articles of the CCRF. The secretariat recalled that COFI welcomed the work of FAO on bycatch, including work on marine mammal bycatch and the recommendations of the Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations. COFI encouraged FAO to continue its work, engaging with Members, relevant experts and organizations, such as the International Whaling Commission and the North Atlantic Marine Mammal Commission, in the development of best practices in the form of technical guidelines. This would require further consultations among Members.

PRESENTATION AND DISCUSSION OF THE DRAFT TECHNICAL GUIDELINES CHAPTERS

10. Experts were given the opportunity to provide general comments and suggestions for improvement of the draft technical guidelines, before entering into more detailed discussions. It was agreed that detailed comments and edits of the draft document would be provided by experts during the meeting and shortly thereafter.

11. The Expert Meeting made the following general observations and recommendations:

- The document generally needs to be shortened, and the FAO Technical Guidelines on "Best practices to reduce incidental catch of seabirds in capture fisheries" could provide an example in this respect.
- The documents should describe in the scope why these guidelines are needed, and add a concluding section.
- The guidelines should avoid the use of subjective and/or emotive language and animal welfare related statements, and increase the focus on clear technical recommendations.
- The guidelines should indicate that there is a range of motivations for reducing marine mammal bycatch that include conservation of vulnerable species and populations.
- Bycatch preventive measures need to be a priority in addition to bycatch reduction measures. In this respect the Expert Meeting proposed to change the title of the technical guidelines to: Guidelines to prevent and reduce bycatch of marine mammals in capture fisheries.
- Bycatch mitigation research is a developing field with continual revisions to best practices.

12. Some experts noted that case studies could be added to illustrate the use of specific measures, as well as the information on the pros and cons of various measures. It was also suggested to find a way to update the guidelines, when needed, and particularly the list of technical measures.

13. The secretariat informed the Meeting of the timeframe for submission of comments on the current draft, the circulation of the next draft to the FAO member countries, and finalization of the document for presentation to COFI 34 in 2020.

14. The Expert Meeting agreed that these guidelines would exclusively focus on prevention and reduction of bycatch of marine mammals in capture fisheries. The guidelines are not intended for situations where marine mammals are the target of a fishery and do not include accidental capture and/or entanglement in aquaculture facility, nor shark/beach nets, nor catch from ghost fishing. The guidelines do also not include guidance on the safe handling and release of incidentally caught marine mammals, although lessons can be learnt in mitigation from such work.

15. Mr Steve Kennelly gave a short presentation on the section of the Working Document **"**Introduction, definitions, scope and guideline objectives". The presentation provided an introduction to the subject, and mentioned that around 130 species and 84 subspecies/ subpopulations of marine mammals are currently recognized throughout the world's oceans, and over 500 000 marine mammals are incidentally captured in a range of fisheries every year.

16. The Expert Meeting made the following recommendations towards improvement of the introductory chapter of the draft technical guidelines:

- include the main definitions, species covered and global estimates on marine mammal bycatch in the first paragraphs;
- include an abstract in the document;
- include references to the Voluntary Guidelines on the Marking of Fishing Gear (VGMFG), which take in consideration abandoned, lost or otherwise discarded fishing gear (ALDFG), the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) and the Ecosystem Approach to Fisheries (EAF);
- distinctions are to be made between industrial- and small-scale fisheries;
- emphasize that the main audience for these guidelines are fisheries managers and policy makers, and that support from all stakeholders is required for the implementation of the guidelines;
- include an adaptive approach to management of the marine mammal bycatch in fisheries, with a feedback loop, in the implementation section;

17. Mr Steve Kennelly gave another short presentation on **Policy instruments and institutional frameworks supporting the conservation of marine mammals in fisheries**, in which he provided an overview of the main global and regional conventions and agreements, as well as international and regional institutions working on the subject. Examples of national level policy measures and regulatory frameworks were also provided, but the Expert Meeting decided that the section on national level measures and its appendix should be removed from the guidelines, because instruments from all countries could not be included.

18. The Expert Meeting made the following recommendations towards improvement of the chapter on policy instruments and institutional frameworks of the draft technical guidelines:

- shorten the chapter by annexing relevant information for the international and regional instruments and removing the table on national level legislation and policies from the document and include only a list of good practices/elements of legal and policy measures that can be taken in relation to marine mammal bycatch;
- replace the detailed information on RFMOs and RFBs with a paragraph on the work of these regional institutions referencing the relevant FAO website page;
- update the sections on CCAMLR, IWC, NAMMCO and CMS and related daughter agreements;

- remove references to polar bears, which have not been reported as bycatch in capture fisheries.

19. Mr Tim Werner made an introduction to **drivers of change to reduce marine mammal bycatch**. He addressed a range of drivers, including, among others, the needs for data collection, knowledge transfer, capacity building and outreach, and guidelines on specific techniques. The presentation was followed by a discussion on implementation of the technical guidelines in general and the chapter referring to implementation.

20. The Expert Meeting made the following recommendations towards improvement of the chapter on drivers of change and the implementation of the draft technical guidelines:

- Distinctions are to be made between industrial- and small-scale fisheries.
- Food security and socio-economic factors are important considerations for small-scale fisheries and in particular for developing countries.
- Compliance and enforcement of the policies and legislation on marine mammal bycatch are essential elements that require greater attention; in this respect, involvement of fishers in the testing of measures as well as in fisheries management related decision-making processes is key to get their support during implementation of the measures.
- Scaling up bycatch mitigation measures from research trials to implementation in the fishery is a necessary next step.
- The roles of certification programmes (e.g. MSC) and Fishery Improvement Projects (FIPs) in implementation of the guidelines need clarification.
- Fisheries management should be adaptive, enabling the testing and introduction of new technologies and measures, and to implement, monitor and evaluate success and adjust as necessary, when implementing these guidelines and technical measures.

21. Mr Tim Werner then presented the chapter on **decision-making process for marine mammal bycatch reduction**. He showed three alternative decision trees to the Meeting to facilitate discussions on management decision making processes.

22. The Expert Meeting indicated a preference to review and update the decision tree that was included in the report of the 2018 Expert Workshop on means and methods for reducing marine mammal mortality in fishing and aquaculture operations. A sub-group was formed to work for revising the decision tree, which will be included in the technical guidelines and is available in Annex D of this report.

23. The Expert Meeting agreed with the revised **decision tree.** It is recognized as a useful tool for fisheries managers and researchers.

24. Mr Tim Werner gave a short presentation on the chapter containing the **Technical Measures**. He started with outlining the categories of bycatch reduction techniques reviewed, which included time-area closures, acoustic deterrents, modifications to fishing gear, changes in fishing operation, and gear switching. Then he provided details on each of the measures. The draft chapter on **research and development** was also covered in the same discussion.

25. The Expert Meeting made the following recommendations towards improvement of the chapter on technical measures of the draft technical guidelines:

- In view of the technical guidelines having fisheries managers as target users, it is important to keep the text short and coherent.
- In the text related to each technical measure it would be useful to include a paragraph on the relative costs of different measures.
- The pro's and con's currently presented in a dedicated table should be moved to the end of each section.
- The acoustic deterrents section should be reorganized and be clear about the differences between types of acoustic deterrents, and distinguish their application by gear type.

- The gear switching table should indicate where examples have been implemented in commercial fisheries, and move information from inconclusive trials to a separate table.
- It was also noted that the tables in Appendix 4 of the report of the 2018 Expert Workshop, with marine mammal bycatch mitigation measures, should be referenced in the technical guidelines.

26. The Expert Meeting discussed the technical measures in detail and various experts proposed to draft specific inputs to improve the technical guidelines. Specific items that were discussed by experts included: real-time dynamic closures, netbinding in trawls, excluder devices and escape holes in gears, acoustic deterrents, move-on rules, the distinction between a weak link and weak rope, ALDFG and marine mammal bycatch, gear switching, catch protection in long-line fisheries, reduction of discarding of offal, individual accountability and bycatch quotas, fishers compensation, and specific fishing operations.

27. The Expert Meeting agreed to maintain a section on research and development. It was suggested to add fishing efficiency to the technical measures section. It was noted that the science-policy interface is important. It was further noted that local, low-tech, low-cost or cost effective bycatch mitigation technology research need more attention in the document. It was further mentioned that satellite monitoring tools could be used to identify areas of marine mammal and fisheries co-occurrence, to support introduction of appropriate bycatch prevention and reduction measures.

28. Mr Steve Kennelly provided the Expert Meeting with a short presentation on the draft chapter on "Awareness, communication and capacity building measures".

29. The Expert Meeting emphasized the need to streamline the draft text, remove redundancy and possibly combine with the implementation chapter. Advocate the engagement of fishers in awareness, communication and capacity building on this subject. It was noted that the seafood industry and fishing gear manufacturers are important stakeholders to involve. The roles of indigenous and traditional peoples and communities was also recognized to be of importance in implementation and communication.

30. Some Experts stressed the importance of social media in communicating and awareness raising on marine mammal bycatch and measures to prevent and reduce such bycatch.

31. Mr Steve Kennelly presented the draft chapter on "Special requirements of developing countries to the Expert Meeting".

32. The Expert Meeting agreed with the text and proposed only minor amendments, including references to the development of low cost and low- tech measures, indigenous peoples, co-management and the ecosystem approach to fisheries, and to remove a reference to the safe handling of entangled marine mammals.

33. The Expert from Japan made a reservation to the conclusions, because he believes that the FAO Guidelines should be introduced mainly to fisheries that take endangered marine mammals or give serious effects to survival of species of marine mammals.

CONCLUSIONS AND RECOMMENDATIONS OF THE MEETING

34. The Expert Meeting made the following conclusions and recommendations:

Conclusions:

- The Expert Meeting agreed that a short report of the meeting be published (in English only) within two months as FAO Fisheries and Aquaculture Report and that the technical guidelines be published by FAO as Technical Guidelines for Responsible Fisheries No. 1, Supplement 4: Guidelines to prevent and reduce bycatch of marine mammals in capture fisheries (in English) before the end of 2019. To this effect, the Expert Meeting agreed on a process to finalize the draft technical guidelines within a short time frame. Publication in other languages will follow in 2020, depending on the resources available.

- While many technologies and management measures have been trialed and tested by scientists to prevent and reduce marine mammal bycatch, the uptake by the commercial fisheries sector is limited. It was noted that such uptake requires incorporation of certain key elements, including fisheries regulations, capacity building and awareness.
- Given the few solutions for marine mammal bycatch mitigation tested in small-scale fisheries, and the large number of small-scale fishers, efforts to transfer technologies and knowledge on this subject from industrial fisheries and testing of specific technologies and options for small-scale fisheries are required.

Recommendations:

- The FAO in consultation with experts and intergovernmental organizations would undertake to update the table in Appendix 4 of the Report of the 2018 Expert Workshop on the means and methods for reducing marine mammal mortality in fishing and aquaculture operations, and facilitate easy access by countries and stakeholders, including possibly through the FAO Bycatch Mitigation Information System.
- FAO, its Members and partner organizations to seek and provide support to developing countries for implementation on the technical guidelines.
- FAO and partner organizations to develop factsheets in support of increasing awareness on the technical guidelines, specific gear related measures, and also to inform and get buy-in from stakeholder groups.
- FAO to create awareness on the technical guidelines and support its implementation, through inclusion of references in background documents for the 34th session of COFI (July 2020), listing of the technical guidelines as info document for the 34th session of COFI, or alternatively organize a side-event to bring marine mammal bycatch in fisheries to the attention of COFI.

ADOPTION OF THE REPORT

35. The report of this Expert Meeting was adopted at 13.30 hours on 19 September 2019.

Appendix A

Agenda

Tuesday, 17 September 2019

Morning session

9.00 – 9.30	Opening of the Expert Meeting (Matthew Camilleri) Introduction of participants Election of the Officers Adoption of the Agenda Housekeeping arrangements
9.30 – 10.00	Introduction of the FAO Code of Conduct for Responsible Fisheries, its technical guidelines and the outcomes of the 2018 Marine Mammals Expert Workshop (Raymon van Anrooy & Pingguo He)
10.00 – 10.30	Coffee break

Presentation and discussion of draft Technical Guideline chapters

10.30 – 11.00	General discussion on the draft technical guidelines
11.00 – 12.00	Introduction, definitions, scope and guideline objectives (Steve Kennelly)
12.00 – 13.30	Lunch

Afternoon session

13.30 – 14.30	Policy instruments and institutional frameworks supporting the conservation of marine mammals in fisheries (Steve Kennelly)
14.30 – 15.30	Drivers of change to reduce marine mammal bycatch (Tim Werner)
15.30 – 16.00	Coffee Break
16.00 – 17.30	Decision-making process for marine mammal bycatch reduction (Tim Werner)
17.30	Welcome cocktail hosted by FAO

Wednesday, 18 September 2019

Morning session

Presentation and discussion of draft Technical Guideline chapters (continued)

9.00 - 10.00	Decision-making process for marine mammal bycatch reduction (continued)
10.00 - 10.30	Coffee break
10.30 – 12.30	Technical guidelines (Tim Werner)
12.30 – 14.00	Lunch

Afternoon session

14.00 – 15.30	Technical guidelines (continued)
15.30 – 16.00	Coffee Break

16.00 – 17.00 **Implementation of the technical guidelines to reduce marine mammal bycatch (Steve Kennelly)**

Thursday, 19 September 2019

Morning session

09.00 – 10.00 Awareness, communication and capacity building measures (Steve Kennelly)

10.00 – 10.30 Coffee Break

10.30 – 11.00 Special requirements of developing countries (Steve Kennelly)

11.00 – 12.00 Conclusions and Recommendations of the Meeting

12.00 – 13.30 Lunch

Early afternoon **- Reserved for the Secretariat to prepare a draft report**

Afternoon session

16.00 – 16.30 Coffee Break

16.30 – 17.30 Adoption of the Report

17.30 Closing of the Meeting

Appendix B

List of participants

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Appendix C

FAO Technical Guidelines for Responsible Fisheries

VOLUME 1. FISHING OPERATIONS

Supplement 4. Guidelines to reduce bycatch of marine mammals in capture fisheries

December 2019 (Draft)

BACKGROUND

1. From ancient times, fishing from oceans, lakes and rivers has been a major source of food, a provider of employment and other economic benefits for humanity. Ocean productivity seemed particularly unlimited. However, with increased knowledge and the dynamic development of fisheries and aquaculture, it was realized that living aquatic resources, although renewable, are not infinite and need to be properly managed, if their contribution to the nutritional, economic and social well-being of the growing world's population was to be sustained.

