Fishing for profit or food? Socio-economic drivers and fishers' attitudes towards sharks in Fiji

Kerstin BJ. Glaus[a,*], Irene Adrian-Kalchhauser[b], Susanna Piovano[a], Sharon A. Appleyard[c], Juerg M. Brunnschweiler[d], Ciro Rico[a,e]

[a] *School of Marine Studies, The University of the South Pacific, Laucala Bay Road, Suva, Fiji*

[b] *Department of Environmental Science, University of Basel, Vesalgasse 1, 4051 Basel, Switzerland*

[c] *CSIRO National Research Collections Australia, Australian National Fish Collection, Hobart, TAS., Australia*

[d] *Independent Researcher, Gladbachstrasse 60, 8044 Zurich, Switzerland*

[e] *Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas, 41092 Sevilla, Spain*

* Corresponding author: Kerstin B.J. Glaus, The University of the South Pacific, School of Marine Studies, Private Mail Bag, Laucala Campus, Suva, Fiji. E-mail: kerstin_glaus@outlook.com.

Abstract

Sharks are an important component of coastal fisheries. Accordingly, the impacts of small-scale shark fisheries are likely significant, but data, including socio-economic drivers, are often scarce. Fiji features active but largely unregulated and unmonitored artisanal fisheries. Data suggest that the country's small-scale shark fisheries have the potential to become more targeted. This study considers the socio-economic value of shark fisheries across stakeholder groups. In 2017, semi-structured interviews were conducted with 211 fishers throughout Fiji, out of which 66.8% reported catching sharks of 11 species. Of those who caught sharks, 19.9% stated to release them dead or alive, while 78.7% retained the sharks. Various reasons were cited for shark retention with the most common explanation being to meet dietary needs. Only 19.8% of the participants who retained sharks sold them, yet fishers who gain additional income from the sale of sharks had significantly higher mean maximum catch rates compared to fishers who retained sharks for consumption. Fewer fishers reported selling shark fins compared to a previous comparable survey. This study indicates a decreasing relevance of small-scale coastal shark fisheries for income generation but an increasing utilisation of shark meat as a substitute for traditional food fishes.

Key words: Elasmobranchs, Small-scale fisheries, South Pacific, Socio-economic Drivers, Fisheries Management

1. Introduction

The capture of sharks occurs worldwide in both oceanic [1] and coastal [2] fisheries. In recent years, international efforts to amend shark fisheries management have intensified and several countries have adopted a National Plan of Action for the Management and Conservation of Sharks [3]. Furthermore, several shark species are now subject to trade restrictions under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) [4]. However, international management strategies have focused primarily on the reduction of overfishing of a few oceanic species [5, 6]. Sharks living primarily in coastal and reef habitats are rarely subject to specific catch limitations [7].

Small-scale fisheries operating in coastal waters throughout the tropics are reportedly catching sharks in large numbers, both as targeted and not-targeted catch [8-12]. The impacts of such fisheries are likely significant. Nevertheless, small-scale fisheries remain often overlooked [13, 14] because they are remote, dispersed and with limited enforcement difficult to monitor, characterise, and manage [15]. Consequently, qualitative and quantitative data of, for example, catch compositions, trends over time and socio-economic drivers are scarce. Yet, such data are needed to manage coastal fisheries so that they do not negatively impact the abundance, distribution and population structure of vulnerable taxa [16], including coastal shark species.

In the Pacific Island countries, small-scale fisheries are an important component of food security, employment and exports, in addition to their recreational and social attributes [17]. To date, small-scale shark fisheries in this region have been assessed by only a handful of studies [18-22]. For Papua New Guinea, data indicate potentially unsustainable levels of shark fishing [21, 23]. Fiji, the South Pacific's economic centre features active but largely unregulated and unmonitored local small-scale finfish and shark fisheries. It incorporates 3000 subsistence fishers [24] throughout the 300 plus islands, where 56 species of elasmobranchs (sharks, skates, and rays) are reported from large-scale oceanic [1, 25] and small-scale coastal fisheries [22, 26]. Fiji is a member of the Western and Central Pacific Fisheries Commission (WCPFC), a signatory of CITES, and of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). On a national scale, a ban on shark lines came into effect in 2012 [25]. In the same year the country decided, contrary to a number of other Pacific Island countries [27], against a National Shark Sanctuary which would have prohibited commercial shark fishing, import, export and sale of shark products [28]. A draft National Plan of Action for sharks was developed in 2013, but is yet to be ratified by the Fijian government (pers. comm. Ian Campbell, WWF Shark

and Ray Initiative Manager). Several coastal shark species (*e.g.*, bull shark *Carcharhinus leucas*, grey reef shark *C. amblyrhynchos*) are included in Fiji's amended Endangered and Protected Species Act [29]. However, this act does not apply to subsistence fisheries. The Fiji Fisheries Act (Laws of Fiji, Chapter 158) in turn applies to inshore fisheries and can empower the Ministry of Fisheries to make regulations which, *inter alia*, either ban a particular species from being harvested, demarcate an area where fishing is restricted, or regulate the '*conservation, protection and maintenance of a stock of fish which may be deemed requisite*'. This provision was used in 2004 to create the legally recognised Shark Reef Marine Reserve (SRMR), a no-take marine protected area (MPA) located off the southern coast of Viti Levu [30, 31].

In the first and only such study available to date, Glaus *et al.* [22] reported that 81.4% of all interviewed fishers on Fiji catch sharks, of which 81.6% declared not to target sharks specifically but catch them as bycatch. Those artisanal shark fisheries have the potential to become more targeted. Reasons for this are that firstly, shark catch is not strictly regulated. To date, regulations that apply to Fiji's inshore fisheries are typically limited to no-take marine reserves. Secondly, regulatory action is complicated by the socio-economic vulnerability of coastal island communities. Remoteness and limited infrastructure can contribute to a lack of income opportunities, and the socio-economic dependence on marine resources is generally substantial [32]. Therefore, differentiating between small-scale artisanal fishing (small commercial operations fishing for food and profit), and subsistence fishing (fishing only for food, no monetary incentive to capture and/or store excess fish) is critical to design suited and targeted interventions that take into account the socio-economic value of shark fisheries across stakeholder groups. Also, an increased understanding of the present situation, including attitudes (both cultural and individual) towards sharks, is key to understanding the underlying motivation of individual fishers and to manage data-poor fisheries [11].

This study was therefore designed to 1) identify socio-economic drivers of Fiji's shark fisheries, and 2) assess fishers' attitudes towards the importance of sharks for food security and income generation. By addressing these gaps, this study adds data to further characterise Fiji's small-scale shark fisheries and could inform a more comprehensive elasmobranch management strategy.

2. Material and methods

2.1 Study area and interviews

To obtain representative data useful to inform management decisions, interviews were conducted from August to November 2017 in all political divisions and all major geographic areas of the Fiji Islands (Fig. S1A, B in Supplementary Information). Semi-structured, in-person interviews [33] were conducted with female and male fishers using a pre-categorised questionnaire (see Supplementary Information for a full list of questions). The questionnaire covered topics related to shark fisheries, such as catch site, frequency, or line specifications, but also attitudes towards sharks such as intentions and perceptions of sharks (see Table 1 for a full list of topics).

