Marine mammals interactions with tuna fishing activities in Indonesian seas

Marine mammals interactions with tuna fishing activities in Indonesian seas

L P Soede[1], D Natasasmita[1], I G Mahendra[1,2], and W Rizki[1]
[1] PT Hatfield Indonesia, LIPI Building 3rd Floor, Bogor 16122, Indonesia

E-mail: mahendra@hatfieldgroup.com

Abstract. For decades, marine scientists have known that fisheries throughout the world result in mortality for cetaceans (whales, dolphins, and porpoises). Incidental catch (also known as by-catch) in fisheries is considered the biggest threat to the survival of cetaceans globally. Migratory species such as cetaceans are exposed to various threats because they are nomadic. From a conservation and management perspective, the level of protection given to cetaceans differs according to their geographical location. This study was conducted to determine the extent of by-catch in the study area and identify measures taken by fishers to minimize by-catch. During a 20-day period, 222 fishers were interviewed in six locations - East Kalimantan, North Sulawesi, Ternate, Morotai, Seram, and Biak - to identify the interaction between marine mammals and tuna fishing activities, particularly related with the usage of different fishing gear and fishing practices. Twenty cetacean species from by-catch were identified by respondents including three species of baleen whales and 17 species of toothed whales (including dolphins). Results from this survey indicated that interactions between marine mammals and tuna fisheries in Indonesian seas are primarily due to cetacean predation on tuna (e.g., pilot whales). To manage and minimize cetacean by-catch in the Indonesian seas, one of the recommendations from the authors of this study is the development of a Marine Mammal Mitigation Plan.

Keywords: Marine Mammals, Cetaceans, By-catch , Tuna, Fishing Gear, Fishing Activities.

1. Introduction

Consumer trends in sustainable tuna fishing and increasing enforcement are driving a need to better understand existing fishing practices to better inform sustainable management. Indonesia tuna fisheries target four major species of large tuna including skipjack tuna (*Katsuwonuspelamis*), yellowfin tuna (*Thunnusalbacares*), bigeye tuna (*Thunnusobesus*), and albacore tuna (*Thunnusalalunga*), using a variety of fishing gear that includes purse seine, long lines, pole and line, hand line and gillnets. As the second most exported seafood commodity, tuna fisheries in Indonesia offer an opportunity to examine fishing practices concerning international market trends[1]. One of these trends is a need to decrease by-catch of marine mammals in tuna fishing practices.

Indonesian seas are an important migratory area for many species; including rare and/or endangered species. At least 35species of cetaceans (Whales and Dolphins) are known exist in Indonesia seas [2–4], however, the spatial and temporal range of cetaceans is still poorly understood [5]. There is evidence of extensive interaction between cetaceans and fisheries worldwide, with many

[2] To whom any correspondence should be addressed (mahendra@hatfieldgroup.com)

species affected and frequently threatened by fisheries activities, particularly in areas where fisheries and cetacean habitat overlap [6]. Fisheries-cetacean conflicts include the incidental taking of marine mammals during fishing operations (i.e., by-catch), entanglement in fishing gear, habitat impacts resulting from certain fishing practices, food competition, parasite transmission, and others. Related to by-catch impacts, the mortality of certain cetacean species (Whales and Dolphins) caused by commercial tuna operations led to the passage of the Indonesian marine mammal action plan. Nevertheless, commercial fishing operations continue to be a major source of incidental mortality of many marine mammal species.

This research was contributed to identify the interactions between tuna fishing activities and marine mammals and to support a better understanding of the combination of factors that cause these interactions, including giving a better understanding of by-catch rates per fishing method, as well as to specify the factors of each fishing method that lead to by-catch. Furthermore, the results of this assessment will be useful to select mitigation strategies in supporting the export of sustainable tuna products through creating responsible tuna fisheries practices and more effective management and provide a foundation for further research.

1.1. Current Understanding

1.1.1. Regulatory Context. The policy and regulatory environment that govern the management of tuna fisheries and cetacean conservation include international treaties, international conventions, inter-governmental organizations, national laws and regulations, subnational regional management organizations and also relevant standards outlined by importer countries.

Indonesia is an important member of several international commissions concerning tuna fisheries management, including The Indian Ocean Tuna Commission (IOTC), Conservation of Southern Bluefin Tuna (CSBT), and the Western and Central Pacific Fisheries Commission (WCFCF). Also, the National Oceanic and Atmospheric Administration (NOAA) has also published import regulations that force all nations who export fish or fish products to the U.S. to meet the standards for protecting marine mammals as outlined in the Marine Mammal Protection Act [7].

Nationally, tuna fisheries are managed through the Government of Indonesia Decree No. 7/1999 on preserving flora and fauna species which protects all species of cetaceans and bans the internal trade of these species. Government Decree No. 8/1999 regarding the exploitation of wild animals and plants species also mentions that exploitation of cetacean species are permitted only for traditional hunting, and limited trade, namely barter. Specifically, the complete protection of whales has been regulated by the Ministry of Defense decree No. 327/Kpts/Um/5 /1978, and Regulation No. 60/2007 regarding the preservation of a wide range of flora and fauna, including conservation of all cetacean life in Indonesia.

1.1.2. Cetaceans in Indonesia. Indonesia has a diverse range of marine mammal species, yet there are few records of their distribution, especially from remote regions. At least 35 species of cetaceans (whales and dolphins) are known to exist in Indonesia seas. This estimation was based on the studies conducted by WWF and Mustika [8,9] and was combined with the previous study by Beasley[10]. They are found in all seas under the national jurisdiction of Indonesia. Each species has a particular habitat and ecological requirements; some of them may overlap with fisheries activities.

