Estimating Cetacean Bycatch from Tuna Gillnet Fisheries in Sri Lanka, Pakistan and India

by

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EXECUTIVE SUMMARY

The Indian Ocean is the second-largest tuna production area in the world and provides important economic benefits to global fishery markets. However, bycatch is a major issue for tuna fisheries in this area, particularly for interactions between drift gillnets and several species of cetaceans. The issue is particularly acute in the Arabian Sea (northwestern Indian Ocean), where drift gillnets are the primary fishing method used by most countries. However, development of effective bycatch reduction strategies is hampered by a lack of data about fishing effort and bycatch in this region.

The present study employed a systematic literature review to develop a coarse estimate of cetacean bycatch, using data collected during port surveys and from observer programs for the three largest tuna drift gillnet countries: Sri Lanka, India and Pakistan, during the period from 1984 to 2019. Cumulative estimates of bycatch increased over this period, driven by increasing tuna captures over time. The study provides only a coarse estimate of bycatch, with many uncertainties associated with the extrapolations, but the magnitude of bycatch is large enough to warrant immediate management action.

Current information needs in the Arabian Sea include better information on fishing effort, such as from the use of electronic monitoring systems on fishing vessels, and tests of bycatch mitigation technology, such as net illumination. However, funding for such ventures is inadequate and the scientific capacity of countries around Arabian Sea is limited. This study provides three recommendations to address this situation: 1) identify priority bycatch areas in each country, and conduct a rapid bycatch assessment in those areas; 2) strengthen cooperation between national governments and international organizations, such as the IOTC and IWC, to address bycatch in the region; and 3) focus research on bycatch mitigation strategies.

Introduction

The tuna fishery has been an important part of the global fishing industry since the nineteenth century (Anderson *et al.,* 2020). At first, tuna fisheries operated in coastal waters with artisanal methods (Anderson *et al.,* 2020). However, with an increasing demand for canned tuna, the fishery became industrialized between 1940s and 1950s (Anderson *et al.,* 2020). The development of more efficient fishing methods, such as longlines and purse seines, allowed the capture of more tunas than traditional fishing methods (Anderson *et al.,* 2020). Furthermore, the development of cold storage and new vessel technology also encouraged more distant water fishing in unexplored fishing areas (Anderson *et al.,* 2020). Today, many countries conduct tuna fishing beyond their exclusive economic zones, and tuna fisheries in the Pacific and Indian Ocean contribute most of the catch to the overall global tuna harvest each year (Lecomte *et al.,* 2017). Therefore, these two areas have become an important focus for tuna fishing management issues (Lecomte *et al.,* 2017).

The Indian Ocean is the second largest tuna production area, and contributes 20% of the world commercial tuna catch, with an estimated 1 million tonnes per year (Lecomte *et al.,* 2017). This catch brings high economic returns to the region. The Indian Ocean generates 16% of the world tuna industry's revenues, approximately $6.5 billion/year from wholesale sales of canned tuna (Lecomte *et al.,* 2017). The Indian Ocean also supports the local and global tuna markets with the production of steak tuna, dried tuna and sashimi (Lecomte *et al.,* 2017). There are mainly two types of tuna fishing in the Indian Ocean: industrial-type distant water fishing and artisanal-type coastal fishing (Lecomte *et al.,* 2017). It is important to mention that unlike other ocean basins, artisanal-type coastal fishing contributes more than half of the tuna catches in the Indian Ocean, which could lead to the potential management issues because artisanal fisheries are more difficult to track and monitor than industrial-type fishing (Lecomte *et al.,* 2017).

With the growing importance of the Indian Ocean to global tuna fishing industry, management issues and conflicts among different fishing parties in that region have become more obvious and need intervention from the international community. Therefore, with the goal to promote cooperation among different fishing parties to support the sustainable development of tuna fishing industry in Indian Ocean, the Food and Agricultural Organization (FAO) of the United Nations established the Indian Ocean Tuna Commission (IOTC) in 1996. The IOTC is an intergovernmental organization responsible for the management of tuna and tuna-like species in the Indian Ocean. Currently, the IOTC is composed of 31 contracting parties which fish for tuna in the Indian Ocean, 2 Cooperating Non-Contracting Parties, and three subsidiary bodies (Compliance Committee, Standing Committee on Administration and Finance, and Scientific Committee) that support the IOTC by conducting scientific research and drafting fishery management plans and regulations.