Sampling was performed opportunistically [34]. The number of interviews at one site was determined on the one hand by availability of interview partners, and on the other hand by topical saturation. When similar themes kept recurring, and no new insights were given by additional data sources, no more interviews were conducted [35, 36].

All interviews were conducted by one of the investigators (KG) and a local female collaborator fluent in English (the official language of Fiji) and Fijian (Bauan dialect, which is commonly used throughout the country). First, permission to interview fishers was requested from the village headman (*Turaga-ni-Koro*) and/or the head of clans (*Turaga-ni-Yavusa*). Headmen and/or chiefs then designated active fishers that could be interviewed. Fishers were then asked to volunteer for interviews. They did not receive incentives for participating. Individual interviews were held in places convenient for fishers [37].

Before the interview, participants received explanations about the purpose of the survey in both Bauan dialect and English. During the interview, fishers identified shark species they catch with the help of an illustrative ID poster. To find out how many different shark species each participant caught, fishers were asked to point at every shark species they catch and each selection was counted. To account for juvenile sharks, participants were asked to provide information on the habitat, length and size of the sharks they caught. During the final section of the interview, they were encouraged to openly talk about their attitudes towards sharks and whether and how sharks were important to them on a personal and/or cultural level. Participants were further asked about their perception on shark and fish abundance. At the end of each interview, additional fishers were identified using snowball sampling, in which interview participants are invited to suggest individuals to participate [38]. All responses were noted as they were encountered. Data confidentiality and anonymity of each participant was assured by omitting names and contact information of each respondent. No leading questions and no *a priori* coding dictionary were used. Every effort was made to

maintain the meaning conveyed by participants. For example, responses indicating that fishers captured sharks to protect themselves and/or their catch, yet without the respective initial intention, were noted as "defence", whereas fishers, who caught sharks with the intention to prevent attacks as a pre-cautionary approach by reducing the amount of sharks in the area, were noted as "reducing risks of shark attacks".

Interviews were conducted under a research permit issued by Fiji Immigration Department to KG and approved by The University of the South Pacific and by Fiji Secretary of Education. All interview procedures were approved under the "Human Ethics Committee" section of the USP Research Committee and performed in accordance with relevant guidelines and regulations.

2.2 Data handling and analysis

To analyse and visualise the responses, data were grouped according to the four administrative divisions of Fiji (Eastern, Western, Northern and Central division). These divisions provide, *inter alia,* the basis for the implementation of fisheries management measurements (pers. comm. Aisake Batibasaga, Director of Fiji Fisheries Department). The number of interviews conducted in each division is summarised in Table 2.

To categorise the handling of caught sharks, fishers' responses to catching sharks were categorised into "shark catch and release" and "shark catch and retain" fishing activities. The latter was subdivided into artisanal fishing activities where sharks can constitute a source of financial income and are sold, and subsistence fishing activities where sharks are consumed, but not sold. To illustrate regional differences in catch compositions, species selected by fishers and numbers of respondents were grouped according to the four administrative divisions.

To visualise attitudes and perceptions, responses representing similar socio-economic drivers were grouped. For example, some informants did not intend to catch sharks because they were afraid of sharks while others responded that catching sharks could cause injuries to the fishers. These responses were grouped as "sharks are dangerous". Answers indicating a positive reflection of sharks (i.e. "sharks are good", "they protect fishers", "they are an indicator for the presence of fish") were grouped as "sharks are good animals". Responses stating that catching sharks was related to financial loss or a lack of financial gain (i.e. "loss of gear", "no market", "no demand") were grouped as "doesn't pay off". Responses implicating a personal sympathy for sharks (i.e. "I like looking at sharks", "sharks are beautiful") were grouped as "emotional connection".

To visualise and compare catch rates between artisanal and subsistence fisheries, weekly catch rates were converted into monthly catch rates. Four weeks were subtracted to prevent overestimations and to account for bad weather conditions and family illness (SP unpublished data). Weekly rates were converted to monthly rates by the following calculation: weekly rate * 48 (weeks) / 12 (months). Respondents catching few sharks provided monthly catch rates while respondents catching many sharks provided weekly catch rates. P-values were calculated with non-parametric t-test. Data were analysed and plotted using R Version 3.2.5 [39], with packages maps [40], mapdata [41], and mapproj [42].

3. Results

3.1 Characteristics of participants and response rates

Two-hundred and eleven fishers were interviewed at 124 study sites (villages and fish markets) in all four administrative divisions of Fiji (Table 2; Fig. S1A, B in Supplementary Information for a map of sites). Interviewees differed in their age, gender and ethnicity (Fig. S1C, D, E in Supplementary Information). Overall, however, the respondent group was homogenous as 91.9% were native Fijians (*iTaukei*) and 80.1% were male. On average, male participants were 46.5 years old (range: 19-76) and female participants were 49.2 years old (range: 32-77; Fig. S1C in Supplementary Information). Response rates to topics varied between 20.4% and 100% (Table 1.).

Topic	*#*	*%*
Fishing frequency times per week	208	98.6
Fishing site river, river mouth, coastline, reef, beyond reef	211	100
Fishing time day time, night time	206	97.6
Fishing gear net, handline, longline, fishing rod, speargun, spear, slingline	211	100
Line Specifications hook size, line capacity (in pounds)	109	51.7
Target species all edibles, bony fish, sea cucumber, turtle, octopus, shellfish, crustacean, giant clam, ray, shark	211	100
Species Caught all edibles, bony fish, sea cucumber, turtle, octopus, shellfish, crustacean, giant clam, ray, shark	211	100
Intentions on catching shark is shark catch intended? Why / why not?	208	98.6

Attitudes towards and importance of sharks what do you think of sharks? Are sharks important to you? Why / why not? How are they important to you?	204	96.7
Bycatch definition accidental or unwanted catch, not fully utilised, not primary target	43	20.4

Table 1 Number (#) of respondents and response rates (%) for each major interview topic.

Division	# fishers	%	# study sites	%
Central division	48	22.8	30	24.2
Northern division	60	28.4	33	26.6
Western division	65	30.8	32	25.8
Eastern division	38	18.0	29	23.4

Table 2 Numbers (#) of fishers interviewed and study sites visited by political division, and percentages (%) of total, respectively.

3.2 Fisheries characteristics

Shark catch and shark retention were common practice among fishers and both artisanal and subsistence fishing was observed. Of the 211 participants two thirds (n = 141) reported catching sharks (Fig. 1). Of those, less than a quarter (n = 28) released sharks dead or alive while the majority (n = 111) retained their catch. Of the 111 interviewees retaining sharks, 79.3% (n = 88) utilised sharks as food source and/or for cultural purposes and 19.8% (n = 22) sold shark products which is indicative of subsistence and artisanal fisheries, respectively (Fig. 1). Of the 22 artisanal fishers, 12 sold sharks to community members or members from other villages, 4 sold sharks to seafood companies while 6 participants did not provide a response. Of the 211 participants, 16 fishers reported that they used to sell shark products but stopped the practice. Of those 16, 9 used to sell shark products to seafood companies while 1 participant used to sell sharks to community members or members associated to other villages.

