sustainable environment, education & development

A Report for

COVID-19 RAPID RESPONSE

Analysis of Elasmobranch Participatory Monitoring Programme Data 2019-2021

Jessica Savage

May - 2021

1 Summary

Madagascar is a hotspot for shark and ray biodiversity with elasmobranchs exploited heavily in both industrial and small-scale fisheries. In the southeast region, small-scale fishing is a particularly important livelihood for coastal communities, with spiny lobsters the main target species. Small-scale elasmobranch fishing is less prevalent in the southeast compared to other regions although elasmobranchs are caught within the wider finfish fishery. Empirical data and local fisher knowledge suggest significant declines in lobster stock, with concerns that further decreases in lobster stock could increase fishing pressure on elasmobranchs. To increase understanding of the diversity of elasmobranch species caught in the wider fishery, a participatory monitoring programme was conducted in three small-scale fishing communities in southeast Madagascar from September 2019 to February 2020 and January to March 2021. A total of 730 landed elasmobranchs were recorded, consisting of at least 30 taxa with guitarfish Acroteriobatus sp. and Rhinobatus sp., and scalloped hammerheads *Sphyrna lewini* frequently landed. The existence of markets for elasmobranch meat and shark fins and the high rate of removal of guitarfish and juvenile scalloped hammerheads is of conservation concern.

Recommended citation:

Savage, J. (2021). Characterising the Elodrato and Sainte Luce Elasmobranch Fisheries. A report for the Darwin Initiative. SEED Madagascar.

2 Table of Contents

3 Introduction

Madagascar is a hotspot for shark and ray biodiversity with an estimated 123 species found within its waters (Baker-Médard & Faber, 2020; Cripps, Harris, Humber, Harding, & Thomas, 2015; Humber, Andriamahefazafy, Godley, & Broderick, 2015). Elasmobranchs (sharks, rays and skates) are heavily exploited in both industrial and small-scale fisheries throughout Madagascar (Cripps et al., 2015). In the southeast, coastal communities are highly reliant on marine resources for livelihoods, as few alternatives exist, and poverty is widespread (Healy, 2018; Savage, 2020). Currently, small-scale fisheries in this region predominantly target spiny lobsters. Although elasmobranchs are exploited in the southeast, small-scale elasmobranch fishing is not as prevalent as in other areas of Madagascar, such as the west coast (Cripps et al., 2015). However, both limited empirical data and local fisher knowledge suggest significant declines in the lobster stock (Long, 2017; Sabatini, Salley, & Ramanamanjato, 2008). Elasmobranchs are caught within the wider fishery, and there are concerns that further declines in lobster stock could result in increased fishing pressure on elasmobranchs.

To improve the sustainability of the lobster fishery, SEED Madagascar (SEED) initiated Project Oratsimba, a community-based fisheries management project. Project Oratsimba aims to secure lobster fishing as a livelihood, which in turn will mitigate the threats posed to biodiversity, including elasmobranchs, caught within the wider fishery. However, little is known about the diversity of elasmobranchs exploited in the southeast. To support lobster fisheries management, it is critical to understand the diversity of elasmobranchs caught within the wider fishery. This report presents the results of an elasmobranch participatory monitoring programme conducted in three small-scale fishing communities in southeast Madagascar between September 2019 to February 2020 and January to March 2021.

4 Methods

This study was conducted in the small-scale fishing communities of Itapera (pilot only, September 2019 - February 2020), Sainte Luce and Elodrato (pilot September 2019 - February 2020 and second period January - March 2021) using mobile data collection (Open Data Kit software). In each community, a data collector(s) was employed and received training on smartphone usage, interacting with fishers and collecting biological data. Prior to the pilot, in April 2019, Blue Ventures provided a series of theoretical and practical training workshops. For the second period of data collection, SEED delivered similar workshops. Regular reviews with data collectors were conducted throughout both data collection periods. Commonly encountered issues included: not saving the survey form following completion, completing multiple survey forms for the same survey day, and not collecting biological data correctly. On two occasions during the pilot, significant amounts of data were lost following accidental factory resets of smartphones. Fewer problems were encountered during the second period of data collection.