The two major management issues that the IOTC is currently dealing with are overfishing and bycatch. Approximately 44% of the tuna catch come from stocks that are overexploited and overfished (Lecomte *et al.,* 2017). Therefore, it is necessary for the IOTC to make proper fishery management plans and regulations for each contracting party to follow and obey. The Scientific Committee is responsible for the analysis of tuna stocks and makes management recommendations to the Commission. The Scientific Committee includes 7 working parties, with four (WP on Billfish, WP on Neritic Tuna, WP on Temperate Tuna, and WP on Tropical Tuna) focusing on the management of tuna stocks.

The second major issue is bycatch, which refers to the unintentional caught of the non-targeted fish species. Bycatch has always been a major issue for the global fishing industry and is undoubtedly a large problem for the tuna industry in the Indian Ocean (Anderson, 2014). Sharks, rays, sea birds, sea turtles and marine mammals are all taken as bycatch in the Indian Ocean (Anderson, 2014). Those animals are top predators in the ecosystem and have low reproduction rates (Anderson, 2014). Therefore, a decline in their abundance has a large influence on the entire marine ecosystem. Among all the tuna fishing methods, gillnets (29500 tonnes/year) and longlines (22130 tonnes/year) cause most of the bycatch (Lecomte *et al.,* 2017). The Scientific Committee established the working party of ecosystem and bycatch to review and analyze bycatch estimates, and make recommendations to the IOTC to reduce bycatch and minimize ecosystem impacts.

However, data deficiency is the largest obstacle to implementing efficient bycatch regulations. Data are lacking regarding bycatch and also fishing efforts and, in some cases, tuna catches. This is likely due to the long-term neglect of these fishery management issues and a lack of support from contracting parties (Anderson 2014). Recently, the issue has gradually became the focus of both International Whaling Commission (IWC) and IOTC. In 2019, IWC and IOTC collectively hold meeting in Kenya to discuss the bycatch mitigation opportunities around Western Indian Ocean and Arabian Sea. In the meeting report, they clearly point out that data deficiency is now the largest and most urgent issue that need to be dealt with in order to efficiently mitigate the cetacean bycatch numbers (IWC, 2019). According to them, most of the countries around Indian Ocean are developing countries, which lack the awareness, funding and scientific capacity to support robust observer programs in the tuna fishing industry (IWC, 2019). This lack of data prevents efficient implementation of bycatch policy (IWC, 2019). Furthermore, although some countries have regulations in regard to bycatch, there is a lack of monitoring and educational outreach to fishermen (IWC, 2019). The situation is particularly acute around the Arabian Sea (northwestern Indian Ocean), where gillnets are the major fishing method for most countries, such as Iran, which contributes to the highest gillnet tuna catches in the Indian Ocean (IWC, 2019). Given the severeness of data deficiency issue, Anderson et al. (2020) has done a comprehensive estimation of cetacean bycatch around Indian Ocean. However, this is the first and only study in recent years that focused on the issue (Anderson *et al.,* 2020). Therefore, considering the potential magnitudes of cetacean bycatch around Arabian Sea, this study wants to take a cetacean bycatch estimation based on Anderson's work with a smaller region focus to better illustrate the urgency of filling data gaps for tuna fishery bycatch in Indian Ocean.

Therefore, the present study will document the severe data gaps for bycatch research in western Indian Ocean. Using cetaceans as a case study, this study will generate a preliminary estimate of bycatch for the countries that have large gillnet fleets. There are three objectives for this study: 1) to provide an overview of knowledge gaps on catch, effort and cetacean bycatch data in this region; 2) to obtain data on bycatch rates from a comprehensive literature review; and 3) to estimate magnitude of cetacean bycatch in Sri Lanka, India and Pakistan from 1984 - 2019. Finally, this study will make several recommendations to improve the current data poor situation and reduce cetacean bycatch in the Indian Ocean.

Methods

Literature Review and Selection: Bycatch Data Collection

There is no reliable, comprehensive dataset documenting cetacean bycatch information in the Indian Ocean, so the only way to obtain bycatch data is through a literature review of previous studies. This review is largely based on two pieces of work conducted by Dr. Charles Anderson: "Cetacean bycatch in Indian Ocean tuna gillnet fisheries" in 2020, and "Cetaceans and Tuna Fisheries in the Western and Central Indian Ocean" in 2014. In 2020, Anderson et al., provided a comprehensive review of the bycatch research for countries around Indian Ocean, and used 10 data sources to extrapolate bycatch to the entire region (Anderson *et al.,* 2020). In the present study, I followed his method in reviewing the work referred to in his study, and selected a subset of these papers to conduct my own extrapolation of the bycatch data.