1.1.3. Tuna Fisheries in Indonesia. Five main species of tuna are fished in Indonesia, including skipjack tuna (Katsuwonuspelamis), yellowfin tuna (*Thunnusalbacares*), bigeye tuna (*Thunnusobesus*), albacore tuna (*Thunnusalalunga*), and Southern Bluefin tuna (*Thunnusmaccoyii*). The main geographic regions known for tuna habitat include the Sulawesi Sea, Maluku Sea, Halmahera Sea, Ceram Sea, Flores Sea, and the Banda Sea. Mostly, tuna is fished using a variety of fishing gear such as longlines, purse seines, pole and line, hand lines, and gill nets.

1.1.4. Cetaceans and Tuna Fisheries Interactions. Cetacean by-catch in tuna fisheries is a significant factor in the long-term conservation and management of marine mammal populations. Interactions between marine mammals and fisheries take several forms. They are mostly caught in purse seine, longline, and gillnet gear. In some cases, fishers who seek a way to protect their gear or catch may accidentally harm or intentionally shoot marine mammals that are interacting with their gear. In other cases, marine mammals and fisheries interact through trophic pathways. The resolution of issues arising from these interactions typically requires different management approaches. Specifically, Indonesian fishers use several cetacean species, especially dolphins to locate the schooling tuna, and often purposely chase and encircle the dolphins in their nets to maximize their catch of tuna. Tuna fishers have exploited this interaction for many decades because the dolphins are easier to be sighted from a distance and make the tuna swimming below them easier to follow and catch.

2. Methodology

2.1.Study Area

Interviews were conducted in six locations, selected based on their proximity to cetacean migration pathways and/or habitats, anecdotal information and results of a desktop study on by-catch, and representation of the location on an important tuna fisheries management area (FMA). For fisheries management purposes have followed the Ministerial Regulation No 18 of 2014 concerning the FMAs regulates 11 FMAs within Indonesia.

The study locations were also located in different FMA in East Kalimantan (FMA 716 and FMA 713), North Sulawesi (FMA 716 and FMA 715), Ternate (FMA 715), Morotai (FMA715, FMA 716, and FMA 717), Seram (FMA 715), and Biak (FMA 717) as shown in figure 1.

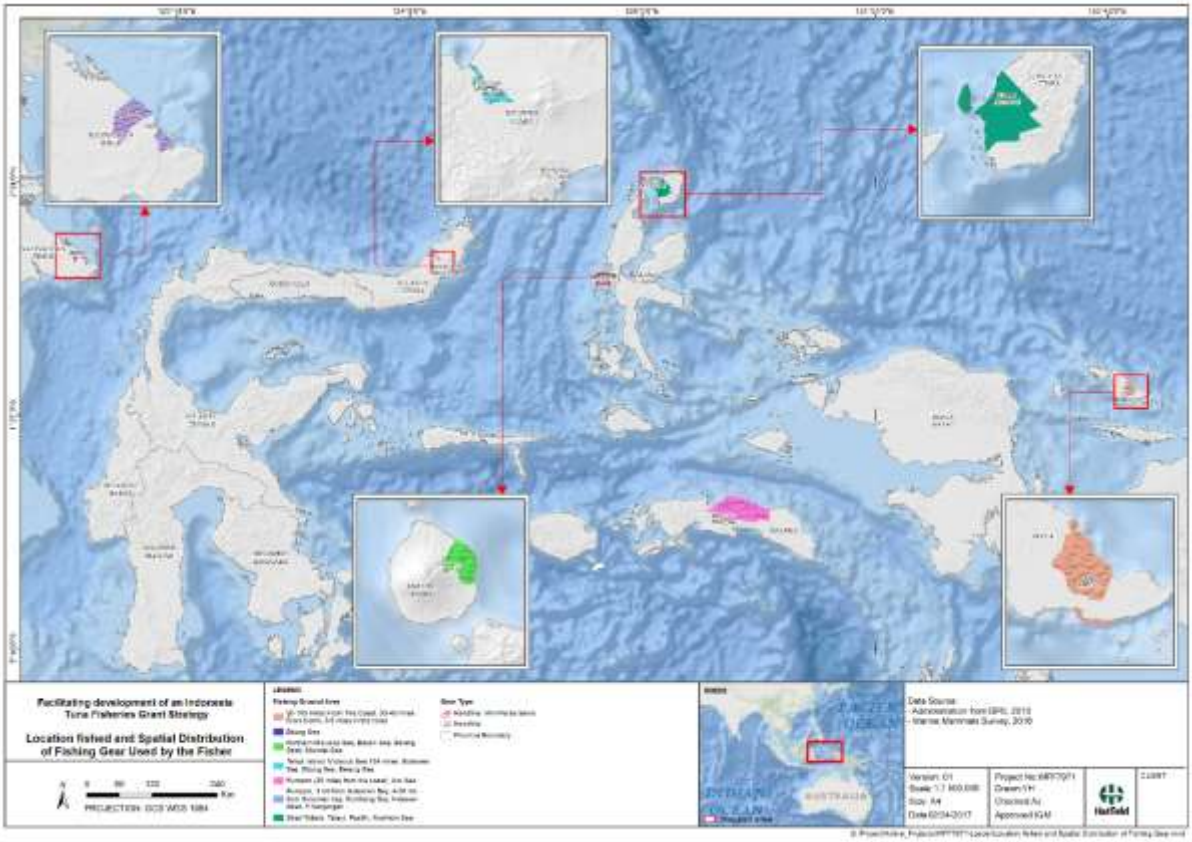

Figure 1. The location of 6 research sites (Biak, East Kalimantan, Morotai Island, North Sulawesi, Seram Island, and Ternate.

