Assessment of target and non-target species catch rates in the Kikori fish maw fishery and local ecological knowledge of locally threatened dolphin species

Final report prepared for the Secretariat of the Pacific Regional Environment Programme (SPREP)

AP_2/39 Assessment of by-catch of threatened marine species by small scale fishers and mitigation options in the Kikori River Delta, Papua New Guinea

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Final report prepared for the Secretariat of the Pacific Regional Environment Programme (SPREP), AP_2/39 Assessment of by-catch of threatened marine species by small scale fishers and mitigation options in the Kikori River Delta, Papua New Guinea

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Summary

Small-scale fisheries sectors in Papua New Guinea (PNG) are generally data poor. In southern Papua New Guinea, a high value fishery targeting teleost swim bladder (traded under the product name 'fish maw') emerged in 2014/15 and has since rapidly developed (hereafter 'the fish maw fishery'). Fishers primarily target jewel fish *Nibea squamosa* and barramundi *Lates calcarifer*, which are sold to local buyers. Despite the absence of a fisheries management plan, there are currently multiple commercial buyers of seafood products in the Kikori region, with the main commodity being fish maw that is exported to high end markets in East Asia. A major constraint to the development of a fish maw fishery management plan is a lack of information on the sustainability of catch and the social and cultural dynamics of fishing communities engaging in the fish maw fishery. Additionally, several species of threatened elasmobranchs are incidentally caught in this fishery, and there is heightened concern about the status of dolphin populations that are also incidentally caught. There is a need to collect information on catch rates of target and non-target species in the fish maw fishery, so that changes in populations can be monitored into the future. For the two species of dolphin: Australian snubfin dolphin *Orcaella heinsohni* and Australian humpback dolphin *Sousa sahulensis*, there is an urgent need to understand population status and the uses and values that dolphin may have to local communities so that appropriate conservation initiatives can be developed.

The present project aimed to 1) document catch-per-unit-effort (CPUE) of target and non-target species within the fish maw fishery operating in the Kikori River Delta; 2) interview fishers in the Kikori region to understand their perceptions of dolphin population status, and document the use and value of dolphin to local communities; and 3) conduct informal meetings with various stakeholders within the fish maw fishery to open dialogue and begin building an understanding of each stakeholder's concerns and needs. From late October 2021 to March 2022, five fishing communities were engaged to enumerate fisheries catch and corresponding fishing effort in the Kikori River Delta. Alongside this, local ecological knowledge surveys were conducted with active fishers throughout the Kikori Delta. The interview questionnaire was structured into four parts to understand: 1) fishers' familiarity with local dolphin species; 2) local fishing characteristics including gear, methods and target species; 3) fishers' interactions with dolphins and perceptions of population changes over time; and 4) any uses and values dolphin have within local livelihoods or culture.

Across catch recorded in gillnets being monitored for CPUE, teleost fish comprised 51 per cent, and elasmobranchs 49 per cent of catch. Target fish maw species (*L. calcarifer* and *N. squamosa)* comprised 22 per cent of the catch. This provides the first data on relative interaction rates of the two groups, as well as for the key target species. One village community erroneously recorded only elasmobranch landings, however, this provided insight into the potentially high volume of landings for two species, winghead sharks *Eusphyra blochii* and river sharks *Glyphis* spp. that may be occurring throughout the spatial extent of the fish maw fishery. Collectively, this study provides useful data from which to track changes in catch abundance and relative catch rates into the future. Similar efforts to monitor landings and CPUE in this fishery in the future will be vital to detecting abundance declines early and ensuring the fishery's long-term sustainability.

The local ecological knowledge surveys with fishers provided valuable information to inform the population status, threats and cultural uses and values of dolphins in the Kikori River region. It was clear from these interviews that gillnets being used to target species for the fish maw fishery are the primary source of mortality and threat to local dolphin populations. While limited understanding of population trends could be sourced from interviewees, it appears that dolphins are currently vulnerable to interacting with gillnet fishing gear, and that interactions almost always result in mortality. The lack of any use or value of dolphin or dolphin products, coupled with accounts of culturally significant beliefs of dolphin, and general support for their conservation, indicate that community-led conservation initiatives or adoption of dolphin mitigation techniques or technologies may have promise, and are initiatives that local communities are likely to engage and participate in.

There is a need for continued collection of information to help inform the development of a fish maw fisheries management plan, and to develop data feedback mechanisms to monitor future changes in populations. Key outstanding knowledge gaps that need to be addressed include: 1) a lack of information on biological parameters to inform sustainable harvest of key target and non-target species; 2) estimates of total catch volume and value of the fishery, including individual products (fish maw, meat, shark fin); 3) information on social aspects and the livelihoods of fishers and communities engaged in the fish maw fishery; 4) an understanding of the local customary governance structure, including resource access rights of individuals of differing Tribal associations; and 5) Information on subsequent export market chains out of the Gulf Province. In the short term, conservation actions are urgently needed to address high mortality rates of incidentally caught dolphins in the fish maw fishery. It is likely that use of interaction mitigating technologies (e.g. acoustic pingers and light emitting diodes), coupled with modifications to fisher behaviours that encourage the active monitoring of soaking gillnets, will have the most positive outcomes.

Contents

List of Acronyms

CEPA	Conservation and Environmental Protection Authority
CPUE	catch-per-unit-effort
NFA	National Fisheries Authority
IUCN	International Union for Conservation of Nature
PBN	Piku Biodiversity Network
PNG	Papua New Guinea
SPREP	Secretariat of the Pacific Regional Environment Programme
WCPFC	Western Central Pacific Fisheries Commission

List of Figures and Tables

1. Introduction

Small-scale fisheries (inclusive of artisanal, cultural and subsistence fisheries) are a crucial aspect of culture, food security and economic opportunity across Pacific nations (Cohen and Foale 2011). Human populations in the Pacific are generally characterised as low density, and much of the day-to-day consumption and sale of fisheries products is centred around low-capacity fishing activities in riverine, coastal and reef environments. While industrialised fisheries do exist in the Pacific (i.e. Western and Central Pacific Fisheries Commission, WCPFC), these fisheries mainly target high value species in offshore pelagic environments. Owing to the lack of prolonged high-capacity fishing pressure in inshore environments, the Pacific generally supports healthier elasmobranch (sharks and rays) populations in inshore and coral reef environments compared to other global regions (Macneil et al. 2020, Grant et al. 2021a). However, there is generally limited information on the threat posed to elasmobranchs from small-scale fisheries. There is also considerable cetacean (whales, dolphins and porpoises) diversity within the Pacific, although population status of these species is not clear due to a lack of survey effort in many regions, and their less frequent capture and reporting of interactions in fisheries (Hendricks and Baird 2022). Collectively, this lack of information makes it difficult to accurately determine population status and major threats for many species of elasmobranch and cetacean in the Pacific. Presently, there is a need to identify the locations where populations are persisting and understand the drivers of threats in these areas so that effective management measures can be implemented to safeguard persisting populations.

Papua New Guinea (PNG) lies in the western Pacific and has received a considerable amount of elasmobranch fisheries and conservation research attention in recent years (White et al. 2018). From 2014, concern has been raised over the rapid development of small-scale fishers targeting teleost swim bladder (traded under the product name 'fish maw'), with the main target species being barramundi (*Lates calcarifer*) and jewel fish (locally known as 'stone fish' *Nibea squamosa*) (Busilacchi et al. 2014, Busilacchi et al. 2021, Grant et al. 2021a, Grant et al. 2021b). These species are targeted with gillnets in riverine influenced inshore environments, and within lower estuarine reaches of rivers. Dried fish maw has a very high value in east Asian markets (Sadovy de Mitcheson et al. 2019), and it appears that there are multiple trade market chains out of southern Papua New Guinea, each with varied value (prices for the main two species targeted reportedly range from USD 300 per kg to USD 3000 per kg within PNG, and end market prices are as high as USD 21,000 per kg) (Busilacchi et al. 2021, Grant et al. 2021a). The pursuit of fish maw has resulted in a shift from 'traditional' artisanal type fishing to modern fishing gears and economic exploitation of this resource. Fishery businesses in the Kikori region and Daru reportedly lease high quality gillnets, and even boats and outboard engines to local fishermen, on the condition that fishermen target and sell their fish maw back to them. The issue is that there is presently no management plan in place for the fish maw fishery within PNG; and, within the Gulf Province, there are no government fisheries management regulations pertaining to use of gillnets and their target species. While a barramundi fishery plan exists in Western Province, this plan has not been reviewed since its inception (NFA 2003), which was before fish maw became a commodity, and its present effectiveness is unclear, though likely outdated (Grant et al. 2021a). While concern exists around unsustainable fish maw fishing practices across southern PNG broadly, there is heightened concern in Gulf Province, with multiple operational fish processing plants and fish maw traders having opened or become engaged in the fish maw trade in the Kikori River since 2015.

A further issue to the sustainability of target species in the fish maw fishery is high catch rates of threatened (listed as Vulnerable, Endangered or Critically Endangered on the International Union for the Conservation of Nature's Red List of Threatened Species, hereafter 'IUCN Red List') species that are caught incidentally. Threatened by-catch (animals caught, other than those being specifically targeted) species includes primarily winghead sharks (*Eusphyra blochii*, Endangered) and river sharks (*Glyphis* sp., Vulnerable) (Grant et al. 2021a). Sawfish (Pristidae, either Critically Endangered or Endangered) (Grant et al. 2021a, Grant et al. 2021b) and two dolphin species (Australian snubfin dolphin *Orcaella heinsohni* and Australian humpback dolphin *Sousa sahulensis*, Vulnerable) are also captured. While elasmobranchs are consumed locally, catch is often surplus to consumption requirements and it is not unusual to see discarded carcasses of finned elasmobranch (sharks and shark-like-rays) around fishing villages, as the value of their meat is significantly lower than that of the target fish species (Grant et al. 2021a). Although 'shark fin' is retained and sold, its value is also significantly lower than of fish maw (Busilacchi et al. 2021, Grant et al. 2021b), and subsequently, shark fin is a supplementary commodity as it is easily harvested, dried and stored for sale (Vieira et al. 2017, Grant et al. 2021a). In an Indo-Pacific context, there is sustainability and conservation concern for the incidentally caught elasmobranch (Grant et al. 2021a) and dolphin (Parra et al. 2017a, Parra et al. 2017b) populations in PNG. Along with Australia, PNG is one of the last remaining refuges for these species, and concerted initiatives to manage their populations should be a priority to safeguard these species and lower extinction risks.

A major constraint to the development of a fish maw fishery management plan in southern PNG is a lack of specific information on effort, catch rates and social-ecological factors such as uses, values and cultural importance of fishing activities to local communities. While some information is available (e.g. Busilacchi et al. 2014, White et al 2015, Busilacchi et al. 2021, Grant et al. 2021a, Grant et al. 2021b), there is a lack of data on species-specific catch rates and volumes, which is a fundamental aspect of fisheries management. For southern PNG's two dolphin species, there is also an urgent requirement to understand population status and their uses and values to local communities owing to recent concerns of localised extinction risk. This project aimed to: 1) document catch-per-unit-effort of target and non-target species within the fish maw fishery operating in the Kikori River Delta; 2) interview fishers in the Kikori region to understand their perceptions of dolphin population status and document the use and value of dolphin to local communities; and 3) conduct informal meetings with various stakeholders within the fish maw fishery to open dialogue and begin building an understanding of each stakeholder's concerns and needs.

2. Methods

2.1 Fisheries monitoring

Five fishing communities within the Kikori River Delta were chosen to enumerate fishing landings (Figure 1). These communities were chosen on the basis of: 1) their active participation in the fish maw fishery; 2) established familiarity and working relationship with the Piku Biodiversity Network (PBN); and 3) collective representation of the upper, middle and lower delta environment.

Between 22 September and 6 October 2021, PBN Staff travelled to Kikori to engage with community leaders in each of the five communities. This ensured that each community was willing to participate, understood the expectations of their participation, and had an opportunity to ask questions about the project. It was also communicated to each community who was funding the study, and that the project was being led by PBN and James Cook University. In late October, the PBN team returned to Kikori to supply fishers with materials for data collection and provided training on how to collect data. Data collection commenced in earnest from November 2021.

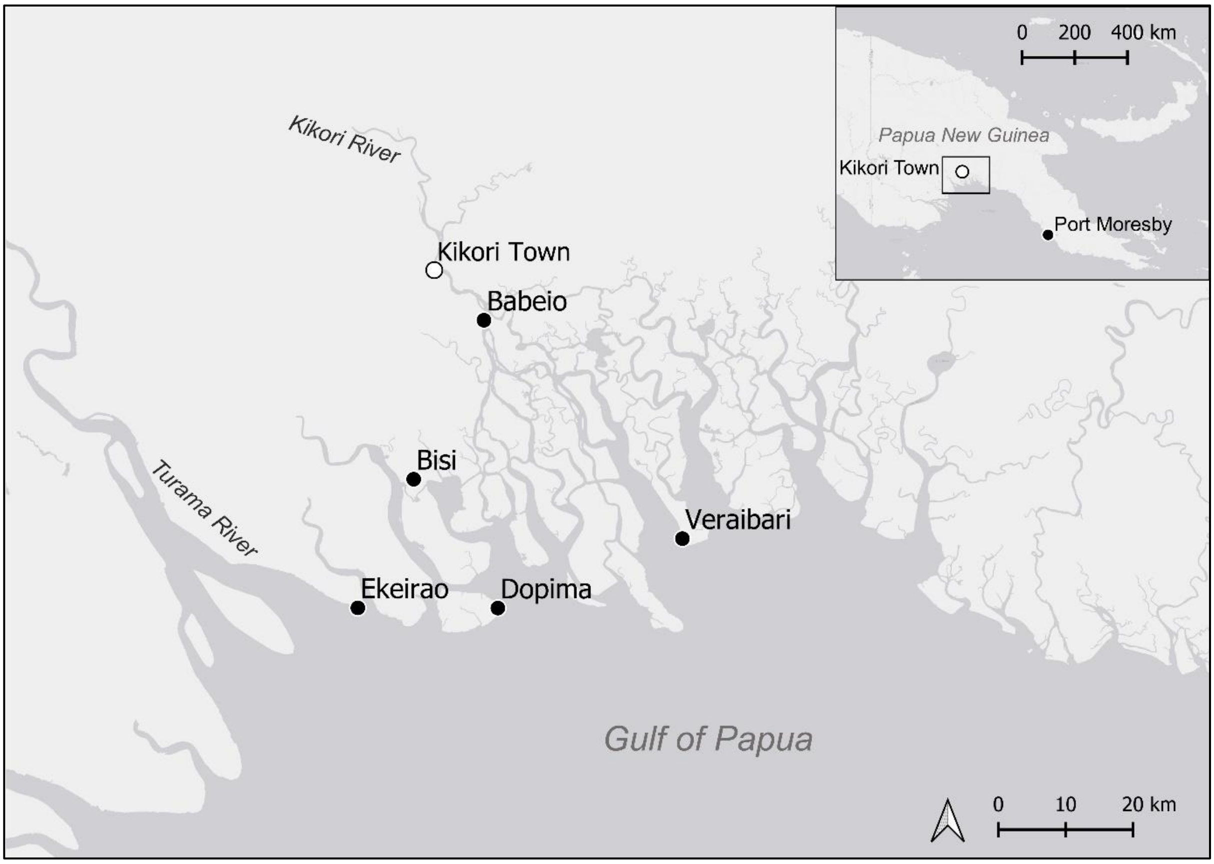

Figure 1. Location of fishing village communities engaged to enumerate fisheries landings.