The survey was designed to collect biological data on: i) species (using photographs); ii) total length (cm) (TL, the length from the tip of the snout to the end of the tail measured to the nearest cm) for sharks and guitarfish (a type of ray), or disc width (cm) (length from wingtip to wingtip measured to the nearest cm) for non-guitarfish rays); and iii) sex (in situ during the second period, analysis of images during the pilot). The survey also collected data on the local species name, presence and absence of fins, and expected price at first point of sale for meat and fins. During the second period data was also collected on whether individuals were targeted or incidentally caught. Data collectors conducted the surveys at the landing sites and aimed to collect data 19 days per month. However, the actual number of surveys conducted depended on phone battery life and skill level of data collectors during the pilot, and the weather during both periods of data collection. Data was retrieved from phones monthly during office visits, as mobile signal in the three communities is unreliable. Individual elasmobranchs were identified to the lowest feasible taxonomic rank. For identification validation, a subset of photos of 30 individuals were sent to experts. For taxa commonly landed, recorded TL was compared to TL at maturity.

5 Results

Over the two data collection periods, a total of 730 elasmobranch landings were recorded, 430 in the first period and 300 in the second period. 51.9% of recorded landings were rays and 48.1% were sharks identified as at least 30 taxa (Table 1). Guitarfish Acroteriobatus sp. and Rhinobatos sp. were the most commonly landed, accounting for 41.2% of total landings followed by scalloped hammerheads *Sphyrna lewini* accounting for 23.9% of total landings (Figure 1).

Table 1. Provisional taxonomic identification of elasmobranchs landed between September 2019 – February 2020 and January – March 2021 in order of frequency (n=730) with IUCN Red List of Threatened Species category (constrained to the Western Indian Ocean where identification was to genus level) and CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix listings. For IUCN Red List categories, the IUCN abbreviations were used: NE for Not Evaluated, DD for Data Deficient, LC for Least Concern, NT for Near Threatened, VU for Vulnerable, EN for Endangered and CR for Critically Endangered.

Individuals recorded	**Latin name(s)**	**Common names(s)**		**ICUN Red List category**	**CITES Appendix**
		Malagasy	**English**		
308	Acroteriobatus sp. Rhinobatos sp.	Lafitany	Guitarfish	DD and NT [1] DD, NT, VU, EN, CR [1]	
174	*Sphyrna lewini*	Antsatsa satraha	Scalloped hammerhead	CR [2]	II[3]
58	*Loxodon macrorhinus*	Atsantsa hejandava, Antsantsa tsingovo, Maranify	Sliteye shark	LC [4]	
24	Mustelus	Antsantsa mety, Antsantsa oviovy, Maranify, Tsingovo		LC, NT, VU, EN [1]	
18	*Rhinoptera javanica*	Fay mena, Fay mboro, Fay vorondreo,	Javanese cownose Ray	VU [5]	
16	Carcharhinus sp.	Antsantsa boriloa, Bevombotra, Henjandava, Mainty lamosy, Mainty tehoka	Requiem sharks	DD, LC, NT, VU, EN, CR [1]	
14	*Galeocerdo cuvier*	Antsantsa vasiandry, Antsantsa sambotsira, Zanabiby	Tiger shark	NT [6]	
14	Carcarhiniformes	Antsantsa boriloha, Antsantsa oviovy, Antsantsa maity teoky, Tsingovo	Ground sharks		
13	Himantura sp.	Fay ravina, Fay sokotsy	Whipray	VU [1]	
12	*Carcharhinus plumbeus*	Bevombotra	Sandbar shark	VU [7]	
11	*Chiloscyllium cf. caerulopunctatum*	Antsantsa votsira	Bamboo sp. possibly bluespotted bamboo shark	DD, NT, VU [1] NE [1]	
10	*Carcharhinus brevipinna* or *Carcharhinus limbatus*	Antsanta boriloha, Antsantsa maity teoky,	Spinner shark or Blacktip shark	VU [8] NT [9]	
8	Mobula sp. (excluding *Mobula alfredi* and *Mobula birostri*)	Fay roaloha	Devil rays (excluding Manta rays)	EN [1]	II[3]
8	Dasyatidae	Fay boka,Fay ravina	Whiptail Stingrays		
7	Torpedinidae	Fay tsitotsy	Electric rays		
6	*Taeniurops meyeni*	Fay ravy, Fay ravina	Blotched Fantail Ray	VU [10]	

