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Abstract

Cetacean surveys using line-transect and photo-identification methodology were conducted in Kuching Bay, Sarawak, Malaysia from March through September, 2011 and 2012 and from March through May 2013. During surveys fishing boats and fishing activity were recorded to quantify the scale of artisanal fishing activity in the bay. During a total of 3670 km and 248 hours of survey effort, a variety of fishing methods were observed, including attended and unattended gillnets, jellyfish-harpooning, stake-nets, bag-nets and fishing from shore (e.g. beach-seining, cast and line, collecting razor clams). Boat–based observations were complemented by interview surveys with fishermen in villages surrounding the study site. Both interviews and direct observations show a clear post-monsoon (March-May) seasonal peak in the presence of attended gillnets as well as jellyfish-harpooning. Encounter rates for unattended gillnets peaked in the pre-monsoon season from September to October. Relative density of observed fishing activity depicted in 2 km × 2 km grid-cells indicates a strong overlap between the primary fishing areas and the preferred habitats of Irrawaddy dolphin and finless porpoises, which are both concentrated in rivers, rivermouths and close to the shore. This overlap suggests that the impact of artisanal fisheries to the cetacean population through bycatch could be high, and interview data confirm that accidental bycatch is prevalent, with 93% of fishermen reporting that they had heard of between one and five cases of bycatch in their village in the past year, and 35% of respondents reporting that they personally had found at least one dolphin accidentally entangled (either live or dead) in their net in the past year. However, the high proportion of attended vs. unattended nets, the fishermen's reported positive perception of cetaceans, and their reported willingness to release dolphins from nets give cause for optimism in the potential effectiveness of targeted action with fishermen to reduce cetacean mortality from by-catch.

Keywords: Artisanal fisheries, cetaceans, Malaysia, Sarawak, distribution, Irrawaddy dolphin, *Orcaella brevirostris*, mitigation, bycatch

Introduction

While terrestrial conservationists have long been aware of the importance of considering the "human dimension" in wildlife management, cetacean research and conservation efforts have traditionally been dominated by animal-centered studies. The relatively recent extinction of the Yangtze river dolphin (Turvey, Pitman et al. 2007) and the ongoing struggle to conserve the Vaquita in the face of unsustainably high levels of fisheries bycatch (e.g. Jaramillo-Legorreta, Rojas-Bracho et al. 2007, Rojas-Bracho and Reeves 2013), are proving that ignoring the human dimension while trying to scientifically establish population numbers and rates of decline, can have irreversible negative consequences.

Four coastal cetacean species, namely Irrawaddy dolphin (*Orcaella brevirostris*), finless porpoise (*Neophocaena phocaenoides*), Indo-Pacific humpback dolphin (*Sousa chinensis;* herewith humpback dolphin) and Indo-Pacific bottlenose dolphin (*Tursiops aduncus)* are found in Kuching Bay, in the Malaysian state of Sarawak (Minton et al., 2011). Irrawaddy dolphins are estimated to number 233 individuals (mark recapture CV = 22.5%, 95% confidence interval 151–360); finless porpoises, 135 individuals (line –transect CV = 31%, 95% confidence interval 74–246) (Minton et al, 2013); and humpback dolphins 84 (mark-recapture CV = 16.4%, 95% CI = 61–116) (Zulkifli Poh et al., in press). All three species are found in nearshore waters, but the Irrawaddy dolphins' established preference for brackish waters (salinity 28.0–30.9 ppt) within a six km radius of rivermouths (Peter, 2012; Peter et al., 2016) appears to bring it most frequently into contact with local artisanal fishing operations. This species displays a high rate of site-fidelity in the Santubong-Salak estuary) rendering it more vulnerable to any anthropogenic threats at that site (Peter, 2012, Minton et al 2013) (Figure 1).

Throughout Sarawak, nearly 14,000 fishermen work on licensed fishing vessels or boats. Of these, 2,218 are registered in the Santubong district (Annual Fisheries Statistics, 2013), an area within the Santubong-Salak estuary which encompasses one component or strata the Kuching Bay (Figure 1). Fisheries bycatch is known to be the most prevalent anthropogenic threat to cetacean populations around the world (Read 2008), and in Asia (Smith & Jefferson, 2002; Smith et al., 2004; Reeves et al., 2008) and is thought to be unsustainably high in Sarawak (Jaaman et al., 2009).