2.1.1 Fisheries data collection

Fisheries data collection occurred from late October 2021 through to April 2022. This period aligns with the peak of the targeted fish maw fishing season, coinciding with the dry season and safer fishing conditions afforded by the absence of southern trade winds.

In late October, fishers from each of the five communities were briefed on the data collection protocol. Fishers were instructed to enumerate the total catch of all species from a single gillnet on each fishing trip during the study period (October 2021–March 2022). Fishing effort data collected (for the gillnet being monitored) included: the date, location, and soak time. Data collected for the characteristics of the gillnet included the mesh size (inches), length of net (horizontal dimension, metres), and drop of net (vertical dimension, metres). Because it is common for fishers to leave a gillnet set in the same spot for several days during optimal fishing conditions, fishers were instructed to begin a new data sheet each time the gillnet was checked for catch. In this sense, the time periods elapsed between fishers checking catch in a semi-permanently set gillnet were treated as individual fishing trips.

Data collected from specimens caught in the gillnet included species and length (cm). Fishers were provided with a species identification guide and a tape measure. Due to morphological similarities among species present in the study area, species were collectively grouped as follows:

> From the blacktip complex, the graceful shark *Carcharhinus amblyrhyncoides*, common blacktip shark *Carcharhinus limbatus*, and the Australian blacktip shark *Carcharhinus tilstoni*, were collectively grouped as 'blacktip sp.'.
>
> River sharks, northern river shark *Glyphis garricki* and speartooth shark *Glyphis glyphis*, were grouped as '*Glyphis* sp.'.
>
> Sharpnose sharks, milk shark *Rhizoprionodon acutus* and Australian sharpnose shark *Rhizoprionodon taylori* were grouped as '*Rhizoprionodon* sp.'.

Wedgefish, eyebrow wedgefish *Rhynchobatus palpebratus* and the bottlenose wedgefish *Rhynchobatus australiae* were grouped as '*Rhyncobatus* sp.'.

Features of sawfish (Pristidae) species differentiation were outlined in the species identification guide, as were differences between *Glyphis* sp. and the bull shark *Carcharhinus leucas*. A camera was also provided to each fisher group in each community. Fishers were instructed to photograph any shark, ray or cetacean specimens caught in the gillnet. Fishers were additionally instructed to photograph any sawfish or cetacean caught during any fishing trip (regardless of whether it was caught in the gillnet being monitored). The camera provided recorded time and date of all photographs, so that catch corresponding to a particular data sheet could be matched to assist with species identification.

2.1.2 Data analysis

All data sheets were entered into Microsoft Excel and consistency checked. Photographs taken by fishers were used to measure species identification accuracy. Fisheries data were analysed at levels of total catch, monthly catch, and village catch. Catch-per-unit-effort (CPUE) was calculated for data provided by Ekeirao and Veraibari villages only (see 2.1.2.1 Data accuracy considerations). CPUE was expressed as the number of catch per hour per 34 m x 7 m of gillnet. These gillnet dimensions were chosen as it was the most common size used by fishers at the time this study was conducted.

2.1.2.1 Data accuracy considerations

It was not possible to determine the proportion of non-successful and successful fishing trips due to a few misunderstandings from fishers during catch recording. Babeio Village reported catch levels that appear to have represented catch from multiple gillnets. On several occasions the number of animals caught exceeded one per metre of gillnet, indicating that catch from multiple nets had been recorded. There was also confusion among the Dopima Village fishers around the recording of net set times, which limited the ability to determine the number of fishing trips that had occurred. It appeared that the net set time was recorded as the time the net was deployed, however, nets remained in the water for several days. While nets were checked and catch recorded intermittently during this period, the original net set time was maintained on all data sheets for each time the net was checked as opposed to providing the actual times when the net was checked (where this would effectively constitute a new fishing trip). It was not possible to correct the data sheets as dates were not noted with net checking times, so it was unclear if some fishing trips concluded on the same day or the next (it is common for fishers to soak nets overnight, including those set in the morning or early afternoon. Therefore, for data collected from Babeio and Dopima Villages, it is unclear how many fishing trips were actually observed, how many nets were used (Babeio), and how long these fishing trips spanned (Dopima). For this reason, data from Babeio and Dopima were excluded from any calculations of CPUE and precluded an understanding of the relative proportion of successful and unsuccessful fishing trips. Due to a lack of engagement from fishers at Bisi Village, CPUE was also not calculated for their data.

A further issue that was encountered with Babeio arose from the instruction to photograph all shark and ray catch, but not teleost catch (this decision was made because teleost species present are easily discernable and well known to fishers, while several genus groups of sharks and rays are morphologically very similar, creating challenges to accurate species identification without proper training). The fishers' understanding of this instruction resulted in only sharks and rays being recorded on data sheets for all months after October, when the PBN team had left the community. While this limited comparisons of the relative rate of interactions with gillnets between teleost and shark and ray species at this site to only data from October, owing to the additional error of Babeio fishers recording catch from multiple nets, the data obtained was a thorough account of their shark and ray interactions over a four-month period.

A final issue that spanned all participating fishers was highly ambiguous measurements of length. While fishers were instructed to take measurements in centimetres, the tape measure provided also had inches marked on the other side. It was clear length recordings included a mix of centimetres and inches as some smaller specimens were well below known sizes at birth (likely due to measurement in inches, rather than cm). For this reason, length data was not included in subsequent analysis.

2.2 Local ecological knowledge surveys

2.2.1 Interview Process and questionnaire

Prior to the commencement of the project, human ethics approval for this research was gained from the Human Resources and Ethics Committee at James Cook University (Approval No. H8556).

Before the commencement of field activities, communities were briefed by PBN of our intention to conduct local ecological knowledge surveys with fishers about dolphins in the Kikori River Delta Region during a short field trip from 22 September to 6 October 2022. These initial conservations were conducted with Village Councillors or community leaders, which provided them an opportunity to ask any questions, and let their communities know in advance about the study. Once the study commenced, most interviewees were recruited upon visitation by the PBN to village communities or fishing camps. Village Councillors or community leaders were firstly engaged and briefed again on the project team's intention to conduct an interview with fishers about their knowledge of dolphins in the Kikori region. Prospective interviewees were identified as those who were fishing as their primary livelihood at the time. In some instances, prospective interviewees were recruited in Kikori Town, which is the region's main commerce centre that fishers regularly transit.

Once a prospective interviewee was identified, they were informed about the themes of the questions they were going to be asked, and that the study was being conducted by the PBN in collaboration with James Cook University. It was made clear to prospective interviewees that the answers provided would be used in a study that aimed to understand the population status of dolphins in the Kikori River Delta region, and that upon completion, the study would be made available to local government agencies and published on a public platform. Prospective interviewees were also clearly informed that they would not be personally identifiable as a result of providing information to this study and were provided an information sheet outlining this information about the study and their role. Prospective interviewees were invited to ask any questions they may have, and then their consent to be interviewed was recorded on the questionnaire. Interviewees were given the option to decide where the interview would be conducted.

The questionnaire used was structured into four sections, with both closed and open answer questions (Appendix 1). The first section aimed to ensure positive identification with dolphins and sought information on their distribution and occurrence. The second section aimed to record fishing characteristics and habits of the interviewee. The third section aimed to record the interviewees interactions with dolphins, and the fourth section explored their uses and values of dolphins. Owing to varied literacy skills within the study region, all questions were asked verbally, and responses were written on the questionnaire by the interviewer. All written answers were reconfirmed verbally to ensure their response was correctly recorded before proceeding to the next question.

The questionnaire was intended to be in-depth survey of fishers' knowledge, and we aimed to survey fishers from a range of communities across the Kikori River Delta rather than pursue large sample sizes within each community. The reason this decision was made is due to the small nature of fishing communities, which tend to fish in collective groups. We considered that one or two in-depth interviews in each community would be sufficient to provide a representation for information being sought from each community, considering logistical constraints to field time and travel within the region.

2.2.2 Data analysis

Responses received from interviewees were entered into Microsoft Excel for analysis. Descriptive statistics (means, ranges and proportions) were produced for quantitative data from closed answer questions. Qualitative data from open answer questions were coded into categorical responses. While some of the data were pooled into the Tribal associations of interviewees for analysis, no statistical comparisons were performed due to small sample sizes. All questions were not always answered by each interviewee or were not applicable based on the interviewee's answer to previous questions. For this reason, the number of interviewees (n) is presented for some aspects of the analysis where less responses than the total amount of interviews conducted were being considered.

2.3 Stakeholder engagement meetings

Over the course of the 2021/2022 fish maw fishing season (October–April), PBN conducted numerous informal meetings and discussion groups with various stakeholders in the Kikori Region. The intention of these discussions was not to formally document any information; rather, they were intended to start a dialogue about perceptions of the fishery and to provide the PBN with information to best direct future activities so that local needs and concerns are being represented. A meeting was also held with the National Fisheries Authority (NFA) in Port Moresby (June 2022), where some of the communities' concerns were highlighted. Collectively, these meetings and discussions allowed the PBN to gain greater understanding of the dynamics and perceptions of various stakeholder groups, and to further assert PBN as a neutral party within these conversations. No results or discussion of these conversations will be presented in this report, as these conversations were had in confidence.

3. Results

3.1 Fishery observations

Four of the five fishing communities engaged in the project collected data over a prolonged period during the study. Catch records were mainly received from targeted fish maw fishing during November 2021 to February 2022, with some additional records from late October 2021, and March and early April 2022. Several fishing locations were used by the fishing communities. Dopima and Veraibari used eight and seven locations, respectively; Ekeirao and Babeio used three; while the limited data from Bisi was all reported to be caught from the village itself (Figure 2). Coastal villages had multiple fishing locations close to the main village, while fishers from Babeio fished with community members from Kemei Village in the western fringe of the Kikori Delta and Meagio Village in lower Turama River.

3.1.1 Species composition and abundance

In total, 261 specimens were recorded across the five fishing communities in the gillnets being monitored (excluding Babeio Village data from November 2021 to February 2022, where only sharks and rays were recorded). Twenty-one species were recorded to species level, including ten species of elasmobranch and eleven species of teleost, while no cetaceans were caught. This diversity is likely to be an underestimate, as several specimens were only noted to broad groupings, which may include more than one species (i.e. Blacktip sp., Pristidae sp., *Rhynchobatus* sp., Siluriformes sp. and 'unidentified shark'). From photographs available (64 specimens), 57 (89%) were identified correctly by fishers. Excluding species that fishers were instructed to identify into broad groupings (e.g. Blacktip sp. and *Glyphis* sp.), 51 out of 58 (88%) were identified correctly to species level. From photographs, all species recorded as 'sharpnose shark' (*Rhizoprionodon* sp.) were able to be identified as *R. taylori*; one Blacktip sp. was identified as *Carcharhinus limbatus* or *tilstoni* (these species can only be separated accurately by vertebral counts or with genetic techniques); five river sharks (*Glyphis* sp.) were identified as *G. garricki* and two as *G. glyphis*; two wedgefish (*Rhynchobatus* sp.) were identified as *R. palpebratus*; and two sawfish (Pristidae sp.) were identified as *A. cuspidata*. Identification errors occurred for five carcharhinids, while one silver jew fish *Nibea Soldado* was incorrectly identified as *N. squamosa*, and one blue salmon *eleutheronema tetradactlyum* was incorrectly identified as a triple tail *Lobotes surinamensis*. While more photographs were available, the corresponding data sheet and specimen could not be confidently identified due to ambiguous times of photographs (e.g. several hours after catch) or incorrect date and time settings on cameras.

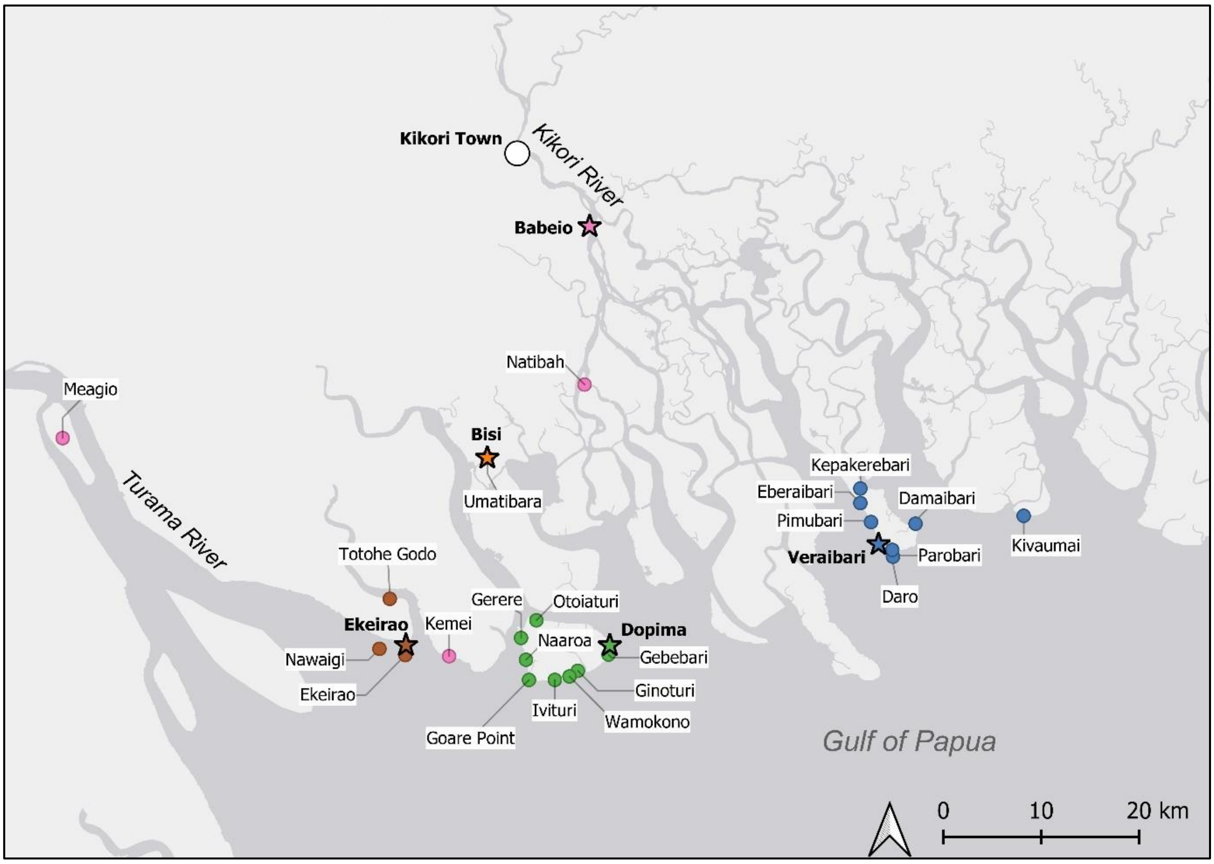

Figure 2. Location of fishing villages engaged in data collection (stars) and sites where fishing data was recorded (circles).