I selected the following standards to select estimates of bycatch for my study: 1) exclude those that were not focused on countries around Arabian Sea; 2) exclude studies that addressed methods other than gillnets; 3) exclude studies conducted before the 1980s; and 4) rely exclusively on studies that employed reliable methods, such as interviews, port surveys and observer programs to collect bycatch data. Furthermore, I only selected studies that generated an estimate of bycatch based on primary data. Any study with only a partial estimate of bycatch number, rather than an annual estimate was be excluded.

I began with Appendix 1 of Anderson et al. (2014), which listed 121 studies, reviewed their abstracts, and selected studies based on the three standards listed above. After this first round of selection, only 23 papers remained. I then used the last standard to choose from these 23 papers by reading details about their methods and results, and finally selected 4 studies. Of these four papers, 2 of are from Sri Lanka, 1 from India and 1 from Pakistan. The earliest study was from 1984 – 1986, and the newest study was from 2012 – 2013. Table 1 below lists detailed information from these four papers. I also consulted with regional experts to make sure there was no other recent research in cetacean bycatch that I had not discovered.

Table 1: *Final Literature Selected for Bycatch Estimation*

Region	**Author**	**Study Period**	**Bycatch Estimates**
Sri Lanka	Leatherwood (1994)	1984-1986	8042-11821
Sri Lanka	Dayaratne & Joseph (1993)	1991-1992	5181
India	Yousuf et al., (2009)	2004-2005	9000-10000
Pakistan	Nawaz & Moazzam (2014)	2012-2013	12000

Data Extrapolation Process

After obtaining the bycatch estimates data as described above, the next step was to extrapolate bycatch for the entire survey period. I calculated bycatch rates (number of cetaceans taken as bycatch/kg of tuna catch) for the survey period. In cases where multiple estimates of bycatch rate existed, I calculated median values. I then multiplied these bycatch rates with the total annual tuna captures (from gillnets only) for the three countries. Annual data for total nominal tuna captures from gillnets were obtained directly from the IOTC website.

Results

Table 2: *Raw estimates of bycatch rate and Total tuna captures (1984 – 2019)*

Country	Bycatch Year Estimated	Bycatch rate (cetaceans/ton of tuna captures)	Total tuna captures (in tonnes, 1984-2019)
Sri Lanka	1984 -1986	0.603	934762
	1991 - 1992	0.248	
India	2004 - 2005	0.170	2069669
Pakistan	2012 - 2013	0.177	1761843

Table 2 shows the bycatch rate calculated based on the bycatch estimation numbers and total tuna capture (tonnes). The total tuna capture (in tonnes) is the sum of nominal tuna capture numbers for each country from 1984 to 2019. From Table 2, it is clear that Sri Lanka has overall higher bycatch rates than India and Pakistan based on reported data. However, the bycatch rates for Sri Lanka are calculated from older time period than India and Pakistan (Table 2).