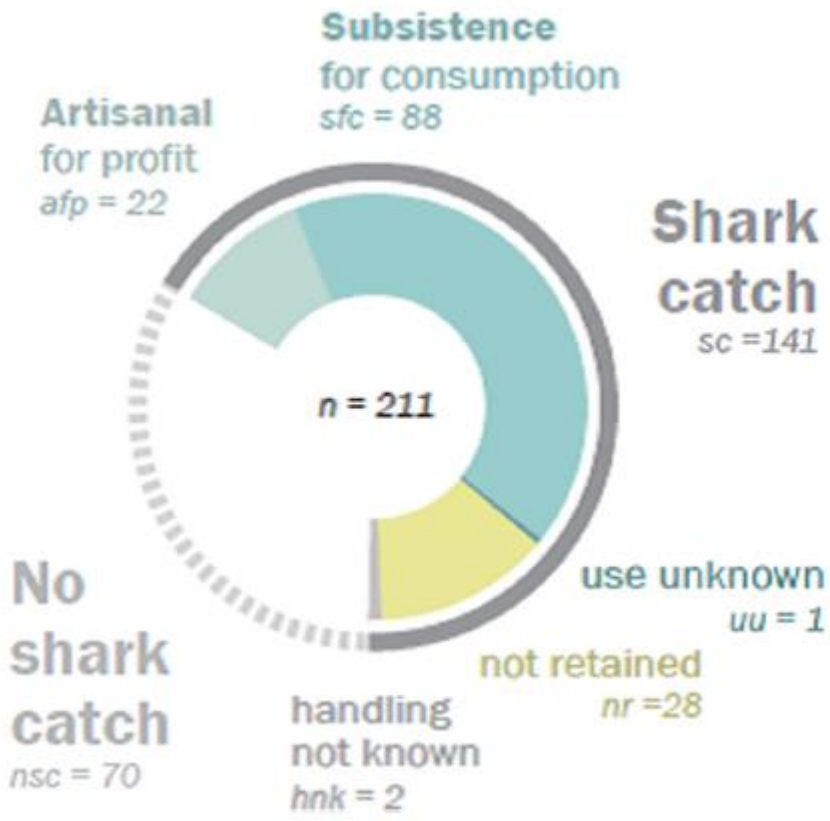

Fig. 1 Number of respondents involved in different types of shark fishing activities

Artisanal fisheries were most common in the Western division, with 10 of the 22 respondents falling into this category. In relation to the number of the respondents per division, subsistence fisheries were most common in the Eastern division, with 23 persons of the 38 participants from this division falling into this category.

Artisanal fishers caught substantially more sharks than subsistence fishers. Of the 88 and 22 fishers who retained sharks for consumption or retained sharks as a source of income, 45 (51.1%) and 19 (86.4%), respectively, provided information on maximum catch rates. Catch rates were significantly higher if respondents caught sharks for profit (between 2 and 87 sharks per month) than when they caught sharks for subsistence purpose only (between 1 and 65 sharks per month; Fig. 2).

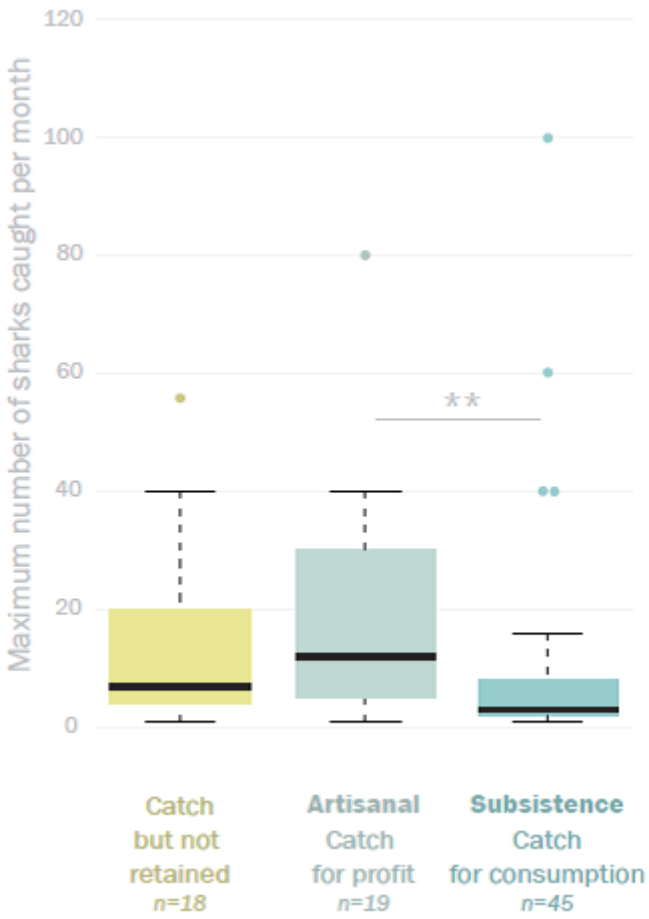

Fig. 2 Boxplots comparing catch rates. Artisanal fishers catch significantly more sharks than subsistence fishers ($p < 0.002$). Black bars correspond to the median of all maximum catch rates given.

3.3 Catch composition

At least 11 shark and 2 ray species were caught of which 6 are vulnerable, endangered or critically endangered according to the IUCN Red List Status [43] (Fig. 3): whitetip reef shark (*Triaenodon obesus*) (17%), blacktip reef shark (*C. melanopterus*) (12.2%), adult (10.4%) and juvenile (7.1%) bull shark (*C. leucas*), tawny nurse shark (*Nebrius ferrugineus*) (6.3%), grey reef shark (*C. amblyrhynchos*) (6.1%), silvertip shark (*C. albimarginatus*) (6.1%), various adult (5.6%) and juvenile (2.5%) hammerhead sharks (*Sphyrna* spp.), zebra shark (*Stegostoma fasciatum*) (4.8%), adult (3.3%) and juvenile (1%) tiger shark (*Galeocerdo cuvier*), sicklefin lemon shark (*Negaprion acutidens*) (1.8%), blacktip shark (*C. limbatus*) (2.5%), wedgefishes (family Rhinidae) (3.8%) and sawfishes (family Pristidae) (0.5%) (Fig. 3A). Thirty-six interviewees (17.1%) indicated that at least in some cases they cannot identify the species they catch.

Overall, the diversity of species caught was similar between divisions (Fig. 3B). Sawfishes were absent from the Central and Eastern divisions. Juvenile tiger, hammerhead and blacktip shark were not reported from the Eastern division, and the sicklefin lemon shark was not reported from the Northern division. The remaining species were reported to be caught in all areas surveyed.

Differences between divisions were identified regarding how frequently certain species were reported, whether juveniles are part of the catch and whether respondents can identify the species. For example, hammerhead sharks including juveniles are a relevant component of the catch in the Central and Northern divisions but not in the Eastern division. Juvenile bull sharks were a relevant catch component in the Northern and Central divisions and less commonly caught in the Western and Eastern divisions. Silvertip sharks were more frequently reported from the Eastern division compared to the three other divisions. Almost a quarter of all selections from the Northern division were “Species Unknown” (Fig. 3B).