2.2.Data Collection

Interview and discussion group surveys were conducted in person and designed to collect several types of data,including experiences and opinions of fishers, opportunistic data on the distribution of marine mammal species (which in turn could help to inform presence estimates), and by-catch incidents on the type of fishing gear associated with marine mammal by-catch.

Interviewees were encouraged to provide their point of view on abundance trends and data on fishing effort, by-catch rates and interactions between fishing and marine mammals. This data collection method can provide information covering large areas, and provides data on the diversity of marine mammals in a broad scale and could be used to confirm anecdotal information on interactions between marine mammals and tuna fishing activities. A total of 222 fishers were interviewed in the six locations over a 20-day period.

2.3.Data Analysis

The results of field interviews and focus group discussions were analyzed qualitatively. Records of conversations were transcribed and the opinions were grouped and categorized. The emerging themes were used as a framework for descriptive analysis. The categories of data analyzed include characteristics of the fishers, characteristics of the cetaceans, types of interactions, and by-catch estimations (table 1).

Table 1.Variables and categories used to analyze results

Description	Variable	Categories/responses
Respondents		
Fishers' base of operations, home villages or harbors where interviews were conducted	Site	Name
Years of experience fishing	Experience	▪ Low: <5 years ▪ Intermediate: 5 to 30 years ▪ High: ≥30 years
Type of fishing gear utilized most often by the respondent	Gear type	▪ Handline ▪ Mini purse-seine ▪ Other
Net size (if applicable)	Size	▪ ≤ 2 inches ▪ > 2 inches
Net length (if applicable)	Length	▪ 0 – 100 meters ▪ 100 – 500 meters ▪ > 500 meters
The estimated depth of fishing activities in meters estimated using the reach of fishing lines	Depth	▪ Shallow: <50 meters ▪ Intermediate: 50 to 100 meters ▪ Deep: ≥100 meters
Distance from shore in kilometers, estimated using fisher's global positioning system (GPS). Note: One nautical mile is approximately 1.85 km.	Distance	▪ Nearshore: <19.31 km ▪ Offshore: ≥19.31 km
Location of fishing activities estimated using fisher's GPS.	Location	▪ Latitude and Longitude
The attitude of the fishers towards cetaceans in each reported interaction	Attitude	▪ Scaring the dolphins away ▪ Following the dolphins ▪ Ignoring the dolphins
Cetaceans		

Description	Variable	Categories/responses
Cetacean species identified in each interaction with fishers	Species	Species names
Time of day that each cetacean sighting occurred	Time of day	▪ Midnight ▪ Late night ▪ Morning ▪ Noon ▪ Afternoon ▪ Evening ▪ Night
The location of each cetacean sighting as estimated by fishers' GPS	Cetacean location	▪ Around fish aggregating devices ▪ While traveling under power
Interactions		
Classified as positive when fishers follow them to find schools of fish. Classified as negative when catch damage or loss occurred (e.g. depredation and scattering of fish) or when gear damage occurred or when cetaceans ended up as by-catch	Interaction type	▪ Negative ▪ Positive ▪ Both
The condition of each cetacean that experienced an interaction with fishers	Condition	▪ Released with no injuries ▪ Released with moderate injuries ▪ Released with serious injuries ▪ Deceased o Consumed o Sold o Used as bait o Dumped ▪ Unknown
Rates of by-catch or interaction? reported by fishers as average per year per vessel	By-catch or interaction rates	▪ Minimal: ≤1 ▪ Low: 2 to 10 ▪ Intermediate: 11 to 30 ▪ High: >30
Mitigations self-imposed by fishers as a result of incidents of by-catch	Mitigation	▪ Change of fishing area ▪ Scare cetaceans away ▪ Waiting for a cetacean to leave ▪ Reduce fishing time ▪ Use of whistle or sound producers

3. Result and discussion

There were no significant impediments experienced during data collection, besides the bad weather that limited the observations and interview process. The interviews and group discussions were held in various locations, including outdoors (in the harbor) and sometimes in respondents' homes.

3.1. Fishers' characteristics and their fisheries practices

All fishers interviewed were males between 23 and 64 years of age, and had more than five years of experience in fishing. Most of them conducted one-day fishing trips and their potential fishing grounds

ranged from0 to 260 km from shore. Traditional fishers used small vessels, called *Katingting* (a short-range vessel with outboard motors and space for two people), and most of them were not equipped with an icebox and didn't bring ice with them during the fishing trip. Only the fishers in Seram had additional temporary storage for fish on-board with some space allocated to ice. In Seram, fishers had also formed fisher groups based on kinship and built better management capacity with these groups.

Regionally, the fishers in North Sulawesi (Bitung and Belang) usually fish in their Fishing Aggregating Devices (FADs) in the Moluccas Sea away from their territory that overlaps with Ternate (more than 111.12 km away), and these fishers use a medium to large scale vessels of about 3 to 21 GT. They were able to travel up to 260 km from shore. In contrast, fishers in Morotai and Biak usually operate *Katingting* by paddle and only fish up to a distance of less than 5 km from shore. They tended to focus their efforts closer to the coast to avoid the high waves in high seas.