Table 1. (continued)

Individuals recorded	Latin name(s)	Common names(s)		ICUN Red List category	CITES Appendix
		Malagasy	English		
5	*Carcharhinus falciformis*	Antsanta boriloha, Antsantsa maity teoky, Mainty lamosy,	Silky shark	VU [11]	II[3]
4	*Aetobatus ocellatus*	Fay Voro	Spotted Eagle Ray	VU [12]	
4	*Mustelus mosis*	Tsingovo	Arabian Smoothound	NT [13]	
3	*Neotrygon kuhlii*	Fay ravy	Kuhl's maskray	DD [14]	
2	*Carcharhinus brevipinna*	Atsantsa maity teoky	Spinner shark	VU [15]	
2	*Carcharhinus leucas*	Atsantsa tsingovo, Atsantsa boriloha	Bull shark	NT [16]	
2	*Pateobatis jenkinsii*	Fay	Jenkins' Whipray	VU [17]	
1	*Carcharhinus obscurus*	Mainty lamosy,	Dusky Shark	EN [18]	
1	*Mobula alfredi*	Fay roaloha	Reef Manta Ray	VU [19]	II[3]
1	*Isurus oxyrinchus*	Antsantsa maitso	Shortfin Mako	EN [20]	II[3]
1	*Carcharhinus albimarginatus*	Bevombotra	Silvertip Shark	VU [21]	
1	Rhynchobatus sp.	Lafitany vontolo	Wedgefish	CR [1]	II[3]
1	*Sphyrna sp.*	Antsantsa satraha,	Hammerhead	VU, CR [1]	II[3]
1	Hemigalidae	Maranify	Weasel sharks		