Figure 1: *Sri Lanka Bycatch Estimates from 1984 -2019*

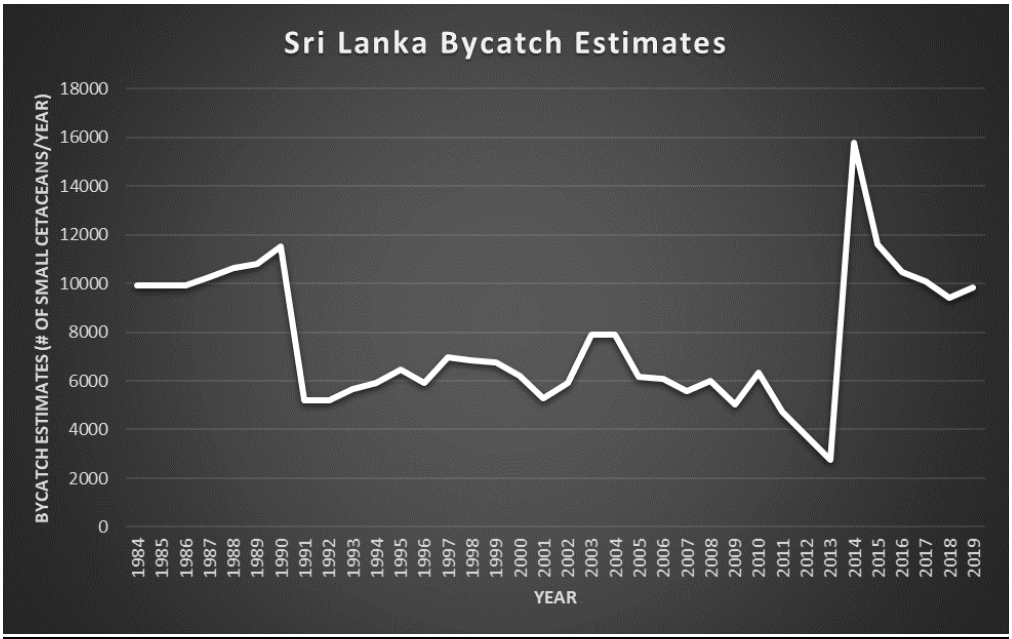

Figure 1 demonstrates two inflection points of bycatch for Sri Lanka over the study period. The first inflection point (1989 – 1991) is due to variation in annual bycatch rates. The second turning point (2013 – 2014) was caused by high tuna captures in the country. Generally, Sri Lanka has experienced a significant increase in bycatch over the study period. It is also important to mention that Sri Lanka had bycatch monitoring programs for cetaceans early in the study period, but these programs have been shut down due to funding limitation and civil unrest in the country (Dayaratne & Joseph, 1993).