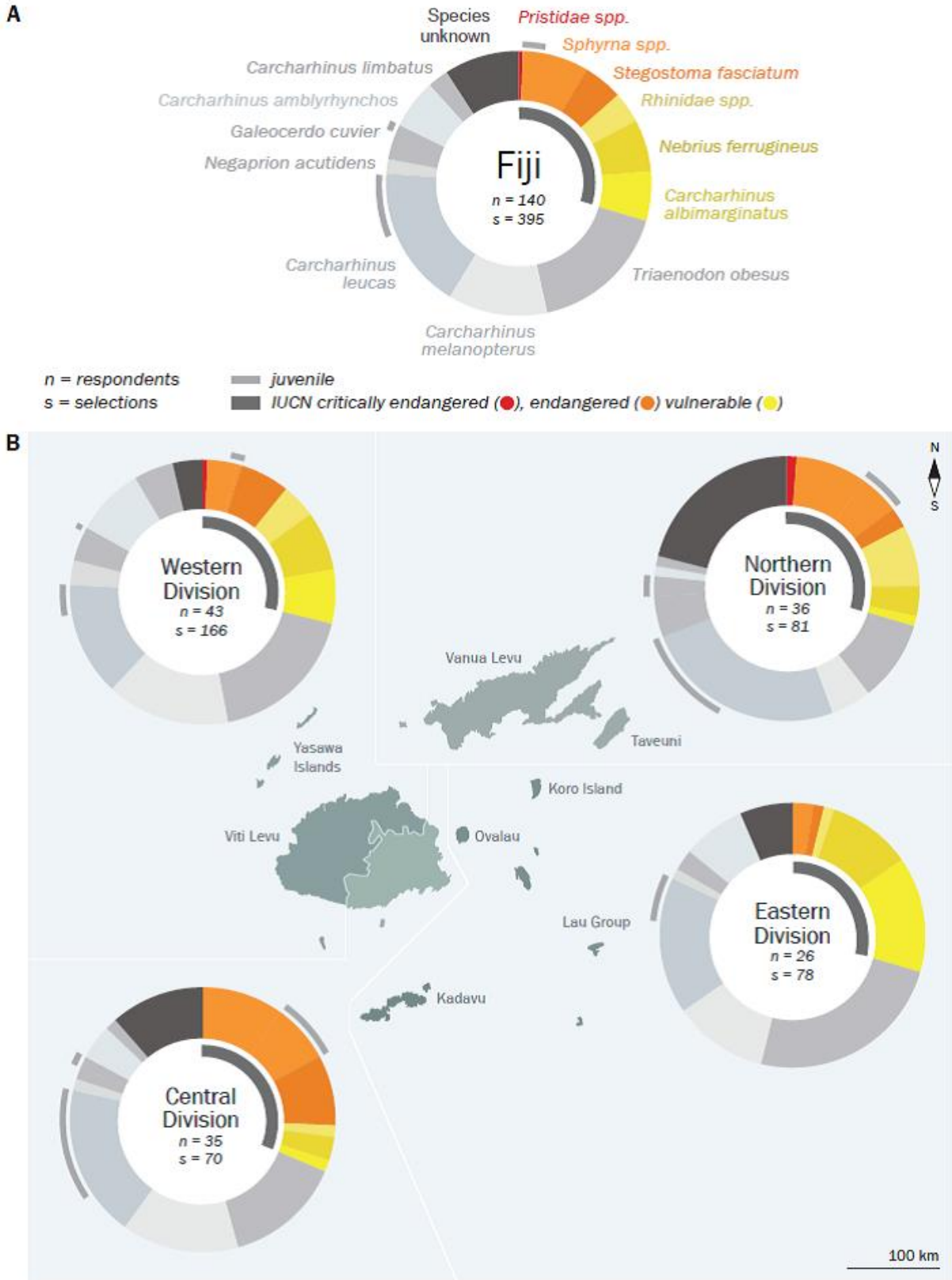

Fig. 3 Catch composition in Fiji and in the four administrative divisions. Number of respondents (n) and number of times a species was identified by the respondents (s).

3.4 Intentions and socio-economic drivers

Release versus retain practices as well as intentions and socio-economic drivers differed between the divisions. Sharks were most frequently retained by respondents from the Eastern division which is also where shark catch was most often intentional (Fig. 4A, B). In the Central division, almost half of respondents indicated that they would release sharks if caught, while less than 10% of respondents would release a shark in the Eastern division (Fig. 4A). Defence was a common topic in the Western and Eastern divisions but less important in the Central and Northern divisions (Fig. 4B). The main drivers for intended shark catches were as sources of food and sources of income but also to substitute a perceived decline of bony fish (Fig. 4C). Reasons why sharks were not targeted were diverse and ranged from negative connotations (avoidance of a dangerous animal) to positive connotations (emotional or cultural significance) to economic considerations (no reasonable revenue; Fig. 4D).