Overall, teleost species constituted 51.0% and elasmobranchs 49.0% of catch. The most abundant species was *E. blochii* (19.9%) followed by *N. squamosa* (16.5%) and *P. macrochir* (13.0%) (Figure 3). The primary target species of the fish maw fishery (*N. squamosa* and *L. calcarifer*) constituted 22.2% of the total catch. Aside from *E. blochii* and *Glyphis* sp., most species (or species groupings) of elasmobranchs were caught in low abundances. Excluding catch recorded as unidentified 'shark' (*n* = 30), 35.9% (83 out of 231) of the overall catch are from species listed as threatened (Vulnerable, Endangered, or Critically Endangered) on the IUCN Red List, and 84.7% (83 out of 98) of the total elasmobranch catch were from species listed as threatened. These proportions are likely to be slightly lower than reality, due to an inability to determine which species within the blacktip sp. complex were caught (*C. limbatus* is listed as Vulnerable, and known to occur in the study region e.g. Grant et al. 2021a).

The amount of recorded catch and species diversity varied between months (Figure 4). The most specimens were recorded in October (*n* = 82) and the least in March (*n* = 10). Generally, the number of catches recorded declined from October, when initial engagements with fishing communities were made. Species diversity was highest in October (13 species from 82 specimens) and January (14 species from 24 specimens). *Nibea squamosa* was the only species caught in every month from October to April. *Eusphyra blaochii* was the most abundant species in October–January, though was not recorded in catches in February–April. Despite being the second most abundant elasmobranch, *Glyphis* sp. were only recorded in November, January and February.

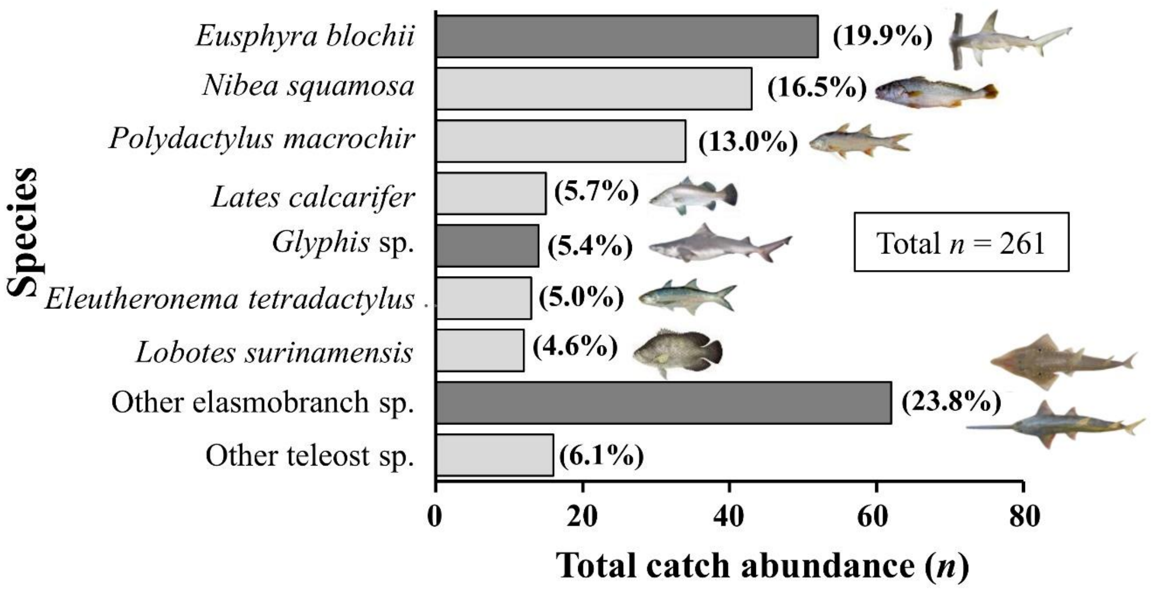

Figure 3. Total catch abundance and top contributing species of catch from gillnets being monitored for catch-per-unit-effort.

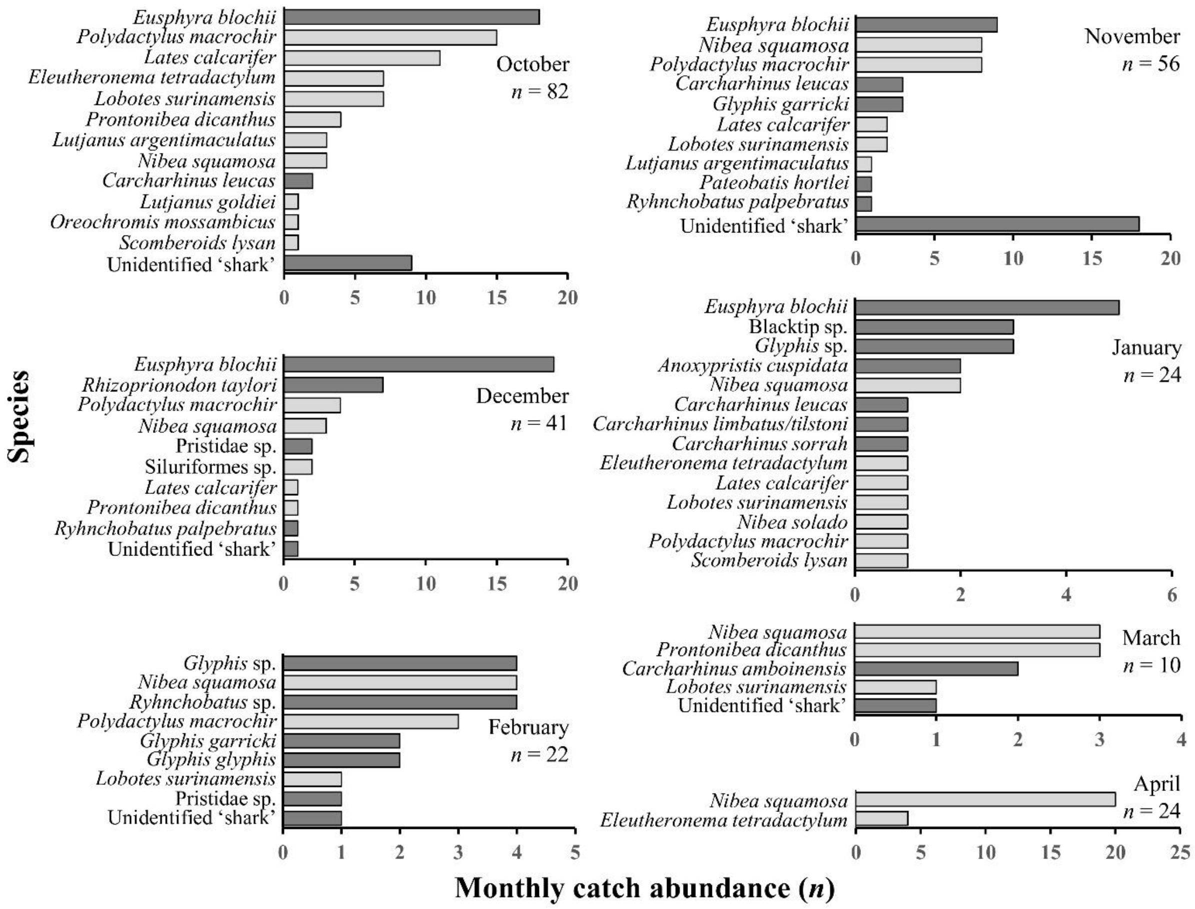

Figure 4. Catch abundances in each month from gillnets being monitored for catch-per-unit-effort.

Across the five fishing communities, Dopima recorded the most specimens (*n* = 108), while Bisi recorded the least (*n* = 7). Dopima's catch was dominated by teleosts (92 out of 108, 85.2%), with *N. squamosa* being the most abundant (22.2%) (Figure 5). Dopima also had the most diversity in catch, with 18 species (or species groupings) recorded. High proportions of elasmobranchs were recorded in Babeio (27 out of 34, 79.4%, only considering data from October, where both elasmobranch and teleost were recorded) and in Ekeirao (59 out of 75, 78.7%), which conducted their fishing activity in the western fringes of the Kikori Delta close to the mouth of the Turama River. High interactions with *E. blochii* were recorded from these fishing communities, with *E. blochii* constituting over half of Babeio's catch (52.9%). Veraibari recorded the most sawfish interactions (three), while a large proportion of catch recorded as unidentified 'shark' (48.6%) precluded further details of their elasmobranch catch composition.

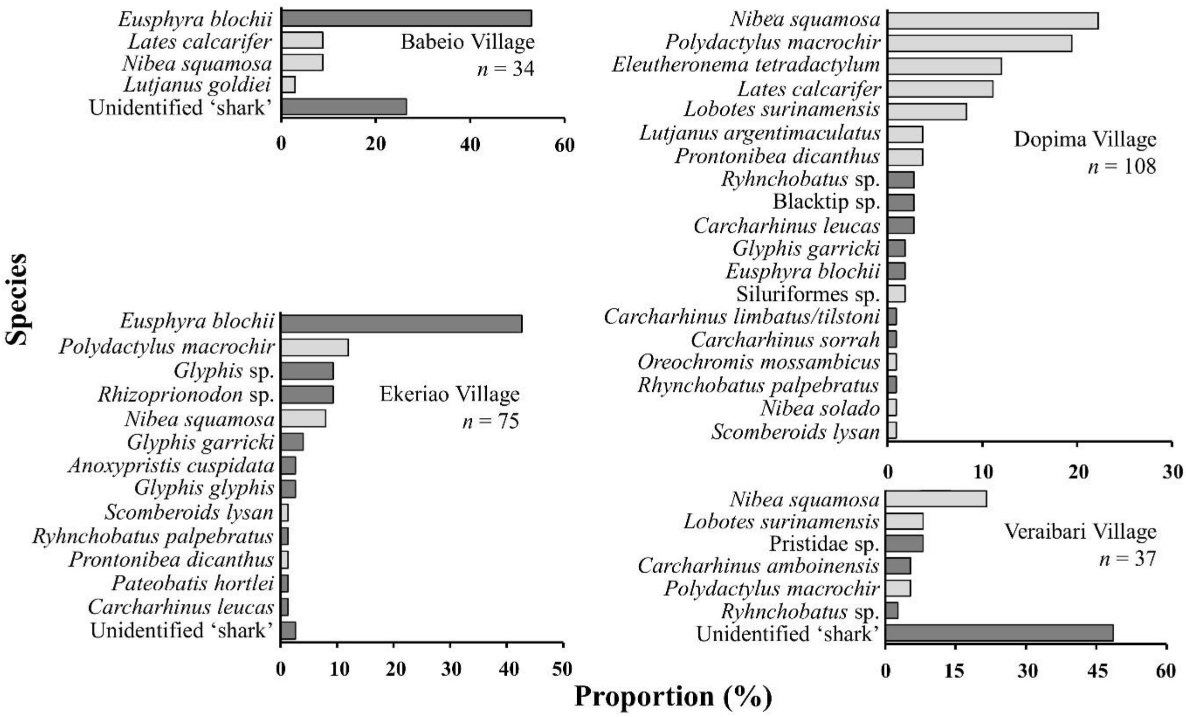

Figure 5. Catch abundances in each village community engaged to monitor catch-per-unit-effort. Data from Bisi Village is not shown as their engagement was very low.

3.1.2 Catch-per-unit-effort

Of the two fishing communities with data allowing calculation of CPUE, Ekeirao had 193.4 fishing hours, and Veraibari had 335.9 fishing hours. Ekeirao had higher CPUE's for elasmobranchs 0.300 $34m^{-1}$ $hour^{-1}$ and teleosts 0.088 $34m^{-1}$ $hour^{-1}$ compared to Veraibari, where elasmobranchs 0.142 $34m^{-1}$ $hour^{-1}$ CPUE was less than half, while teleost 0.077 $34m^{-1}$ $hour^{-1}$ was similar. Among Ekeirao catches, *E. blochii* 0.165 $34m^{-1}$ $hour^{-1}$ had the highest CPUE, while unidentified 'sharks' 0.106 $34m^{-1}$ $hour^{-1}$ had the highest CPUE in Veraibari. CPUE of *N. squamosa* was 0.031 and 0.047 $34m^{-1}$ $hour^{-1}$ in Ekeirao and Veraibari, respectively.

3.1.3 Babeio elasmobranch catch

Data recorded by Babeio Village from November 2021 to February 2022 included only elasmobranchs (*see 2.1.2.1 Data accuracy considerations*), and each day's catch had included catch from multiple gillnets (although it was not clear how many gillnets the catch corresponded to). During this period, a total of 1,112 elasmobranchs were recorded from six species (Figure 6). *Eusphyra blochii* constituted the largest proportion of catch (862 out of 1,112; 77.5%), followed by *Glyphis* sp. (191 of 1,112; 17.2%), and *C. leucas* (27 of 1,112; 2.4%). Across these three species collectively, 97.1% of the elasmobranch species recorded by Ekeirao are threatened on the IUCN Red List (*E. blochii*, Endangered; *Glyphis sp*. and *C. leucas*, Vulnerable). While the amount of catch recorded varied between months, it was unclear if this was relative to fishing effort. In February, all fishing effort was conducted from Meagio, within the Turama River (an upper estuary environment), where only *E. blochii* and *Glyphis* sp. were recorded (Figure 2). All fishing in November – January was conducted at Kemei (a lower estuary environment).

Table 1. Total catch and catch-per-unit-effort for species caught in gillnets being monitored by Ekeirao and Veraibari Villages.