2. However, for nearly three decades, because of the dramatic increase of pollution, abusive fishing techniques worldwide, and illegal, unreported and unregulated fishing, catches and landings have been shrinking and fish stocks declining, often at alarming rates.

3. Stock depletion has negative implications for food security and economic development and reduces social welfare in countries around the world, especially those relying on fish as their main source of animal protein and income such as subsistence fishers in developing countries. Living aquatic resources need to be properly managed, if their benefits to society are to be sustainable.

4. Sustainability of societal benefits requires a recovery of depleted stocks and maintenance of the still-healthy ones, through sound management. In this regard, the adoption of the United Nations Convention on the Law of the Sea, in 1982 was instrumental. The law provides a new framework for the better management of marine resources. The new 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, which embrace some 90 percent of the world's marine fisheries.

5. In recent years, world fisheries have become dynamically developing sectors of the food industry, and many States have striven to take advantage of their new opportunities by investing in modern fishing fleets and processing factories in response to growing international demand for fish and fishery products. It became clear, however, that many fisheries resources could not sustain an often uncontrolled increase of exploitation. Overexploitation of important fish stocks, modifications of ecosystems, significant economic losses, and international conflicts on management and fish trade still threaten the long-term sustainability of fisheries and the contribution of fisheries to food supply.

6. In light of this situation, while recognizing that the recovery of depleted stocks is still urgent and avoiding depleting still-healthy stocks as important, FAO Member States have expressed the need to further develop aquaculture as the only immediate way to bridge the gap between the dipping capture fisheries output and the increasing world demand for seafood.

7. Indeed, in the last three decades, aquaculture has recorded a significant and most rapid growth among the food-producing sectors and has developed into a globally robust and vital industry. However, aquaculture also has been shown at times to carry the potential to cause significant environmentally and socially adverse impacts.

8. Thus, the 19th Session of the FAO Committee on Fisheries (COFI), held in March 1991, recommended that new approaches to fisheries and aquaculture management embracing conservation and environmental, as well as social and economic, considerations were urgently needed. FAO was asked to develop the concept of responsible fisheries and elaborate a Code of Conduct to foster its application.

9. Subsequently, the Government of Mexico, in collaboration with FAO, organized an International Conference on Responsible Fishing in Cancun in May 1992. The Declaration of Cancun, endorsed at that Conference, was brought to the attention of the United Nations Conference on Environment and Development Summit in Rio de Janeiro, Brazil, in June 1992, which 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.

10. The 102nd Session of the FAO Council, held in November 1992, discussed the elaboration of the Code, recommending that priority be given to high seas issues and requested that proposals for the Code be presented to the Session of COFI in 1993.

11. The 20th Session of COFI, held in March 1993, examined in general the proposed framework and content for such a Code, including the elaboration of guidelines, and endorsed a time frame for the further elaboration of the Code. It also requested FAO to prepare, on a fast track basis, as part of the Code, proposals to prevent reflagging of fishing vessels which affect conservation and management measures on the high seas. This resulted in the FAO Conference, at its 27th Session in November 1993, adopting the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, which, according to FAO Conference Resolution 15/93, forms an integral part of the Code. It was also recognized and confirmed that issues of responsible aquaculture development and aquaculture sustainability should be addressed in the formulation process so that these be appropriately covered in the envisaged Code.

12. This implicit recognition of the importance of governance in aquaculture is underlined in Article 9.1.1 of the Code, which requires states to "establish, maintain and develop an appropriate legal and administrative framework to facilitate the development of responsible aquaculture". In addition, at the beginning of the new millennium, there is growing recognition of the significant potential for the use of ocean and coastal waters for mariculture expansion. The outstanding issue in this area is that, unlike in capture fisheries, the existing applicable principles of public international law and treaty provisions provide little guidance on the conduct of aquaculture operations in these waters. Yet, experts agree that most of the future aquaculture expansion will occur in the seas and oceans, certainly further offshore, perhaps even as far as the high seas. The regulatory vacuum for aquaculture in the high seas would have to be addressed should aquaculture operations expand there.

13. The Code was formulated 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. The Code is also in line with the Agreement for the Implementation of the Provisions of this Law, namely the 1995 Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. It is equally in line with, *inter alia*, the 1992 Declaration of Cancun and the 1992 Rio Declaration on Environment and Development, in particular Chapter 17 of Agenda 21.

14. The development of the Code was carried out by FAO in consultation and collaboration with relevant United Nations Agencies and other international organizations, including non-governmental organizations.

15. The Code of Conduct consists of five introductory articles. Nature and scope; Objectives; Relationship with other international instruments; Implementation, monitoring and updating; and Special requirements of developing countries. These introductory articles are followed by an article on General principles, which precedes the six thematic articles on Fisheries management, Fishing operations, Aquaculture development, Integration of fisheries into coastal area management, Post-harvest practices and trade, and Fisheries research. As already mentioned, the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas forms an integral part of the Code.

16. The Code is voluntary. However, certain parts of it are based on relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea of 10 December 1982. In capture fisheries, the Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the Parties, such as the Agreement to Promote Compliance with Conservation and Management Measures by Fishing Vessels on the High Seas, 1993. In aquaculture, the provisions of the Code implicitly encourage participatory governance of the sector, which extends from industry self-regulation, to co-management of the sector by industry representatives and government regulators and to community partnerships. Compliance is self or enforced by peer

pressure, with industry organizations having the ability to exclude those who do not comply and governments only checking periodically.

17. The 28th Session of the Conference in Resolution 4/95 adopted the Code of Conduct for Responsible Fisheries on 31 October 1995. The same Resolution requested FAO *inter alia* to elaborate appropriate technical guidelines in support of the implementation of the Code in collaboration with members and interested relevant organizations.

18. The expanding role and increasing contribution of aquaculture to economic growth, social welfare as well as global food security was recognized and reiterated at international levels such as the 1995 FAO/Japan Conference on the Contribution of Fisheries and Aquaculture to Food Security, the 1996 World Food Summit, the 1999 Ministerial Meeting on Fisheries, the 2000 FAO/NACA [Network of Aquaculture Centers in Asia and the Pacific] Conference on Aquaculture in the Third Millennium and its Bangkok Declaration and Strategy, and most recently, the 2009 World Summit on Food Security.

19. The application of the ecosystem approach to fisheries and aquaculture as strategies for the development of the sector contributes to the implementation of the provisions of the Code, thereby enforcing the technical, ecological, economic and social sustainability of the industry.

1. Introduction

There are 130 species and 84 subspecies/subpopulations of marine mammals distributed across all the world's oceans, grouped under cetaceans[1] (whales, dolphins, and porpoises), pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatees), sea otters and polar bear (IUCN, 2019). Marine mammals typically are large bodied animals with long lifespans, delayed maturation, and low reproductive output. They play a vital role in the many ecosystems in which they occur. Mortalities of individuals can therefore have detrimental effects on populations and ecosystems.

For millennia, humans have exploited marine mammal species for food and other products. In recent decades, due to declines in populations and on animal welfare grounds, many marine mammals have become protected species under international conventions and national level legislations. Not all marine mammal species are under threat and fisheries targeting specific marine mammals can be found in some regions. In a majority of fisheries the catch of marine mammals is however not desired. In these fisheries marine mammals are considered bycatch which negatively affect 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 (Peres Roda *et al*., 2019). In addition, the definition applied here also includes any animal adversely affected by the 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 mammals (Read *et al.*, 2006; Žydelis *et al.*, 2009; Reeves *et al.*, 2013).

There are many records of marine mammal bycatch occurring in all types of fishing gears —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), but for mysticete whales the main risk comes from gillnets and the buoy lines of pots used to catch crustaceans, fish, and whelks (Johnson *et al.*, 2005; van der Hoop, 2012). Longline fishery interactions mainly involve toothed cetaceans attracted primarily to the target

[1] Cetacean is any species of the Order Cetacea, which comprise whales, dolphins, and porpoises; Pinnipeds are species in the suborder Pinnipedia in the order Carnivora, including seals, sea lions, fur seals and walrus.

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 and see the *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, subsistence and non-industrial 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*).

Despite recognition of the problems associated with marine mammal bycatch, the issue remains unresolved in many parts of the world. This is especially true in developing countries where surveillance of fishing activities is largely inadequate, yet marine mammal interactions are known to occur in significant numbers (Teh *et al*., 2015; Temple *et al*., 2019).

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

- lower revenues due to marine mammals preying on bait or 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 resulting in decreased demand for its products; and
- stricter regulatory measures such as closures and gear modifications that can increase costs and lost fishing opportunity.

In summary, bycatch in fisheries is an important threat to the persistence, health and recovery of many marine mammal populations. Furthermore, interactions of marine mammals with fishing operations can affect the viability of capture fisheries in both large-scale industrial and small-scale fisheries.

Rationale

During the past few decades, there has been heightened awareness and attention regarding the development of solutions to reduce marine mammal bycatch in fisheries. Whilst there has been a great deal of work on solutions, their implementation has remained slow. While a number of reviews have focussed on particular aspects of marine mammal bycatch mitigation (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), 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. Specifically, the Code in its article 6.6 notes 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”. The same Code (in Article 7.6.9) notes 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”.

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

At various sessions of the FAO Committee on Fisheries (COFI) members emphasized the need to step up efforts to reduce bycatch and discards, and more recently specific concerns about bycatch of marine mammals were raised. At its 31st Session in 2014 the Committee reiterated, *inter alia*, that bycatch and subsequent mortality of marine mammals was a problem that required greater attention. During the 32nd and 33rd sessions of COFI in 2016 and 2018 the subject was raised again 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 an increasing number of FAO's Member States, FAO developed these technical guidelines with extensive inputs from relevant experts and Member States.

Scope

FAO Technical Guidelines[2] have been developed since 1995 on many fisheries subjects, including aquaculture development, fishing operations, fisheries management, responsible fish utilization, and integration of fisheries into coastal area management. This document "Guidelines to prevent or reduce bycatch of marine mammals in capture fisheries" is Supplement No. 4 under Volume 1. Fishing Operations. The first three supplements under Volume 1 deal with vessel monitoring systems, incidental bycatch of seabirds, and safety at sea in fisheries.

These guidelines will be globally promoted 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 relevant to the bycatch of marine mammals in capture fisheries.

It is important to note that these guidelines do not relate to targeted harvest of marine mammals, but instead on 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 disentangling marine mammals from fishing gears or return and handling of animals stranded on beaches. Guidelines and procedures for handling and release of bycaught marine mammals have been developed by other groups (*e.g.*, Whaley and Borkowski, 2009). This document also does not include 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* marine mammal bycatch in capture fisheries.

2. Decision-making process for marine mammal bycatch reduction

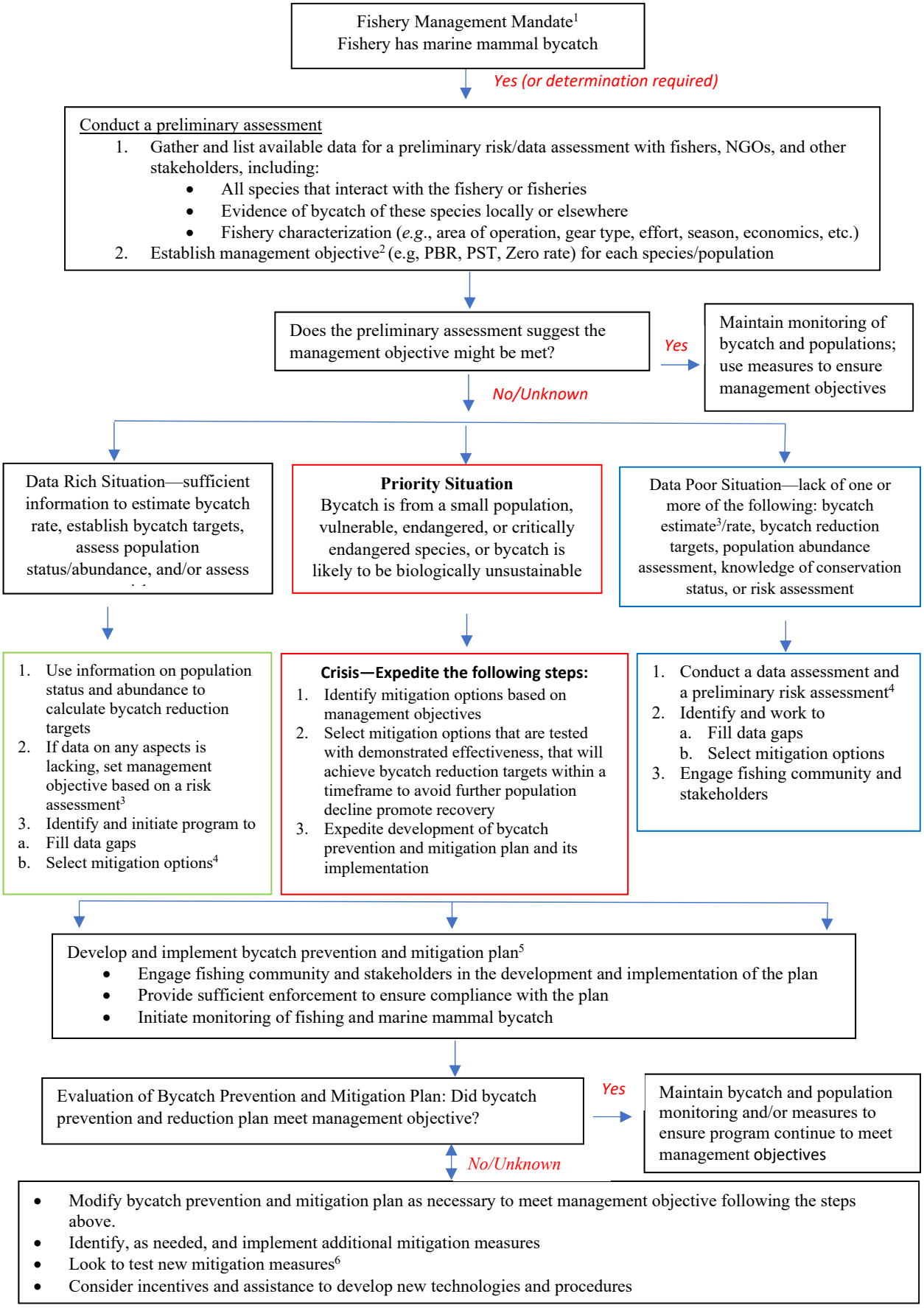
Figure 1 presents a flowchart that can serve as a tool to assist stakeholders in identifying steps that can be followed in leading to an action or a solution related to marine mammal bycatch. The first question fisheries managers should ask is whether or not marine mammal bycatch is a problem in their 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 population trends, biology, ecology, bycatch rates, and fisheries that interact with them (location, seasonality, gear, practices, economic and social aspects, etc.). Spatio-temporal overlays of critical marine mammal habitats and fishing grounds (co-occurrence) can identify the most critical areas to protect from offending fishing gear.