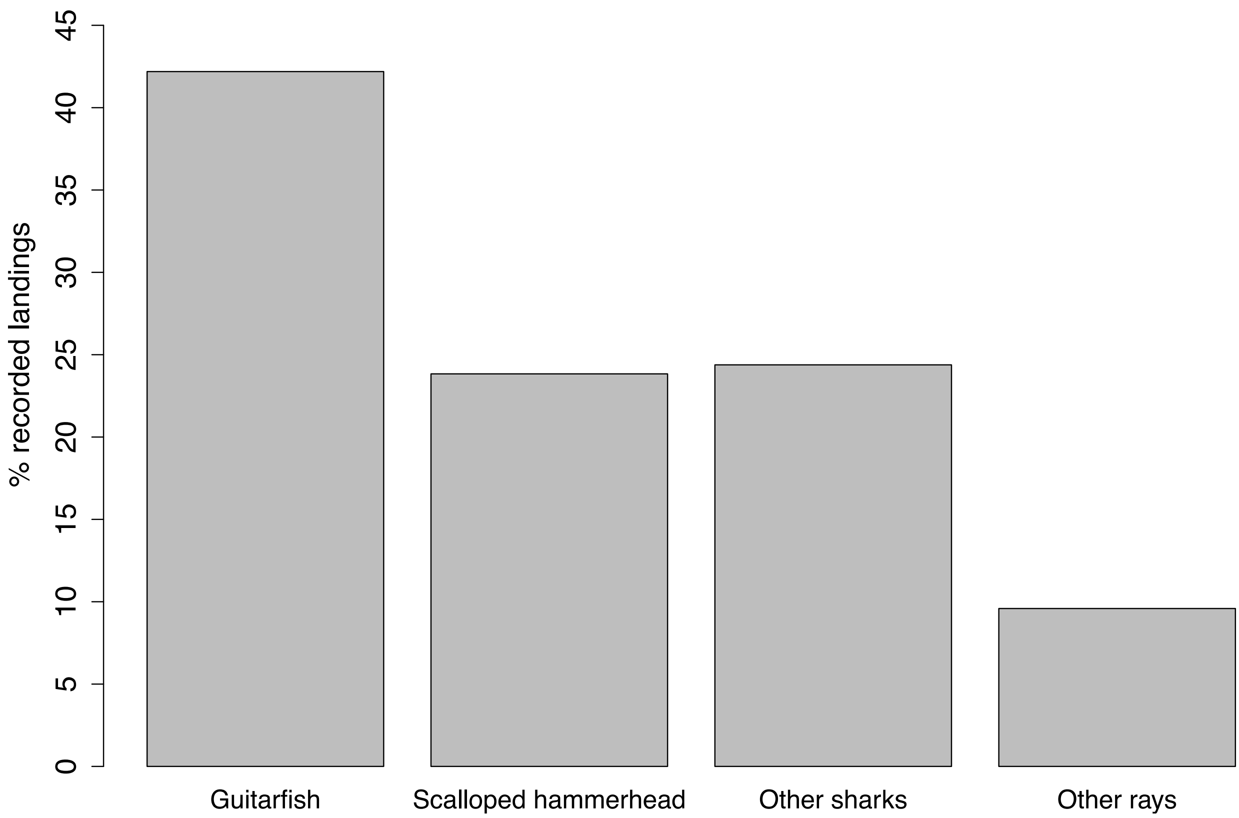

Figure 1. Composition of elasmobranchs landed between September 2019 - February 2020 and January - March 2021 (n=730).

[1]IUCN, 2021 [2]Rigby et al., 2019 [3]CITES, 2021 [4]Simpfendorfer & Stevens, 2003 [5] Dudley, Kyne, & White, 2006 [6]Ferreira & Simpfendorfer, 2019 [7]Musick et al., 2009 [8]Rigby et al., 2020 [9]Burgess & Branstetter, 2009 [10]Kyne & White, 2015 [11]Rigby, Sherman, Chin, & Simpfendorfer, 2017 [12]Kyne, Dudgeon, Ishihara, Dudley, & White, 2016 [13]Pollom et al., 2019 [14]Kyne & Finucci, 2018 [15]Rigby et al., 2020 [16]Simpfendorfer & Burgess, 2009 [17]Manjaji Matsumoto, Fahmi, & White, 2020 [18]Rigby, Barreto, et al., 2019 [19]Marshall et al., 2019 [20]Rigby, Barreto, Carlson, Fernando, Fordham, Francis, Jabado, et al., 2019 [21] Espinoza, González-Medina, Dulvy, & Pillans, 2016

5.1 Guitarfish

45.8% of guitarfish landed were female and 54.2% were male (n=299). The mean TL for females was 87 cm (range: 25 – 122 cm, n= 135) and for males 85 cm (range: 22 – 145 cm, n=162). To compare the TL of guitarfish landed to TL at maturity, two candidate species *Acroteriobatus leucospilus* (TL at maturity: male and female 56 cm) and *Acroteriobatus zanzibarensis* (TL at maturity: male 64 cm, female unknown) were used (Last et al., 2016). The majority of both female and male guitarfish landed were above the TL at maturity for both, *A. leucospilus*, 81.0% of females and 83.3% of males, and *A. zanzibarensis,* 77.4% of females and 65.4% of males (Figure 2). These data therefore suggest that the majority of guitarfish landed were mature.