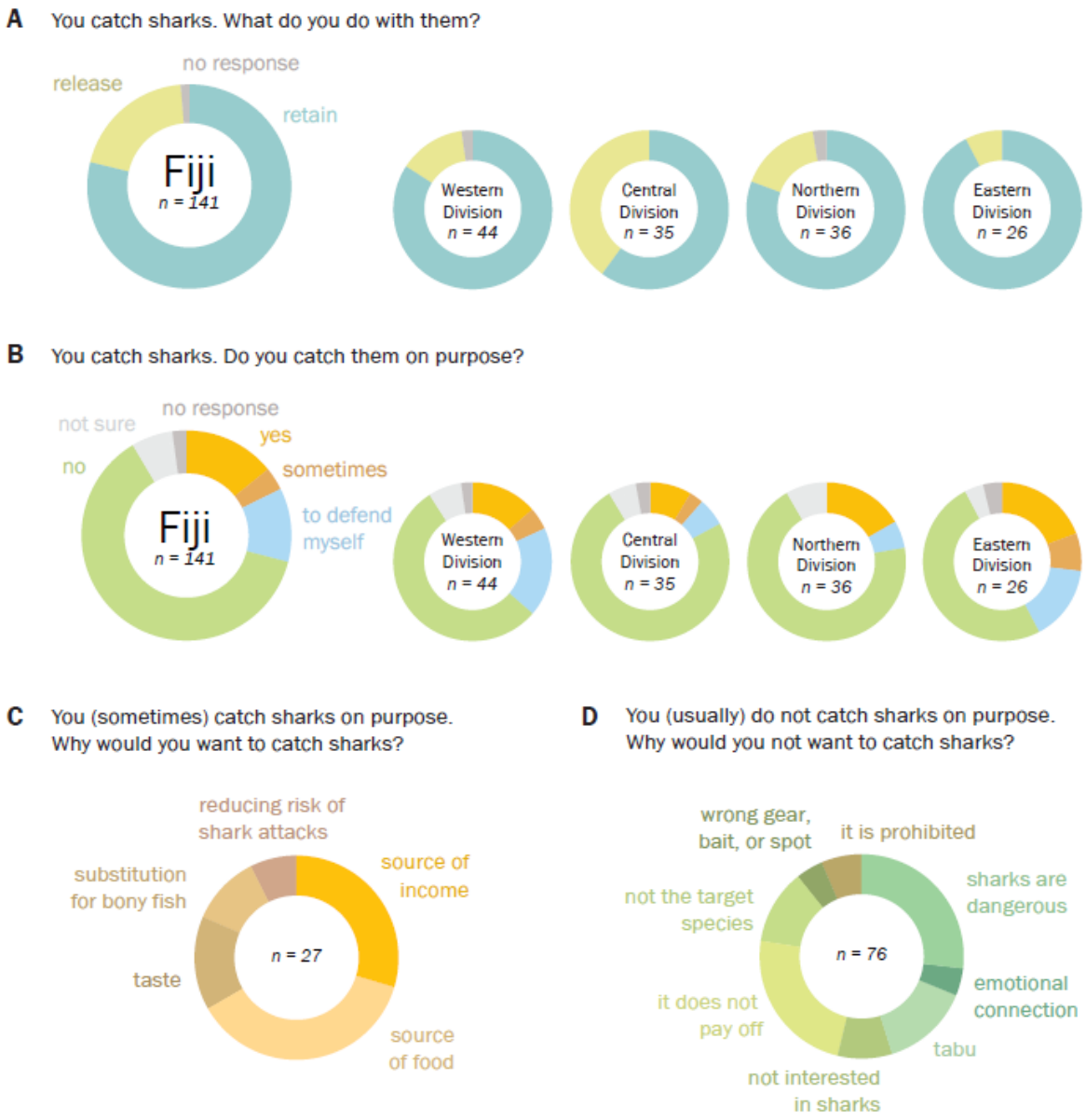

Fig. 4 Shark utilization, intentions and socio-economic drivers for shark catches

3.5 Attitudes towards sharks and stock changes

The attitudes of participants on sharks were highly divergent. Of the 204 interviewees who communicated their attitudes towards sharks, 67 (32.8%) classified sharks as “dangerous animals” while 54 (26.5%) stated that sharks are “good animals”. Noteworthy, considering sharks as “good animals” includes different conceptualisations, including the cultural relevance of sharks (e.g. sharks protect fishers) as well as their ecological relevance (e.g. sharks are indicators for the presence of fish). Sharks were viewed by 33 (16.2%) participants as “just another fish”, and 16 (7.8%) considered sharks as “nuisance or competitor” during their fishing activities.

Similarly, opinions regarding the importance of sharks varied among interviewees. Of 208 participants who communicated their opinion regarding the importance of sharks, 78 (37.5%) stated that sharks were not important while 48 (23.1%) valued sharks as an important additional food source. The cultural relevance of sharks to Fiji was highlighted by 35 (16.8%) of the participants. Sharks were an important source of income to 13 (6.3%) of the participants, and 9 (4.3%) mentioned that sharks have an important ecological function, without specifying the function any further.

Two thirds of participants had the impression that local bony fish stocks are in decline while sharks have become more abundant. Of 114 fishers who communicated their experience regarding changes in the abundance, 71 (62.3%) mentioned that bony fish stocks decreased and 42 (36.8%) stated that bony fish stocks increased or remained constant. Of the 71 respondents who stated that fish stocks decreased, 22 (31%) mentioned that shark stocks are in decline. Of 130 participants who provided an answer concerning the abundance of sharks, 42 (32.3%) perceived shark stocks as depleting while 79 (60.8%) reported an increase in the number of sharks. Of the 79 respondents who observed an increase in shark stocks, 49 (62%) fishers utilise sharks as food source, while 12 (15.2%) respondents soldsell shark products. Hence, 55% of the respondents who utilise sharks as a source of income perceived an increase in the number of sharks.

4. Discussion

4.1 Socio-economic drivers and fishers' attitudes

This study is the first focused exploration of socio-economic drivers and fishers' attitudes towards sharks in Fiji's small-scale shark fisheries. Shark fishing occurred throughout Fiji. In a previous study, sharks were predominantly reported to be taken as bycatch and not directly targeted [22]. However, if what is reported as bycatch is in fact accidental catch, bycatch is often difficult to elucidate and can change on a daily basis [11]. Hence, this survey focused on whether fishers catch sharks and if they do so, what do the fishers do with the catch. This allows for distinguishing between artisanal fishing for food and profit, and subsistence fishing only for food, with no monetary incentive to capture and/or store excess fish.

The main driver for Fiji's small-scale coastal shark fisheries is to meet dietary needs. Approximately one third of fishers considered sharks as not important and dangerous animals, whereas a quarter of the respondents had a positive attitude and valued them as important additional food source. Overall, comparably fewer fishers reportedly caught sharks than previously documented (66.8% this study *vs*. 81.4% [22]), indicating a possible decline in Fiji's small-scale shark fisheries. However, it is important to note that both study sites and

interviewed fishers did not overlap in the two surveys, so it remains unknown if indeed fishers from the previous survey stopped targeting or taking sharks.

Sharks were previously not considered an important source of food in many parts of Fiji mainly due to traditional taboos, availability of bony fish [18] and dislike of the meat [22]. Today, shark meat is widely consumed due to its comparably low cost (5 FJD (2.4 USD) per kg of meat or for a small shark). Data in the current study supports the notion of an increased importance of shark meat as a food source with fishers recently finding new ways to prepare shark meat (which was previously considered low-quality and non-tasty). More fishers reported selling shark products than previously documented [22]. The meat is primarily sold to community members, at local markets or at market stalls along the roadside, indicating that there is existing domestic demand. Exploited fish stocks [18] and the perceived increase in shark numbers may be increasing the use of sharks to meet dietary and financial needs. Systematic surveys of major fish markets in Fiji (*e.g.*, Labasa, Ba, Lautoka) could help to assess the actual volume and origin of sharks sold. Additionally, collecting data on-board small-scale fishing vessels in different locations would be the next logical step to help frame the importance of sharks compared to fin fishes into a reliable perspective.

Whereas a previous survey of Fiji's coastal shark fisheries documented anecdotal evidence that interest in shark fins increased in recent years [22], this was not confirmed in the present study. A possible reason for the observed change in Fiji's shark fin trade, which is linked to the *bêche-de-mer* trade, may be that in 2017 the closure of the latter fishery was initiated [44]. Consequently, middlemen who used to encourage shark targeting do not visit villages on the same regular basis. Fishers now appear to sell shark fins directly to seafood companies from where they are distributed to local restaurants. Hence, the shark fin trade has likely shifted from a previously export oriented market [22] to one currently dominated by domestic outlets (*e.g.*, Asian restaurants). Similarly, Vieira, Kinch, White and Yaman [19] observed a fall in shark fin production after the closure of the *bêche-de-mer* fishery in Papua New Guinea. The results from this study could indicate that Fiji might follow the same pattern. But as shark fins remain a highly priced item, domestic trade in shark fins could be expected to continue, creating a risk that small-scale fisheries may eventually deplete shark populations significantly [45].