This study attempts to examine more closely the "human dimension" of cetacean conservation in the Kuching Bay, by using boat surveys to extract fine scale data on distribution and relative abundance of fishing activity and techniques, complemented with interviews to understand fishermen's habits, gears, and perceptions of cetaceans. By combining these two datasets, we identify what we believe could be effective measures to collaborate with fishermen and mitigate the risk of cetacean mortality from by-catch and increase successful live-release-rates, improving cetacean survival rates for the four species in our study area.

Methodology

Survey area

The survey area, defined as the "Kuching Bay" for its proximity to the city of Kuching, the capital of Sarawak, East Malaysia, comprises three components or strata, including the Salak-Santubong Bay, the Bako-Buntal Bay, and interconnecting portions of the Telaga Air and Salak River, as well as the Santubong and Buntal Rivers (Figure 1). The southern part of the study area comprises a series of interconnecting rivers and mangrove channels, as well as sandy and rocky coastlines. While portions of the rivers reach maximum depths of 11–12 m, both of the major bays are shallow, not exceeding 10 m in depth as far as 15 km from shore. The substrate throughout the study area is predominantly fine silt and sand and the waters range from brackish (approximately 28 ppt in rivers and estuaries to saline [32 ppt] in the most offshore areas of the area; Peter, 2012).

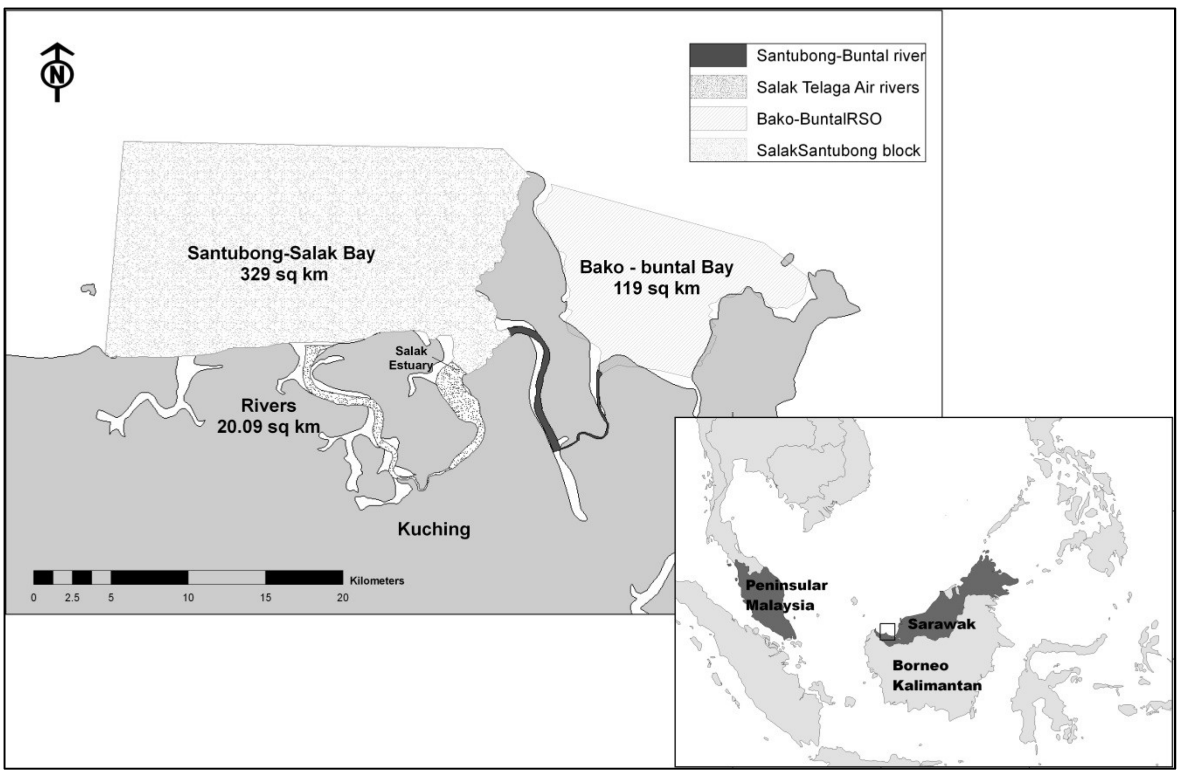

Figure 1: Map of Kuching Bay, showing the three strata of the Santubong-Salak Bay, the Bako-Buntal Bay, and the interconnecting river systems.