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

In evaluating mitigation options, it is important to appreciate the need for local testing of modifications to fishing gear and practices. One technique that may show negative results in reducing bycatch may produce positive results with only minor modifications to the gear in another area. One study may produce different results in a season of year atypical from historical conditions. Pingers with different frequencies, power outputs, or duty cycles, or in how they are spaced along a net can greatly affect their performance.

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

Figure 1. Flowchart for Developing a Marine Mammal Bycatch Prevention and Reduction Plan under the FAO Code of Conduct for Responsible Fisheries



Flowchart notes.

[1]*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 Code of Conduct for Responsible Fisheries 6.6). *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. 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* (FAO Code of Conduct 7.6.9).

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

[3]This 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 modeling different population trends for bycaught species based on spatial overlap between fishing locations and marine mammal habitat use and occurrence, and can be used to estimate the level of risk to those populations.

[4] Mitigation techniques are described throughout Chapter 3 and in FAO 2018, and 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 and voluntary mitigation measures, identify research needs, and include timelines for implementation and evaluation.

[6] *…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* (Code of Conduct 7.2.2g). *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* (Code of Conduct 8.5.1). *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.* (Code of Conduct 8.5.2).

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. Catch in pots can also attract otters. In contrast to this depredation behavior, inadvertent capture most typically occurs with large baleen whales and small cetaceans entangled in buoy ropes of pots or gillnets, small cetaceans and pinnipeds in gillnet webbing and purse seines set where animals aggregate, and in bottom or midwater trawls. Trawl interactions generally involve marine mammals exploiting them as a feeding opportunity but then accidentally becoming trapped.

By far, the highest number of marine mammal bycatch occurs from 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 to long-term reductions in population sizes may be negligible. Instead, they may be more problematic for the economic loss to fishers due to damage or removal of catch or gear.

An understanding of the nature of the interaction is important for identifying which mitigation measures are most appropriate. Generally, the most successful mitigation strategies have emerged from collaborations among fishers, fisheries managers, marine mammologists, and fisheries engineers, each of whom contributes critical expertise that should form part of any project intending to evaluate bycatch reduction measures.

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

1) time-area closures;
2) acoustic deterrents;
3) modifications to fishing gear;
4) changes in fishing operations;
5) other strategies.

The main emphasis of these strategies is on preventing interactions altogether so as to ensure long-term population survival of the animal and its population while avoiding potential pain, suffering, and mortality to the animals involved. In addition, preventing bycatch avoids problems for fishers who may lose gear, time, positive public perception or flexibility in operations, and eliminates the hazards associated with setting free animals that become ensnared or entangled in their gear. Due to variability between species, populations, fisheries and local conditions, each fishery must consider the appropriateness of the different techniques, often through trials before their full implementation in a fishery. 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, *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) contribute to marine mammal bycatch. However it is often 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 where the initial encounter occurred. These guidelines therefore make very few references to ALDFG, while acknowledging that the problem does get extensively addressed by conservation organizations and fisheries management agencies.

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 not increase bycatch of other species nor significantly alter the ecosystem they inhabit[3].

3.1 Time-area closures

Time-area closures, also referred to as spatial closures, can be effective in reducing interactions between marine mammals and fishing gear in areas where they both occur, and especially where marine mammals aggregate, such as breeding grounds, areas with seasonal prey abundance, migration corridors, or other critical habitats. Time-area closures ban or restrict fishing within all or a subset of a particular fishing zone, permanently or for a defined period of time (FAO, 2011). The most restrictive are permanent closures that are applied to all fisheries (marine protected areas 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 most endangered species, spotted 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 can vary between national and local jurisdictions. Regardless of closure type, it needs to be of appropriate size to meet management objectives, located in the right places or times, be effectively managed 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).

Time-area closures to restrict gillnet fishing have been established in several countries in response to concerns about marine mammal bycatch, including Australia, New Zealand, Mexico, United States of America, and the European Union (FAO, 2018). Some areas may be temporarily closed through a dynamic process, only going 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 operations. Such conditional regulations include the 'consequence closures' to protect harbor porpoise (*Phocoena phocoena*) off the eastern United States of America, banning gillnets when the Potential Biological Removal target is reached (NMFS, 2010a), and 'dynamic closures' 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 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 habitat and in close proximity to (4 to 11 nautical miles) to all breeding sites, with the remaining area of the fishery split into seven zones, each of which are 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 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 bycatch dolphins or bycatch rates within a specified period exceed management limits (AFMA, 2019a; 2019b). These management arrangements promote an individual responsibility approach designed to create incentives for fishers to innovate and adopt best practices. This approach avoids unfairly penalizing fishers who minimize bycatch, but requires all fishers to be 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).

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

As a bycatch reduction measure, time-area closures generally have the objective of avoiding extinction and enabling the recovery of a population or species. It is therefore important to determine quantitatively measurable management targets (*e.g.*, monitoring needs to determine whether bycatch is at or below mortality numbers that do not prevent a population from maintaining or reaching a biologically viable size). For the most endangered and vulnerable populations, time-area closures are among the most preferred management measure because they remove fishing gear out of harm's way. However the time-area closures should be implemented timely, before populations are so low that intrinsic rates of species recovery are severely hindered.

Many fisheries closures are static in space and time, while geographic distributions of marine mammals and target fish species can be dynamic. Under these circumstances, static closures provide fewer safeguards, because area restrictions are more effective when high bycatch consistently occurs in the same areas and seasons (Murray *et al.*, 2000; FAO, 2011). In addition, 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 of 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 include marine mammal distribution, abundance, survival rates, population viability, year-to-year variability, distribution of fishing effort, and level of bycatch. To be effective, time-area closures should have positive impacts 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 dolphin in the vicinity of a small reserve in New Zealand that ban the use of gillnets and found that the reserve increased the means of survival probability for the resident population, but the reserve size was insufficient for the recovery of the overall population. Slooten (2013) modeled the potential for population recovery of this endangered species throughout its entire range under the existing time-area management system, and concluded that the existing scheme (reserve locations, sizes, and management regimes) would not likely lead to Hector's dolphin's population recovery, nor prevent the species from continuing its decline. Rojas-Bracho and Reeves (2013) concluded that protected areas needed to encompass the entire range of the vaquita (*Phocoena sinus*) in order to completely eliminate bycatch and give the remaining population a higher probability of recovery. In Brazil, Prado *et al*. (Animal Conservation, *in review*) conclude that the compliance and effectiveness of gillnet regulations have proven insufficient to reduce franciscana (*Pontoporia blainvillei*) bycatch to sustainable levels. The authors showed that gillnet exclusion zones cover only a small proportion of the areas with the highest risk of bycatch in the State of Rio Grande do Sul.

The consensus from these studies is that adopting time-area closures as a principal management response for reducing bycatch of marine mammals has not achieved adequate or, indeed, measurable population recovery. This does not mean that they do not 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 time-area closures should also note that fishers generally oppose time-area closures, which typically exclude them from preferred fishing grounds. In addition, many countries, primarily developing ones, lack the capacity to effectively enforce and monitor the closures (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 time-area closures.

Pros	Cons	Marine Mammal Target
Eliminate all or nearly all bycatch within the area designated (when effectively enforced). May have other ecosystem benefits during the period when the closure is in effect, such as avoiding environmental consequences from fishing or helping to rebuild fish population.	Not always achieves the ultimate conservation benefit of population recovery. Require reliable information on marine mammals (such as foraging areas) and fisheries activity; and effective management, monitoring and enforcement. Benefits limited to area(s) designated. Can concentrate fishing effort outside the boundary in a small area which can increase bycatch. Tend to be static so less appropriate under dynamic spatial changes in marine mammal distributions and fisheries effort. Generally unpopular with fishers, who become excluded from preferred fishing grounds.	All species and populations that spend substantial time in the area.

Box 1. Needs for establishing, monitoring, and enforcing time-area 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 programs 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 time-area closures across the total range of a population, as different fisheries pose varying entanglement and bycatch risk 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 time-area closures are of appropriate size, in the right locations, implemented during appropriate times, effectively managed to mitigate the bycatch threat, avoid introducing new threats, and can 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 time-area 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 for establishing representative areas and the criteria for no-take/closed areas, and engage all stakeholders in the full process from area selection to evaluation and monitoring.
7. Educate decision-makers on all types of time-area closures, and ensure they understand when these and other fisheries management measures may sometimes be more effective than spatial closures.
8. Build or further develop in-country capacity for carrying out all the needs mentioned above.

In the development and implementation of time-area closures it is further important to apply ecosystem approach to fisheries (EAF), the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication, 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 deterrents

Acoustic deterrents (pingers, primarily) can serve as an effective bycatch reduction measure in certain situations. Experimental trials and fisheries observer data from monitoring of marine mammal bycatch in some fisheries have both shown that pingers can exclude certain species of marine mammal within the range of the sound field. However, an opposite effect can occur in which some marine mammals become attracted to the devices, while others can suffer serious injury from the use of deterrents with high sound outputs.

Acoustic deterrents consist of a range of devices that emit sound using electrical or mechanical means, or are designed to be acoustically reflective to echolocating cetaceans. They may be deployed on or near fishing gear, and include categories of devices referred to as pingers, acoustic harassment devices (including seal-scarer devices), and passive acoustic devices. Their intended use is to enhance detection of fishing gear by those cetaceans that echolocate for prey detection and other reasons, or to create an alert or unappealing sound that may cause animals to avoid the sound source. The units that actively produce sound span a range of power outputs 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 how different units were designed to function.

> *Pingers* tend to be relatively small, cylindrical shaped units roughly the size of a beverage can that produce sound at different frequencies but generally in the 3-70 kHz range, and less than 180 dB (re 1 pPa @ 1 m). Some devices operate at random frequencies, for example, Dolphin Deterrence Devices produced by STM Products between 5-500 kHz. They are most commonly used for avoiding bycatch of small cetaceans, harbor porpoise in particular, in gillnets.
>
> *Acoustic Harassment Devices (AHDs)* are intended to deter animals from approaching fish traps or aquaculture cages and sea pens by 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.
>
> *Predator sounds* mainly include the playback of killer whale calls, and have the intention of prompting marine mammal prey species to flee or avoid the area where the sound is emitted.
>
> *Passive acoustic deterrents* 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.

The most critical consideration is whether or not these deterrents elicit a behavioral response in a particular species so that bycatch is prevented or reduced substantially. Ample evidences show that acoustic deterrents only elicit a behavioral response leading to bycatch prevention in only some marine mammal species. From studies of behavioral responses, controlled experiments comparing nets with and without pingers, and multi-year monitoring of bycatch levels, pingers have shown to be effective in reducing bycatch or causing area avoidance for at least 7 (but possibly 12) species.Harbor porpoise, striped dolphin (*Stenella coeruleoalba*), franciscana (*Pontoporia blainvillei*), beaked whales (Ziphiidae. 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). Acoustic deterrents appear ineffective with dugong (*Dugong dugon*) (Hodgson *et al.*, 2007). Even though some North Atlantic right whales (Nowacek, 2004) showed a behavioral response to high frequency sound exposure, and humpback whales (*Megaptera novaeangliae*) to pinger sounds (Lien, 1992; Harcourt *et al.*, 2014; Pirotta *et al.*, 2016), there is no evidence that this type of reaction will help prevent entanglements in fishing gear. Some species,

such as bottlenose dolphins (*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). There is no indication that pingers deter bottlenose dolphins from entering trawl nets (Allen *et al.*, 2014). Sea lion interactions in gillnets, both California (*Zalophus californianus*) and South American (*Otaria flavescens*) sea lions, appear to increase when acoustic deterrents are used, which 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 higher frequency of 70kHz, instead of 10kHz, showed similar reduction in franciscana 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 behavior of target fish, leading to reduced target catch (Doksæter *et al.*, 2009).

Passive acoustic deterrents can be relatively inexpensive and easy to implement, but have yet to produce conclusive evidence that they work, and would be limited to echolocating marine mammals that also do not depredate bait or catch.

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

Besides species-specific differences, the effectiveness of acoustic deterrents is also a function of experimental design, the fishery where tested, the sound created by the unit, ambient noise level, gear type, and fishing practices. Therefore, tests of the devices should be carried out in local fisheries before their implementation. Monitoring bycatch when using pingers is also critical to ensure bycatch reduction targets are being met, even when they have been shown to reduce bycatch experimentally, because the results reported from experiments often show greater reductions than when implemented in a fishery more widely (Dawson *et al.*, 2013).

Introducing unnatural sounds in the environment is far from straightforward. Many variables influence how they propagate as well as how the sound is 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 (the periodicity and duration 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. In Box 2 some guidelines for deploying pingers are presented.