	Ekeirao Village		**Veraibari Village**	
Species	***n***	**Catch 34 $m^{-1}hour^{-1}$**	***n***	**Catch 34 $m^{-1}hour^{-1}$**
Anoxypristis cuspidata	2	0.010		
Carcharhinus amboinensis			2	0.012
Carcharhinus leucas	1	0.005		
Eusphyra blochii	32	0.165		
Glyphis sp.	12	0.062		
Lobotes surinamensis			3	0.018
Nibea squamosa	6	0.031	8	0.047
Pateobatis hortlei	1	0.005		
Polydactylus macrochir	9	0.047	2	0.012
Pristidae sp.			3	0.018
Prontonibea diacanthus	1	0.005		
Rhizoprionodon taylori	7	0.036		
Ryhnchobatus palpebratus	1	0.005		
Ryhnchobatus sp.			1	0.006
Scomberoides lysan	1	0.005		
Unidentified 'shark'	2	0.010	18	0.106
Elasmobranch sp.	58	0.300	24	0.142
Teleost sp.	17	0.088	13	0.077

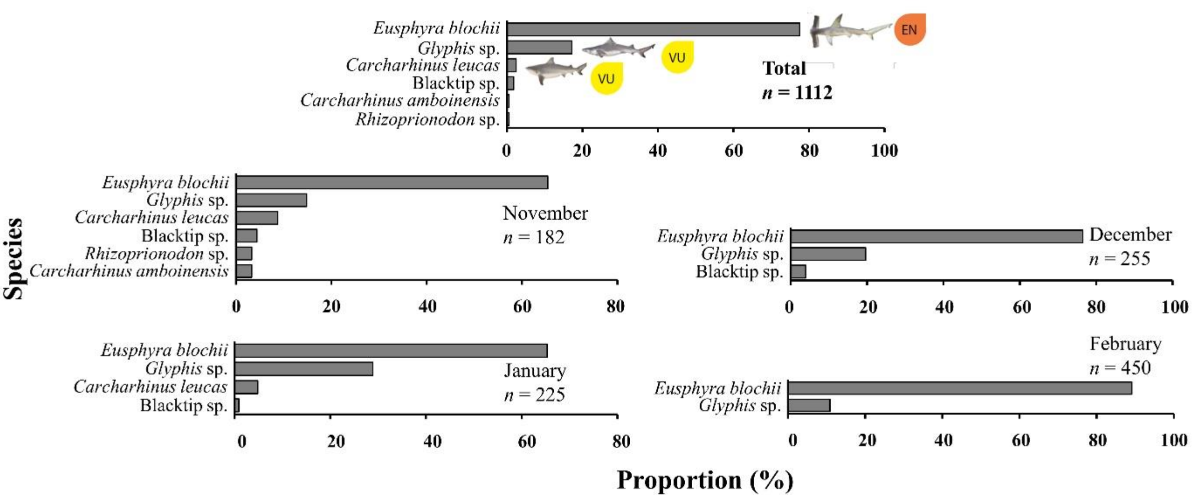

Figure 6. Total and monthly elasmobranch catch from gillnets set by community members of Babeio Village

3.1.4 Other observations

On 28 February 2022, a largetooth sawfish *Pristis pristis* specimen was photographed by Ekeirao fishers. The specimen photographed appears to be a recapture of a *P. pristis* that had its rostrum amputated on a previous capture (Figure 7, panels A–C). At the front of the head where the rostrum attaches to the cranium, the wound was rounded, indicating some healing had occurred. The wound appeared inflamed and red and was not a square cut. Ordinarily, the rostrum is cut perpendicularly (often with a machete), leaving a more bluntly horizontal wound at the time of initial removal (Figure 7, panel F). This specimen also appeared to be emaciated with the chondrocranium visible under the skin. Another larger *P. pristis* specimen was captured by the same fishers on 10 February. This specimen had been retained, with its rostrum and caudal fin amputated to untangle it from the gillnet. While no length measurement was recorded, the specimen appears to have been a mature male, with long claspers evident. We estimate it to be approximately 3 m – 4 m in length. Both of these *P. pristis* specimens were likely caught in the upper estuary of the Turama River, where Ekeirao fishers were recording fisheries data at the time. Neither specimen was recorded on data sheets, so it is unclear if they were caught in Ekeirao fishers' gillnets, or in gillnets from another group of nearby fishers (at the time these fishers were fishing with members of the Meagio Village community).

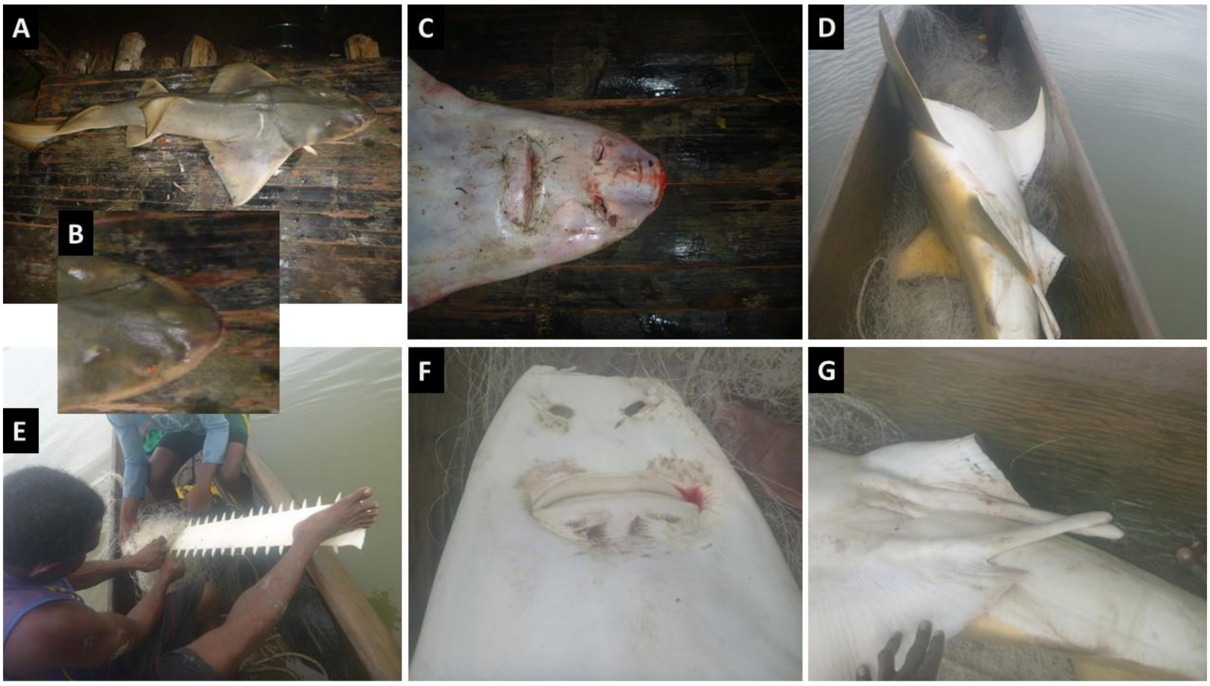

Figure 7. A juvenile largetooth sawfish Pristis pristis *caught with no rostrum (A–C), and a large male* P. pristis *caught and retained by fishers (D–G). Both specimens were caught in the Turama River.*

3.2 Local ecological knowledge surveys

In total, 22 interviews were conducted across 15 different village communities (Figure 8). Twelve interviewees were from village communities in the lower delta, eight were from communities in the middle and upper delta, and one was from an upstream community. One interviewee was from Masusu Village in the Turama River, though this fisher was living at Ekeirao Village at the time. These village communities were associated with seven different Tribes. Ages of interviewees ranged from 21 years to 40 years (mean 28 years), and all were male.

3.2.1 Identification of dolphins

All 22 interviewees could recognise a dolphin from a photograph, and 21 (95%) reported that they had seen a dolphin in the Kikori River or Delta region. When asked if more than one type of dolphin occurred in the region, 16 (73%) interviewees responded that there were; five (23%) interviewees said there was only one; and one interviewee did not know. All 16 interviewees reporting more than one type said there were two types that were differentiated by having either a 'long nose' or a 'round head'. Additionally, 10 of these interviewees reported that the long nose type has ‘two colours’ (a white, pink, or ‘light’ belly, and grey or ‘dark’ on top), while the round head type is grey, brown, or dark all over. Three of these interviewees also indicated the long nose type ‘jumps’ out of the water more often than the round head type, and so they are easier to see when the water is rough. One interviewee also indicated that the long nose dolphin is more common ‘in the sea’ (indicating the roundhead type is more commonly seen within the delta. Of the five interviewees that indicated only one type, three were familiar with the round head type, while the other two did not provide any distinguishable features.

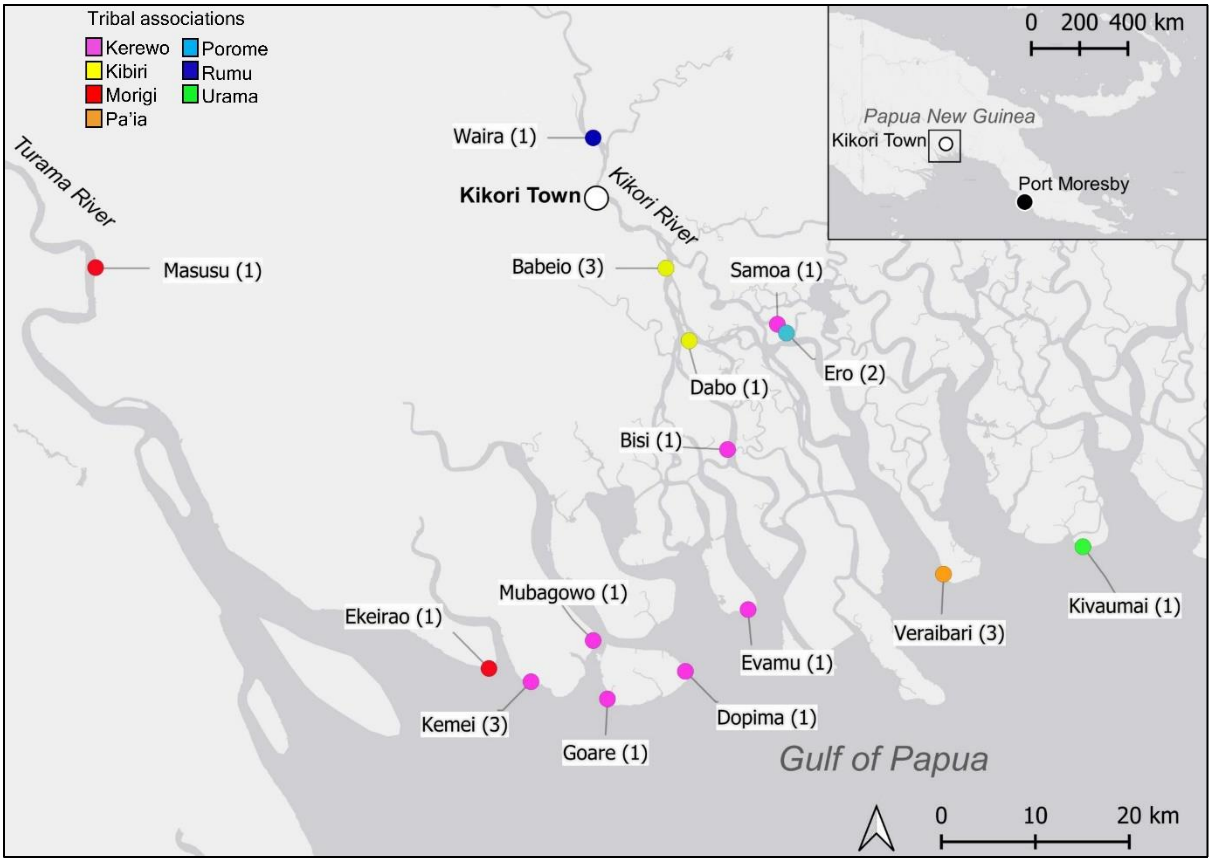

Figure 8. Location of village communities where local ecological knowledge interviews for dolphins were conducted. The number of interviews conducted in each interview is given in parentheses, and the Tribal association is indicated by colour.

From the descriptions of types of dolphins described by 19 of the interviewees, it was possible to allocate these types to the two local species and determine their local names and the environment types that each were known from (Table 2). *Orcaella heinsohni* (corresponding to the roundhead type), was called Pidu by five of the six Tribes. Some interviewees in two of these Tribes also referred to it as roundhead or short nose, while interviewees from Porome only referred to it as roundhead. *Orcaella heinsohni* was reported from delta/estuary and coastal environments by all interviewees, while two interviewees additionally reported this species from freshwater environments. *Sousa sahulensis* (corresponding to the longnose type) was called longnose by five of the six Tribes, while names such as Pidu, Pidu-dolphin, and Pidu-longnose were also used by interviewees. *Sousa sahulensis* was reported to occur in coastal environments by all interviewees, while interviewees in three Tribes also reported it from delta/estuary and offshore environments, and interviewees in two Tribes also reported it from freshwater environments. The interviewee from Waira Village, the most upstream community included, stated that he was not aware of any language names for dolphins (Rumu Tribe), nor did he know how many types occurred in the area. This interviewee commented that he knew them to occur in lower delta and coastal environments.

Table 2. Common names of each type of dolphin and the environments they are reported in for each Tribe. Information was provided by 19 interviewees that had described features of one or two of the species known to locally occur. No information is provided for the Rumu Tribe as the single interviewee had not seen dolphins in the Kikori Region before.

		Orcaella heinsohni		***Sousa sahulensis***	
Tribe	**No. of types**	**Common names**	**Environment types**	**Common names**	**Environment types**
Kerewo	2	Pidu, Roundhead	Delta/estuary, Coast, Offshore, Freshwater	Longnose, Pidu, Pidu-dolphin	Delta/estuary, Coast, Offshore, Freshwater
Kibiri	2	Pidu, Roundhead, Shortnose	Delta/estuary, Coast	Longnose	Coast
Morigi	2	Pidu	Delta/estuary, Coast	Pidu-Longnose	Coast, Offshore
Pa'ia	2	Pidu	Delta/estuary, Coast	Pidu, dolphin	Delta/estuary, Coast, Offshore
Porome	2	Roundhead	Delta/estuary, Coast, Freshwater	Longnose	Delta/estuary, Coast, Freshwater
Urama	2	Pidu	Delta/estuary, Coast, Offshore	Dolphin, longnose	Coast, Offshore

When asked if there are particular seasons when dolphins occur more often, 7 out of 21 (33%) interviewees said that dolphins occur year-round, 13 (62%) reported seasonality (9 interviewees reported November to February, while four were unsure), and one interview did not know. When asked about seasonality between the two types of dolphin, 9 out of 22 (41%) reported no difference, 6 (27%) did not know, and 6 (27%) said that there were more *S. sahulensis* sightings during 'Christmas and New Year time' (which corresponds to the middle of the dry season).

3.2.2 Fishing characteristics of interviewees

All interviewees indicated either that fishing is their primary livelihood, or that fishing makes up a substantial portion of their livelihood along with other activities. These alternate activities include targeting mud crab (1 out of 22), pigs (1) and shellfish (1) alongside fish; employment through either Exxon (1) or Oil Search (1); or sale of timber (1). The interviewee from Waira Village considered gardening to be his overall primary livelihood, but indicated that fishing had been his primary livelihood for the past three years.

On average, interviewees in each Tribe had at least ten years of fishing experience in the Kikori River region. Responses for how long fishing had been their primary livelihood varied, though most interviewees reported less than ten years (Table 3). Fishing gear types used by interviewees included gillnet, hook and line, dip/prawn net, spear, and poison. All interviewees primarily used gillnets, while eight also reported frequent use of hook and line, and one reported use of spear. Gillnet mesh sizes ≥4 inches were used by all interviewees, with additional use of smaller mesh sizes only being reported by five (23%) interviewees. Methods of fishing included shore based, paddle canoe and motorboats (which may be either fiberglass 'banana boats' or wooden canoes with outboard engines). Of these methods, interviewees said that motorboats are used most often (or preferred) because they can travel farther distances, it is easier to set nets and lift anchors, and motorboats have more space. Paddle canoes are generally used if the fishermen do not have fuel or if they are fishing close to the shore. Shore based fishing is generally conducted if the section of river is small and shallow, or if there is no access to a boat or canoe. The most common environments fished included delta/estuary and/or coastal environments, while two interviewees (10%) additionally reported freshwater and two (10%) additionally reported offshore.

Table 3. Characteristics of interviewees within each Tribes' experience with fishing, and the gear types, methods and the environments they fish.