Most fishers interviewed in this study used hand lines as their fishing gear (table 2). The average water depth of fishing activities was about 50 meters. The average distance from shore reported by the fishers is less than 22 km. Generally, they focused their fishing efforts within the 12-mile territorial sea boundary.

Regarding by-catch, there were both positive and negative attitudes towards cetacean interactions reported by the fishers. The positive interactions happened when they used cetacean species as guides to find their catch targets, while the negative interactions happened when the cetacean species ate their baits and their fishing targets in the FADs.

In addition, surveys also involved questions about fishing depth categorized into three groups: 0-50 meters, 51-100 meters, and >100 meters below sea level. From the survey data, handline fisheries were also shown to be the preferred method with 97.7% (n=217) of fishers using this method.

Table 2. The number of fishing gear per depth operation in all sites

Fishing type and depth (m)	Biak	East Kalimantan	Morotai (Moluccas)	North Sulawesi	Seram Island	Ternate (Halmahera)	Total
HL 0-50	34	5	6	-	-	-	45
HL 51-100	-	1	13	-	-	27	41
HL>100	20	1	18	32	60	-	131
MPS 0-50	-	3	-	2	-	-	5
Total	**54**	**10**	**37**	**34**	**60**	**27**	**222**

Note: HL: Handline, MPS: Mini Purse Seine

Table 2 indicated that the preferred depths of the handline fishers in North Sulawesi, Seram, and North Maluku were more than 100 meters, compared to depths of between 51 to 100 meters in Ternate and Morotai, and depths from 0 to 50 meters in Biak and East Kalimantan. Mini purse seine fisheries were only found in East Kalimantan and North Sulawesi. All purse seiners are fishing at less than 50 m depths. The seine nets typically use a mesh size of about five centimeters.

Handline fishers spent between one to five days at the sea per trip and purse seine fishers spent more than 15 days. The North Sulawesi fishers spent three to seven days or more per trip due to the distance of fishing locations.

3.2.Marine mammal presence and spatial distribution

During the survey, there were 20 species of cetaceans reported by the fishers, consisting of three baleen whales and 17 toothed whales and dolphins. The more frequently the cetaceans sighted were spinner dolphin (12.08%) and sperm whale (10.76%), followed by pantropical spotted dolphin (9.9%), rough-toothed dolphin (8.58%), bottlenose dolphin (8.51%), humpbacked dolphin (7.52%), melon-headed whale (7.46%), striped dolphin (6.44%), orca (6.47%), and false killer whale (5.68%). Other species were mentioned less than 5% of the sightings and rarely seen in multiple locations (table 3). Some of them were sighted only in one location, such as the Bride's whale in East Kalimantan, and Fraser's dolphin in North Sulawesi.

Table 3. Summary of marine mammal sightings reported by a fisherman in all sites.

Species ID	Species Name	Latin Name	Number of Sightings	The proportion of TotalSightings (%)
BlW	Blue Whale	*Balaenopteramusculus*	58	3.83
DSW	Dwarf Sperm Whale	*Kogiasimus*	4	0.26
BrW	Bride's Whale	*Balaenopteraedeni*	1	0.07
FKW	False Killer Whale	*Pseudorcacrassidens*	86	5.68
FW	Fin Whale	*Balaenopteraphysalus*	26	1.72
KW	Orca	*Orcinus orca*	91	6.01
MhW	Melon-headed Whale	*Peponochepalaelectra*	113	7.46
PKW	Pygmy Killer Whale	*Feresaattenuata*	35	2.31
SfPW	Short-finned Pilot Whale	*Balaenopteramusculus*	22	1.45
SpW	Sperm Whale	*Pysetermacrochepalus*	163	10.76
BD	Bottlenose Dolphin	*Tursiopstruncatus*	129	8.51
FD	Fraser's Dolphin	*Lagenodelphishosei*	1	0.07
HbD	Humpback Dolphins	*Sousa spp*	114	7.52
ID	Irrawaddy Dolphin	*Orcaellabrevirostris*	4	0.26
PSD	Pantropical Spotted Dolphin	*Stenellaattenuata*	150	9.90
RD	Risso's Dolphin	*Grampus griseus*	69	4.55
RtD	Rough-toothed Dolphin	*Steno bredanensis*	130	8.58
SbCD	Short-beaked Common Dolphin	*Delphinus delphis*	38	2.51
SD	Spinner Dolphin	*Stenellalongirostris*	183	12.08
StD	Striped Dolphin	*Stenellacoeruleoalba*	98	6.47
Total			1,515	100

The sighting time was classified in six classes includes night, daylight, morning, evening, afternoon, and anytime. Anytime means that fishers usually saw cetaceans in all periods of the day. The high number of sightings at "anytime" of the day shows a high spatial presence (figure 2). However, a specific study is still needed to correlate sighting time with some parameters such as season, sea surface temperature, or other environmental factors that may affect cetacean activity and presence.