The costs of purchasing pingers and operating expenses can be a significant barrier for their use. Gillnets require several pingers along a net string at varying intervals, meaning that fishers must acquire and maintain many units. Some models may also have safety issues such as anecdotal reports of possible injury from hauling solid objects, and units that can rupture when the battery becomes exposed to water when operating in deep waters.

Box 2. Some guidelines for deploying pingers.

- 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 long-term effects of using pingers.
- The type of gear should be considered (*e.g.,* trawls versus gillnets).
- 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.
- Review the range of acoustic deterrents and select the one with sound characteristics and a duty cycle that best meets the focal species, fishery, and environment.
- Engage fishers, gear engineers, marine mammologists, fisheries managers, and other stakeholders in evaluating and deploying pingers.
- Calculate an acceptable bycatch level or reduction effect, and ensure adequate monitoring and enforcement of pingers in the fishery.
- Identify any unintended consequences on other species and the environment exposed to the sound source.
- Maintain the operating condition (*e.g.,* sufficient battery charge, no leakage) of pingers.

The use of acoustic deterrents without a well thought out plan of deployment and appropriate monitoring can cause more harm than good. 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. Potentially negative consequences to fishers, marine mammals and the environment may include habitat exclusion (if the units are deployed in a dense fishery that is also a major critical habitat for marine mammals), excessive ensonification (overly filling an area with an introduced source of sound), habituation, physical harm (such as long-term hearing impairment when using AHDs), and safety concerns, even though many of them are often overstated. For example, habituation has not been reported from fisheries in the United States of America east (multi-species gillnet) and west coast (driftnet) fisheries which have long-term monitoring data (FAO 2018). Nevertheless, they are valid concerns that need to be considered prior to implementing in a fishery. Pros and cons of using acoustic deterrents in gillnet (and possible trawl) fisheries are presented in table 2.

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

Pros	Cons	Marine Mammal Target
Have demonstrated reduction in marine mammal bycatch for some species, and in some cases over many fishing seasons. Do not tend to affect target catch. Supported by a range of studies involving field trials, behavioral responses, and fisheries monitoring. 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.	Do not work for all species. Effect may be nullified or reduced depending on where they are deployed. In a few cases, can initially cause species or populations to habituate in which case the deterrent effect no longer works without adjustments (*e.g.*, change in frequency). Exclude some marine mammals from critical habitats when used at a large scale and overly ensonify an environment. Require units that are functioning properly to avoid the risk of increased bycatch. Some units emit high power outputs that can cause hearing impairment and other adverse health effects to marine mammals. When implemented, bycatch reduction occurs but is generally less than the reduction level recorded	Pingers tested show that their application can reduce bycatch or increase area avoidance for at least 7 (but possibly 12) species (Harbor porpoise, striped dolphin, franciscana dolphin, beaked whales (Ziphiidae). Cuvier's, Hubb's, Stejneger's, and Baird's beaked whale). Possibly effective for Burmeister's porpoise. They do not appear effective for dugong, North Atlantic right whales, humpback whales, and in many instances for bottlenose dolphins. Sea lion interactions in fishing nets, of both California and South American appear to increase when acoustic deterrents are used which

Help reduce depredation by pinnipeds with increased sound frequency.	in scientific trials; they therefore are a less preferable option for highly endangered species. There are reports that pingers use can pose risks to fishermen through devices exploding or during hauling, owing to increased gear weight. At certain frequencies, pingers can lead to increased depredation and bycatch through the dinner bell effect.	can, however, be managed by increasing pinger frequency.

In summary, there is much evidence that supports pingers as one of the best available technical measures to mitigate bycatch of some species in predominantly 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 widespread implementation. Their use should be subjected to on-going 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 in trawls

Trawl fisheries with 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 of turtle excluder devices (TEDs). An excluder device usually consists of a grid that allows the target catch to pass through to the codend but not a marine mammal due to 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). Escape responses and other behaviors of marine mammal species must be known, as well as size and shape differences between target and bycatch animals. For each fishery, towing speed, depth, gear characteristics, vessel size and the space available for hauling and stowing gear must be taken into account when designing or implementing a marine mammal excluder device (Baker *et al.*, 2014; Hamilton and Baker, 2019). Towing and hauling speeds made a difference in the number of Australian fur seals (*Arctocephalus pusillus doriferus*) caught in trawls in this same fishery (Hamer and Goldsworthy, 2006). Due to low interaction rates during testing, however, these authors made no conclusions on the effect of excluder devices in reducing bycatch which the authors hypothesized be explained by few entries into the nets.

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

Video monitoring reveals that dolphins swim out of the mouth of the net (Wakefield *et al.*, 2017), as well as through the escape opening. The escape holes for bottlenose dolphins as reported in the Wakefield *et al.* (2017) study involved 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 provided mixed results, with some escapes but also some 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 due to 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 *(Delphinus delphis),* Antarctic fur seal (FAO, 2018), and Southern sea lions (*Otaria flavescens*), with minimal effects on target catch; however, the fate of escaped 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 interaction (Lyle *et al.*, 2016). However, dead seals were also observed to fall out of the net equipped with a bottom opening seal exclusion device (SED). The most advisable approach based on recent research is to decrease the chances of these fall-outs by attaching a hood or kite to the escape opening located at the top of the net that 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 has been reported with a backward facing cover (Tilzey *et al.*, 2006).

Fishers along the central coast of Chile find the use of excluder devices appealing not necessarily from a mammal conservation perspective, but because dead sea lions in the trawl net affect the operation. Rapid release of animals cause fewer squid being preyed or damaged (Sepulveda, *pers. comm.*).

Excluder devices are typically tailored to individual fisheries, fishing vessels and bycatch species because single design is not suitable for all circumstances. A small disadvantage of excluder devices is that they effectively render onboard observers blind to the extent of marine mammal interactions and effectiveness of the excluder devices. Underwater video monitoring would be essential to monitor interaction levels, detect cryptic mortality and optimize excluder design.

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). This may include the optimal location for devices, size and visibility of escape opening, through better understanding of dolphin behavior inside the net and factors that contribute to dolphin mortality (van Marlen, 2007). A soft or semi-flexible grid angled to a bottom escape opening has been used in a multi-species trawl fisheries, with a decline in target catch (Stephenson and Wells, 2006; Zeeberg *et al.*, 2006).

Among other design considerations, barriers located further forward in the net between 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).

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. Pros and cons of using excluder devices in trawl nets for reducing marine mammal bycatch are presented in Table 3. Still, 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, requiring further research. In some cases, reductions of target catch may result, which should be minimized through net design and further modification.

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

Pros	Cons	Marine Mammal Target
When properly designed for the species targeted, they tend to function adequately. Effect on target catch is minimal but more of a concern with devices used for small cetaceans.	Post-release survival requires more documentation. Use of devices may increase gear drag and fuel costs. Many interactions go unobserved and may result in unaccounted mortality. Appear generally more effective with pinnipeds than cetaceans. May reduce target catch.	Bottlenose dolphins, Common dolphins, and potentially other small cetaceans; Australian, Southern, and Antarctic fur seals, other pinnipeds.

Weak ropes/links – pots and gillnets

Weak ropes or sections of rope with lower breaking strength in buoy lines of pots and gillnets may help entangled baleen whales shed gear, thereby reducing mortality and serious injury.

An analysis of ropes retrieved from entangled whales off eastern North America found that whales of larger body size were more frequently entangled in ropes of higher breaking strength. The analysis concluded that whales would be more likely to break free from ropes with breaking strengths of 770 kg or less (Knowlton *et al.*, 2016). Instead of using a single weak link with the design specifications used in the United States of America lobster fishery that is placed immediately below the buoy, alternative designs would distribute lower breaking strength along its length. Based on at-sea testing in the United States of America lobster fishery and computer modelling studies, ropes with 770 kg braided sleeves represent a suitable option at least for inshore waters, giving whales an enhanced ability to self-release from the ropes (Knowlton *et al.*, 2018). Two current design options are available. one involves constructing the entire rope with this virgin breaking strength; 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 portions.

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 kg are placed just below the buoy at the uppermost portion of the vertical line in gillnet and pots (NMFS, 2007). Weak links are also required for other portions of gillnets s. Depending on the area fished the load threshold can range between 90 and 900 kg, and generally 270 – 680 kg. However, there is no evidence to support that weak links incorporated 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 have these links attached (*see* Large Whale Entanglement Reports[4] from NOAA's Greater Atlantic Regional Fisheries Office Protected Resources division).

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 should be encouraged to reduce bycatch of odontocetes in longlines provided they do not result in significant reductions in catch volume and preferred sizes of the target species.

Weak hooks in pelagic longline fisheries involve decreasing their bending strength to a point at which they straighten and facilitate release when bitten by marine mammals, while remaining strong enough to retain target catch (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. Off Hawaii, a trial of weak hooks showed no statistical difference in tuna catch between weak and strong hooks, with the majority of straightened hooks occurring in the weak hooks (Bigelow *et al.*, 2012). However, the study was not carried out during the season when the largest tuna tended to be caught. Weak hooks involve minimal change and expense to current practices, and do not require knowledge of how animals cue into gear or fishing operations. This technique may reduce bycatch but 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 is presented in Table 4.

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

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

Pros	Cons	Marine Mammal Target
Studies conducted in the United States of America northeast fixed gear fisheries show that ropes with reduced breaking strength can lower the incidence and severity of larger mysticete whale entanglements. Comparable catch between traditional and modified gear. Weak hooks can be straightened by marine mammals and facilitate escape from the hook gear.	Weaker ropes in pot fisheries may not work with heavier offshore gear, and do not entirely eliminate entanglements. Weaker longline hooks may produce reduced catch of larger size classes of target species. Post-hooking survival remains undocumented.	Pilot whales (*Globicephala* spp.), false killer whales, pelagic odontocetes, North Atlantic right whales, other mysticetes.

Tie-downs/lowered net profile - gillnets

For small cetaceans caught in bottom-set, midwater or driftnet gillnet fisheries, tie-down nets may be used to reduce bycatch of these animals.

Tie-downs are lines that are shorter than the height of the fishing net, and its terminal ends are attached to the float line and lead line at equal horizontal distances along the net. Tie-downs reduce the profile of the gillnet and create a more curved net shape vertically. In a trial that examined the effect of tie-downs on bycatch of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in a sink gillnet fishery for monkfish (*Lophius americanus*) off the eastern United States of America , no common dolphins (*Delphinus delphis*) were caught in gillnets with tie-downs in a total of 120 hauls of the combined net types, while six were caught in gillnets without tie-downs (and an additional three unidentified species of dolphins) (Fox *et al.*, 2011). An analysis of the United States of America observer data found the use of tie-downs was associated with lower harbour porpoise bycatch rates 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 would be to deploy the net so 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 sub-surface set, however they also reported reduced target catch. 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). Evaluation of these techniques needs to record the impact on target catch to ensure that the results of a net with a lower vertical profile is simply reducing catch and bycatch owing to the reduced fishing area of the net. In Pakistan lowering the driftnet top lines to 2 m below the surface reduced bycatch of cetaceans, however additional experiments are required to determine if the reductions were due to reduced net height or marine mammal densities (IWC, 2019).

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 Target
Reduces bycatch of some small cetaceans.	May reduce target catch. Tie-downs can increase bycatch of other species such as sea turtles especially in gillnets.	Harbor porpoise, common dolphin, other cetaceans.

Ropeless fishing - pots

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

Ropeless fishing involves retention of buoy lines at or near the sea-floor 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 may be triggered by a digital timer or an acoustic release. If groundlines are used to attach pots together at the seafloor, grappling is another retrieval option. Individual pots might also use inflatable bags to bring them to the surface.

Australia's New South Wales rock lobster pot fishery 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, demonstrating the technology's viability (DeAlteris, 1999; Hopkins and Hoggard, 2006; Allen and DeAlteris, 2007), but challenges remain. These challenges included the following:

1. Surface buoys provide visual markers to all fishers and other boaters about the presence of underwater gear. Eliminating them could lead to a higher incidence of gear conflicts because other fishers are unaware there is gear underneath.
2. Acoustic releases, which give fishers the greatest flexibility 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.
3. 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 snared during retrieval.
4. 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 visually detect a surface buoy.

None of these challenges seem insurmountable, but 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 Target
Should eliminate or significantly reduce entanglements of whales (as well as leatherback sea turtles, and basking sharks); no significant effect on target catch reported.	Requires considerable evaluation of appropriate gear designs for different fisheries, including development of a system for visualizing buoyless gear at depth. Expensive Possibility of losing gear.	Mysticete whales.

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, because many Critically

Endangered North Atlantic right whales feed at, or very close to, the seabed (Hamilton and Kraus, 2019). Lobster pot fishers in the United States of America northeast also report a number of operational challenges (FAO, 2008), 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 Target
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. May increase 'hang-downs', in which ropes become lodged under rocks and therefore make it more difficult to haul gear. 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 through which target species can enter but prevent or deter predatory marine mammals, especially pinnipeds and sea otters, from entering and 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, a pole that extents to the base of the pot-collar was found not to impact catch rates or lobster size (Goldsworthy *et al.*, 2010). 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 of particular diameters prevent seals in the Baltic Sea from gaining entry into cod pots (Königson *et al.*, 2015a). Hatfield *et al.* (2011) found in 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 United States of America west coast pot fisheries 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 is relatively simple to implement, they require careful design considerations so that they 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 Target
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 using a conical net that surrounds the target catch during hauling, and over time recorded fewer observations of sperm whales in the same 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 Target
Some evidence showing reduced depredation rates. The cost of new equipment may be at least partially offset by an increase retained catch (neither removed nor partially eaten through depredation). Continued and persistent use of these devices possibly alters depredation behavior in marine mammal populations. Higher target species retention rates, better quality.	Units can sometimes fail to release components that encapsulate target catch, or become tangled. Deployment takes additional time and results in increased labor 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). Additional techniques are described that may be worth considering but to date have not developed to a stage in which they show effectiveness or promise, or may result in catch levels that are too low to support viable fisheries. They include camouflage of target catch in pelagic longlines, increasing the vertical tension or stiffness of gillnets and buoy lines, decreasing gillnet mesh size, 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

Purse seine sometimes accidently encircle dolphins while targeting tuna. When marine mammals occur in a purse seine net, prior to completing the hauling procedure a fishing vessel should release them.