Boat-based surveys

Data collection: Observation of fishing boats and fishing gears was conducted concurrently with line transect surveys for cetaceans in the nearshore waters of the Kuching Bay on an almost monthly basis from March through October in 2011 and 2012 and from March through May 2013. The standard cetacean line-transect methods that were used are described in detail in Minton et al. 2013. This methodology was further enhanced by the recording and classification of all observations of active fishing activity during transects, and the detailed recording and classification of fishing activity observed within a 500m radius of observed cetacean groups.

Data analysis – Survey tracks and precise sighting locations recorded with a handheld GPS were downloaded at the end of each day and saved in different formats for later processing in Google Earth® and/or ArcMap®. Observation details were entered in a spreadsheet, and both tracks and observations were imported into Google Earth and ESRI's ArcMap for viewing, mapping and analysis. On-effort portions of tracks in the Kuching area were analyzed in ArcGIS 10.2 and overlaid with a 2 km × 2 km grid. An encounter rate for fishing activity was calculated by dividing the cumulative number of on-effort observations of fishing boats and fishing activity by the sum of all on-effort survey track within each grid cell. Cells were then colour-shaded by encounter rate value to provide a visual representation of variations of density in fishing effort. The encounter rates were pooled by month and then analyzed by season, i.e. March-May (post-Northeast monsoon), June-August and September-October (pre-Northeast monsoon). The fishing activity encounter rates were also categorized by year to detect which method of fishing was the most commonly observed across the years.

Interview surveys

To compliment direct observations of artisanal fishing activity, questionnaire interviews were conducted with fishermen throughout the study area. The questionnaire comprised 61 questions (17 open-ended and 44 closed), binned into 10 categories designed to gauge fishermen's level of experience, specifications of their fishing gear and fishing practices (including target species, fishing areas and average catch), and their perceptions of, and interactions with cetaceans, including rates of bycatch of cetaceans and other non-target species such as marine turtles. Interviews were conducted by an MSc candidate local to the study area and able to appreciate linguistic and cultural sensitivities of the area. Interviewees were selected with help from the head of the village's Fishing Association or the "Ketua Kampung" (village chief), with the selection criteria that fishing be their primary economic activity.

Before the interview began, each respondent was informed of the nature of the study, and was given a choice of a small token of appreciation (Sarawak Dolphin Project T-shirt or cap, "Idriss the Irrawaddy Dolphin" colouring book and pencils, stickers, etc) in exchange for the time volunteered for the interview.

Open-ended responses were categorized post-hoc in the analysis, to allow some quantitative analyses. Care was taken during the interviewing not to ask leading questions or impart any bias toward what would comprise a “good” or “bad” answer (Pilcher and Kwan, 2012). Following the interview, the researcher assigned scores to each interview for the respondent’s perceived “openness”, “comfort with the interviewer”, “confidence in answers” and “level of interest”.

Nine villages around Kuching Bay were selected for interviews, with a targeted total of over 300 responses. Statistical data and descriptions of fisheries practices and demographics were also taken from reports prepared by colleagues within our own research institution and from the Department of Marine Fisheries Sarawak. Because the number of responses being analyzed for this manuscript was low (17 in total), simple descriptive statistics and percentages were used (e.g. Amir, Berggren et al. 2002, Zappes, Simoes-Lopes et al. 2016). As more responses are coded and analyzed, more complex statistical analyses that will allow calculation of annual by-catch rates with confidence levels are envisaged (Moore, Cox et al. 2010)

Results

Fisheries observations

A total of 3670 km and 248 hours were spent on-effort during the 2011-2013 line transect surveys. Sixty-nine Irrawaddy dolphin and 45 finless porpoise sighting were recorded throughout the study period, with encounter rates of 0.28 sightings per hour and 0.18 sightings per hour respectively. Seventeen additional sightings of humpback dolphin, bottlenose dolphin and an unidentified dolphin species were also made during the surveys

Table 1: Survey period, distance covered, hours spent surveying and number of dolphin sightings per survey period by months and by year.