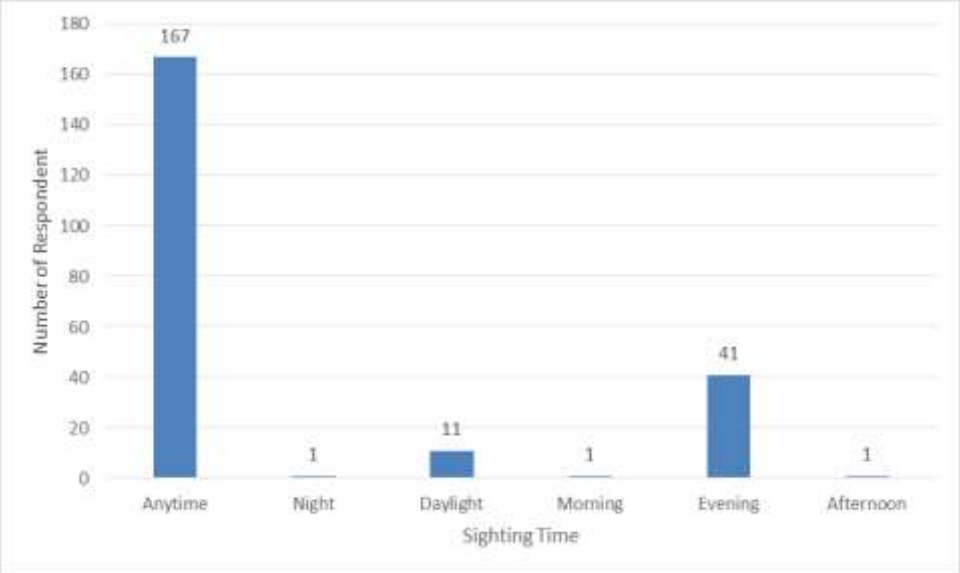

Figure 2. The sighting time of marine mammals.

As shown in table 4, the highest diversity of identified species have appeared in Seram, with 10 species sightings, including False Killer Whale, Orca, Melon Headed Whale, Sperm Whale, Hump Backed Dolphins, Pantropical Spotted Dolphin, Risso's Dolphin, Rough Toothed Dolphin, Spinner Dolphin, and Striped Dolphin. This may be biased from the sample size as Seram had a higher number of respondents than the other study areas.

The most marine mammal sightings were reported from Biak, with five species and a total of 122 species sightings reported. Biak was also the location with the highest number of sightings for Blue Whale (32), Dwarf Sperm Whale (4), Short-finned Pilot Whale (10), Bottlenose Dolphin (54), and Short-beaked Common Dolphin (18). The highest number of sightings of Fin Whales was in Ternate (26). In North Sulawesi, there are two types of rare marine mammals that were found including Fraser Dolphin and Irrawaddy dolphin. Bride's Whale was only sighted in East Kalimantan and Pygmy Killer Whale was only sighted in Morotai.

Table 4. Highest concentrations of sightings per species

Species Name	Highest Number of Sightings	Location
Blue Whale	32	Biak
Dwarf Sperm Whale	4	Biak
Short-finned Pilot Whale	10	Biak
Bottlenose Dolphin	54	Biak
Short-beaked Common Dolphin	18	Biak
Bride's Whale	1	East Kalimantan
Pygmy Killer Whale	27	Morotai
Fraser's Dolphin	1	North Sulawesi
Irrawaddy Dolphin	4	North Sulawesi
False Killer Whale	53	Seram
Orca	53	Seram
Melon-headed Whale	60	Seram
Sperm Whale	60	Seram
Humpback Dolphins	60	Seram
Pantropical Spotted Dolphin	60	Seram
Risso's Dolphin	53	Seram
Rough-toothed Dolphin	60	Seram
Spinner Dolphin	60	Seram
Striped Dolphin	53	Seram
Fin Whale	26	Ternate

3.3. Interactions between marine mammals with tuna fishing activities

The fishers have described their interactions with cetaceans based on three categories: scaring them away, following them, and ignoring them. From the surveys, 65.8% of fishers reported following the dolphins, compared to only 13.1% that actively tried to scare them away; 21.2% of fishers surveyed said they ignored dolphins (figure 3). Data collection from this survey also found that marine mammal by-catch occurred during all types of interactions. By-catch occurred in all categories of interactions, but were highest when fishers were engaged in activities to scare cetaceans away (by-catch reported 38% of the time), compared to incidents of by-catch that occurred during interactions when fishers were following the dolphins (6% of the time)and when fishers ignored the dolphins (4% of the time) (figure 3).

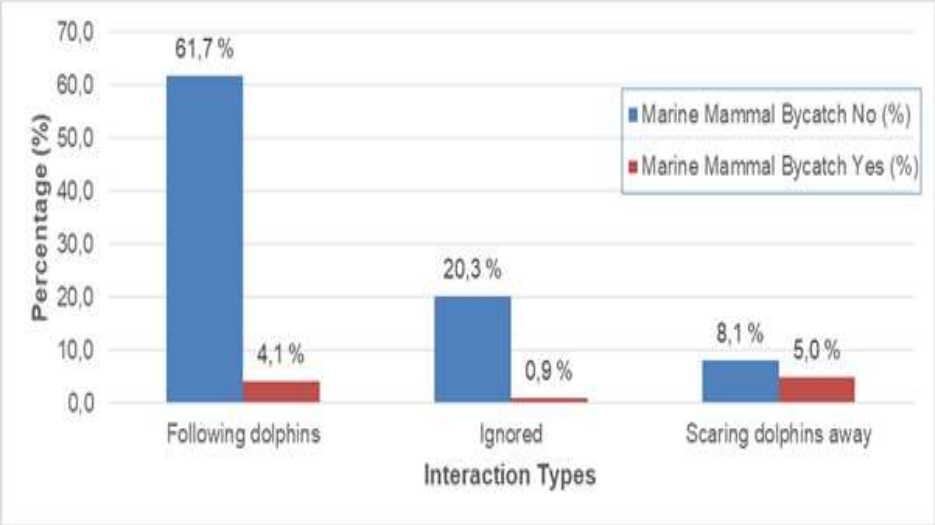

Figure 3. Fishers' attitudes on interactions compared with the rate of by-catch .