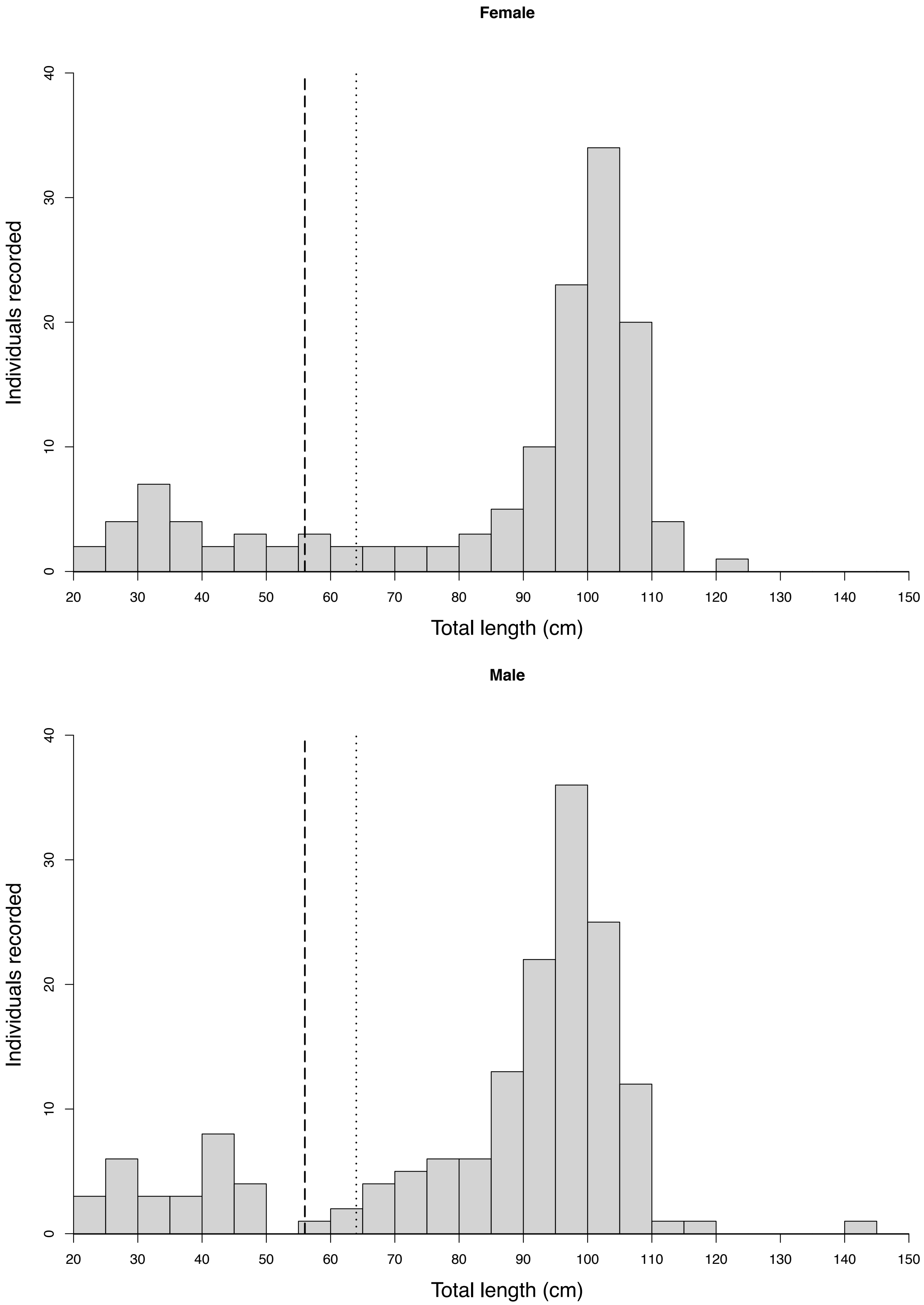

Figure 2. Length (TL) frequency distribution for female (n= 135) and male (n= 162) guitarfish (Acroteriobatus sp. and Rhinobatus sp.) landed between September 2019 – February 2020 and January – March 2021 compared to TL at maturity for two candidate species *A. leucospilus* (dashed line) and *A. zanzibarensis* (dotted line)(Last et al., 2016).

5.2 Scalloped Hammerheads

48.5% of scalloped hammerheads landed were female and 51.5% were male (n=174). The median total length for females was 52 cm (range: 45 – 178 cm, n=82) and 52 cm for males (range: 35 – 240 cm, n=87). The majority of both female and male scalloped hammerheads landed, 100.0% and 93.1% respectively, were below the minimum TL at maturity (212 cm for females, 140 cm for males) and were juvenile (Compagno, 1984). Of those juveniles, 85.2% (n=169) were within the reported range of TL at birth (minimum: 42 cm, maximum: 55 cm) (Compagno, 1984) (Figure 3). Elsewhere it is reported that the mean pre-caudal length, the length from the tip of the snout to the beginning of the tail, (i.e., less than the TL) for scalloped hammerheads at one year of age is 50.3 cm (Duncan & Holland, 2006). These data therefore suggest that a high proportion of scalloped hammerheads landed are young juveniles, likely zero to one years old.