Tribe (*n*)	Mean years fishing (range)	Mean years fishing as primary livelihood (range)	Gear types used	Median gillnet mesh size (inches) (range)	Fishing methods	Environment types fished
Kerewo (9)	14 (2-20)	9 (1-20)	Gillnet, hook and line, other	5 (1.5-7)	Shore based, paddle canoe, motorboat	Freshwater, delta/estuary, coast, offshore
Kibiri (4)	13 (9-20)	6.75 (5-9)	Gillnet, hook and line, other	5 (5-6)	Shore based, paddle canoe, motorboat	Delta/estuary, coast
Morigi (2)	17.5 (15-20)	13 (6-26)	Gillnet, hook and line, other	7 (7)	Paddle canoe, motorboat	Delta/estuary, coast
Paia (3)	16.5 (15-20)	5.33 (3-7)	Gillnet, hook and line, other	7 (6-7)	Shore based, paddle canoe, motorboat	Delta/estuary, coast
Porome (2)	13.5 (7-27)	5 (4-6)	Gillnet, hook and line, other	6 (5-6)	Shore based, paddle canoe, motorboat	Delta/estuary, coast
Rumu (1)	25	3	Gillnet, hook and line, other	1–4	Paddle canoe	Freshwater, delta/estuary
Urama (1)	10	6	Gillnet	5	Shore based, motorboat	Delta/estuary, coast

All interviewees reported that they target a 'fish maw species', with 19 out of 22 (90%) reporting stone fish (*Nibea squamosa*), 13 (62%) reporting barramundi (*Lates calcarifer*), and 11 (52%) mentioning both. Other species reported to be targeted alongside 'fish maw species' included salmon (either blue salmon *eleutheronema tetradactylum* or king threadfin *Polydactylus macrochir*, 7 out of 22, 33%), black jewfish (*Protonibea diacanthus*, 5, 24%), catfish (Siluriformes spp., 4, 19%), black bass (*Lutjanus goldei*, 2, 10%). Tilapia (*Oreochromis* sp.), triple tail (*Lobotes surinamensis*), and mullet (Mugilidae sps.) were all reported by one interviewee (5%).

Interviewees reported setting 1–6 gillnets when they fish, with a median of three (Figure 9). Most interviewees reported a range, as the number used on a given fishing trip depends on the number of other fishers with whom they are conducting fishing activities. Reports of 1 generally indicated the number used when fishing individually. Soak times for gillnets generally ranged from 4 to 6 hours with a median of 5 (Figure 9). Only three interviewees reported soak times longer than 6 hours (7–8, 10–11, and 24 hours). Reasons provided for the soak times were all related to needing to leave the gillnet undisturbed for enough time to catch fish and the need to wait for the tide to change (gillnets are most often set and checked on the slack tide). In a subsequent question, all fishers indicated that they leave gillnets soaking overnight (which would constitute a soak time of 10–12 hours at minimum). Of the 22 respondents, 7 (32%) said they always do, 9 (41%) said they often do, and 5 (23%) said they sometimes do, while one interviewee did not provide an answer. In most instances, the reason for leaving gillnets overnight was orientated around catching more fish due to less disturbance ‘in’ or ‘on’ the water. A few interviewees mentioned safety concerns around crocodile presence when fishing at night. When asked if they catch more of their target species at day or night, 14 (64%) of the interviewees said they catch more at night, 6 (27%) said there is no difference in number, and 2 interviewees did not provide a response.

When asked how many other fishers the fishing activities are usually conducted with, ranges were usually given (e.g. 4–6). Overall, group fishing activities were reported to be conducted by 3–10 fishers with a median of 6 (Figure 9). Reasons for these group sizes included helping each other set and check the nets, lift the anchors, and to generally balance tasks. Two interviewees mentioned that females also come on fishing trips that are based out of fishing camps to assist with cooking.

Most fishers (11 out of 22, 50%) purchased their gillnets from local stores in Kikori Town, 8 (36%) of the interviewees purchased their nets in Port Moresby, and 6 obtained their gillnets from local ‘buyers’, ‘the company’, ‘the industry’, or ‘seafood plant’ (these all refer to local licensed commercial buyers of fish products, including fish maw). Fishers who obtained gillnets from licensed buyers were asked about the arrangement. Three interviewees indicated that they were given gillnets on the condition that catch was sold back to the buyer, with one stating that “He was given (his) first net by Kikori Fish Plant. All fish he gets on that net goes to Kikori Fish Plant. The Fish Plant will sometimes give ice and esky too. The Fish Plant gives the net and they (the fishers) pay it off with the fish they catch”. The other three interviewees did not provide an answer.

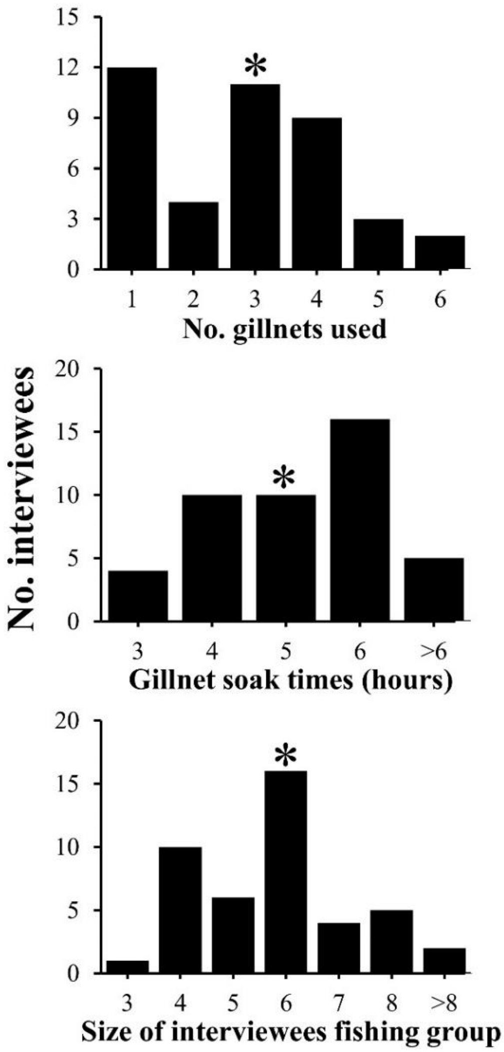

Figure 9. Number of gillnets reported to be used by interviewees during fishing activities (Top). Reported gillnet soak times (amount of time the gillnet is left in the water before checking for catch) (Middle). Number of other fishers that interviewees conduct group fishing activities with (Bottom). Asterisks indicate the median values of responses.

3.2.3. Dolphin interactions

Half (11 out of 22, 50%) of the interviewees stated that they had caught at least one dolphin before. These 11 interviewees all reported that these captures were incidental while targeting fish maw species (*N. squamosa*, *L. calcarifer*, and *P. diacanthus*), and all stated that incidental captures occurred in gillnets. When asked about the fate of dolphin found in gillnets, 8 of 11 (73%) said they were always dead, while 3 (27%) said they were usually dead. When incidental captures happen, 8 (73%) interviewees said only single individuals are caught, and 3 (27%) said that either individuals or multiple animals may be caught at any one time. Most (17 of 21, 81%) interviewees said that when they see dolphins, they are mostly freely swimming in the river, 2 (10%) said they mostly see them as a result of catching them, 3 (14%) interviewees said they are seen as a result of catching them as much as they are seen freely swimming, while one interviewee had not seen dolphins in the region (though knew of their existence). Dolphins were seen either individually or in pods (14 out of 21, 66%) by most interviewees, while 5 (24%) said they only see them in pods and 2 (10%) said they only see individuals.

Interviewees were asked how often they presently see free swimming dolphins (n = 21) and catch dolphins (n = 11). They were also asked about how often they historically recalled seeing free swimming dolphins (n = 18), and how often they were caught (n = 18) (Figure 10). Responses indicated that dolphins are sighted slightly more frequently in the present than interviewees recall historically, though differences were minor. Responses for capture indicate that dolphins were more commonly caught historically by at least a few interviewees, though most indicated they have never been regularly caught. In interpreting this data, it is important to consider that interviewees may have different perceptions of what 'historically' means (i.e. when they were children, or when they started fishing etc), as well as the mean age (28 years) and range (21 years–40 years) of interviewees. Interviewees were also asked when they last saw a dolphin freely swimming, and when they last caught a dolphin. Most (15 out of 21, 71%) interviewees had seen a dolphin at least once within the year, two (10%) said it had been greater than a year, two (10%) said it had been greater than five years, while one interviewee had never seen a free-swimming dolphin (only captured), and one interviewee did not provide an answer. Of the 11 interviewees that had caught a dolphin before, ten (91%) had caught one in either 2021 or 2022, while one interviewee (9%) said they last caught one in 2018.

Most (14 of 21, 66%) interviewees reported no changes or did not know if there had been any changes in dolphin numbers over time. Four (19%) reported that numbers had decreased, and three (14%) reported that numbers had increased. Of the seven interviewees that reported changes, reasons given for decreases all included remarks about there being too many nets in the water now, and that too many dolphins were being caught. Reasons given for increases included that there are "too many females giving birth", and "too many nets in the water". It was apparent that these reports of increases related to more dolphins being caught in nets presently, which was interpreted as there being more dolphins in the environment (opposed to a greater number of nets, and increased likelihood of capture). Six of the fourteen interviewees that reported no changes indicated that if there are, in fact, changes, it is likely due to the number of nets in the water presently (implying that if there are any changes they would be decreases).

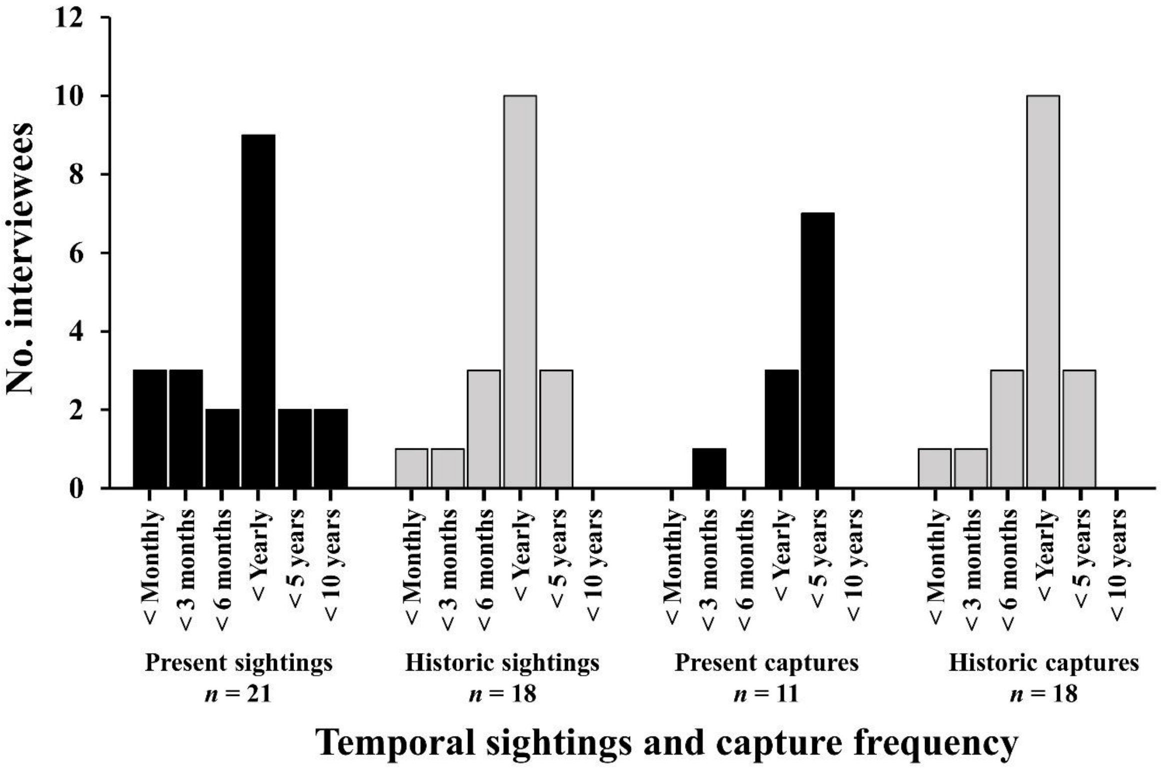

Figure 10. Frequency of present dolphin sightings and captures contrasted with frequencies of historic dolphin sightings and captures as reported by interviewees. Number of interviewees that provided a response are indicated by n.

3.2.4 Uses and values of dolphin

Interviewees were asked if they retain or would retain dolphins if caught. Thirteen out of twenty-two (59%) said they never retain (or would never), two (9%) interviewees reported that they sometimes retain, one (5%) reported that he always retains dolphins, while six (27%) did not provide an answer. Reasons given for retaining dolphins were to collect the skull for the Pidu Project, and to bury the dead body on the beach or ‘throw it in the bush’. One interviewee that had answered ‘never retain’ had not caught a dolphin before, although said he might keep the skull for the Pidu Project if he found a dead one in his net. Of those that indicated never retaining a dolphin, the reasons for this are because they do not eat dolphin and there is no use to keep them. All interviewees (22, 100%) reported that they do not eat dolphin meat, the sale of dolphin is not important to their economy or food security, and that dolphins are never targeted for cultural reasons.

Thirteen out of twenty-two (59%) interviewees said they have cultural beliefs around dolphins, while nine (41%) said they do not, or did not know. Cultural beliefs included stories of an ancestral origin of dolphins and its relationship to humans (6 out of 13), or an environmental or ecosystem belief connected to dolphins (7) (Table 4). Additionally, one interviewee that responded to not having a cultural belief around dolphins, shared a story that had been passed to him that indicated a connotation of dolphins being part of the environment: “Around Goare there are five humpback dolphins that travel there. When I was little living in Goare, they said those five dolphins travelled together. In good weather you will see them. They travel as five humpback dolphins. The villagers see them playing and spitting water. Today I don’t know if they (the people at Goare) see them or not”.

Table 4. Cultural beliefs relating to dolphins held by interviewees. Cultural beliefs are organised into Tribal associations. Number of interviewees providing each belief are indicated by n.

Tribe	*n*	Ancestral/origin belief
Kerewo	3	*The first dolphin (referred to as Pidu) was a man who turned into a dolphin at Kerewo (a village named Goaribari at the time). This man killed his mother to wear her skin to dance at the village party, acting as a female. People at the party found out that this man was not actually a woman. He was ashamed and jumped into the water and became Pidu. Pidu came from a man and a man was Pidu. We remember this story.*
Pa'ia	2	*Their ancestor, Pidu, was previously a man. Something happened, so the man jumped in the water and became the Pidu. Now they do not target this dolphin and instead, let it swim free.*
Urama	1	*We have our Pidu story. Pidu used to be a man and he turned into a roundhead dolphin, and we call him "Pidu".*
		Environmental/ecosystem belief
Kerewo	2	*Dolphins usually bring different types of fish to the shore.*
Kibiri	1	*They say dolphins bring fish, so they bring fishing season.*
Pa'ia	2	*The dolphins bring the fish. When you see dolphins/Pidu, you know fish are there (or are coming).*
Porome	1	*When you have dolphins, you know you have a lot of fish. If no dolphins, might be a sign of no fish anymore.*
	1	*Dolphins are part of our environment and we need to care for our environment*

Of the 22 interviewees, 10 (45%) reported that if dolphins disappeared from the Kikori region, this would not affect them, their beliefs, their family or culture. Another 10 (45%) said that this would affect them, and 2 (10%) did not provide a response. Eight interviewees gave a response of how this loss would affect them, with cultural values (4), loss of ecosystem value (three) and emotional impact (3) being the main themes. Some of these interviewee's responses spanned more than one theme. These responses should not be interpreted to suggest that only these themes were felt by the interviewees, although these were the explicitly stated themes given from their responses.