Survey period	Effort hour	Effort km	Total Irrawaddy dolphin sightings	Irrawaddy encounter per hour of effort	Total finless porpoise sightings	Finless porpoise encounter per hour of effort	Total humpback dolphins, bottlenose dolphins and unidentified species sightings
Mar-May	121:35:00	1796.41	34	0.280	27	0.222	6
Jun-Aug	76:29:00	1138.02	23	0.301	8	0.105	8
Sept-Oct	49:57:00	736.12	12	0.240	10	0.200	3
TOTAL	**248:01:00**	**3670.55**	**69**	**0.278**	**45**	**0.181**	**17**
2011	108:25:00	1557.74	34	0.314	20	0.184	7
2012	99:01:00	1490.80	24	0.242	17	0.172	9
2013	40:35:00	622.00	11	0.271	8	0.197	1
TOTAL	**248:01:00**	**3670.55**	**69**		**45**		**17**

Among the types of fishing activities observed were boats with fishermen attending driftnets and trammel nets (referred to as attended gillnets from here on), unattended driftnets and trammel nets (collectively referred to as unattended nets), boats with fishermen harpooning jellyfish (jellyfish-harpooning), stake-nets, bag-nets and fishing from shore (e.g., beach-seining, cast and line, collecting razor clams). Stake-nets or locally known as "belat" are gillnets that are stretched between two or more stakes driven into the bottom within the inter-tidal area, along the coast. They are usuallly set at the periphery of mangroves during high tide and fish are harvested at low tide.

Throughout the three-year study period, the use of attended nets was the most commonly observed fishing activity with mean annual encounter rates of 0.253, 0.227 and 0.159 per km searched respectively. Use of unattended nets was the second most frequently recorded fishing activity. Jellyfish harpooning was most frequently observed in 2012 with encounter rates of 37 observations per hour, or 0.103 per km searched (Table 2).

There was a clear post-monsoon (March-May) seasonal peak in the relative density of attended gillnets as well as fishing boats of any kind and jellyfish-harpooning (encounter rates of 0.270 and 0.078 boats per km of search effort respectively). The highest encounter rates of fishing boats and fishing activity recorded during any period were attended nets in the June to August period at 0.188 nets per km of search effort, whilst the second highest is unattended nets during the same season at 0.095 nets per km of search effort. Three-year averages by season indicate a peak in use of unattended nets in the September-October period (mean encounter rate value of 0.128 observations per km).

Table 2: Types of fishing activities observed during boat surveys and encounter rates per season (3-year average of number of observations in the season divided by cumulative search effort in that period).

Season	**March-May**		**Jun-Aug**		**Sept-Oct**	
	Avg obs of season	Obs/km of effort	Avg obs of season	Obs/km of effort	Avg obs of season	Obs/km of effort
Attended gillnets *	95.737	0.270	67.152	0.188	63.423	0.179
Unattended gillnets *	18.753	0.053	33.890	0.095	45.165	0.128
Jellyfish harpooning	27.833	0.078	18.828	0.053	15.375	0.043
Handline (from boat)	5.922	0.017	3.138	0.009	2.883	0.008
Bag-nets	4.145	0.012	24.162	0.068	16.817	0.048
Handline (from shore)	2.566	0.007	0.941	0.003		
Stake nets	6.317	0.018	6.903	0.019	9.610	0.027
Trawler + Trawl net	1.184	0.003	2.510	0.007	0.480	0.001

*includes trammel nets, drift nets and set nets

Reasoning that unattended nets are more likely to lead to cetacean mortality than attended nets, grid cells representing combined three-year encounter rate values for unattended nets were superimposed with locations of cetacean observations during the surveys (Figure 2). Unattended nets were distributed mostly along the coast of Santubong Peninsula, in the interconnecting river systems and throughout the Bako-Buntal Bay. The highest relative densities of unattended gillnets were found in the Santubong River and Buntal River (0.19-0.9 gillnets per km). The figure shows a high degree of overlap between Irrawaddy dolphin observations and the distribution of unattended nets in the Santubong estuary, and the Salak and Santubong Rivers. Meanwhile the locations of finless porpoise, and to a lesser extent, humpback dolphin observations overlap with those of unattended nets mostly in the Bako-Buntal Bay. To test the perceived overlap of fishing activity and cetacean distribution, Spearman correlation rank tests were run on two datasets: the on-effort cetacean encounter rate per grid cell vs the encounter rate with unattended nets in the same grid cells, and Irrawaddy dolphin encounter rate per grid cell vs. the encounter rate with any type of net – attended or unattended. Dolphin encounter rates were moderately positively correlated with fishing activity encounter rates for both data sets (r_s = 0.498, n = 276, $p < 2.2x10^{-16}$ for on-effort cetacean encounter rate per grid cell vs the encounter rate with unattended nets; r_s = 0.497, n = 276, $p < 2.2x10^{-16}$ for Irrawaddy dolphin encounter rate per grid cell vs. the encounter rate with any type of net – attended or unattended).