3.3.1. Scaring Dolphins. Cetaceans are viewed as a nuisance by some fishers when they are fishing with specific fishing gear because it will affect the volume, quality, and profitability of the catch, called depredation. The Rough Toothed Dolphin, Orca, False Killer Whales, and Pilot Whales have become experts in stealing a variety of fish species from longlines fishing gears and FADs around all sites. Therefore, the fishers always try to keep them away from their vessels or FADs by scaring them away; typically by throwing some objects such as stones, wood or oil bottles and creating noise to keep them away.

3.3.2.Following Dolphins. By following the dolphins, traditional fishers get some benefits because the dolphin will lead them to their fishing targets, including tuna, but can lead to harmful interaction between cetaceans and fishing gear. Based on our discussions with the fishers at each site, by-catch incident of this type of interaction is due to two effects; the dolphins will take their fishing bait from hand line fishing gear as their food or the dolphins will accidentally catch inside the purse seine.

3.3.3. Ignoring Cetaceans. When the fishers ignore the dolphins, some respondents indicated that by-catch incidents still happened. These interactions have mostly occurred with Rough Toothed Dolphin or Pilot Whales which are very disruptive towards fishing activities.

3.3.4. By-catch Estimation. Based on the discussions resulted in all sites, fishers explained that the mortality or serious injury of marine mammals, or by-catch , could result from different tuna fisheries practices. However, by-catch could have severe consequences for the demography of affected populations and endanger the existence of some species.

From the result of interviews in figure 4, respondents shared that dolphin species constituted the majority of by-catch because fishers usually followed the dolphins to locate tuna and other fish. The area with the highest number of by-catch reports was North Sulawesi site (20.6%), and mostly due to when fishers used mini-purse seines. Reports of by-catch were also in Seram (15%) East Kalimantan (10%) and in Biak (9.3%) that use of the same fishing gear, handline. Meanwhile, in Morotai and Ternate, there was no by-catch reported; this may be because there is local wisdom that historically, whales and dolphins are considered as the fishers' friends, and they shouldn't be caught.

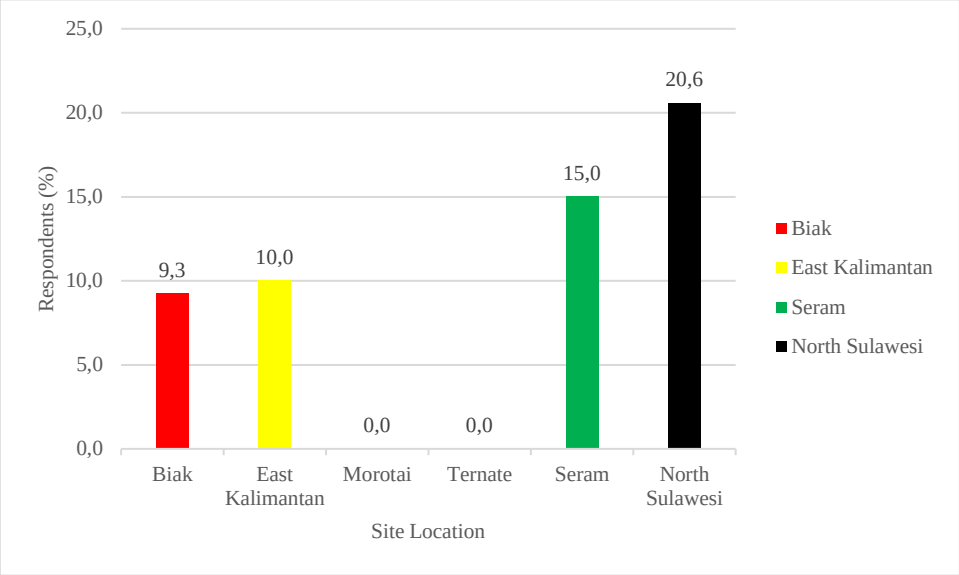

Figure 4. Cetacean by-catch percentage per site locations

Figure 5 shows where incidences of by-catch occurred during the fishing activity, and when using which fishing gear. The highest number of respondents that was reported by-catch were the handline fishers (n = 15) and the incidences occurred both during travel to the FADs and when they were fishing around the FADs.