4.2 Regional differences

Levels of artisanal and subsistence shark fisheries differed between political divisions. Fiji's capital Suva is located in the Central division and represents the country's economic centre. Also, the shark diving

industry mainly operates in the Central division. Access to education, employment options and the availability of alternative income opportunities at the community level may explain why comparably fewer respondents stated to catch and retain sharks in this part of Fiji. By contrast, the Eastern division consists of rural areas and remote islands where markets and income opportunities are not readily accessible or available. Also, tourism is comparably less developed. Therefore, dependence on marine resources for subsistence is typically high and it is not surprising that more fishers reportedly catch sharks intentionally in the Eastern division compared to other divisions. But certain regions within the Eastern division (*e.g.*, Lau Group) were under-sampled, hampering a comprehensive analysis of the whole division.

The diverse Western division consists of both remote villages and economic relevant regions for tourism and international trade. The Western division appeared as a potential hotspot for artisanal shark fisheries, a pattern which was also observed in a previous survey [22]. Data from the current study indicate that proximity to markets in Viti Levu's north-west facilitates the sale of shark products, and selling shark carcasses along the roadside is common practice among villagers (KG personal observation). In the Northern division, artisanal shark catches and utilisation occur more commonly than in the Central and less than in the Western divisions. This division is home to the traditional worship of the shark god *Dakuwaqa*. It was previously assumed that due to traditional beliefs, catching sharks was taboo (*i.e.*, fishing not allowed). Although some primarily older fishers respect the traditional taboo, assuming that cultural beliefs nowadays still prevent a marine resource from being utilised is misleading.

4.3 Catch composition

With the exception of the shortfin mako (*Isurus oxyrinchus*), all the other shark species reported in a previous survey [22] were confirmed in this study. In addition, this study confirmed that the blacktip shark is caught in Fiji's shark fisheries. Whitetip reef, blacktip reef and bull sharks numerically dominated fishers' reports. Compared to a previous survey, fewer fishers reported to catch blacktip reef sharks (34.3% this study *vs*. 54.4% [22]). Given that this shark is easy to identify and a common inshore and fairly resilient species [46], as fewer fishers in the current study reported catching this species, this ad hoc information may indicate stock depletion. However in this survey, study sites were different and more fishers associated to villages along major rivers were interviewed than in the previous study. The latter may also explain the prevalence of bull and hammerhead sharks in the Central and Northern division. The bull shark uses, like numerous other carcharhinids, shallow coastal areas including estuaries and riverine systems as nursery habitat [47-52]. Fiji's

largest such system, the Rewa River (Central division) is confirmed to offer such habitats [53] and the Dreketi River (Northern division) likely does so as well. Although the Western division has a large riverine system, the Sigatoka River, juvenile sharks were less common in catches reported from there. Fishers along this river stated that its topography has heavily changed due to landfalls, dredging and mining activities. While for example bull sharks were common 10 to 15 years ago, encounters and catches of those species along the Sigatoka River are reportedly rare nowadays. Crucially, given the present context,it is important to take into account the various stressors impacting different shark species and populations when devising management measures.

Availability of reliable data such as correct species identification is key to management measures. In a previous such survey, the majority of interviewed fishers identified species correctly [22]. Reports of wedgefishes (family Rhinidae) and sawfishes (family Pristidae) have been of special interest. The presence of *Rhynchobatus australiae* was confirmed from Fiji's inshore waters [22]. Seeto and Baldwin [54] reported green sawfish (*Pristis zijsron*) and *Pristis* spp. from Fiji based on the provenance of specimens held in several Australian ichthyology collections. Due to the lack of contemporary reports, *Pristis* spp. were deleted from the Fiji faunal record [55]. With the caveat that specimens identified by fishers as being sawfishes could not be confirmed with DNA barcoding, if indeed species from this family are caught in Fiji, this would represent a 3000 km eastwards range extension [56, 57]. Given the species' conservation status, follow-up studies concerning the occurrence of sawfishes in Fiji are recommended.

4.4 Management implications

This study shows that elasmobranchs, including species with an IUCN conservation status ranging from Vulnerable to Critically Endangered, are a common part of Fiji's artisanal and subsistence fisheries. The focus on species specific mitigation measures (that allow elasmobranchs which face an elevated risk of extinction) to recover is paramount. A first step would require an amendment of the Fiji Fisheries Act (Laws of Fiji, Chapter 158) to ban sawfishes, wedgefishes, hammerhead, zebra, tawny nurse and silvertip sharks from being harvested. However, achieving a management-induced reduction in catch is reactive only and far from simple [58]. Management is ultimately about regulating the action of people, and associated human reactions have to be understood. In this study, fishers seemed to be largely unaware of sharks' vulnerability to overexploitation or they blamed foreign high-seas fleets for depleted shark and undersized fish stocks. In addition, sharks were seen as dangerous animals or simply as important additional food source and were of

little importance to many fishers. Together with the low socio-economic status of some fishing communities, these attitudes can pose a serious dilemma for management and/or lead to ignorance of measures.

The capture of juvenile sharks reported in this study is of special concern. Many elasmobranch species display long-term site fidelity including philopatric behaviour to shallow estuarine regions [50, 59, 60] where small-scale fishing pressure can be high. Monitoring catches of juvenile elasmobranchs around the main Fijian rivers should therefore be a priority. Furthermore, a strict enforcement of the existing gillnet ban in rivers and estuaries is strongly recommended. The most promising management approach to reduce the fishing mortality of juveniles is, however, to give critical habitats a protected area status including core zones where fishing is not allowed. Core zones should be monitored strictly to prevent illegal fishing and information about prohibitions, protections and enforcement has to be sent to community leaders as otherwise measures will not result in any protection for elasmobranch populations. To avoid negative consequences on the livelihood of those that fish for subsistence, uses of offshore resources could help maintain future food security [61] while fishers could also be trained and employed temporarily as inshore fish wardens through more efficient use of public funds. One limitation of protecting critical habitats is that sharks might only indirectly benefit from this measure. Therefore, any reactive prohibition needs to be developed with a proactive national recovery plan.

5. Conclusions

This study identified socio-economic drivers and fishers' attitudes towards sharks in Fiji's small-scale shark fisheries. It highlighted the opportunistic nature of the fisheries that affect multiple endangered inshore shark species and underpinned the fact that socio-economic factors must be analysed to fully understand shark fisheries. The research described here does not attempt to cover all aspects of Fiji's small-scale fisheries but rather focuses on a more detailed characterisation of the country's shark fisheries. The method used in this study is simple and enables an understanding of the drivers and attitudes to elasmobranch utilisation under a variety of circumstances. This methodology can be further applied to other Pacific Island countries to understand shark catches in small-scale fisheries in a Pacific-wide context. Additional scrutiny especially in biological data, species composition, CPUE and market surveys would assist the overall description of the system and complement the previous work describing Fiji's small-scale shark fisheries. Despite the inherent complexity of fishing communities, exploring alternative pathways for fishers to reach economic independence could help reduce market driven exploitation of a limited resource. In the present scenario, and coupled with

Fiji's voluntary commitment during the 2017 United Nations Ocean Conference to the conservation of all elasmobranchs within its territorial waters by 2020, the need for area closures, strict enforcement of the existing fisheries policies and for improved national measures for elasmobranchs with an elevated extinction risk is required.