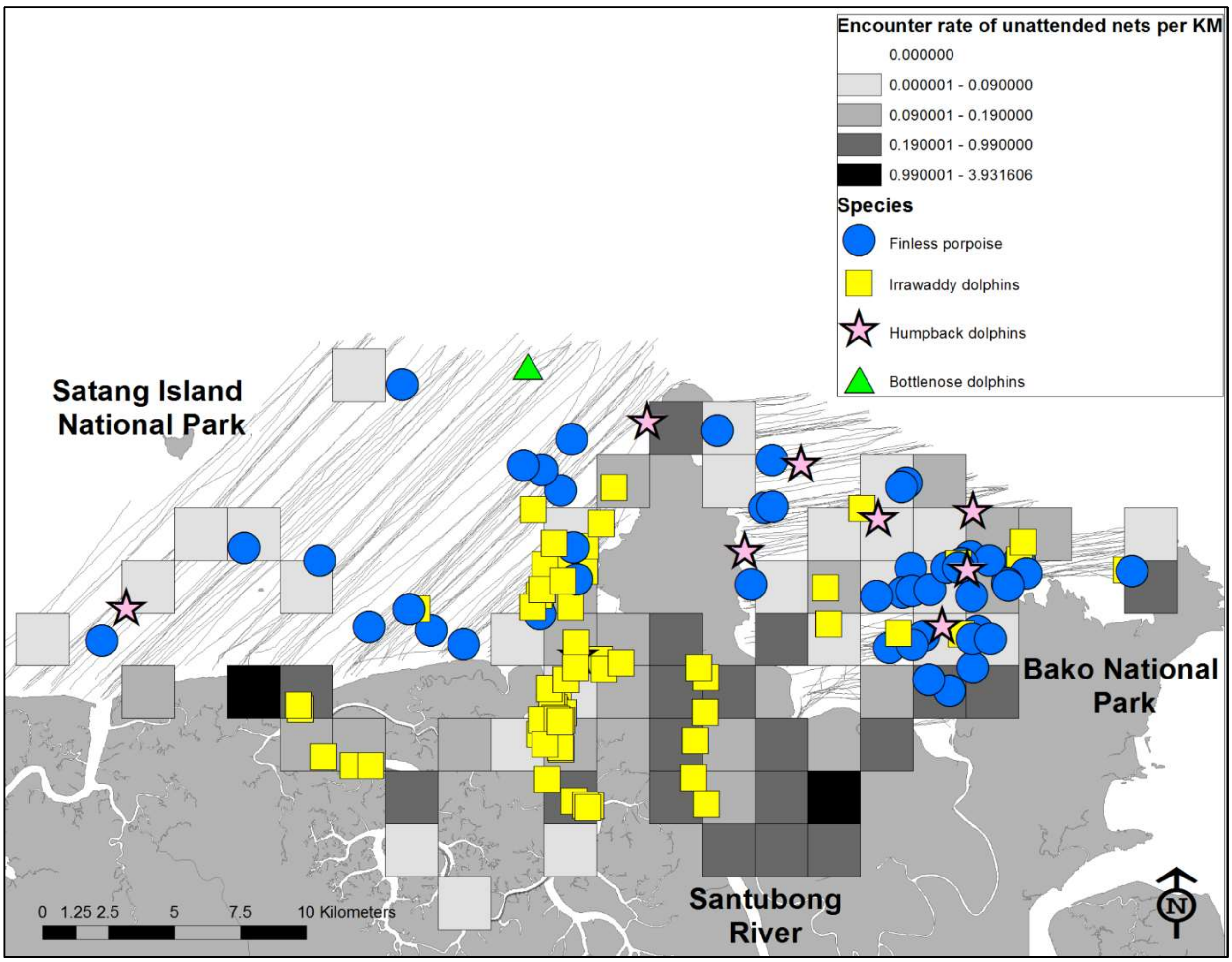

Figure 2: Relative densities of unattended gillnets expressed by the numbers sighted per km searched in 2 km by 2 km grid cells superimposed with sightings of on-effort cetacean species in Kuching Bay.