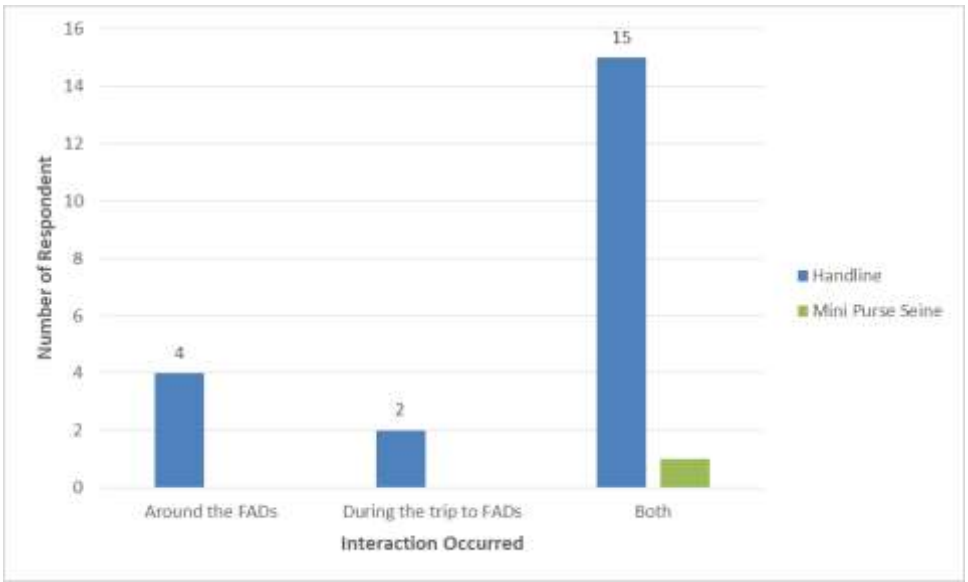

Figure 5. Cetacean by-catch compared between fishing gear and interaction occurred.

Figure 6 showed the comparison of by-catch incidents between fishing gear types and length of fishing trips. The results indicate that most of the by-catch incidents occurred during short fishing trips of 2 days (n = 13), both for handline and purse seine fisheries. Overall, the fishers reported that the cetaceans accidentally caught in fishing gear are most often released alive.

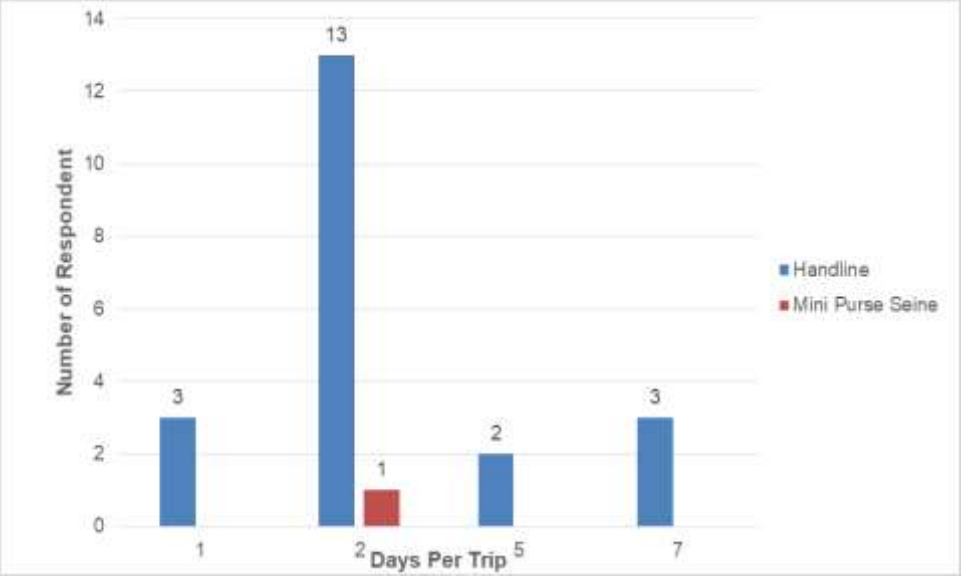

Figure 6. Cetacean by-catch compared between fishing gear and fishing day practices.

4.4 Marine mammal mitigation

During the survey, it was clear that fishers were not happy when pilot whales would eat their tuna catch, but they never mean to harm or kill them. They have been aware that marine mammals are protected species and they also have several ways to influence the presence of these cetacean species and reduce the negative impacts of interactions, including:

1. Scaring dolphins away before setting their gear by throwing objects at the animals (stones or oil bottles) or creating noise by hitting their vessels:
2. Turning off the fish attraction lights (at night) to stop any cetaceans from coming;
3. Releasing the live cetaceans caught in handlines;
4. Moving to another fishing area when they found Orca around the FADs;
5. Waiting until the cetaceans leave the fishing ground area; and
6. Stopping the fishing activities. This action usually only implemented by the medium and large scale vessels.

Many fishers reported that sounds are an effective mitigation method to avoid the by-catch during fishing activities, especially for Orca and Rough Toothed Dolphin species around the FADs. There is a local myth of people in East Kalimantan that the sound of a rooster will drive dolphins away.

While there are some examples of particular species or populations that have recovered from severe over-exploitation from commercial whaling and hunting in previous centuries, many cetacean populations and species continue to face increasing threats. In many nations and regions around the world, cetaceans are safeguarded by legislation, international agreements and in designated sanctuaries, but effective conservation and management of cetaceans can only be achieved if it is underpinned by a solid understanding of the patterns in the occurrence of interaction between cetaceans and fisheries.

Although the percentage of overall sightings per species, as recorded by this survey, cannot be used to estimate the overall frequency of occurrence of interactions for any particular species or area, it is apparent that the relative importance of doing further assessments is high. Fisheries and cetaceans occupy the same space all the time, spinner dolphins, for example, were reported by more fishers than any other species, with over 12% of the sightings.

For those species of cetaceans known to have a high occurrence of interaction, or by-catch , with tuna fisheries, it is important to know where and when these species show up at fishing grounds. This type of information can be the focus of future surveys by including cetacean sightings by fishers on catch logs and would help to inform mitigation planning

It appears that by-catch occurs more often during fishing trips two days in length rather than shorter or longer trips, regardless of gear, but this is probably affected by the small sample of respondents. Mitigation and prevention efforts that focus on developing fishers' knowledge around ways to avoid interactions may benefit from starting with this group of fishers.