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. This solution was developed following the well-known tuna dolphin problem, and is widely used in that region's purse seine tuna fishery. The backdown procedure is effective when combined with the use of the dolphin-safe or Medina 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 net remaining in the water to form a long channel. The water current also pulls the end of the channel under water 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 reduced mortality of several species of dolphins in the eastern tropical Pacific.

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

Pros	Cons	Marine Mammal Target
Facilitates the escape of dolphins and sea lions trapped in nets during hauling.	Requires additional crew to assist in dolphin escape.	Small cetaceans; pinnipeds.

Gear switching

Where solutions to marine mammal bycatch seem limited, and the challenges of implementing them look extremely daunting, or no strategies appear viable, fisheries managers should consider changing the type of gear used in a fishery to one that maintains commercial viability but pose less risks to marine mammals. Table 11 assessed three different alternative types of gear to gillnets —pots, longlines, or trawls— and focused primarily on comparing target catch abundance and size selectivity with assumptions about reducing marine mammal bycatch, or recorded comparisons of both.

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

Location	Target catch	Marine Mammal Bycatch	Alternative Gear Tested	Result	Reference
Baltic Sea (Sweden)	Cod (*Gadus morhua*)	Seals	Longline	Comparable catch levels; reduced seal interactions	Vetemaa and Ložys, 2009
Baltic Sea (Sweden)	Cod	Harbor porpoise	Longline	Comparable catch levels based on logbook data; seasonally dependent	Königson and Hagberg, 2007
Iceland	Cod	Harbor 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 and harbor 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 fishes	Harbor porpoise	Pots	Higher species selectivity (cod) in pots, but CPUE higher with gillnets; no bycatch of porpoise in either gillnets or pots, but seabirds caught only in gillnets	Pusch, 2011
Baltic Sea (Sweden)	Cod	Seals	Pots	The focus of the experiment was on evaluating catchability of cod in pots with different mesh sizes; Seal exclusion from pots inconclusive	Ovegård *et al.*, 2011
Gulf of California (Mexico)	Shrimp (*Penaeus stylirostris* and *P. californiensis*)	Vaquita	Pots	First study was inconclusive with no shrimp caught; the more recent trial showed that the gear had commercial potential	Walsh *et al.*, 2004; Villadsen, 2018
Gulf of California (Mexico)	Shrimp (*Penaeus stylirostris* and *P. californiensis*)	Vaquita	Trawls	Several trials 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 successfully used to target gummy shark, comprising 60 percent of catch. Some increase in seabird bycatch	Knuckey *et al*. (2014)

Longline vs. gillnet

Demersal longlines can be an alternative to bottom-set gillnets with comparable catch for target species, but in at least one case only during certain times of the year and at certain locations Königson *et al.*, 2015b). 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), which 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 with their longer soak times. This can increase the quality and price in the market. In the Icelandic fishery for Atlantic cod (*Gadus morhua*) and other demersal fish species, a shift from gillnets towards longlines has occurred in the last couple of decades. The gear shift is market driven, as the market has more demand for fresh product instead of the traditional salt cod. In 1989, around 25 percent of the landed catch of cod was caught in gillnets, while 13 percent of the catch was caught on longlines. In 2017, 7 percent was caught in gillnets, but 31 percent on longline (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 down to around 60 vessels in 2016-2018 (MFRI, 2019). The consequence is that estimated bycatch of harbour porpoise has dropped considerably due to lower gillnet effort (Pálsson *et al*., 2015).

Pot vs. gillnet

Where entanglements of large whales or other endangered groups of non-target species is unlikely or minimal, fishing with pots has sometimes 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, 2003; Zollett, 2009; Reeves *et al*., 2013), the mortality is much lower than in gillnets. In cases where the risk of bycatch mortality in trawls is relatively low, trials conducted often focus on comparing the effect on target catch and less on monitoring bycatch of marine mammals.

Summary – gear switching

Several gear-switching trials undertaken to date have produced encouraging results indicating a high 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 that 1) the bycatch of the animals of concern is significantly reduced, 2) catches of target species are comparable to gillnets or the fishing gear in concern, and 3) they result in no negative consequences to other species or ecosystems.

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

Pros	Cons	Marine Mammal Target
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 may be slightly lower.	

Codes of Conduct/Practice

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

- Prohibiting the direct setting on or encirclement of dolphins to catch tuna in fishing areas covered under the *Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean and the Indian Ocean Tuna Commission*.
- 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 failed.

  Some of these measures may be directly responsible for reductions in dolphin bycatch (Hamer *et al*., 2008).

- 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 with the Southeast Trawl Fishing Industry Association (SETFIA, 2007) the operational measures to reduce bycatch of marine mammals 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
    - after gantry lights switched off during night trawling if large numbers (>5) of marine mammals congregate around vessel when gear is hauled the vessel should steam away from them before setting gear again.

Tilzey *et al*. (2006) indicate that implementing this code reduced seal bycatch by half.

Conclusions regarding technical measures

Many options exist for reducing bycatch of marine mammals but they generally require evaluation within a local fishery to determine if they are as effective as concluded in another fishery. Between different locations, a lot of variability exists in fishing practices, marine mammal population characteristics, oceanographic conditions, local scientific and management capacities, and social, cultural, and economic circumstances that 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 misperception that the problem is being solved. Several fishing groups promote best practices which 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 surface ropes that connect buoys to avoid whale

entanglement. The assumption underlying this practice is that whales feed and travel in surface waters. However, species such as the North Atlantic right whale feed at multiple depths (Baumgartner *et al*., 2017) and migrate at different depths (Mate *et al.*, 1997).

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, maintain sufficient target catch levels, and not increase bycatch of other threatened species. In many cases, there should be a willingness to retest the same technique with adjustments in its design or deployment as suggested by a previous field trial. Some modifications may render a measure effective when previous trials showed no or insufficient bycatch reduction. Using a combination of techniques can also provide the level of bycatch reduction required, or provide added insurance for any mitigation to a single measure.

Involving fishers from the outset in identifying solutions 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 into modified fishing practices, and have a critical role in the design and testing of gear modifications.

3.5 Other strategies

Several market-based strategies have been put forward as potential tools for reducing bycatch, however to our knowledge only some have been used and only in combination with one or more of the mitigation techniques discussed above.

Conservation Offsets/Compensatory Mitigation. This concept would identify alternative off-setting conservation measures for bycatch of a marine mammal, 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 nesting areas on land. As far as we are aware, this approach has not been implemented, 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).

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. 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). These consisted of buyouts to facilitate fishers to change their livelihood from fishing; switch-outs that supported fishers to replace gillnets and trammel nets to another gear type that would not cause vaquita bycatch; and rent-outs which compensated fishers to fish only outside of a refuge established to conserve the vaquita. These authors concluded that the benefits of the program had mixed results, and ultimately the species population has declined so that only an estimated ten individuals remain (CIRVA, 2019). Squires (2010) provides a review of other fisheries buyouts. In that review and from the examples mentioned above, for the objective of reducing marine mammal bycatch buyouts are best considered a 'transition policy' to a sustainable fishery rather than a stand-alone measure.

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 by Maunder *et al*. (2000) 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.

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 Program (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, equivalent 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.

In two Australian fisheries, spatial closures in particular fishing zones can be applied to individual fishers when the total number of bycatch dolphins or bycatch rates within a specified period exceed management limits (AFMA 2019a, b). 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 United States of America groundfish fishery and how quotas on bycatch, as well as target catch, creates an incentive to the fisher holding an ITQ to minimize bycatch. This permits the fishers to continue fishing and adopt techniques that seek to avoid bycatch. A study by Bisack and Sutinen (2006) modeled the benefits of ITQs versus time-area closures for harbor 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, in all cases, ITQs incurred the lowest cost to the fishery.

Credit Systems or Penalty-and-Rewards Systems. No examples exist yet for these types of market-based programs for marine mammal bycatch. The concept involves rewarding vessels that satisfy a bycatch limit, adopt a recommended bycatch-reducing gear or operating technique, refrain from fishing in an undesired area or time, or adopt 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, costs of a 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 program 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 that a multitude of technologies and methods have been trialed for reducing bycatch of marine mammals in capture fisheries. It was also shown that further research, trials, development and dissemination of successes and failures is highly needed. Various marine mammal bycatch reduction research and development areas that require specific attention are discussed in this chapter.

4.1 Modeling 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. 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. For these species and populations, emergency measures are required that completely eliminate bycatch, at least until the population achieves significant recovery. 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, it offers an alternative approach 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 will most likely occur and therefore might 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 of data collection and analysis, as well as testing in field trials, including recording actual bycatch to determine correspondence with what the models show. This approach uses historical or real-time information appropriate for fishing in the present day, but does not factor in the effects of dynamic shifts in prey availability, fishing occurrence, and other changes in oceanographic conditions. This makes their utility less certain for future planning, but with sustained data collection they can eventually improve their ability to predict areas of greatest bycatch probability.

4.2 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 therefore can reduce fishing time in output-controlled fisheries, and thus help reduce bycatch. Better business models that maximize profits can potentially achieve additional benefits of reducing bycatch (Burgess *et al.*, 2018). A reduction in fishing effort can also take the pressure off unintended catch levels, and can help create more sustainable fisheries. The consequences may affect individual fishers who may become displaced from the fishery, yet this sacrifice may be justifiable on social, economic, and environmental grounds. Effort reduction is not uncommon in fisheries, and will be inevitable in the future. Improvements in fishing efficiency may yield adequate financial returns to fishers while reducing the time the gear is deployed in the ocean. This can include decreasing soak time and, for pot fisheries in which multi-pot strings are used, reducing the ratio of vertical lines to units of gear. In other words, it involves trawling up so that more pots are attached to fewer vertical lines (NMFS, 2015). Kite-Powell *et al.* (*unpublished report*) showed encounter probabilities in the northeastern United States of America would be reduced under a trawling up scheme. However, in reaction to this measure, some lobster pot fishers reacted by increasing the diameter of buoy lines they use, which likely decreases the probability that whales can break free of gear (Knowlton *et al*., 2016). Increasing the number of pots/string will also increase groundline length, and groundlines are another source of whale entanglements. It is thus important to note that any potentially beneficial change must also account for unintended consequences.

4.3 Marine mammal and target catch sensory biology and behavior

A modification to fishing gear that prevents bycatch of marine mammals while having no effect on target catch would be the optimal result to be achieved. Identifying differences in the sensory systems or behavior between marine mammals and target species provides a promising field of research. It does however require a good understanding of how marine mammals and target catch 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 catch perceive their environment or introduced stimuli. Some promising bycatch prevention measures will likely become identified by exploiting these differences, which will require basic scientific research on sensory biology and behavior of target and non-target animals.

Visual deterrents

This technique involves altering the color, luminosity, or appearance of fishing gear to make them more visually detectable by large whales or small cetaceans. Preliminary field work on rope coloration 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, a finding that was statistically significant (Kraus *et al.*, 2014). Another experiment on whale eyesight examined the use of sonar in humpbacks (Beamish, 1978). In that study, a humpback was blindfolded and run through a maze. With blindfolds on, the whale failed to navigate the maze, but with blindfolds off, the whale successfully completed the maze, even at night.

Altering rope color 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 color 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 a curiosity or other attractant response from some species.

Apart from color and luminosity, results from field experiments with short lengths (20 cm) of flexible rope whiskers attached at 1 m intervals along vertical buoy lines suggested that minke whales may be able to visually detect ropes more readily than buoy lines without them (Kot *et al*., 2012).

There is a lack of studies on behavioral responses at night and at greater depths where mysticetes also occur and engage in feeding. There are likely different levels of entanglement risk due to swimming depth, behavior at night, or whether an animal is alone or in a group, as well as how color or luminosity is detected deeper in the water. Differences in behavioral responses between species, populations, and even individuals are also possible. All of this needs further investigation.

Circadian/feeding cycles

A largely uninvestigated technique is altering the time of day in which fishing occurs which might produce adequate catch while reducing marine mammal bycatch. Obviously, this tactic is infeasible for some fisheries if the target species and marine mammals are mixed all the time, whether for feeding or other activities.

Acoustic deterrents

Acoustic techniques are one of the more tested measures for reducing marine mammal bycatch. Certain designs might produce fewer prolonged effects, such as by evoking an alert response of shorter duration. This alert might warn a marine mammal to 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 area of on-going research is to identify how to elicit such a startle response (Culik *et al.*, 2015; Götz and Janik, 2014). As pingers are generally costly, especially many are needed, there is research undertaken on using empty glass or plastic containers filled with pieces of metal that might produce a similar effect as pingers but at a fraction of the cost.

Economic and social aspects related to bycatch reduction

Even when fishing trials indicate the potential of using alternative gear to reduce bycatch of marine mammals, rarely do they also include complementary studies (economic, political, social, cultural, etc.) that can facilitate the uptake by fishers and advance from a research to an implementation phase. Even when the science shows the effectiveness of alternative fishing techniques, rarely do they become adopted (Eayrs and Pol, 2018). It is needed to build on the encouraging results from trials by conducting supporting studies that assess social, cultural and economic barriers towards implementing the gear- or fishing operations changes. Furthermore, because there is often resistance to change within fisheries, the science –policy interface should be developed and persistence on the part of scientists and fisheries managers is needed to help address barriers and to provide incentives for the uptake of more sustainable practices.