Figure 2: *India Bycatch Estimates from 1984 -2019*

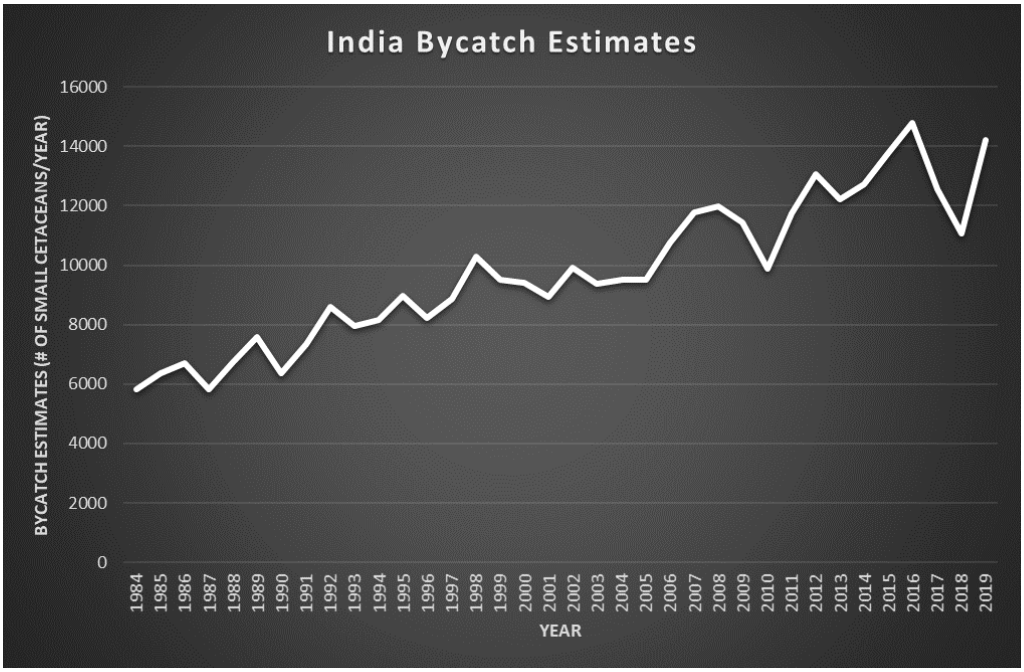

Figure 3: *Pakistan Bycatch Estimates from 1984 -2019*

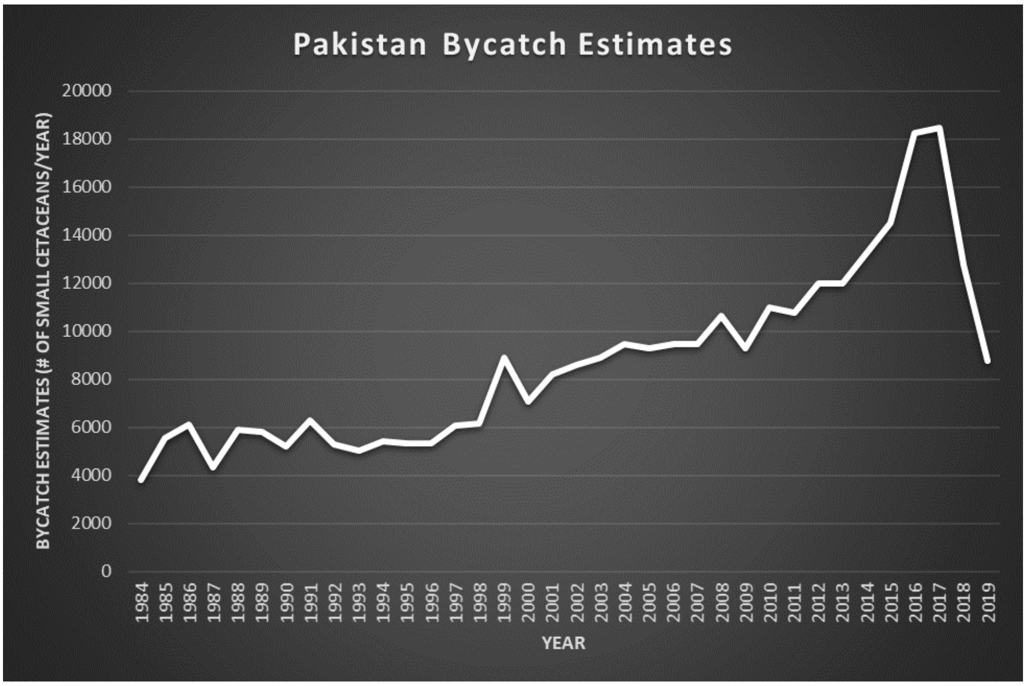

Figure 2 demonstrates bycatches from India. which have increased steadily over the study period. A similar pattern is present in Figure 3, which shows bycatches for Pakistan. Like India, Pakistan also has experienced a steadily increasing trend in bycatch over the years with minor fluctuations. It is important to point out that Pakistan has decreasing estimates on cetacean bycatch after 2016, likely due to the decreasing tuna captures in the gillnet fishery.

Discussion

Uncertainties and Assumptions

The results described here are highly uncertain and have likely been influenced by several factors, including temporal variation in the abundance of the cetaceans in each country. It is worthwhile to notice that the present study generated a single bycatch rate and applied it to the entire study period. However, the bycatch rate of cetaceans certainly changed over time as cetacean abundance was not constant. For example, if fewer cetaceans are present due to bycatch, the future bycatch rates will be decreased because there are fewer cetaceans.

The accuracy of these estimates depends on the data used to parameterize each country's bycatch rates. The bycatch rate of Sri Lanka comes from data collected in the 1980s. Therefore, the estimation results of the country in recent days are unlikely to be representative as conditions have certainly changed in recent days. The bycatch rate of India comes from more recent dates from 2004 - 2005, so these estimates should be more accurate than those of Sri Lanka. The bycatch rate of Pakistan comes from 2012-2013, which is the most recent bycatch rate in this study. Therefore, Pakistan will have more accurate bycatch results compared to Sri Lanka and India.

The ideal situation would be to estimate bycatch number from different time periods (for example: 1980s – 1990s, 1990s – 2000s, 2000s – 2010s. and 2010s – 2019s) for each country, which would provide a more accurate result. However, with large data gap exists and very few studies focuses on estimating the cetacean bycatch around the Arabian sea, the estimates from this study are the best results possible.

Comparison with Previous Studies

The general estimation methods used by the present study and those used by Anderson et al., (2020) are similar. Both used observations of bycatch from previous studies and then calculated cetacean bycatch per unit tuna catch, and finally extended estimates of bycatch rate to cover the entire study period. It is also worthwhile to note that the data used here were also included in the Anderson et al., (2020) paper. However, the present study excludes some of the research that Anderson et al., used in their study because of the time period, region and data selection methods.

Furthermore, the present study used some different methods than the Anderson et al. paper in dealing with initial bycatch numbers. Anderson's paper took either the maximum or the minimum of the range instead of taking the median number as done here. Medians were used in this study because we believe they are more representative than either maximum or minimum values to represent bycatch numbers. The extrapolation process about how bycatch rates were extrapolated to the entire study period was not explained clearly in Anderson's research. However, the general process is inferred to be similar as this study because they also used tuna catch records from the IOTC website. It is essential to point out since this research uses the similar tuna catch records from IOTC website as Anderson's research, the uncertainties included in their tuna catch dataset (such as over-reporting the tuna catch from some countries for financial and political reasons) also apply to the data used in this study. Moreover, like Anderson's study, the present study also assumes a direct relationship between the tuna captures and bycatch, which means the bycatch of cetaceans will vary with the tuna captures.