When interviewees were asked if they would support conservation measures or species protections for dolphin species in Papua New Guinea, 20 out of 21 (95%) said they would, and one interviewee did not provide a response. More than half (11 52%) of the interviewees expressed a need to conserve dolphins for future generations or felt a customary ownership responsibility to maintain their environment for the future. Five out of 21 (24%) stated it was important for the environment or ecosystem's health, 3 of 22 wanted to maintain the intrinsic value dolphins had to them, and 4 of 22 interviewees gave answers that did not connect to a theme e.g. "Because dolphin numbers are going down" and "Free them and let them move freely".

Interviewees were additionally asked if they had any ideas around how dolphins could be better protected from fishing activities. Of the 14 who provided a response, 12 interviewees explicitly identified that gillnets were the problem to be addressed. Three main themes were apparent and 6 out of 14 (43%) indicated a need to modify fishing gear to reduce dolphin interactions. These respondents either indicated a reduction in mesh sizes or a mechanism to keep dolphins away from the nets. One interviewee, however, expressed that while a reduction in mesh size could benefit dolphin, he acknowledged that it would impact the ability to catch large fish. Three out of 14 (21%) interviewees suggested spatial controls to the setting of gillnets. These interviewees cited concerns around fishers blocking off small creeks or channels within the delta with their nets, which prevented dolphins being able to travel through. Two out of 14 (14%) interviewees suggested reductions in fishing effort were needed ("there are too many nets in the water"), while 4 out of 14 (28%) interviewees gave responses that were broad in nature e.g. "We need to control unnecessary activities on the water" and "Must control the fishing nets and their fishermen".

4. Discussion

4.1 Fisheries monitoring

The present study has provided useful information on the interaction rates of target teleost species and by-catch elasmobranch species in the fish maw fishery operating in the Kikori Delta. Across catch recorded in gillnets being monitored for CPUE, teleost fish comprised 51 per cent, and elasmobranchs 49 per cent of catch. This provides the first data on relative interaction rates of the two groups, as well as for the key target species *L. calcarifer* and *N. squamosa*. The elasmobranch landings erroneously recorded by Babeio Village fishers also raise concern around the potential volume of landings from the fish maw fishery that may be occurring throughout southern PNG. Collectively, this study provides useful data from which to track changes in catch abundance and relative catch rates into the future, and similar efforts to monitor landings and CPUE in this fishery in the future will be vital to detecting abundance declines early and ensuring the fisheries long-term sustainability.

4.1.1 Distribution of fishing effort

The distribution of locations fished by the participating fishing communities offers insights into the inter-community relationships and access to the fish maw fishery. The coastal communities (Dopima, Ekeirao and Veraibari) conducted most of their fishing close to the main village. Meanwhile, Babeio fishers conducted some fishing in the upper delta at the site of their village, but also conducted a considerable amount of fishing downstream, with fishers from both Kemei and Meagio Villages. The upper Kikori Delta where Babeio Village is located, is primarily freshwater, occasionally receiving saltwater influence during large spring tides. It is likely that greater abundances of larger individuals of the target species occur closer to the coast, particularly in the late dry season for *L. calcarifer* (Blaber et al. 2008). Recent surveys in southern PNG indicated that targeted fish maw fishing primarily occurs in lower estuarine and coastal environments (Grant et al. 2021a, Grant et al. 2021b), and Eisemberg et al. (2015) found fishing camp density in the Kikori Delta to be higher close to the coast despite human population density mainly being centred toward the upper estuary. It appears that Babeio community fishers leverage family relationships in lower delta and coastal village communities to access these more lucrative fishing grounds. It is likely that this practice also occurs in other village communities situated outside of the spatial bounds of the fish maw fishery.

There is presently no information on how these inter-community relationships operate, and how catch and profit is partitioned among members of different community groups in these instances of resource sharing. The determination of spatial boundaries and resource allocation among customary landowner groups can be complex, and temporally dynamic within PNG (Cinner et al. 2012). The fish maw fishery has expanded in effort rapidly in recent years and there is a possibility of future conflicts and social tensions arising around access to this fishery between local communities. The chances of conflicts emerging among communities will likely increase in the event of future over-exploitation as seen in other situations of natural resource exploitation in the Pacific (e.g. Warner 2000, Pomeroy et al. 2007), and we consider future over-exploitation to be a high risk owing to the intense fishing pressure currently occurring. Therefore, the need to understand the social and cultural dynamics governing access to the fish maw fishery should be considered by fisheries managers and included in future research priorities.

4.1.2 Catch composition and diversity

A relatively wide range of species was recorded by fisheries monitors. Catch was dominated by diadromous species known to tolerate lower salinities. The exception to this was *E. blochii*, the most abundant species, which are generally considered to only be transient in estuarine environments (Grant et al. 2019). This may indicate that this species is more tolerant of lower salinity environments than presently understood, or that increased tolerance may be a characteristic of this southern PNG population. Furthermore, a range of size classes appear to have been caught, however this length data was prone to errors (*see 2.1.2.1 Data accuracy considerations*). The present high abundance of *E. blochii* can be attributed to their thin and elongated cephlofoil, which likely increases their catchability in gillnets across the spectrum of their length classes compared to other species. It is therefore unclear if their higher catch rate reflects high population abundance compared to other species or their increased catchability compared to other species. It is possible that the delta environments of the Gulf of Papua provide juvenile habitat for *E. blochii*, and future research to determine the recruitment from these areas to the breeding population (e.g. Yates et al. 2012) would be useful to inform the importance of local protections within the spatial boundaries of the fish maw fishery that appears to be mainly operating within delta environments and coastal fringes.

The main two target species (*L. calcarifer* and *N. squamosa*) constituted just over a fifth of total catch. It is hard to put their relative abundance into context, as there is limited information available on previous catches in the region. In the 1970s, Haines (1979) noted that *L. calcarifer*, *Nibea* sp., and *P. macrochir* were 'common' in the lower Kikori-Purari Delta, although it is not possible to reconstruct catch composition from data provided, and it is unclear what mesh size gillnets were used. Interestingly, while *C. leucas*, *Glyphis* sp. and *P. pristis* were recorded by Haines (1979), there is no mention of *E. blochii* in catches, despite some sampling locations being close to the coast where fishing activity was observed in the present study. During elasmobranch specific surveys conducted by Grant et al. (2021a) in the lower Kikori Delta, *Glyphis* sp. were the most abundant, and about triple the abundance of *E. blochii,* which was the next most common elasmobranch species. While the surveys of Grant et al. (2021a) were more limited in temporal scope, and only included catch from a single village (Dopima, formally Goare Village), it appears that abundances of species differ spatially throughout the Kikori Delta. This is further supported by the differing relative catch abundances across villages in the present study. Despite the fish maw fishery having been in operation in the Kikori region since at least 2015, the present data will provide a useful future reference for monitoring changes in catch diversity and relative abundances of both target and bycatch species. Furthermore, the CPUE data provided will be useful to future management as a measure of population density. Efforts should be made to continue monitoring catches of this fishery into the future, and this will need to include a wide spatial range of fishing communities, and ideally include fisheries independent surveys also.

4.1.3 Conservation concern

The primary concern arising from the present observations is the high abundance of threatened elasmobranch species being incidentally caught in this fishery. These high abundances of threatened species indicate that: 1) southern PNG is supporting populations of these species that have declined or become locally extinct in other global areas; and 2) that the risk of population declines is likely to be high, as evidenced by population declines of these species in other global regions. For example, *E. blochii* was formally common around river outflows from the Arabian Seas through to Australia but has declined significantly in its western range due to fisheries pressure (Smart and Simpfendorfer 2016). In the Arabian Seas region, this species is now considered Critically Endangered (Jabado et al. 2018). The presence of high densities of threatened elasmobranchs in southern PNG indicates that historic fishing pressure has been less than in other areas of the Indo-Pacific, and that southern PNG has provided a 'stronghold' for these species. However, there are now concerns that the recent increase in fisheries effort associated with the fish maw fishery carries potential to quickly deplete these populations. There is already evidence of significant declines in abundances of sawfish in southern PNG (Grant et al. 2021b), and without management initiatives to address elasmobranch by-catch is it likely that other species will follow a similar population trajectory in the near future.

An issue for informing tolerance levels to fisheries mortality for the main by-catch species, *E. blochii* and *Glyphis* sp., is an absence of age and growth information, which precludes our ability to estimate the productivity of these species. This limits our ability to inform the urgency of management measures required to safeguard their populations. Elasmobranchs generally have 'slow' life histories, exhibiting slow growth rates, late maturation, and low fecundity (Cortés 2000). This makes elasmobranchs susceptible to fisheries exploitation and protracts population recovery times (Simpfendorfer and Dulvy 2017). It is unlikely that the present fisheries pressure from the fish maw fishery to which *E. blochii* and *Glyphis* sp. are exposed would be within sustainable bounds. Furthermore, *E. blochii* is also taken as by-catch in the Gulf of Papua Prawn Trawl Fishery (White et al. 2019), and thereby has compounded fisheries exposure from two different sectors in southern PNG. With continued increases in fisheries effort in southern PNG, the lack of management or species protections for threatened elasmobranch species in PNG is an issue that requires attention from local authorities.

A further concern in the present catch abundances was the lack of sawfish. Local ecological knowledge surveys in the Kikori region had indicated significant declines of sawfish (Grant et al. 2021b), and the present data helps to substantiate this. In previous surveys in the Kikori and Purari region during the 1970s for example, sawfish were noted to be as commonly caught as *L. calcarifer* and *P. macrochir* (Haines 1979). A key driver of sawfish vulnerability to fisheries is their long-toothed rostrum that is easily entangled in fishing nets. This is likely the largest factor that has driven their widespread declines globally (Yan et al. 2021). For fishers dealing with entangled sawfish, the rostrum poses a risk to the fisher's safety during dis-entanglement, and also poses a risk to fishing nets, which may become ripped and damaged. For these reasons, amputation of the rostrum is a common method used by fishers for dealing with sawfish in gillnets. The anecdotal observation of a recapture of a juvenile amputee sawfish that appears to be heavily emaciated, adds to the growing body of evidence that amputation of the rostra leads to eventual death (Morgan et al. 2016). The small size of this individual would ordinarily be a size class expected in upstream freshwater environments, and it is possible that it had been washed down from upstream of the Turama River, due to a waning ability to swim against the current. Fishers in the Turama River are noted to amputate rostra of entangled sawfish, although owing to the prevalence of the Seventh Day Adventist denomination of Christianity in Turama River communities (who can only consume 'scaly' fish as part of their religious obligations), sawfish are seldom retained for consumption, unlike other regions of PNG (Grant et al. 2021b). This observation underlines that there is a need to work with local fishers to develop safe release methods for sawfish, and to encourage safe release among fishers operating both within the fish maw fishery as well as in upstream nursery environments throughout southern PNG. A project to develop a safe release guide for sawfishes is currently being conducted by the members of the present authorship team (https://saveourseas.com/project/re-writing-the-sawfish-story-inspiring-community-driven-conservation-of-sawfishes-in-papua-new-guinea/).

4.2 Local ecological knowledge surveys

The local ecological knowledge surveys with fishers in the present study has provided valuable information to inform the population status, threats and cultural uses and values of dolphins in the Kikori River region. It is clear from these interviews that gillnets being used to target species for the fish maw fishery are the primary source of mortality and threat to local dolphin populations. While limited understanding of population trends could be sourced from interviewees, it appears that dolphins are currently vulnerable to interacting with gillnet fishing gear, and that interactions almost always result in mortality. The lack of any use or value of dolphin or dolphin products, coupled with accounts of culturally significant beliefs of dolphins and general support for their conservation, indicate that community-lead conservation initiatives or adoption of dolphin mitigation techniques or technologies may have promise for future conservation management initiatives (SPREP is currently working with the Piku Biodiversity Network and Dr I. Beasley on by-catch mitigation measures).

4.2.1 Fishery characteristics, threat and population status

Gillnets are the most commonly used fishing gear in the Kikori region, and currently pose the greatest risk to dolphin populations through drowning following entanglement. Globally, net based fisheries present the greatest threat to dolphin species, having led to population declines in many other regions (Reeves et al. 2013). Dolphins may be attracted to fishing gear for feeding purposes (including depredation) or may passively interact with gear that has been set within their habitat area (Hamilton and Baker 2019). It is not clear if fisheries interactions of *O. heinsohni* and *S. sahulensis* in the present study location are the result of adjacent feeding or depredating from gillnets, or whether they are passively encountering gear during routine ecological movements. From the descriptions of gillnet fishing activity provided by interviewees, it appears that daytime fishing usually involves setting gillnets for 3–6 hours, during which time nets and surrounding water is left undisturbed to enhance chances of catching fish. All interviewees reported overnight soaking of gillnets, where nets do not appear to be checked until the following morning. Collectively, the gillnet soaking times used by interviewees far exceed the breath hold capacities of inshore dolphins (e.g. Noren et al. 2002). Considering the soak times presently used by interviewees, it is therefore unsurprising that dolphins are commonly found dead when entangled in fishing gear.

Cetacean species in general are vulnerable to additional mortality, as they have life history traits that include long reproductive life spans, low adult natural mortality, and low productivity (Hamilton and Baker 2019). Therefore, it is likely that the present fisheries related mortality of dolphins from the fish maw fishery is having impacts at the population level. Furthermore, both *O. heinsohni* and *S. sahulensis* are listed as Vulnerable on the IUCN Red List on the basis of small mature population sizes (suspected to be less than 10,000 mature individuals across these species' whole ranges) (Parra et al. 2017a, Parra et al. 2017b). It is thought that both species occur in small and fragmented sub-populations throughout their respective ranges; *O. heinsohni* typically occurs in sub-populations < 150 individuals (Parra et al. 2017a), while *S. sahulensis* averages 54–89 individuals per sub-population (Parra and Cagnazzi 2016). Gene flow between sub-populations also appears to be limited (e.g. Parra et al. 2006, Brown et al. 2014). This indicates that local population sizes in southern PNG are likely to be inherently small and possibly isolated, adding further concern to the impact these fisheries mortalities are having. Presently, current estimates of mortality are inferred by documenting skulls of by-caught dolphin that have been retained by fishers (Beasley unpublished data). Only 4 out of 22 (18%) interviewees indicated that they retain (or might retain) dolphin skulls for the Pidu Project. This indicates that present mortality levels estimated through skull documentation may be underestimating catch levels by as much as 82% if these skull retention rates are indicative for retention rates for all local fishers across the Kikori region.

While it is strongly suspected that populations of *O. heinsohni* and *S. sahulensis* are declining in southern PNG, it is difficult to determine the timing and magnitude of declines from information provided by interviewees. For example, most interviewees did not report that they had observed changes in the numbers of dolphins during their lifetimes, and a secondary question exploring population trends only indicated small differences between present and historic sightings and capture frequencies. There are two plausible explanations for the lack of perceived population declines: 1) populations of dolphin in the Kikori region may never have been substantially high historically; or 2) populations may have already depleted before the present interviewees began fishing, and thus a 'shifting baseline' (Pauly 1995) has occurred in the local fishers' perspective of dolphin abundances. A third, and less likely scenario is that dolphin populations have not depleted significantly during the lifetimes of the interviewees. Unfortunately, there is a complete lack of historic information available on dolphin populations in southern PNG, so it is not possible to determine population levels prior to development of the present fish maw fishery. To overcome this knowledge gap, future local ecological knowledge surveys could specifically target older community members in the Kikori region to provide insights on dolphin populations at more historic temporal scales than the ages of current interviewees allow. Furthermore, gaining an understanding of the population structure of *O. heinsohni* and *S. sousa* would help inform the severity of the threat that the fish maw fishery is having on these populations. Both species additionally occur along the tropical coastline of Australia, and it is possible that localised mortality in southern PNG is being masked by population movements from other parts of these species' ranges, which could in turn be implicating Australia's conservation priorities for these species. However, studies within the Australian ranges of these species indicate that they occur in small localised sub-populations with limited gene flow (e.g. Brown et al. 2014), making population replenishment in PNG by migration from Australian populations unlikely.