5. Implementation of these guidelines

5.1 Driving change to prevent/reduce marine mammal bycatch

Change in fishing practices ultimately depends on fishers themselves, but 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 unmet need for altering fishing practices, including 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 adopting new fishing gear or methods, fishers generally do not make the transition voluntarily (Eayrs and Pol, 2018). In northern countries such as the U.S and those of Europe, new regulations in fisheries are generally the main drivers for change. This is discouraging given that much of the world's fishing sector is located in and operates in developing countries where many endangered and threatened marine mammals also live, and in which there is limited focus on bycatch reduction. Even where there may be interest among and options for fishers to reduce bycatch in this sector, the high cost of new gear may make it inaccessible to them, and 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. In these countries, small-scale fisheries are prominent, and governance and surveillance of fishing activities is lacking. In fact, many vessels and fisheries are unregistered and insufficiently described; and monitoring is mostly land-based (Teh *et al*., 2015; Castro *et al*., sub). Further, the incidental catch of marine mammals sometimes represents a source of income and food supply (Gillman, 2011), and so bycatch reduction measures may evoke social conflicts (Teh *et al.*, 2015).

Despite examples of self-motivated fishers implementing bycatch solutions to improve their CPUE (Werner *et al.*, 2006), nearly all measures that reduce bycatch of marine mammals have been a result of regulations. Governments and other fisheries management organizations therefore have important roles 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 all. Consequently, marine mammal bycatch reduction often fails to emerge as one of the top priorities in fishery management. In this respect, it may be relatively easier to introduce marine mammal bycatch reduction measures in fisheries that are being managed actively already. Examples of actively managed fisheries can be found in high value fisheries, such as tuna fisheries. These fisheries are subject to negotiated management measures (such as quotas) and involve considerable engagement by governments, regional fisheries management bodies, fisherfolk 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 bycatch reduction and other conservation challenges. However, these legal measures need to be combined with 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 and commitment towards addressing the bycatch of marine mammals problem.

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 related to the development and implementing of marine mammal bycatch reduction programmes.

Some overarching measures that deserve attention when promoting prevention and/or reduction of marine mammal bycatch in fisheries include:

- More detailed region by region strategies to prioritize risky fisheries and vulnerable populations, whilst at the same time generally increasing the level of bycatch monitoring;
- 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 to marine mammal bycatch to countries where this information is lacking;
- Building local capacity for marine mammal population assessments, fisheries surveys, field trials of potential deterrents and monitoring any tangential impacts and the long-term consequences of measures;
- Building a greater commitment to collect data on marine mammal populations, fishing grounds and effort, physical and biological oceanographic characteristics, and 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;
- Collaborative effort of sociologists, economists, and change management experts in bycatch mitigation programs to identify paths that can lead from scientific success to implementation of changes and reinforce the importance of social engagement, communitarian approaches, bottom-up approaches;
- Creating greater public outreach regarding the scale of the problem, to include elaboration of the potential losses in ecological and economic benefits from marine mammal population declines, 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.

5.2 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;
- 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 RFMOs and the signatories to the various agreements and MoUs described in the Annex to these guidelines;
- Global organizations such as FAO and the International Whaling Commission;
- Non-government organizations, including environmental groups; and
- Organizations of fishers, individual fishing companies, owners, captains and crews;

The extent and manner by which each entity implements these Guidelines 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, UN Environment, IWC) and regional fisheries management organizations. These characteristics make that government agencies are assigned the most important roles for implementing these Guidelines.

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

- Use these Guidelines to craft particular management measures to prevent or reduce marine mammal bycatch and incorporate the associated enabling legislation;
- Integrate these Guidelines in routine fisheries management decision-making processes within their jurisdictions and regionally;
- Establish collaboration mechanisms among their component agencies to develop compatible standards, tools, mitigation measures and regulatory regimes aimed at preventing/reducing marine mammal bycatch.
- Standardize monitoring and reporting procedures regarding marine mammal bycatch.
- Develop long-term capacity to coordinate data collection, assessments and mitigation measures.
- Share information about measures that prevent or reduce marine mammal bycatch among their component jurisdictions and throughout their region.
- Consider measure to evaluate accountability, adaptability, effectiveness, practicability, socio-economic aspects, timeliness and transparency in implementing these Guidelines.
- Participate in appropriate regional fisheries bodies to assess, share and evaluate measures that prevent/reduce marine mammal bycatch.
- Implement cooperation and integration programmes with other organizations and entities within their country and regionally to further these Guidelines across states, nations and regions;
- Use these Guidelines as a resource when developing certification schemes for sustainable fisheries.
- Support research and management activities financially within their country that are designed to assist in marine mammal bycatch prevention/reduction.
- Adopt principles of adaptive management when implementing and assessing various measures to prevent/reduce marine mammal bycatch.

Regional bodies

Regional bodies, such as RFMOs and regional environment organizations can play a strong role in the implementation of these Guidelines by integrating the various measures detailed here into fisheries and ecosystem management and conservation frameworks and plans that applies across large areas of the world's oceans.

Potential roles of regional bodies in implementing of these Guidelines include:

- Where appropriate, draft and implement binding measures to prevent/reduce marine mammal bycatch and incorporate appropriate text into other regional agreements.
- Share information about measures that prevent or reduce marine mammal bycatch with their component States.
- Use their collaboration mechanisms to address common issues, such as through the development of compatible standards, tools and information aimed at marine mammal bycatch prevention/reduction.
- Develop and implement standards and harmonized measures to reduce bycatch of marine mammals in their fisheries.
- Ensure appropriate levels of monitoring and reporting regarding marine mammal bycatch throughout their region.
- Develop long-term capacity to coordinate data collection, assessments and mitigation measures throughout their region.
- Consider appropriate levels of accountability, adaptability, effectiveness, practicability, socio-economic aspects, timeliness and transparency.
- Establish and support working groups to provide scientific advice on bycatch management in fisheries and ensure that marine mammals get adequate attention in such working groups;
- Encourage the participation of scientists and managers with expertise on marine mammal bycatch prevention and reduction in appropriate scientific committees and working groups.

- Implement cooperation and integration programmes throughout their region to further these Guidelines across member States and neighboring regions.
- Ensure consistency in management and legislations among jurisdictions within the region.
- Ensure compliance with marine mammal bycatch prevention and reduction measures.
- Encourage and financially support research and management activities to evaluate the effectiveness of, and investigate new, marine mammal bycatch mitigation measures.
- Adopt 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:

- Distribute these Guidelines to all Member States, post on appropriate websites and social media platforms and promote at relevant conferences and events.
- Develop collaborative mechanisms to address common issues, such as through the development of compatible standards, tools and information for dissemination to member entities.
- Encourage the standardization of monitoring and reporting procedures regarding marine mammal bycatch.
- Encourage the development of long-term capacity to coordinate data collection, assessments and mitigation measures.
- Cooperate with other organizations and entities to build capacity for implementation and monitoring of these Guidelines across Member States.
- Share information about measures that prevent or reduce marine mammal bycatch at international fora.
- Inform other stakeholders and the public of actions taken to monitor, prevent and reduce the bycatch of marine mammals.
- Monitor the progress made in the implementation of the Guidelines using FAO's existing biennial CCRF questionnaires and 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. NGOs usually 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:

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

- Rate different fisheries based on marine mammal bycatch as one of the factors in their environmental criteria.

Fishers, their representative bodies and certification schemes

At the core of the interaction between the fishing sector and marine mammals are fishers themselves. That is, the captains, crews, vessel owners and organizations of the fishing fleets whose gears catch, kill, release or otherwise interact with marine mammals. This is therefore the main group of stakeholders that these Guidelines will affect, and their implementation of these Guidelines will be key to preventing and reducing bycatch of marine mammals throughout the world. Fisherfolk organizations play generally an important role in fisheries management decision making processes, particularly when an EAF is applied. These organizations have a mandate to discuss and negotiate on behalf of 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:

- Embrace these Guidelines and relevant codes of conduct that deal with marine mammal protection;
- Develop and adopt responsible fishing codes/practices consistent with these Guidelines;
- Participate in fisheries research, management and decision-making processes that relate to marine mammal bycatch prevention/reduction;
- Be aware 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.
- Promptly report bycatch of and interactions with marine mammals to competent authorities as required to contribute to data collection and scientific assessment
- Ensure that crew members are trained on with marine mammal bycatch issues and measures available to mitigate impacts.
- Work together to share information and educate others regarding the content of these Guidelines and suggestions for the development and testing of measures to prevent or reduce marine mammal bycatch.
- Lobby, advocate and engage management bodies on topics related to marine mammal protection.
- Develop and use outreach, education and awareness materials.
- Recognize that they are important players in marine mammal stewardship, ensure that they contribute to formulating objectives, marine mammal protection measures suitable for their operations and swiftly implement them.
- Contribute 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.

Fisheries certification programmes play an increasing role in promoting sustainable fisheries. Such programmes provide market advantage to those fisheries that make changes that result in more sustainable outcomes, which 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, but there are many other international, regional and national certification programmes around.

Fisheries improvement projects (FIPs) are often an important step towards certification of a fishery. In FIPs the fishing industry collectively introduces environmental or management improvements. FIPs 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 greater verification and the commitment to enter assessment for certification after some years.

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). Details of codes of conduct/practice of these fisheries organization are listed in a previous section.

6. 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 s, NGOs, fishing companies, owners, fisherfolk organizations, captains and their fishing crews.

National and local governments

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

- Ensure that all information used for communication and awareness-building is accurate, up-to-date and appropriate for the target audience(s);
- Provide and share such information and raise the level of awareness of marine mammal bycatch issues and measures needed to address them to fishers, other governments and jurisdictions, policy-makers, other relevant stakeholders and the general public;
- Develop outreach, education and awareness materials in appropriate formats and local languages for appropriate platforms (such as websites and social media e.g. Twitter, Facebook and Instagram platforms) that can be used to disseminate information within and beyond their agency;
- Identify and ensure appropriate training needs are met for managers, technologists and particularly fishers in regards to measures to reduce marine mammal interactions and mortalities;
- Develop frameworks for long-term cooperative working relationships on marine mammal bycatch reduction with all stakeholders, management authorities at all levels, NGOs and fishers, including providing accurate and timely information on marine mammal bycatch-related issues, regulations and activities;
- Identify opportunities for cooperative planning to reduce inconsistencies among management frameworks at all levels;
- Collate and share 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.
- Provide opportunities for fisheries managers and policy-makers to increase their knowledge of marine mammal bycatch and potential solutions. That is, they should be provided with up-to-date information, advice and options regarding marine mammal bycatch, socioeconomic impacts and potential solutions;
- Ensure 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;
- Take account of fishers' opinions and suggestions on effective measures to reduce marine mammal interactions;
- Provide clear explanations to fishers on 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;
- Communicate 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;

- Coordinate and strengthen the activities and programmes of fishers' cooperatives, companies and similar organizations to mitigate marine mammal bycatch;
- Provide adequate training to fishers in:
    - the use and maintenance of appropriate technology and practices to reduce marine mammal bycatch,
    - mechanisms that allow fishers to develop their own solutions,
    - 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.
- Provide 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;
- Incorporate issues of particular relevance to their jurisdiction and stakeholders regarding the cultural use of marine mammals and indigenous rights/issues regarding such species including any totemic aspects.

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 mandate areas as they involve, and have regular liaison 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:

- Collect and share data and information on bycatch of marine mammals;
- Establish and support working groups to provide scientific advice on bycatch management in fisheries and ensure that marine mammals get adequate attention in such working groups;
- Develop standards and harmonized measures to reduce bycatch of marine mammals in fisheries;
- Build capacity for the implementation of marine mammal protection measures by members including 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:

- Facilitate the development of international guidelines and best-practice approaches.
- Promote these Guidelines in various high-level platforms and venues to raise awareness of the issue, and support capacity-building programmes, especially in Developing States.
- Collect and share information and raise the general level of awareness of Member States on marine mammal bycatch issues, and measures needed to address these issues. Platforms for sharing information and raising awareness could include websites and social media.
- Produce factsheets and other materials for stakeholders in multiple languages.
- Develop frameworks for long-term cooperative relationships with Member States, regional bodies and NGOs.
- Identify opportunities for cooperative planning to harmonize standards and measures and reduce inconsistencies among management frameworks at a global level.
- Collate and share 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:

- Ensure that all information used for communication and awareness-building is accurate, up-to-date and appropriate for the target audience(s).

- Provide and share such information and raise the level of awareness of marine mammal bycatch issues, and measures needed to address them, to fishers, governments and jurisdictions, policy-makers, other NGOs and the general public.
- Develop outreach, education and awareness materials in appropriate formats that can be used to disseminate information within and beyond their organization.
- Develop platforms for sharing information and raising awareness, including websites and social media.
- Develop frameworks for long-term cooperative working relationships on marine mammal bycatch reduction with all stakeholders, management authorities at all levels, other NGOs and fishers.
- Collate and share best practice methods for:
    - reducing impacts on animals that are caught and released, and
    - effective communication and training.
- Take account of fishers' opinions and suggestions on effective measures to reduce marine mammal interactions; and
- Support, advocate, lobby for, and provide appropriate funding for programs 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 their 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:

- Share 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.
- Contribute to the development of outreach, education and awareness materials that are in formats appropriate for captains, crews, etc..
- Participate 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.
- Share 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.
- Provide their own opinions, observations and suggestions on effective measures to reduce marine mammal interactions to each other and management agencies.
- Communicate amongst each other on issues related to marine mammal bycatch;
- Coordinate and strengthen the activities and programmes of fishers' cooperatives, companies and similar organizations to mitigate marine mammal bycatch.
- Actively participate 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.

7. Special requirements of developing countries

States should give full recognition to the special requirements of Developing States, in particular, least developed and Small Island Developing States, and small-scale fisheries in relation to their capacity to implement marine mammal bycatch reduction measures in fisheries consistent with these Guidelines, including the assessment of risk and feasibility.

Small-scale non-industrial fisheries represent a particularly difficult challenge. They impact many of the world's most endangered marine mammals, yet solutions in these fisheries are largely absent. Identifying practical approaches in these fisheries must be a critical emphasis moving forward if we are to succeed in overcoming this major threat to marine mammals.