Acknowledgements

We are grateful to Anaseini Ledua for her support, advice and translation - without her this research would not have been possible. We thank all fishers for attending the survey, Ian Campbell (Shark Conservation Programme, WWF-Fiji) and Mike Neumann (Beqa Adventure Divers) for their continued advice and support during the project. This work was supported by The University of the South Pacific, Strategic Research Themes Program for Research and Innovation (Grant No. SRT/ F1006-R1001-71502-663 to CR and SP). KG was supported by Ausbildungs-Stiftung fuer den Kanton Schwyz und die Bezirke See und Gaster and by the Pacific Scholarship for Excellence in Research & Innovation of The University of the South Pacific.

References

[1] E. Gilman, S. Clarke, N. Brothers, J. Alfaro-Shigueto, J. Mandelman, J. Mangel, S. Petersen, S. Piovano, N. Thomson, P. Dalzell, Shark interactions in pelagic longline fisheries, Marine Policy 32(1) (2008) 1-18.
[2] J.K. Baum, R.A. Myers, D.G. Kehler, B. Worm, S.J. Harley, P.A. Doherty, Collapse and conservation of shark populations in the Northwest Atlantic, Science 299(5605) (2003) 389-392.
[3] J. Fischer, K. Erikstein, B. D'Offay, S. Guggisberg, M. Barone, Review of the Implementation of the International Plan of Action for the Conservation and Management of Sharks, FAO2013.
[4] Convention on International Trade of Endangered Species of Wild Fauna and Flora, Sharks and manta rays. https://cites.org/eng/prog/shark. (Accessed 3 May 2018).
[5] N.K. Dulvy, S.L. Fowler, J.A. Musick, R.D. Cavanagh, P.M. Kyne, L.R. Harrison, J.K. Carlson, L.N. Davidson, S.V. Fordham, M.P. Francis, Extinction risk and conservation of the world's sharks and rays, Elife 3 (2014).
[6] N.K. Dulvy, J.K. Baum, S. Clarke, L.J. Compagno, E. Cortés, A. Domingo, S. Fordham, S. Fowler, M.P. Francis, C. Gibson, You can swim but you can't hide: the global status and conservation of oceanic pelagic sharks and rays, Aquatic Conservation: Marine and Freshwater Ecosystems 18(5) (2008) 459-482.
[7] W.D. Robbins, M. Hisano, S.R. Connolly, J.H. Choat, Ongoing collapse of coral-reef shark populations, Current Biology 16(23) (2006) 2314-2319.
[8] S. Blaber, C. Dichmont, W. White, R. Buckworth, L. Sadiyah, B. Iskandar, S. Nurhakim, R. Pillans, R. Andamari, Elasmobranchs in southern Indonesian fisheries: the fisheries, the status of the stocks and management options, Reviews in Fish Biology and Fisheries 19(3) (2009) 367-391.
[9] L. Robinson, W. Sauer, A first description of the artisanal shark fishery in northern Madagascar: implications for management, African Journal of Marine Science 35(1) (2013) 9-15.
[10] J.J. Bizzarro, W.D. Smith, R.E. Hueter, C.J. Villavicencio–Garayzar, Activities and catch composition of artisanal elasmobranch fishing sites on the eastern coast of Baja California Sur, Mexico, Bulletin, Southern California Academy of Sciences 108(3) (2009) 137-151.

[11] A.J. Temple, J.J. Kiszka, S.M. Stead, N. Wambiji, A. Brito, C.N. Poonian, O.A. Amir, N. Jiddawi, S.T. Fennessy, S. Pérez-Jorge, Marine megafauna interactions with small-scale fisheries in the southwestern Indian Ocean: a review of status and challenges for research and management, Reviews in Fish Biology and Fisheries (2017) 1-27.
[12] F. Arreguin-Sanchez, M. Zetina-Rejón, S. Manickchand-Heileman, M. Ramırez-Rodrıguez, L. Vidal, Simulated response to harvesting strategies in an exploited ecosystem in the southwestern Gulf of Mexico, Ecological Modelling 172(2-4) (2004) 421-432.
[13] S. Salas, R. Chuenpagdee, J.C. Seijo, A. Charles, Challenges in the assessment and management of small-scale fisheries in Latin America and the Caribbean, Fisheries Research 87(1) (2007) 5-16.
[14] J. Moore, T. Cox, R. Lewison, A. Read, R. Bjorkland, S. McDonald, L. Crowder, E. Aruna, I. Ayissi, P. Espeut, An interview-based approach to assess marine mammal and sea turtle captures in artisanal fisheries, Biological Conservation 143(3) (2010) 795-805.
[15] R. Chuenpagdee, L. Liguori, M.L. Palomares, D. Pauly, Bottom-up, global estimates of small-scale marine fisheries catches, Fisheries Centre Research Reports, Vol 14, Nr. 8,(2006).
[16] J.K. Pinnegar, G.H. Engelhard, The 'shifting baseline'phenomenon: a global perspective, Reviews in Fish Biology and Fisheries 18(1) (2008) 1-16.
[17] L.C. Teh, L.S. Teh, B. Starkhouse, U.R. Sumaila, An overview of socio-economic and ecological perspectives of Fiji's inshore reef fisheries, Marine Policy 33(5) (2009) 807-817.
[18] M. Juncker, M. Robert, E. Clua, Coastal Shark Fisheries in the Pacific–a brief overview of current knowledge, Coral Reef Initiatives for the Pacific, SPC, Noumea, New Caledonia (2006).
[19] S. Vieira, J. Kinch, W. White, L. Yaman, Artisanal shark fishing in the Louisiade Archipelago, Papua New Guinea: Socio-economic characteristics and management options, Ocean & coastal management 137 (2017) 43-56.
[20] S. Foale, Sharks, sea slugs and skirmishes: managing marine and agricultural resources on small, overpopulated islands in Milne Bay, PNG, Working Paper. Australian National University, Canberra, Australia (2005).
[21] L. Teh, J. Kinch, K. Zylich, D. Zeller, Reconstructing Papua New Guinea's Marine Fisheries Catch, 1950–2010, Fisheries Centre Working Paper Series# 2014 9 (2014).
[22] K.B. Glaus, I. Adrian-Kalchhauser, P. Burkhardt-Holm, W.T. White, J.M. Brunnschweiler, Characteristics of the shark fisheries of Fiji, Scientific reports 5 (2015) 17556.
[23] S. Vieira, L. Yaman, A summary of the available data on shark fishing activities in Papua New Guinea, Unpublished Draft Paper for ACIAR Project: Sustainable Management of the Shark Resources in Papua New Guinea: Socioeconomic and Biological Characteristics (January) (2015).
[24] T. Hand, D. Davis, R. Gillett, Fisheries sector review: Republic of the Fiji Islands, Asian Development Bank (2005).
[25] S. Piovano, E. Gilman, Elasmobranch captures in the Fijian pelagic longline fishery, Aquatic Conservation: Marine and Freshwater Ecosystems 27(2) (2017) 381-393.
[26] K. Swamy, Shark fisheries in Fiji: their management and future issues of concern., in: S. R (Ed.), Case studies of the management of elasmobranch fisheries., FAO Fisheries Technical Paper, Rome, Italy, 1999, pp. 580-607.
[27] E.J. Techera, Fishing, finning and tourism: trends in Pacific shark conservation and management, The International Journal of Marine and Coastal Law 27(3) (2012) 597-621.
[28] S. Harper, K. Zylich, L. Boonzaier, F. Le Manach, D. Pauly, D. Zeller, Fisheries catch reconstructions: islands, part III, Fisheries Centre Research Report, Vol 20, Nr. 5. (2012).
[29] Parliament of the Republic of Fiji, Endangered and Protected Species Act 2002, 2017. http://www.fiji.gov.fj/getattachment/1ab8df05-da24-41a4-96e5-f49120e327b0/Act-10---Endangered-and-Protected-Species-(Amendme.aspx. (Accessed 3 May 2018).
[30] J.M. Brunnschweiler, J.L. Earle, A contribution to marine life conservation efforts in the South Pacific: The Shark Reef Marine Reserve, Fiji, Cybium 30(4) (2006) 133-139.
[31] J.M. Brunnschweiler, The Shark Reef Marine Reserve: a marine tourism project in Fiji involving local communities, Journal of Sustainable Tourism 18(1) (2010) 29-42.
[32] J.D. Bell, J.E. Johnson, A.J. Hobday, Vulnerability of tropical Pacific fisheries and aquaculture to climate change, SPC FAME Digital Library2011.