Fisheries questionnaire results

Due to unforeseen circumstances, only 17 of the over 300 interviews that were conducted have been entered, coded and shared with the first two authors for analysis. These 17 interviews were conducted in the village of Santubong, one of the largest fishing villages located in the heart of the study area.

Respondents ranged from 43 to 73 years old, with a mean age of 53. 76% were deemed to be "experienced" fishermen with a minimum of 15 years of experience, and all but one (who also drives a dolphin watch tour-boat) are full-time fishermen. All respondents were male, and indicated that their fathers and grandfathers were also fishermen. While all of the respondents appeared open and comfortable with the interviewer, and 94% also appeared interested and confident in their answers, a single respondent appeared uninterested and not confident in his answers.

Boats used by the fishermen ranged from 19 to 38 feet in length and 4 to 8 feet in width, and were powered by outboard engines ranging from 5 to two-60 horsepower (hp), with the exception of the dolphin-watch operator who used a 200hp engine. All respondents owned their own boat and considered themselves "captains" of their vessels or did not designate fixed crew positions. Table 3 below summarizes the types of fishing gear that fishermen reported owning and using, the seasons that they are in use, and the target catch of each type of gear. Drift nets (71% of respondents), trammel nets (49%), and "Set nets" (18%) (collectively referred to as attended or unattended "gillnets" when observed during boat surveys) account for the vast majority of reported gears in use. Only 18% of respondents reported using hook and line, 12% use longlines, and only 6% reported using trawlers, Note that many respondents own and use more than one type of gear and thus provided multiple responses.

88% of respondents say they target estuarine habitats for their fishing operations, and 35% say that they (also) target "deep waters", but only 12% cite a preference for rivers. Fishermen generally indicated preferred water depths of 7-20m, although one fisherman with a larger, more powerful boat, targets offshore waters of 30m depth or more.

Almost all respondents, with the exception of the dolphin tour boat driver fish on a daily basis during high season which is defined as days in a month when spring tides occur, usually between 15-20 days per month and during new moon and full moon phases. Biological and ecological activities of marine fishes and invertebrates are known to be synchronized with the lunar rhythm, with most species reaching their peak activity during high tide or full moon phases (McDowall, 1969). 41% of respondents continue to fish daily during low season, while the remaining respondents conduct less frequent trips during neap tides. Catches are relatively modest, with average catches reported between 25 and 100kg, and 58% of respondents reporting average catches between 20 and 50kg per fishing trip 35% of respondents perceived an increase in their catch quantities in past years, while 53% perceived a decrease and 12% did not perceive any change.

Every single respondent reported seeing dolphins regularly over the past five years and on a continuing daily or weekly basis, either while actively fishing (94%) or while traveling to fishing areas (100%). All fishermen were easily able to indicate what they perceived as the most frequent sites to observe dolphins. These included the Santubong estuary (65% or respondents), around Salak Island (53%) and in the Santubong River (35%).

Not a single respondent knew of a dolphin hunter in the village of Santubong and only one respondent knew of a case of a dolphin hunted in a village across the bay 10 years ago. 76% of respondents report that they occasionally or frequently observe dolphins feeding on their discarded fish. When shown illustrations of the dolphin species occurring in the region, fishermen clearly recognized the difference between species, and all respondents identified Irrawaddy dolphins as the species engaged in this behaviour (with one also citing finless porpoise), and cite anchovies as the species of fish they are most often discarding.

When asked to identify which types of gear are most likely to be damaged by cetaceans, 93% of respondents cited gillnets such as driftnets, trammel nets and set nets. Most respondents seem to agree that larger mesh sizes are more likely to be damaged by dolphins due to (temporary) entanglement while feeding near nets.