In particular, consideration should be given by States, international and regional organizations, international financial institutions and other entities to enhance the capacity of Developing States to reduce marine mammal bycatch in their fisheries through financial and technical assistance. This should be done 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:

- 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;
- Establish appropriate allowances for particular traditional/cultural/indigenous harvests of marine mammals;
- 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;
- research and development;
- Carry out socio-economic studies on the effects of marine mammal bycatch reduction measures;
- Technology transfer and training;
- Awareness raising, communication and capacity building measures;
- Provide support to prevent, deter and eliminate Illegal, Unreported and Unregulated Fishing, particularly as it pertains to marine mammal interactions; and
- Develop social engagement and co-management initiatives.

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Appendix 1 – International and regional policy instruments and institutional frameworks supporting the conservation of marine mammals and reduction of their bycatch in capture fisheries

There exists a large number and variety of policy instruments and frameworks that support the conservation of marine mammals. Many are directly or indirectly relevant to impacts due to fisheries bycatch.

There are instruments relevant and applicable at a global, regional and/or national scale.

International instruments

The most important global instruments include.

United Nations Convention on the Law of the Sea

The **United Nations Convention on the Law of the Sea** (LOSC, 1982), identifies rights and obligations of Member States and gives an international basis for pursuing the protection and sustainable development of the marine and coastal resources. Of the approaches presented, sustainable use and conservation of marine living resources of the high seas, strengthening international, including regional, cooperation and coordination apply 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 including selective fishing gear and techniques.

One international agreement under LOSC is the agreement related to the **Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks** (UNFSA) (2011). Under this agreement, the Member States and other signed entities are committed to conserve 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) and 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 adoption of appropriate scientific evidence-based measures.

FAO's International Guidelines on Bycatch Management and Reduction of Discards

FAO's subsequent **International Guidelines on Bycatch Management and Reduction of Discards** (FAO 2011) identify endangered, threatened, and protected species (including marine mammals) as a bycatch problem and recommend that Member States should assess fisheries, identifying any endangered and protected species bycatch and identify where bycatch species may overlap with fishing operations through use of seabed maps, and/or species distributions and ranges. Further, 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 forty 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 internationally coordinate conservation measures 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 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 a new 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's Conservation Committee; and a multi-disciplinary Expert Panel to advise the Coordinator and the SWG. The BMI works closely with the Global Whale Entanglement Response Network (GWERN), which addresses welfare, conservation and human safety impacts of large whale entanglement in fishing gear and marine debris.

The IWC also has a resolution encouraging 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. One of these initiatives is the Global Whale Entanglement Response Network which provides trainings to countries on whale migration routes to help them disentangle whales in distress.

Convention of Biological Diversity

The **Convention of 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, 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 agreed to moratoria on all large-scale pelagic driftnet fishing on the high seas by 30 June 1992.

Regional instruments

At a regional scale, there exist many codes, conventions, agreements, MoUs and guidelines for the conservation of marine mammals in fisheries. Some of the most important ones are.

Convention on the Conservation of Migratory Species of Wild Animals

Falling under the above-mentioned **Convention on the Conservation of Migratory Species of Wild Animals** (CMS), are.

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

- 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 cetaceans (20 species) in the agreement area. It came into play in 1994 and 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 in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area** (ACCOBAMS, 1996), specifically protects cetaceans in the Mediterranean area.
- The Trilateral Agreement between Denmark, Germany, and the Netherlands on the **Conservation of Seals in the Wadden Sea** (1991), prohibits the killing or harassment of seals in the Wadden Sea, specifically for the harbor 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 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. Because this is one of the few relevant instruments from the African region, it is covered in greater detail below.

UNEP's 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) Protection and conservation of cetacean habitats including feeding, breeding and calving grounds, and b) Protection, conservation and the recovery of cetacean populations in the Mediterranean Sea Area.

Convention on the Conservation of Antarctic Marine Living Resources

The **Convention on the Conservation of Antarctic Marine Living Resources** (CCAMLR) is an international treaty developed, inter alia, to prevent the harvest of krill at a rate that is detrimental to the ecosystems and animals for which it is a food source, particularly seabirds, seals, whales, and fish (CCAMLR 2014). It has several Conservation measures to reduce the incidental mortality of, or injury to, seabirds and marine mammals during trawl fishing including the mandatory use of marine mammal exclusion devices on trawls in most areas.

CCAMLR requires the reporting of the numbers of marine mammals of each species caught and released or killed for trawl, longline and pot fisheries 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 commit to the sustainable and responsible use of marine mammals. This also includes a focus on animal welfare and minimising animal suffering related to both hunting and bycatch. With regard to bycatch, direct cooperation started in 1998 through a working group that addresses conservation, management and animal welfare. In 2014, NAMMCO's Scientific Committee established another working group on by-catch with the aim of identifying all fisheries that have potential by-catch of marine mammals. It is to

review and evaluate current by-catch estimates and provide advice on improved data collection and estimation methods to obtain best estimates of by-catch over time, for use in stock assessments. NAMMCO also established a Working Group on Bycatch, Entanglements and Live Strandings (BYCELS) in 2017 to provide advice on such issues. It is to ensure that its 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. Several 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)'s Conservation and Management Measure 2011-03. Cetaceans, Guidelines for the Protection of Cetaceans from Purse Seine Fishing, and the General Fisheries Comiission for the Mediterranean and Black Sea (GFCM) with specific work on data collection for the Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries.[6].

Indian Ocean Tuna Commission

The **Indian Ocean Tuna Commission** (IOTC) issued in 2013 its Resolution 13/04 on the Conservation of Cetaceans, which includes several binding measures, including.

- 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 into consideration the safety of the crew 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.

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

Inter-American Tropical Tuna Commission

The Inter-American Tropical Tuna Commission (IATTC) members adopted the **Agreement on the International Dolphin Conservation Program** (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) 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 five thousand annually, through the adoption and implementation of the following.

- 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;
- Within the framework of the IATTC, the promotion and support of research to improve gear, equipment, and fishing techniques, 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;
- Requiring their respective 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

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 in 2011 with 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, e.g., 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.
- Record any catch of cetaceans on the catch logsheet.

Appendix 2 - National policy instruments and institutional frameworks supporting the conservation of marine mammals and reduction of their bycatch in capture fisheries

National Instruments

Many guidelines and codes of practice regarding marine mammal protection are national in scope and/or involve local level instruments. National governments are responsible for managing most of the world's fisheries, therefore their policy, management and legislative instruments are among the most important for directly implementing measures to reduce the bycatch of marine mammals. Many countries have such instruments, but listing them all in this annex falls outside the scope of these guidelines.

The common elements of effective legislation at a national level includes 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 risk to the population. Regulatory frameworks should include processes for implementing and evaluating the effectiveness of bycatch prevention and mitigation measures. Additional 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 are essential components. Finally, for national regulation to be effective, sufficient and long-term funding is required.

Some examples of national level legislation are provided in the following table.

Country	**Relevant legislation**	**Management**
Australia	Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Regulates actions that will have, or are likely to have, a significant impact on all listed threatened and migratory species (which includes marine mammals). Includes allowances for cultural use by indigenous people.
Brazil	Federal Law No. 7,643 of Brazil	Prohibits fishing, or any form of intentional harassment, of all cetacean species in Brazilian jurisdictional waters.
	Interministerial Normative Instruction MPA / MMA No 12	Specifically deals with criteria and standards for fishery planning using gillnets in the Brazilian jurisdictional waters of the Southeast and South to mitigate sea turtle and marine mammal bycatch.
Brunei Darussala	Wild Fauna and Flora Order, the Wildlife Protection Act and the Fisheries Order of 2009	Makes it an offence anywhere in Brunei to. take, disturb, sell or dispose of any aquatic mammal, fail to release any aquatic mammal taken accidentally, if alive, or to inform the Director of Fisheries if it is dead.
Cambodia	Proclamation No. 1033 On the Protection of Natural Areas, 1994	Prohibits the hunting and fishing of mammals, amphibians, reptiles and aquatic animals for tusks, bones, feathers, horns, leather and blood.
Canada	Marine Mammal Regulations in the Fisheries Act	Provides a set of rules that govern the taking (fishing, hunting) and treatment of marine mammals in Canada, in Canadian fisheries waters and by Canadian fishing vessels in the Antarctic. Includes allowances for cultural use by indigenous people.
China	Wildlife Protection Law of the People's Republic of China	Applies to the protection of wildlife and related activities within the territory of the People's Republic of China and other waters under its jurisdiction. Wildlife and the products thereof as provided for in this Law refer to the entirety (including ova and eggs), parts and derivatives of wildlife. Wildlife under national protection are classified as grade-1 and grade-2 protected wildlife and currently include 17 cetaceans.
European Union countries	EC Habitats Directive as transposed by the EC (Natural Habitats) Regulations	Provides strict protection to all cetaceans within the Exclusive Economic Zone. Special Areas of Conservation (SACs) must be proposed for. Bottlenose Dolphin, Harbour Porpoise, Common Seal and Grey Seal.
	OSPAR Convention to Protect the Marine Environment of the North East Atlantic	Establishes two marine protected areas to protect Harbour Porpoise.

India	Wildlife (Protection) Act, 1972.	Protects all species of marine mammals in all of India's seas are protected such that the capture, use and trade of marine mammals are punishable.
Indonesia	Fisheries Regulations	Specifies that fishing vessels must take conservation measures for species associated with tuna, including sharks, marine turtles and marine mammals
	Ministry of Marine Affairs and Fisheries Regulations (2012)	Requires that sharks, marine mammals, marine turtles and other by-catch that has been captured accidentally to be released alive if possible and dead specimens to be reported.
Malaysia	The Malaysia Fisheries Act	Makes it an offence to. fish, disturb, harass or catch aquatic mammals in waters beyond state jurisdiction, fail to release a live aquatic mammal caught accidentally or to report the accidental capture of a dead aquatic mammal or turtle to a fisheries officer and prohibits fishing for turtles and aquatic mammals outside state waters.
	Sarawak's Wildlife Protection Ordinance	Governs the management and conservation of wildlife in Sarawak, and lists all whales, dolphins and porpoises, dugongs and marine turtles as Totally Protected Animals
Myanmar	Notification for Control of Endangered Fish Species	Makes it an offence to fish for, harass, catch, kill, possess, sell, buy, export or transport any endangered species as specified which includes Dugongs, whale, dolphin, as well as all species in the CITES list of endangered species. Any such species caught unintentionally must be released immediately or disposed of as directed by a Fishery Officer.
New Zealand	Marine Mammals Protection Act 1978 of New Zealand	Provides for the protection, conservation, and management of marine mammals. Regulates human contact or behaviour with marine mammals either by commercial operators or other persons, in order to prevent adverse effects.
Philippines	Wildlife Resources Conservation and Protection Act, 2001	Includes the listing of Dugongs as critically endangered.
	Fisheries Administrative Order No. 185	Bans the collection, trade or export in, wounding or killing any species of dolphin, whale or porpoise, although the Director of BFAR may issue a special permit for research or exhibition. Such animals caught accidentally must be released immediately.
	Fisheries Administrative Order No. 208	Prohibits the taking of Rare, Threatened or Endangered species as listed by CITES and therefore includes many marine mammals.
	The Philippine Fisheries Code, 1998	Prohibits the collection, sale, purchase, possession, transport, export, forwarding or shipping out of aquatic species that are listed in CITES or categorised as threatened by the IUCN
Thailand	Ministry of Agriculture and Cooperatives Regulations on Fisheries, Prohibition of Fishing of Dolphins B.E. 2533 (1990)	Prohibits any fishing of dolphins except with written permission from the Director General of Fisheries or a delegated official.
United Kingdom of Great Britain and Northern Ireland	Conservation of Offshore Marine Habitats and Species Regulations 2017 (COHSR)	Protects whales, dolphins, porpoises and seals. Covers waters from 12 to 200 nautical miles
	Wildlife and Countryside Act 1981 (WCA)	Protects whales, dolphins, porpoises and seals. Covers waters from 0 to 12 nautical miles.
United States of America	United States of America Marine Mammal Protection Act of 1972	Protects all marine mammals, including cetaceans (whales, dolphins, and porpoises), pinnipeds (seals and sea lions), sirenians (manatees and dugongs), sea otters, and polar bears within the waters of the United States of America.

	United States of America Endangered Species Act of 1973	Provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend.
	Import Provisions Rule to the Marine Mammal Protection Act (NMFS, 2016)	Requires countries to validate that non-exempt fisheries exporting seafood to the United States of America adopt measures considered comparable to those used in the United States of America to mitigate marine mammal bycatch
Viet Nam	National Assembly Law No. 55/2014/QH13	Prohibits collecting, trading and consuming wildlife identified on the list of protected endangered, precious and rare species (this includes whales of *Balaenoptera* spp. and dolphins of *Delphinidae* spp.).
	National Assembly Law No. 20/2008/QH12	Prohibits hunting, fishing, illegally killing, consuming, transporting, buying or selling species on the list of endangered precious and rare species prioritised for protection (which includes marine mammals), or advertising, selling or consuming their parts.
	Government Decree No. 82/2006/ND-CP	Makes it an offence to export, import, re-export, introduce from the sea, transit, breed, rear or artificially propagate Endangered Species of Precious and Rare Wild Fauna and Flora as listed in its Appendix (which includes whales and dolphins).

For illustrative purposes, additional information is provided here on legislation in place in selected countries specifically related to marine mammal bycatch reduction in capture fisheries.

United States of America

The Marine Mammal Protection Act (MMPA) is managed by the United States of America federal government. The National Marine Fisheries Service, part of the National Oceanic and Atmospheric Administration within the Department of Commerce, is responsible for managing cetaceans, otariids, and phocids. The United States of America Fish and Wildlife Service, part of the Department of the Interior, is responsible for managing odobenids, sirenians, otters, and polar bears.

The MMPA makes it illegal to take marine mammals without a permit. This means people may not hunt, harass, capture, or kill any marine mammal, part of a marine mammal or attempt to do so. It also prohibits the import and export of marine mammals and their parts or products. The Act also formalized the marine mammal health and stranding response program to improve the response of stranding and unusual mortality events.

Exceptions to these prohibitions include.