[33] H.R. Bernard, Research methods in anthropology: Qualitative and quantitative approaches, Rowman & Littlefield2017.
[34] I. Boxill, C.M. Chambers, E. Wint, Introduction to social research: With applications to the Caribbean, University of The West Indies Press1997.
[35] G. Guest, A. Bunce, L. Johnson, How many interviews are enough? An experiment with data saturation and variability, Field methods 18(1) (2006) 59-82.
[36] M. Crouch, H. McKenzie, The logic of small samples in interview-based qualitative research, Social science information 45(4) (2006) 483-499.
[37] S. Piovano, G. Basciano, Y. Swimmer, C. Giacoma, Evaluation of a bycatch reduction technology by fishermen: A case study from Sicily, Marine Policy 36(1) (2012) 272-277.
[38] D.D. Heckathorn, Respondent-driven sampling: a new approach to the study of hidden populations, Social problems 44(2) (1997) 174-199.
[39] R. RDevelopment CORE TEAM, R: A language and environment for statistical computing, R foundation for statistical computing Vienna, Austria, 2008.
[40] R.A. Becker, A.R. Wilks, R. Brownrigg, T.P. Minka, maps: Draw geographical maps, R package version 2 (2013).
[41] R. Becker, A. Wilks, Brownrigg R. mapdata: Extra Map Databases. R package version 2.2–6, 2016.
[42] M.A. Deckmyn, Package 'mapproj', (2017).
[43] The IUCN Red List of Threatened Species, IUCN Red List, 2017. www.iucnredlist.org. (Accessed 3 May 2018).
[44] L. Lacanivalu, Beche-de-mer On The Radar Again, 2018. http://fijisun.com.fj/2018/03/17/beche-de-mer-on-the-radar-again/. (Accessed 30 April 2018).
[45] J.F. Caddy, R. Mahon, Reference points for fisheries management, Food and Agriculture Organization of the United Nations Rome1995.
[46] J. Mourier, S. Mills, S. Planes, Population structure, spatial distribution and life-history traits of blacktip reef sharks Carcharhinus melanopterus, Journal of fish biology 82(3) (2013) 979-993.
[47] M.R. Heupel, B.G. Yeiser, A.B. Collins, L. Ortega, C.A. Simpfendorfer, Long-term presence and movement patterns of juvenile bull sharks, Carcharhinus leucas, in an estuarine river system, Marine and Freshwater Research 61(1) (2010) 1-10.
[48] J.K. Carlson, M.M. Ribera, C.L. Conrath, M.R. Heupel, G.H. Burgess, Habitat use and movement patterns of bull sharks Carcharhinus leucas determined using pop-up satellite archival tags, Journal of Fish Biology 77(3) (2010) 661-675.
[49] T.H. Curtis, D.H. Adams, G.H. Burgess, Seasonal Distribution and Habitat Associations of Bull Sharks in the Indian River Lagoon, Florida: A 30-Year Synthesis, Transactions of the American Fisheries Society 140(5) (2011) 1213-1226.
[50] B. Tillett, M. Meekan, I. Field, D. Thorburn, J. Ovenden, Evidence for reproductive philopatry in the bull shark Carcharhinus leucas, Journal of Fish Biology 80(6) (2012) 2140-2158.
[51] B. Yeiser, M. Heupel, C. Simpfendorfer, Occurrence, home range and movement patterns of juvenile bull (Carcharhinus leucas) and lemon (Negaprion brevirostris) sharks within a Florida estuary, Marine and Freshwater Research 59(6) (2008) 489-501.
[52] J.I. Castro, The shark nursery of Bulls Bay, South Carolina, with a review of the shark nurseries of the southeastern coast of the United States, The reproduction and development of sharks, skates, rays and ratfishes, Springer1993, pp. 37-48.
[53] A.D. Marie, C. Miller, C. Cawich, S. Piovano, C. Rico, Fisheries-independent surveys identify critical habitats for young scalloped hammerhead sharks (Sphyrna lewini) in the Rewa Delta, Fiji, Scientific reports 7(1) (2017) 17273.
[54] J. Seeto, W.J. Baldwin, A checklist of the fishes of Fiji and a bibliography of Fijian fish, Division of Marine Studies, School of Islands and Oceans, Faculty of Science, Technology & Environment, The University of the South Pacific, Suva Campus2010.
[55] C. Duffy, J. Seeto, T. Trnski, Review of records of sawfishes (Chondrichthyes: Pristidae) from Fiji, with deletion of Pristis zijsron Bleeker, 1851 and Pristis sp. from the fauna, Zootaxa 3115 (2011) 65-67.

[56] S.C. Peverell, Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on sawfish ecology, Environmental Biology of Fishes 73(4) (2005) 391-402.
[57] J. Stevens, R. McAuley, C. Simpfendorfer, R. Pillans, Spatial distribution and habitat utilisation of sawfish (Pristis spp) in relation to fishing in northern Australia, A report to Department of the Environment, Water, Heritage and the Arts 31 (2008).
[58] S. Vieira, M. Tull, Restricting fishing: a socio-economic impact assessment of artisanal shark and ray fishing in Cilacap, Bulletin of Indonesian Economic Studies 44(2) (2008) 263-288.
[59] N.M. Whitney, R.L. Pyle, K.N. Holland, J.T. Barcz, Movements, reproductive seasonality, and fisheries interactions in the whitetip reef shark (Triaenodon obesus) from community-contributed photographs, Environmental Biology of Fishes 93(1) (2012) 121-136.
[60] A. Chin, A. Tobin, M. Heupel, C. Simpfendorfer, Population structure and residency patterns of the blacktip reef shark Carcharhinus melanopterus in turbid coastal environments, Journal of Fish Biology 82(4) (2013) 1192-1210.
[61] J.D. Bell, M. Kronen, A. Vunisea, W.J. Nash, G. Keeble, A. Demmke, S. Pontifex, S. Andréfouët, Planning the use of fish for food security in the Pacific, Marine Policy 33(1) (2009) 64-76.