Consideration of historic fisheries in southern PNG may provide some insights into when the threat of gillnet fisheries began and inform the likely timing of dolphin population depletions. Gillnets were first introduced into the Gulf Province in the early 1970s as part of a government lead initiative to increase access to protein and improve nutrition standards of local communities (Haines and Stevens 1983). Initially, adoption of gillnets was slow, and by the time studies on local fisheries concerning development of the Wabo-Purari Hydro dam were completed (~1980s), there was no indication that gillnets were being widely used, evidenced by a few commercial fish buyers that had struggled to engage local communities to supply fish to them (Haines 1977, Haines and Stevens 1983). Over the next few decades there is very limited information available, though intermittent gillnet and driftnet fisheries were trialled in the Gulf of Papua during the late 1980s and early 1990s (White et al. 2017). In 2012, Eisemberg and Berra (2016) found that local fish species (including those presently targeted for fish maw) were being caught by gillnets in the Kikori River and Delta region and were being sold at the local Kikori Town market. At the time, gillnets were the primary gear being used. From 2015, various commercial seafood buyers and fish maw traders began operations. This coincided with the development of the fish maw fishery in the Gulf of Papua, and use of gillnets and motorised boats has increased rapidly in this time. These fisheries businesses are known to supply gillnets and outboard engines to local fishers (Grant et al. 2021a, Grant et al. 2021b), which was also reported in the present study. Therefore, it is likely that local dolphin populations have been subject to fisheries pressure for several decades, although the intensity of this pressure has undoubtably increased in the most recent decade.

The number of years that interviewees had considered fishing to be their primary livelihood, generally corresponds to the time that the fish maw fishery emerged. It is likely that the fish maw fishery offered more stability to income that could be made from fisheries as a livelihood, and furthermore, the price of fish maw likely created incentive for local people to pursue fishing in delta and coastal environments. Collectively, while it is likely that fishers have been using gillnets in the Kikori region since the 1970s, it is clear that since 2015, fishing effort has substantially increased (Grant et al. 2021a), and this has possibly coincided with use of larger mesh sizes, and generally greater fisheries capacity as fisheries effort is now specifically targeting certain species i.e. fish maw species (Grant et al. 2021a, Grant et al. 2021b), rather than being more of a broader unselective fishery as it was historically (Haines and Stevens 1983). This greater participation in fisheries as a livelihood by local people in the Kikori region is a possible explanation for some interviewees indicating that dolphins are more commonly seen presently, compared to historically, as it is likely that these interviewees are now spending more time on the water for fishing activities, and consequently are encountering dolphins more often. Furthermore, captures of dolphins appear to have generally increased over the fishers' lifetimes, and higher catch rates are possibly being interpreted as there being more dolphins presently. However, these higher present catch rates are most likely due to much higher fisheries effort compared to historic fishing effort levels.

4.2.2 Uses and value of Dolphin

Among interviewees, there appears to be no use or value of dolphin as a traditional food source or economic resource. However, dolphins do appear to have cultural value to local communities, through connections with ancestral stories, or as a bioindicator of fish productivity. This contrasts with other marine fauna in the region. Pig-nosed turtle *Carettochelys insculpta* for example, also hold cultural value to local people through their seasonal breeding migrations and predictable nesting sites (Eisemberg et al. 2015). Local communities value *C. insculpta* as a traditional food source, with upstream migrations and harvesting of eggs being an environmental indicator for the onset of the dry season (Eisemberg et al. 2011). Similarly, sawfishes (Pristidae spp.) have traditional consumptive values and occur in various cultural stories among people of the Kikori region, which may relate ritualistic capture for initiations into 'man-hood', or ritualistic practices regarding human pregnancy and infant health (Grant et al. 2021b). The difference between the cultural value of dolphins compared to these other species is that, across multiple Tribes, dolphins are perceived as 'human-like' and, in the case of *O. heinsohni*, are thought to have a direct human origin or ancestor. It is likely that these perceptions of 'human qualities' are the reason that they are disregarded for consumption. This distinction is important with respect to garnering community engagement and participation in dolphin conservation initiatives, as it appears there are no drivers for targeted fishing or retention of incidentally caught individuals, which are significant implications for the development of conservation initiatives for *C. insculpta*, sawfishes and other threatened elasmobranchs within the Kikori region.

4.2.3 Considerations for the conservation of dolphins

Understanding how threatened and vulnerable marine species fit into local culture and resource use is vital to the development of culturally appropriate conservation initiatives that are likely to achieve genuine engagement and participation by local resource users (Booth et al. 2019). The absence of consumptive or economic values of dolphins was reflected in the positive indication that all interviewees would be supportive of dolphin conservation measures for PNG. Similar levels of outright support of conservation initiatives were also recently documented in the Kikori region for sawfishes (Grant et al. 2021b), although the reasons for interviewee support differed. In the present study, more than half of interviewees cited themes of customary ownership and preservation of dolphins for future generations, while 8 of 22 interviewees cited themes of ecosystem health (5) or intrinsic value (3). Grant et al. (2021b) found that reasons given for support of sawfish conservation were mostly orientated around intrinsic and ecosystem values (8 of 15), or preservation of a traditional food source (4 of 15), with 6 out of 15 Kikori interviewees citing themes of customary ownership and wanting to ensure longevity for future generations alongside these other themes. In comparison with conservation initiatives for *C. insculpta* (spatial protections and sustainable harvest strategies [Eisemberg et al. 2015]) and sawfishes (or elasmobranchs generally) (e.g. sustainable harvest strategies and compliance with international trade restrictions and conservation agreements [Grant et al. 2021a, Grant et al. 2021b]), development of conservation initiatives for dolphin have the advantage of not needing to consider intrusions on direct cultural harvest activities, or income losses due to lowered permissible harvest.

Most interviewees in the present study indicated that gillnets were the primary issue to be addressed to protect dolphin species within the fish maw fishery. Self-identified conservation ideas fell into three main themes that reflect common 'top down' fisheries management controls: reductions in fisheries effort; gear modifications; or spatial restrictions. Of these, 'reductions in fishing effort' was the least occurring theme, despite most interviewees acknowledging the presently high levels of fishing effort during other parts of the interview. As a management tool in the fish maw fishery, achieving reductions in fishing effort would be challenging, as this would likely be perceived by local fishers as a constraint on their ability to ensure their food and economic security. However, there is likely scope for fisheries managers to explore options to establish maximum effort levels in the fishery (e.g. a limited entry licensing scheme or total allowable catch threshold) in order to curb the present trend of rapidly increasing fishing effort and thereby control future increases. Spatial protections present another challenge to implementation. Within the fish maw fishery, different Tribes or family groups have customary tenure over different sections of the land and waterways. These customary landowners have self-governing measures that concern access rights to certain areas and natural resource extraction from those areas (e.g. Cinner 2009). While it may be intuitive to identify dolphin 'hotspots' and pursue fishing activity exclusions in such 'hotspots', challenges may arise in equality of the extent of spatial exclusion areas required within the customary waters of different Tribes and family groups. Considering fishing is the primary livelihood of most communities in the Kikori Delta and coastal region, spatial protection initiatives will need to be co-developed with local communities to ensure that implicating factors with respect to local customary governance structure and access rights to traditional fishing areas are carefully incorporated to achieve equitable and culturally ethical outcomes (e.g. see Cinner et al. 2012 for discussions around approaching co-management options in coral reef fisheries in PNG).

To secure reductions of dolphin mortality in the short term, it is likely that conservation initiatives pursuing gear modifications and behavioural changes of fishers will have the best outcomes. Presently, there is a need to explore options to mitigate dolphin interactions with gillnets and to increase survival of individuals that do interact with gillnets. Globally, there are various technologies that are being trialled for mitigating cetacean interactions with fisheries. These commonly include 'pingers' (electronic devices with low acoustic output) and light emitting diodes (LEDs) (Hamilton and Baker 2019). These technologies can have varied success across different species and environmental contexts (e.g. Santana-Garcon et al. 2018, Bielli et al. 2020). Therefore, the appropriateness of these technologies will require experimental trials to ensure they are: 1) effective in reducing interactions of dolphins; 2) functional in the local environment and on the gear used by local fishers (additionally considering access to electrical service constraints in the Kikori region); and 3) that they do not impact the capture of target species. Alongside investigation into interaction mitigation technologies, it is likely that behaviour of fishing practices can be modified to increase survival of incidentally captured individuals. Minor adjustments such as encouraging fishers to attend soaking gillnets would allow prompt release of animals and help prevent mortality from drowning. Development of safe-release guides for the local fisheries context coupled with awareness campaigns could be a positive step that would be achievable in the near-term.

5. Conclusions and recommendations

The fish maw fishery in southern PNG presents many complex social and resource sustainability considerations. Issues with threatened species interactions are presently the most prominent and time sensitive symptoms identified from present and recent research activities and are largely the result of the absence of a fisheries management plan. Presently, short-term management actions need to pursue mitigation and increased survival of incidentally captured threatened species (of which the urgency to prevent local extinctions is probably highest for dolphins and already severely depleted sawfishes). Alongside this, there is still a strong requirement to support and provide information toward the development a fish maw fisheries management plan, and to establish data feedback mechanisms that allow monitoring of changes in target and non-target species populations over time. This will facilitate long-term precautionary management strategies that allows early detection of sustainability, social welfare, or threatened species issues, and provides managers with greater time and ability to find solutions and overcome problems as they are detected. Without having a clear management agenda and data feedback mechanisms in place to monitor fishery status against this agenda, future management and conservation initiatives risk forming a continual series of reactionary management needs, where time to find solutions is limited, and problems may be highly complex by the time they are identified. The present situation of trying to find solutions for preventing the local extinction of dolphin species, for example, is a textbook case of such reactionary management that has resulted from a lack of early detection indicators within a management framework for the fish maw fishery.

To assist future management and research directions within the fish maw fishery, the following are outstanding knowledge gap considerations that restrict our ability to identify and provide appropriate management advice to fisheries managers and local communities:

- Information on biological parameters (age, growth, productivity, and stock structure) of target and key non-target species.
- Estimates of total catch volumes, fisheries effort, and value of fishery products (fish maw, meat and shark fin), and identifying improvements that could be made to local licensed buyer documentation of purchase and trade information.
- Information on social and livelihood aspects of fishers and communities engaged in the fish maw fishery, and how profits are being used and shared within family groups and communities.
- Information on the local customary governance structure, including resource access rights of individuals of differing Tribal associations and the possibility of future social division issues pertaining to the fish maw fishery.
- Information on the subsequent export market chains of fish maw products out of the Gulf Province.

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Appendix 1 – Local ecological knowledge questionnaire

Inshore Dolphin Questionnaire Survey number:__________

Age of interviewee: Sex:

Tribal association (if any): Name of village/fishing camp:

Participant consents to being interviewed, and is understanding of all aspects mentioned in the Information Sheet. They have been given a copy of the information sheet, and have been provided the opportunity to ask questions: Yes/No

Part I Dolphin distribution and occurrence

1. Have you ever seen dolphins in the Kikori River or Delta/coastal region during your life time (picture on last page) – this includes seeing them freely swimming or in fisheries catch

Yes/No (If no go to Part II)

2. Are there different types of dolphin that you see in the Kikori region?

Yes/No (If No go to Q2 c)

a) If Yes how many different types?

____

b) If Yes, how are they separated? (e.g. colour/shape/size – include as much detail as you can)

____

____

____

____

____

c) What is the language name for dolphin? (or names if multiple different types)

____

____

____

____

3. What type of environments do you see dolphin (or each different type) within the Kikori Region?

Type I name ________________: Freshwater | Delta/estuary | Coast (close inshore) |Offshore

Type II name ________________: Freshwater | Delta/estuary | Coast (close inshore) |Offshore

Etc.

4. Are there particular seasons when dolphin occur more often?/or occur in particular environments more often? (try be specific to wet/dry season, then month)

____

____

____

(If answered yes to Q2)

a) Are their any differences in seasonal occurrence between different types of dolphin?

____

____

____

____

Part II Fishing characteristics

5. Is fishing your primary livelihood? (i.e. source of income or most time consuming day-to-day activity)

Yes/No

Other (if No):

____

____

6. How many years have you been fishing for? How many years has fishing been your primary livelihood?

   Years fishing _______ As primary livelihood ______

7. Have you always fished in the Kikori region? Yes/No

   (if No) how long have you fished in Kikori Region?___________

   Where did you fish before?

____

8. Which type of environments have you mainly fished in within the Kikori region (circle all that apply)?

   Freshwater | Delta/estuary | Coast (close inshore) |Offshore

Make clear to interviewee that the rest of the survey questions are only for Kikori fishing activity

9. What type of fishing gears do you use?

Gillnet | Dipnet/prawn net | hook & line | fish trap | spear | other(s): ________________________

Which of these do you use most often? (if seasonal differences, briefly explain gear and season)

Gillnet | Dipnet/prawn net | hook & line | fish trap | spear | other(s): ________________________

____

____

   a) If Gillnet mentioned to be used, what mesh sizes are used?

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | other(s) including overlay combinations: _____________________

10. What is the main target species you aim to catch when you go fishing? (may be more than one)

____

____

____

11. (If Gillnet mentioned in Q7) How many nets are set each time you go fishing?

____

____

a) Typically, how long (e.g. hours) are nets left in the water before being checked?

___

b) Why do you leave them for this time period? (i.e. why not check more often or leave longer?)

___

___

___

___

12. Do you leave nets soaking over night?

    Yes/No – if Yes:

    Always | Often | Sometimes | Occasionally | Never

    a) In general, do you catch more of your target species during the day or overnight? (if any response other than 'Never')

___

___

    b) Are there other reasons for letting nets soak overnight?

___

___

___

___

13. How many other fishers do you typically go fishing with? (include number or range if variable and if this includes males and females)

___

Why this number (or range)? (prompt for logistical, social, cultural, or family reasons if any)

___

___

___

___

___

14. When you fish, do you: (circle all that apply)

Fish from directly from shore | use a paddle canoe | motorized boat

Which is the main method you use? ____________

Explain why:

___

___

___

___

____

15. Where do you purchase or 'get' your gillnets from? (if a lease, explain the arrangement in detail)

____

____

____

____

____

____

____

____

____

____

Part III Interactions with Dolphin

16. Do you ever catch dolphin? Yes/No

(if yes) which fishing gear(s)? ____

(if Gillnet) which mesh sizes? ____

17. Do you ever target dolphin, or are they caught accidentally when trying to catch other fish?

Targeted | Accidental | Both

(if accidental) what type of fish were you trying to catch? ____________________________

18. When you catch dolphin, are they alive when you find them in your gear(net)?

Always | Most of the time | Not usually | Never

19. From the times that you have seen dolphins in the Kikori region, do you *mainly* see them freely swimming, or as a result of catching them?