- Permitted incidental take (e.g., unintentional take) in the commercial fishing industry managed through the Marine Mammal Authorization Program.
- Authorized incidental take that may occur during non-fishing activities including oil and gas development, military readiness activities, renewable energy projects, construction projects, and research.
- Permitted directed take and import for scientific research, enhancement, commercial or educational photography, and public display.
- Permitted import, export, and receipt of parts for scientific research.
- Pre-act determinations for marine mammal parts taken before December 21, 1972.
- Take by Alaska natives for subsistence use or to create and sell authentic articles of handicrafts and clothing.

In addition to managing the taking of marine mammals, NOAA Fisheries also performs the following conservation and management actions.

- Development and implementation of conservation plans for species designated as depleted.
- Development and implementation of take reduction plans to minimize bycatch of mammals in commercial fishing gear.

- Coordinating the Marine Mammal Health and Stranding Response Program and investigating marine mammal unusual mortality events.
- Partnering with other nations to ensure that international trade does not threaten species.
- Investigating and prosecuting violations of the MMPA.

The Government of the United States of America is using its influence as a major importer of seafood to prompt changes in fishing practices within countries of origin. Under the Import Provisions Rule to the Marine Mammal Protection Act (NMFS, 2016), it is requiring countries to validate that non-exempt fisheries exporting seafood to the United States of America adopt measures considered comparable to those used in the United States of America to mitigate marine mammal bycatch.

Australia

Under Australia's **Environment Protection and Biodiversity Conservation Act** 1999 (EPBC Act), all cetaceans (whales, dolphins and porpoises) are protected in all Australian Commonwealth waters from the 3 nautical mile state waters limit out to the boundary of the Exclusive Economic Zone (i.e. out to 200 nautical miles and further in some places). It is called the Australian Whale Sanctuary. Within the Sanctuary it is an offence to kill, injure or interfere with a cetacean. Severe penalties apply to anyone convicted of such offences.

Under the EPBC Act, all seals and sea lions occurring within Australian waters are listed so it is an offence to kill, injure, take, trade, keep, or move any of them on Australian Government land or in Commonwealth waters without a permit. Where these animals occur in state jurisdictions relevant state legislation applies.

In addition, the EPBC Act requires that any action that has, will have or is likely to have a significant impact on a threatened species must be referred to the Department of the Environment for assessment before the action goes ahead.

Dugongs are also protected under the EPBC Act, and various State and Northern Territory legislations. But dugongs are an integral part of the traditional culture of many coastal indigenous peoples. They may be legally hunted by Aboriginal and Torres Strait Islander people under section 211 of the Native Title Act 1993 for personal, domestic or non-commercial communal needs.

All states and territories in Australia also have legislation to protect whales and dolphins within their waters (ie within the 3 nautical miles). For example.

- In NSW, marine mammals such as whales, dolphins, dugongs, seals and sea lions, and marine reptiles such as turtles and sea snakes are protected under the **NSW Biodiversity Conservation Act 2016**,
- In Queensland, marine mammals are protected under the **Queensland Nature Conservation (Wildlife Management) Regulation 2006**, and
- In South Australia, under the **National Parks and Wildlife (Protected Animals – Marine Mammals) Regulations 2010** under the National Parks and Wildlife Act 1972.

New Zealand

Details of the **Marine Mammals Protection Act 1978** of **New Zealand** are.

- The Minister may approve a population management plan in respect of one or more species, being threatened species or other species of marine mammal.
- In the case of any marine mammals ranging outside New Zealand fisheries waters, the maximum allowable level of fishing-related mortality set shall be based on a fair and equitable consideration of the proportion that the estimated fishing-related mortality of marine mammals within those waters bears to the total estimated mortality of marine mammals in all waters (including waters outside New Zealand fisheries waters).
- In determining the maximum allowable level of fishing-related mortality for threatened species or any other marine mammals, the Minister.

    - in the case of any threatened species, shall determine a level of fishing-related mortality which should allow the species to achieve non-threatened status as soon as reasonably practicable, and in any event within a period not exceeding 20 years.
    - in the case of any other marine mammal, shall determine a level of fishing-related mortality which should neither cause a net reduction in the size of the population nor seriously threaten the reproductive capacity of the species.
- Area-based limits shall be set only.
    - for populations of threatened species that are geographically or genetically discrete; and
    - for areas corresponding to areas having effect under the Fisheries Act 1996 as fisheries management areas or quota management areas.
    - In setting any area-based limit for a threatened species, the Minister shall determine a level of fishing-related mortality for a discrete population referred to above which should neither cause a net reduction in the size of the population nor seriously threaten the reproductive capacity of that population.
- Notwithstanding anything in any other enactment, but subject to the Act, no person shall.
    - hold a marine mammal in captivity; or
    - take any marine mammal, whether alive or dead, in or from its natural habitat or in or from any other place without first obtaining a permit to do so from the Minister or from any person or persons authorized in that behalf by the Minister. The Minister may prescribe criteria and standards in respect of such permits
- No person shall import into New Zealand or export from New Zealand any marine mammal or marine mammal product except pursuant to a permit issued under the Act.
- A permit is not required.
    - for any person who finds or collects bones, teeth, ivory, or ambergris that have already separated naturally from a marine mammal if that person, as soon as practicable, notifies the Director-General or an officer of the find, and gives details of the time, place, and circumstances under which the find was made.
    - by any person who finds any dead marine mammal or part of one and, if authorized to do so by an officer and acting pursuant to his directions, sends the mammal or part to the Department of Conservation or to any approved research establishment, laboratory, or public museum.
    - by any person taking from or bringing into New Zealand any marine mammal product, being an ornament or an item for personal use or adornment made wholly or principally from any part or parts of a marine mammal, if the marine mammal product accompanies that person from or into New Zealand or comprises part of that person's belongings and was in existence in a similar form as at the commencement of the Act
- Dead marine mammals must be disposed of in accordance with the advice of an officer or person authorised by the Minister, which advice shall be given, where practicable, after consultation with the occupier of the place where the marine mammal is found.
- The Minister may also, by notice in the Gazette, define any place and declare it to be a marine mammal sanctuary, and may vary, redefine, or abolish the sanctuary.

Nothing in the New Zealand Act shall affect

- any person who gives any humane assistance, care, or medication to any stranded, sick, or injured marine mammal if (where known) details of the mammal's species, length, sex, and condition, or a general description of the mammal, and details of the treatment and any results of the treatment are forwarded to the Director-General or an officer as soon as practicable.
- the moving of any marine mammal by or under the direction of any officer in the interests of public safety or the well-being of the mammal.
- the destruction of any aged, sick, distressed, or troublesome marine mammal by or under the direction of an officer or person authorized by the Minister.

New Zealand also has separate legislation regarding purse-seining that protects marine mammals such that no person shall use any purse seine net for the purposes of fishing unless.

- that person has in the net an escape panel or aperture from which any dolphin or porpoise can readily escape; and
- that person follows a fishing practice acceptable to the Director-General.

The United Kingdom of Great Britain and Northern Ireland

Under the Conservation of Offshore Marine Habitats and Species Regulations (COHSR) and CHSR regulations, it is an offence to kill, injure, capture, possess or keep any whale dolphin or porpoise, damage or destroy a place of resting, shelter or breeding of such species, or disturb, transport, expose, sell, exchange, advertise for sale, or use prohibited or unauthorised method to capture or kill, any whale, dolphin or porpoise. The Wildlife and Countryside Act (WCA) makes it an offence to disturb whales or dolphins, and to transport, expose, sell, exchange, advertise for sale, or use prohibited or unauthorised method to capture or kill, any whale, dolphin or porpoise.

All seals are also protected from unauthorised methods of killing (under the section 1 of the **Conservation of Seals Act** 1970). For example, they can only be killed by a rifle that uses ammunition with a muzzle energy of at least 600 footpounds and a bullet that is a minimum of 45 grains. Anyone can control individual seals during the closed season or in a conservation order area to prevent damage to their fishing nets, tackle or catch – section 9 of the Conservation of Seals Act. The seal must be in the vicinity of their equipment at the time of control. However, there are conditions that need to be met to use this 'netsman's defence'.

The COHSR (mentioned above) also protects all seal species from 12 to 200 nautical miles and the CHSR protects bearded, grey, common, harp, hooded, ringed seals from 0 to 12 nautical miles. The WCA protects any wild animal from 0 to 12 nautical miles and the Conservation of Seals Act 1970 section 1 also protects all seals from 0 to 12 nautical miles.

The grey seal (*Halichoerus grypus*) and common seal (*Phoca vitulina*) are also protected from being killed, injured or taken during specific closed seasons - the grey seal's closed season is 1 September to 31 December and the common seal's is 1 June to 31 August. However, the Secretary of State and devolved administrations can extend that protection to the entire year for either or both species in any area specified in an order.

Both grey and common seals on the east and south-east coast of England (from Berwick to Newhaven) are protected all year from being killed, injured or taken ——**Conservation of Seals (England) Order** 1999—. This includes the counties of Durham, East Riding of Yorkshire, East Sussex, Essex, Hartlepool, Kent, Kingston-upon-Hull, Lincolnshire, Medway Towns, Middlesbrough, Norfolk, North East Lincolnshire, North Lincolnshire, North Yorkshire, Northumberland, Redcar and Cleveland, Southend-on-Sea, Stockton-on-Tees, Suffolk, Thurrock, Tyne and Wear and the administrative area of Greater London. They are also protected in territorial waters next to England that are south of a line drawn from the point on the mainland at 55'48.67N 02'02.0W and next to any of the areas specified above to no further west than a line drawn true south from Newhaven Breakwater Health Light (50'46.5N 00'03.6E).

The trading and importing of seal products is regulated for all species of pinnipeds —seals, sea-lions and walruses— by the **Seal Products Regulations** 2010. The regulations introduced an EU-wide ban (**European Commission's Regulation** 737/2010) on commercially importing and marketing all seal products and any related products. The ban applies to all seal products unless any of the following are true. If they.

- result from traditional hunts conducted by Inuit and other indigenous communities and contribute to their subsistence
- result from hunts regulated under national law with the sole purpose of the sustainable management of marine resources and where the products are marketed on a non-profit basis
- are exclusively for the personal use of travellers or their families and only occasionally imported

There is also a ban on commercially importing harp and hooded seal pup skins and any products containing such skin.

Ireland

The protection afforded to marine mammals in Ireland is summarised as.

- Harbour Porpoise. protected under Annexes II and IV of the EC Habitats Directive, the Protected species of Wildlife (Amendment) Act and the OSPAR List of Threatened and Declining Species and Habitats;
- Bottlenose Dolphin. protected under Annexes II and IV of the EC Habitats Directive, the Protected species of Wildlife (Amendment) Act;
- All cetacea. protected under Annex IV of the EC Habitats Directive and Protected species of Wildlife (Amendment) Act; and
- Grey Seal/Harbour Seal. protected under Annex II of the EC Habitats Directive and Protected species of Wildlife (Amendment) Act.

Canada

The **Marine Mammal Regulations** specify that no person shall fish for marine mammals except under the authority of a licence issued under the Regulations or under the Aboriginal Communal Fishing Licences Regulations. The latter referring to.

- An Indian or Inuk other than a beneficiary may, without a licence, fish for food, social or ceremonial purposes for
    - seals;
    - cetaceans, except beluga in certain areas, bowhead whales, right whales and narwhal; and
    - four walrus in a year.

A person, other than a person referred to above, who resides immediately adjacent to any of certain specified Sealing Areas may fish for seals without a licence in any of those Sealing Areas for food purposes.

The regulations also specify that no person shall disturb (see below definition) a marine mammal except.

- when carrying on a work, undertaking or activity that is authorized, otherwise permitted or required under the Act;
- when fishing for marine mammals under the authority of the Regulations;
- in the manner set out in a licence issued under the Fishery (General) Regulations authorizing them to fish for marine mammals for experimental, scientific, educational or public display purposes; or
- in the manner authorized under the Species at Risk Act.

Disturb includes to approach the marine mammal to, or to attempt to,

- feed it;
- swim with it or interact with it;
- move it or entice or cause it to move from the immediate vicinity in which it is found;
- separate it from members of its group or go between it and a calf;
- trap it or its group between a vessel and the shore or between a vessel and one or more other vessels; or
- tag or mark it.

In the case of a listed marine mammal, or a whale, dolphin or porpoise in resting position or with its calf, there are numerous detailed restrictions regarding approaching such animals using various vehicles and staying certain distances away at particular times of the year.

Other regulations include.

- No person shall attempt to kill a marine mammal except in a manner that is designed to kill it quickly.

- No person shall fish for a marine mammal without having on hand the equipment that is necessary to retrieve it.
- No person who kills or wounds a marine mammal shall.
    - fail to make a reasonable effort to retrieve it without delay; or
    - abandon or discard it.
- No person who kills a cetacean or walrus shall waste any edible part of it.

The Expert Meeting to "Develop Technical guidelines to reduce bycatch of marine mammals in capture fisheries" was held at FAO headquarters in Rome, Italy, on 17–19 September 2019. Twenty-nine fisheries and bycatch experts and observers from FAO Members participated in the meeting: Argentina, Australia, Brazil, Canada, Chile, Denmark, Iceland, Japan, Norway, Russian Federation, Sweden, and the United States of America. The meeting was also attended by experts from various regional and international organizations. The meeting aimed to prepare "Technical guidelines to reduce bycatch of marine mammals in capture fisheries" that are directed at decision-makers, planners, managers, and all those involved in developing and implementing policy and technical interventions relevant to the bycatch of marine mammals in fisheries.

The meeting was organized by FAO in response to the request from the Committee on Fisheries at its 33rd session in 2018 to develop technical guidelines on this subject. At the meeting the experts reviewed and discussed technical measures that can be applied for the reduction of bycatch of marine mammals in fisheries, including: time-area closures, acoustic deterrents, modifications to fishing gears and changes in fishing operations. The meeting also discussed research and development needs for reducing bycatch of marine mammals, drivers of change, and the roles of a range of stakeholders in terms of implementing the guidelines, awareness raising, communication and capacity building.

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