Information on the time of day when sightings occur would have to be combined with more detailed information on fishers' activities to interpret the findings. Variables other than diurnal behavior patterns of cetaceans that may contribute to anticipating the presence of marine mammals can include seafloor profile ([11,12] thermocline [13], and sea surface temperature (SST) [14,15]. However, the influence of such factors is often considered to be indirect since prey distribution is also likely to be affected by oceanographic variables, such as tides, and currents during the time sighting.

5. Conclusion and recommendation

Results from this rapid survey have confirmed that interactions between cetaceans and tuna fisheries in Indonesian waters, and that by-catch occurs mostly because cetaceans are wanting to eat the same targets as the fishers are catching. Although some of the fishermen feel disturbed by their presence, they don't want to kill or harm these marine mammals because many of them believe that dolphins and marine mammals bring luck by showing them the location of their tuna. Measures to manage FADs appear relevant for mitigation of interactions of fisheries with cetaceans. More study is required to better understand the rate of by-catch per fishing method, and the specific factors of each fishing method that lead to by-catch. The actual effect of applying sound to deter cetaceans should be studied as well.

The following recommendations can stimulate further discussions, and hopefully, lead to further studies and taking early action on managing marine mammal interactions in fisheries:

1. Additional studies are required to get more complete information, especially on by-catch released activities;
2. Further study is needed to validate the information about the type of interaction pattern with different fishing gears, and the actual condition on the cetacean caught in fishing gear;
3. Implement the application of remote sensing and sonar technology to detect the existence of marine mammals below the surface; and
4. Conduct a cetacean mitigation pilot, including the establishment of a community of best practice in a tuna fishing village, gain some sustainable fishing certification and improve the value-added innovation in fishing practices.

The knowledge sharing with the staff of *Masyarakat dan Perikanan Indonesia* (MDPI) and Danielle Kreb from Rare Aquatic Species of Indonesia (RASI) Foundation have been especially valuable and we thank these organizations for their support and look forward to continuing working with them. Also, we thank the Walton Family Foundation (WFF) and the David and Lucile Packard Foundation (DLPF) for their cooperation in financial support of this program.

Finally, and importantly, we thank all fishers for their trust, time, and willingness to participate in this study.

6. References

[1] Preiwati L A 2014 *Marine and fisheries in figure 2014* (Jakarta (ID): Statistics Indonesia **302)**
[2] Kreb D and Budiono 2005 Cetacean diversity and habitat preferences in tropical waters of East Kalimantan, Indonesia *Raffles Bull. Zool*

[3] Mustika P L K, Hutasoit P, Madusari C C, Purnomo F S, Setiawan A, Tjandra K, and Prabowo W E 2009 Whale strandings in Indonesia, including the first record of a humpback whale (*Megaptera novaeangliae*) in the Archipelago *Raffles Bull. Zool*
[4] Mustika P L K, Sadili D, Sunuddin A, Kreb D, Hadi S, Ramli I, Suprapti D, Ratha J, Lazuardi E, Rasdiana H, Miasto Y, Sari R P, Annisa S, Terry N and Monintja M M P 2016 *Rencana Aksi Nasional (RAN) Konservasi Cetacean Indonesia 2016-2020 (the Cetacean National Plan of Action (NPOA) for Indonesia 2016-2020)* (Jakarta, ID: Ministry of Marine Affairs and Fisheries)
[5] Ender A I, Muhajir, Mangubhai S, Wilson J, Purwanto and Muljadi A 2014 Cetaceans in the global center of marine biodiversity *Mar. Biodivers. Rec.***7**
[6] Northridge S, Natale A D, Kinze C, Lankester K, de Zarate V O, and Sequeira M 1991 *Gillnet fisheries in the European Community and their impacts on the marine environment*
[7] NOAA 2016 *Compliance Guide – Marine mammal protection act import provisions to reduce marine mammal by-catch* (NOAA Fisheries: International Affairs and Seafood Inspection)
[8] WWF 2011 *Laporan pengamatan incidental mammalia laut Kawasan Konservasi Daerah (KKPD) Kabupaten Alor, Periode Monitoring 2009-2011*
[9] Mustika P L K, Birtles A, Everingham Y and Marsh H 2015 Evaluating the potential disturbance from dolphin watching in Lovina, North Bali, Indonesia *Mar. Mammal Sci.*
[10] Beasley I, Jedensjö M, Wijaya G M, Anamiato J, Kahn B and Kreb D 2016 Observations on Australian Humpback Dolphins (*Sousa sahulensis*) in waters of the Pacific Islands and New Guinea *Advances in Marine Biology*
[11] Hui C A 2006 Undersea Topography and Distribution of Dolphins of the Genus Delphinus in the Southern California Bight *J. Mammal.*
[12] Selzer L A and Payne P M 1988 The Distribution of white-sided (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) vs. environmental features of the continental shelf of The Northeastern United States *Mar. Mammal Sci.*
[13] Reilly S 1990 Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific *Mar. Ecol. Prog. Ser.*
[14] Gaskin D E 1968 Distribution of *Delphinidae* (*Cetacea*) in relation to sea surface temperatures off Eastern and Southern New Zealand *New Zeal. J. Mar. Freshw. Res.*
[15] Brager S and Schneider K 1998 Near-shore distribution and abundance of dolphins along the West Coast of the South Island, New Zealand *New Zeal. J. Mar. Freshw. Res.*

Acknowledgment

This assessment has been conducted to gain a better understanding of the combination of factors that contribute to interactions between cetaceans and tuna fisheries. Certainly, better and more complete information is urgently needed to fully understand the impact of these interactions and to inform management activities.