The result between this study and Anderson's study are also different in the sense of scale. Anderson's study focused on cetacean bycatch for the entire Indian Ocean, so they do not present regional results as done in this study. However, it is clear in their result that the overall trend of annual cetacean bycatch number (individuals/year) also increased between the 1950s and 2020s. This overall trend overlaps with the country trends demonstrated in this study. However, according to Anderson's result, they estimate a decreasing bycatch rate in recent years which has been offset by the increasing magnitude in tuna captures from gillnet. Therefore, we still have increased a positive trend in cetacean bycatch over time.

Current Work and Future Recommendations

Cetacean bycatch in tuna gillnet fisheries in the Arabian Sea has drawn the attention of the IOTC and the IWC (International Whaling Commission). Despite a lack of data and research to tackle the problem, scientists have proposed several solutions to address the issue: The first is to increase electric monitoring to document cetacean bycatch (IWC, 2019). Previous experiments have shown that closed-circuit television (CCTV) can effectively provide video footage, time and GPS locations of bycatch events (IWC, 2019). However, electronic monitoring requires the cooperation from fishermen, and there are costs to install, maintain and operate the tools, which are unlikely to be affordable by small-scale artisanal fisheries (IWC, 2019). The second is to deploy technical mitigation tools, such as acoustic deterrents and net illumination to nets (IWC, 2019). However, the evidence is mixed regarding the effectiveness of these mitigation methods, not to mention the costs associated with their use (IWC, 2019). There are some low tech and low-costs methods, such as using the plastic and glass bottles to create acoustic alarms (IWC, 2019). However, currently there have been no large-scale experiment to demonstrate the effectiveness of those methods (IWC, 2019). Finally, crew-based observer programs offer an opportunity to address current data gaps in fishing efforts and bycatch, and a previous study in Pakistan has demonstrated the effectiveness of such observer programs (Nawaz & Moazzam, 2014).

It is clear that data gaps are the most important obstacle to mitigating cetacean bycatch in the Indian Ocean. Currently, we do not have any reliable datasets that provide a comprehensive picture of fishing effort and bycatch on national scales. This data gap is very hard to fill because of a lack of political willingness, the financial ability to sustain systematic monitoring programs (IWC, 2019). With this in mind, a better way to solve the problem would be to identify several prioritized bycatch areas to focus on for each country, and do a rapid bycatch assessment in those areas. An IWC workshop on bycatch mitigation opportunities identified several bycatch hotspots in the Arabian Sea. Thus, I would recommend investing human and financial resources (in the form of either crew-based observer program or remote electrical monitoring) to investigate fishing effort and bycatch in these areas first to start filling current data gaps (IWC, 2019).

The second recommendation is to strengthen cooperation between national governments and international organizations to deal with the bycatch issue in the Indian Ocean. The Bycatch Mitigation Initiative (BMI) in IWC could serve as lead of such cooperation. Currently there is no effective international body that focuses on cetacean bycatch mitigation in the Arabian Sea, which hampers implementation of large-scale bycatch mitigation programs in the region (IWC, 2019). The BMI could serve a platform for stakeholders from different countries to meet, develop a regional road map to tackle the problem, provide a framework for sustainable funding of bycatch work, and also provide technical assistance and toolboxes with other international organizations (such as WWF, FAO etc.). It is very important for the countries around Arabian Sea to have a common agreement regarding the severity of the issue. The more communication that countries have with each other, the more likely such common understanding can be built.

The third recommendation is to increase research on bycatch mitigation strategies. As noted above, scientists have proposed several ways that could reduce cetacean bycatch. However, none of those methods have been proven to work effectively (IWC, 2019). Therefore, large-scale experiments and research are needed to evaluate current bycatch mitigation strategies. If we engage the international body of cetacean mitigation research as suggested above, funding issues could be solved by engaging participants from different national governments. Furthermore, economic evaluation and market incentive research should also be conducted at the same time in dealing with the costs for small-scale fishermen to deploy these mitigation strategies. The effectiveness of the bycatch mitigation strategies and their costs need to be addressed first in order for the fishermen to be motivated in participating in the bycatch reduction program.

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