Freely swimming | Within catch | no difference

20. When you see dolphins freely swimming, are they in groups or just one dolphin by itself?

Groups | Individuals | Both

21. How often do you see dolphins swimming? Would you say once every…

Week | Month | 3 months | 6 months | Year | less than 1 per year | less than one per 5 years | less than one per 10 years

22. When you catch dolphin during a fishing trip, do you ever catch more than one individual at the same time?, or are they only caught singularly?

Singularly | Multiple | Both

23. How often to you catch dolphin? Would you say at least one every….

Week | Month | 3 months | 6 months | Year | less than 1 per year | less than one per 5 years | less than one per 10 years

(if changes in catch frequency relating to seasons mentioned, explain)

____

____

____

24. When you began fishing, how often do you recall dolphin being caught?

    Weekly | Monthly | 3 months | 6 months | Yearly | less than 1 per year | less than one per 5 years | less than one per 10 years | I don't remeber

25. How often did you see them freely swimming at that time?

Weekly | Monthly | 3 months | 6 months | Yearly | less than 1 per year | less than one per 5 years | less than one per 10 years | I don't remember

26. When was the last time you caught a dolphin?

____

27. When was the last time you saw a dolphin(s) freely swimming in Kikori region (this excludes caught animals)?

____

28. Have you noticed any changes in the number of dolphins in the Kikori region during your life time?

    Increase | Decrease | No change

    Note any comment about severity/magnitude of change

____

____

____

29. What do you think has caused these changes (may be more than one reason, push for *why*)?

____

____

____

____

____

Part IV Uses and Values of Dolphin

30. When you encounter a dolphin in your fishing gear, do you keep it, or release it?

Always retain | sometimes retain | Never retain |

Why?

____

____

____

31. (For those that report retention) What are the uses of dolphin when you keep them?

Consumption of meat | sale and trade

Other:

____

____

a) If sold (any part) what is the value and who do you sell to?

(note if sold whole or per piece – how many pieces per dolphin?_

____

____

32. Would you prefer to eat dolphin meat compared to (i.e. which is tastier)

Fish Yes/No

Shark Yes/No

Turtle Yes/No

Dugong Yes/No

Crab Yes/No

Prawn Yes/No

33. Is the sale of dolphin products an important part of your economy?

Yes/No

34. Is the capture of dolphin an important part of the your food security?

Yes/No

35. Are dolphin ever targeted or eaten for a cultural reason or practice (e.g. wedding feast, initiation ritual, other spiritual reason)?,

Yes/No

elaborate (include as much detail as you can, including why if answered No).

____

____

____

____

____

____

____

____

____

____

36. Are there any cultural/spiritual beliefs around dolphin, today? Historically? (if there is, try an clarify if currently practiced/believed) (e.g. their presence may indicate a season or something)

37. If dolphin disappeared from Kikori region, would this effect you, your beliefs, or your family and culture? Yes/No

How?

38. Would you support any conservation measures and/or species protection for dolphin if they were proposed for Papua New Guinea? Why or why not?

Is there any part of your relationship with dolphin you would **need** to maintain (e.g. food/ritual/ceremony) if they were protected?

39. Excluding any necessary catch for cultural practices or rituals that yourself or other Tribal groups may have, Do you have any ideas of how dolphins could be better protected from general fishing activities in Kikori region?

____

____

____

____

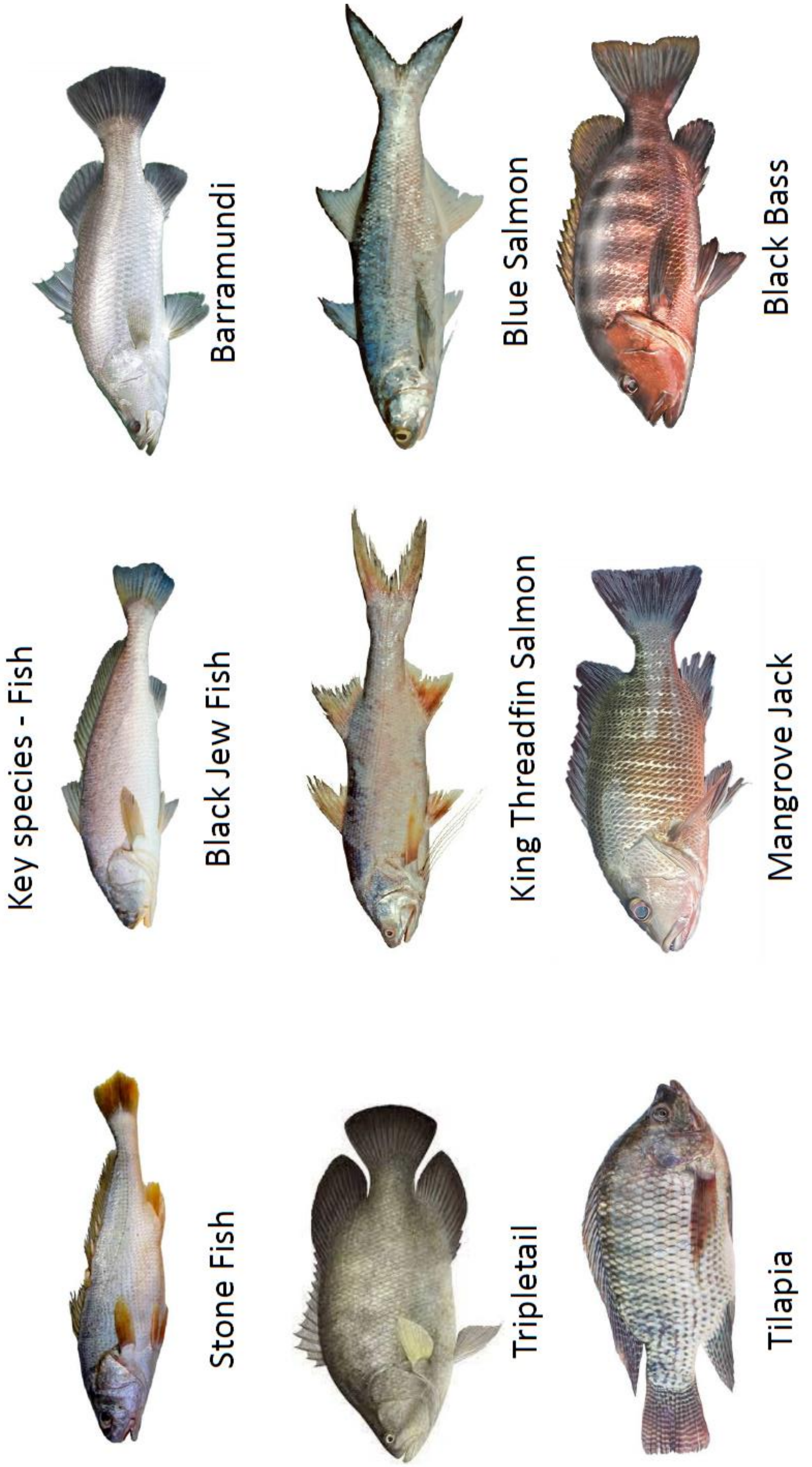
____

____

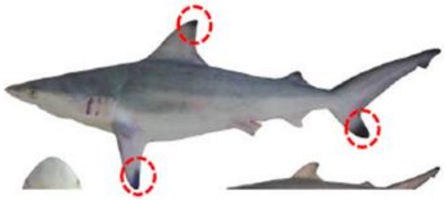
____

Remember to provide information sheet and reaffirm what data will be used for and that the participant will not be identifiable within this study, and that they can contact you at …. If they wish to withdraw from the study.

Appendix 2 – Fish maw fishery identification guide

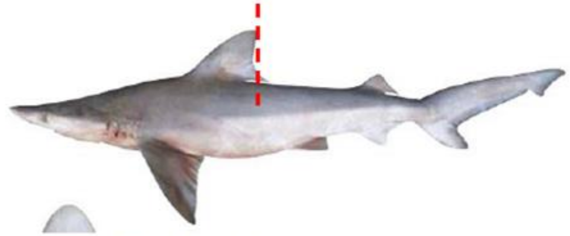


Key species - Sharks

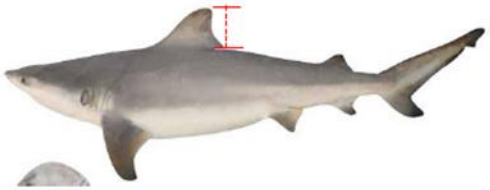


Black tip shark
- Black tips on fins

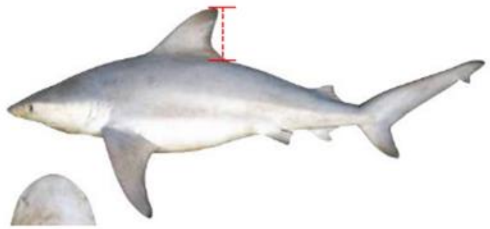
Sharpnose shark
- Very small and thin
- Grey or brown



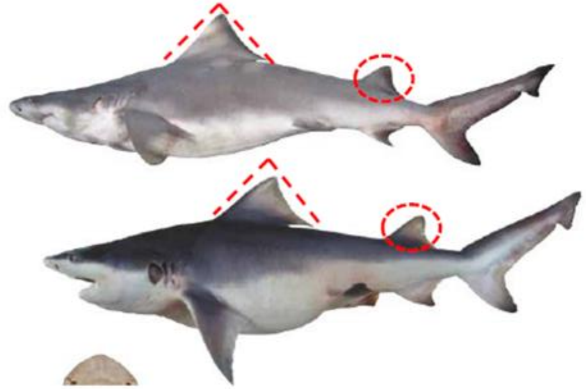
Creek shark
- No black markings on fins
- Not very common



Bull shark
- Small back fin
- Tail fin may be black
- Similar to pigeye shark, though small dorsal fin

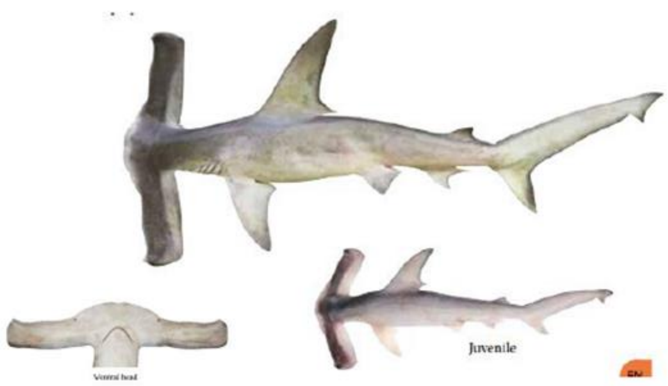


Pigeye shark
- Tall back fin
- Similar to bull shark though larger back fin
- Not as common as bull shark

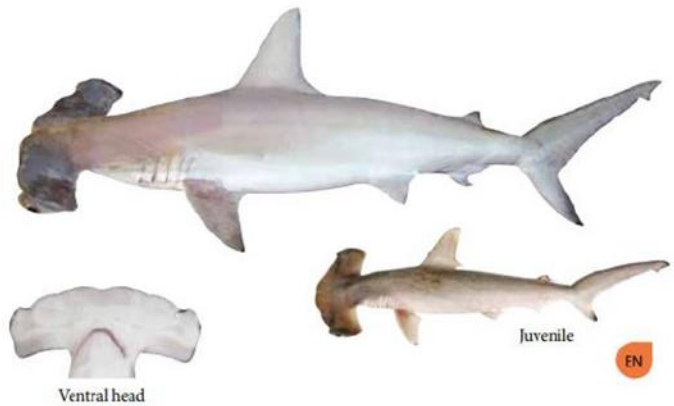


River shark
- **Triangular** back fin
- 2nd back fin large (about half the size or more of main back fin)
- Very common

Key species - Sharks



Winghead shark
- Wide thin head
- Common

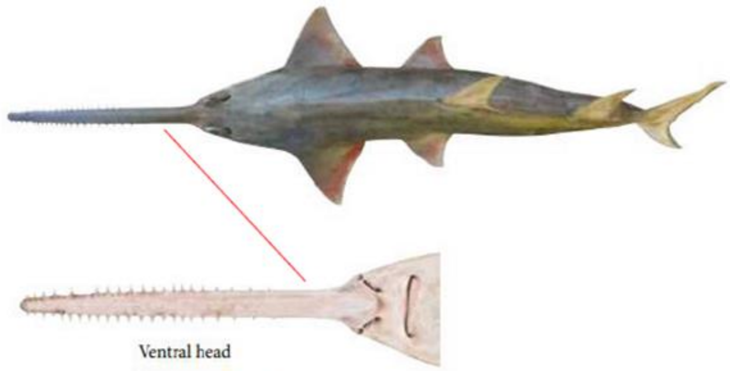


Hammerhead shark
- Thicker head
- Not very common

Wedgefish
- White spots

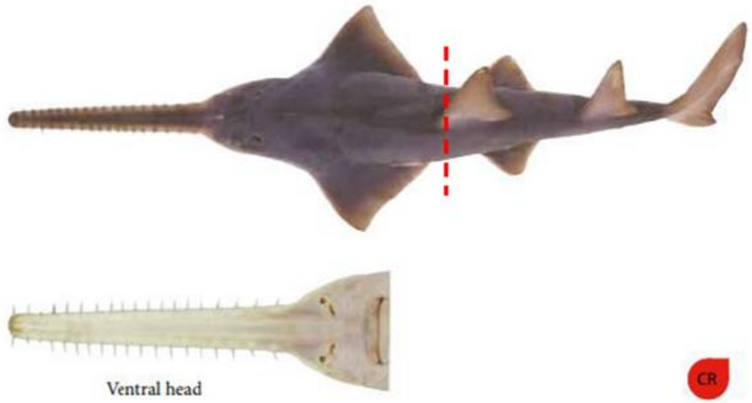
Guitarfish
- No white spots

Key species - Sawfish



Narrow sawfish

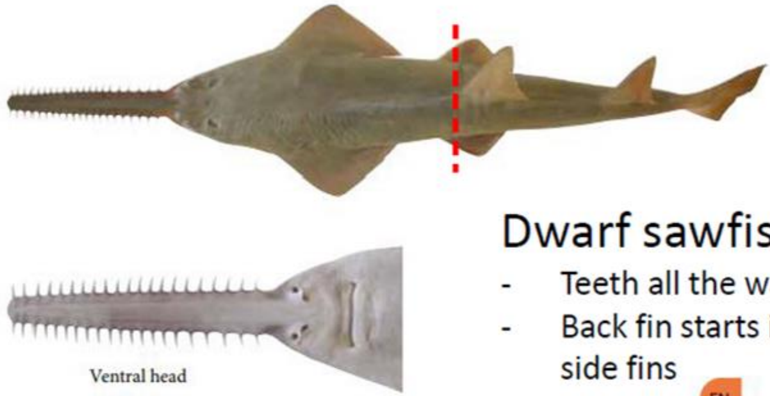
- No teeth on saw close to mouth
- Saw is thin



CR

Largetooth sawfish

- Teeth all the way along saw
- Back fin starts in front of side fins



Dwarf sawfish

- Teeth all the way along saw
- Back fin starts in line with side fins

EN

Taking photos of sharks and sawfish – Take **2** photos of Body and Head

1. BODY

Side on photo – eye and back fin clear

Top down – Can't see eye or back fin

2. Head

Side on for sharks, top down for sawfish

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