When asked about bycatch of cetaceans (including those found either dead or alive), 41% of respondents reported hearing of 1-2 cases per year in their village, 29% of 2-5 cases per year, and 23% of more than 5 cases per year in their village. Perhaps more useful for extrapolation of reliable by-catch estimates are the answers given to the question "how many dolphins have you caught?": 59% of respondents reported that they had not caught a dolphin in the past year, 23.5% responded that they had caught 1-2 in the past year, 11.8% replied that they caught 2-5 per year and no respondents reported catching more than 5 dolphins per year. All respondents listed Irrawaddy dolphins as the species involved in the bycatch, with one respondent indicating finless porpoise and other indicating humpback dolphins as well. All respondents without exception indicated that they would release a dolphin found alive in their net, while they differed in their response to finding a dead dolphin. Only 18% indicated that they would report it to researchers or the authorities, 12% said they would sell it (presumably for human consumption or bait), and 70% said that they would discard the carcass. There was no real consensus on what time of year dolphins were most likely to be by-caught with almost every month being cited by one respondent or another and 41% of respondents saying that no month was more likely than any other.

Table 3: Summary of fishing gears and target species for each gear

Type of gear	% of respondents using (%)	Length range (m)	Height range (m)	Mesh size range (inch)	Twine type	Month/season/tide of use	Target species
Driftnet*	71	20–820m length	3-10m	1.5–7	100% monofilament	16% say no particular time, 66% set at spring tide, 25% also set in March, April, May or June, only one fisher sets in Aug/Sep	Pomfret and threadfin most common. Also - bombay-duck, Indian mackerel, queenfish, pick handle barracuda, grouper, slender shad, anchovy, ray, lobster, catfish
Trammel net*	47	30–1300m length	minimum 2.5m	1.5–1.75	62% multifilament, 38% multi/mono	87% set this at neap tide only, one user says no particular time	Prawns only
Setnet (nylon)*	18	50–1000m length	at least 5m	3.5–7	33% monofilament, 67% multi/mono	March, April, August, September, spring tide, no particular time	Spanish mackerel, longtail tuna, dorab wolf-herring, ray, silver pomfret, Atlantic tripletail, queenfish, threadfin, slender shad, harpoon spadefish, twospot catfish, bronze pufferfish,
Hook and line	18	n/a	n/a	n/a	n/a	No particular time	John's snapper, bronze's pupperfish,
Long line	12	120m				March, April, June, August	Ray and Atlantic tripletail
Trawl	6	685m	2.5m	1.75	mono	March, April, September, October	Prawn, anchovies

*collectively classified as gillnets during boat-based surveys

All respondents have generally positive attitudes toward dolphins, perceiving them as harmless, and unanimously supporting the regulations that they were all aware of: that it is illegal to intentionally kill dolphins, but that it is not illegal to accidentally entangle dolphins in fishing gear. Interestingly, 56% of respondents believe that the number of dolphins present in their area has increased since they started fishing, while 44% believe it has decreased. Bizarrely fishermen who perceived an increase sometimes gave the same reasons for change as those who perceived a decrease. The most frequent of these perceived reasons was entanglement (31% of respondents), but others also named increasing or decreasing food sources, migration, changing water quality and coastal development, shark predation and feeding by tourists. All but one respondent (who didn't know or didn't have an opinion) thought that it is important to have dolphins around. When asked why their presence is important, 56% cited the potential income from dolphin tourism, 43% praised their role as indicators of fish availability, and 19% believe they are generally "good for the environment".

Discussion

Attended gillnets like driftnets and trammel nets accounted for the highest proportion of fishing in Kuching Bay. Boat-based survey encounter rates for this gear were highest in the post-monsoon seasons, from March to May. This coincides with the results from the interviews which indicated that driftnets account for over 70% of fishing gear used, and that these are usually set during spring tides in those months. Sarawak State statistics also indicate a peak in fishing activity during this season, as the three-year average for marine fish landings in Sarawak between March and August was 11,140 metric tons (between 2010 and 2012), while that for September to February, was 10,080 metric tons. (Annual Fisheries Statistics, 2010; 2011;2012).

In contrast, encounter rates with unattended gillnets peak in the pre-monsoon season (September to October). This is likely due to unpredictable weather which makes it less comfortable and more risky for fishermen to stand by and tend their gillnet. Fishermen indicated that unattended nets are usually left unchecked for up to 12 hours, some even as long as 18 hours. This practice is almost certain to pose a more serious threat to cetaceans, as the fishermen would not be on hand to notice and release an entangled dolphin before it died. The authors are aware of at least one such incident in September 2012 when a finless porpoise calf was caught and killed in a trammel net at Pulau Lakei near Bako National Park.

These preliminary results highlight the spatial overlap between fishing activities and cetacean occurrence, and indicate that the impact of fisheries to the cetacean population through accidental bycatch could be high. Eighteen stranding and entanglement cases were reported to the Sarawak Dolphin Project since its launch in 2008. While the team does its best to keep up with local news and social media platforms to find out about strandings, the questionnaire results show that only 18% of responding fishermen would report bycatch while 70% would discard the carcass. The vast majority of cases, particularly those in remote areas are almost certainly not reported or discovered. The analysis of these first 17 questionnaire results indicate that the remaining data from the almost 300 additional interviews conducted in eight additional villages could provide a means of extrapolating more realistic bycatch rates for Kuching Bay. The responses that indicate how frequently individual fishermen have discovered entangled dolphins in their own nets, should allow the authors to calculate a rough estimate of the minimum number of entanglements that occur per year in the Kuching area, as done by Amir et al. (2002). Unfortunately, a flaw in the design of the questionnaire and recording of responses (due to the unexpected frequency of successful live releases of dolphins), may make it difficult to determine how many of these entanglements actually resulted in cetacean mortality (see further discussion below).

These responses, once encoded and analyzed can also be used to design optimally effective mitigation strategies to reduce cetacean bycatch and the number of cetacean mortalities occurring after entanglement. Results to date indicate that the following four-pronged strategy is likely to be effective:

- The formation of a stranding response team and an entanglement hotline: The team should be based on collaboration between wildlife rangers, scientists, local public, police force, marine personnel and the fire department. Social media and conventional media (radio/TV/newspapers) should be used to advertise this hotline and response team, even in remote areas, to ensure higher chances of survival for any bycaught animals and the opportunity to collect more accurate statistics on stranding rates and circumstances.
- Workshops and awareness raising sessions in fishing villages: These should aim to share the study results regarding cetacean distribution and overlap with fishing gears and the increased risk associated with unattended gillnets. Previous studies in the same area have shown that even half-day workshops can be very effective in imparting key conservation messages that are retained by villagers for at least two years following the intervention (Minton, Zulkifli Poh et al. 2012). The fishermen will be encouraged to stay with gillnets as much as possible and not to leave them unattended overnight. The media's help will be sought to disseminate this information to a larger public through print, online or radio medium.
- Work should be conducted with local fishing communities to learn how proficient they are at monitoring for bycatch as it occurs in their attended nets, and whether or not they are using appropriate techniques to release live cetaceans. If low detection rates, or inappropriate handling techniques are observed, training workshops can be organized for heads of fishing associations and heads of villages on effective techniques to monitor for entanglement and release live dolphins: Experts (e.g from the International Whaling Commission or other bodies) can be brought in to give hands-on training on release techniques. Participating village leaders and heads of fishers' associations can then

cascade the training to more fishermen resulting in increased participation and knowledge of all the community involved.

- Follow-up questionnaires to obtain more precise mortality estimates: To address the flaw in this study which does not distinguish between entanglement/bycatch that results in mortality vs. entanglements that result in successful live release, a subset of respondents to this study in different participating villages should be contacted again, , in order to calculate a robust live to dead entanglement ratio that can be applied to the estimate obtained from the analysis of the 300+ questionnaires in this study. This will allow more accurate estimate of mortality rates from fisheries interactions in the study area.

Conclusion

Overall this study has proved highly useful and points toward some potentially effective ways to reduce cetacean mortality in Sarawak. However, caution should be exercised, as the questionnaire results analyzed thus far may not be representative of the much larger proportion of responses that have not yet been encoded and analyzed. While the fishing effort encounter-rate data observed during line-transect surveys is complete and reliable, it is possible that the fishing gears and methods and perceptions vary from one village to another and that the mitigation measures that seem most likely to be effective in Santubong will be less successful in other villages. However, if these initial results do prove to be representative of the wider fishing community in the Kuching Bay (more likely in our view), it is worth putting some of these mitigation measures into practice a soon as possible, and conducting follow-up line-transect studies and questionnaires to determine whether they have resulted in a reduction of entanglement rates and cetacean mortality in the region.

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