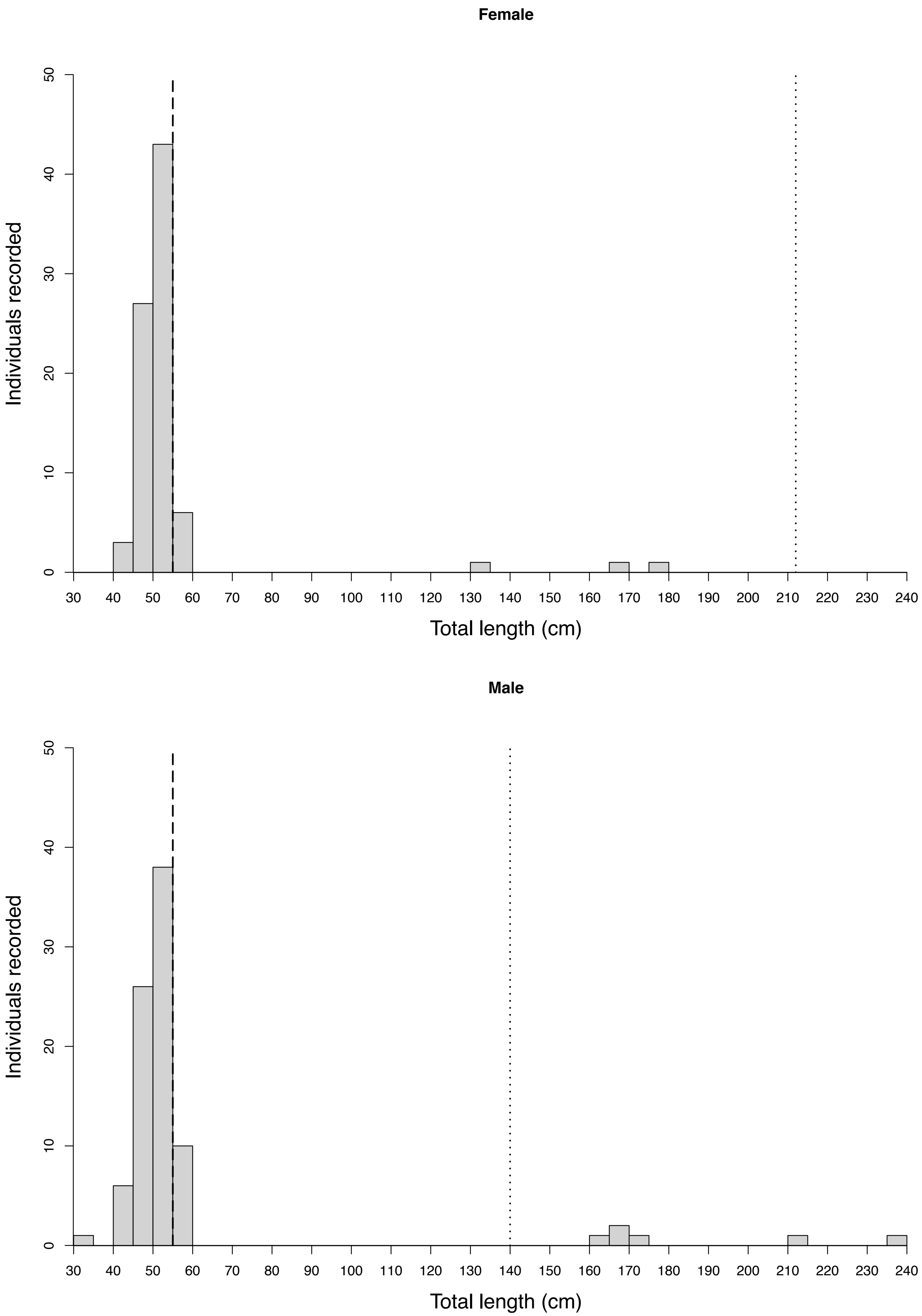

Figure 3. Length (TL) frequency distribution for female (n=82) and male (n=87) scalloped hammerheads landed between September 2019 - February 2020 and January - March 2021 compared to maximum TL at birth (dashed line) and minimum TL at maturity (dotted line) (Compagno, 1984).

5.1 Incidental Capture

The majority of all elasmobranchs landed were caught incidentally, either when fishers were targeting other finfish species or when fishers had no pre-determined target species. 18.4% of guitarfish, 35.6% of scalloped hammerheads, 41.7% of other shark species, and 31.3% of non-guitarfish rays were identified by fishers as deliberately targeted (Figure 4). This data was not collected during the first period of data collection.

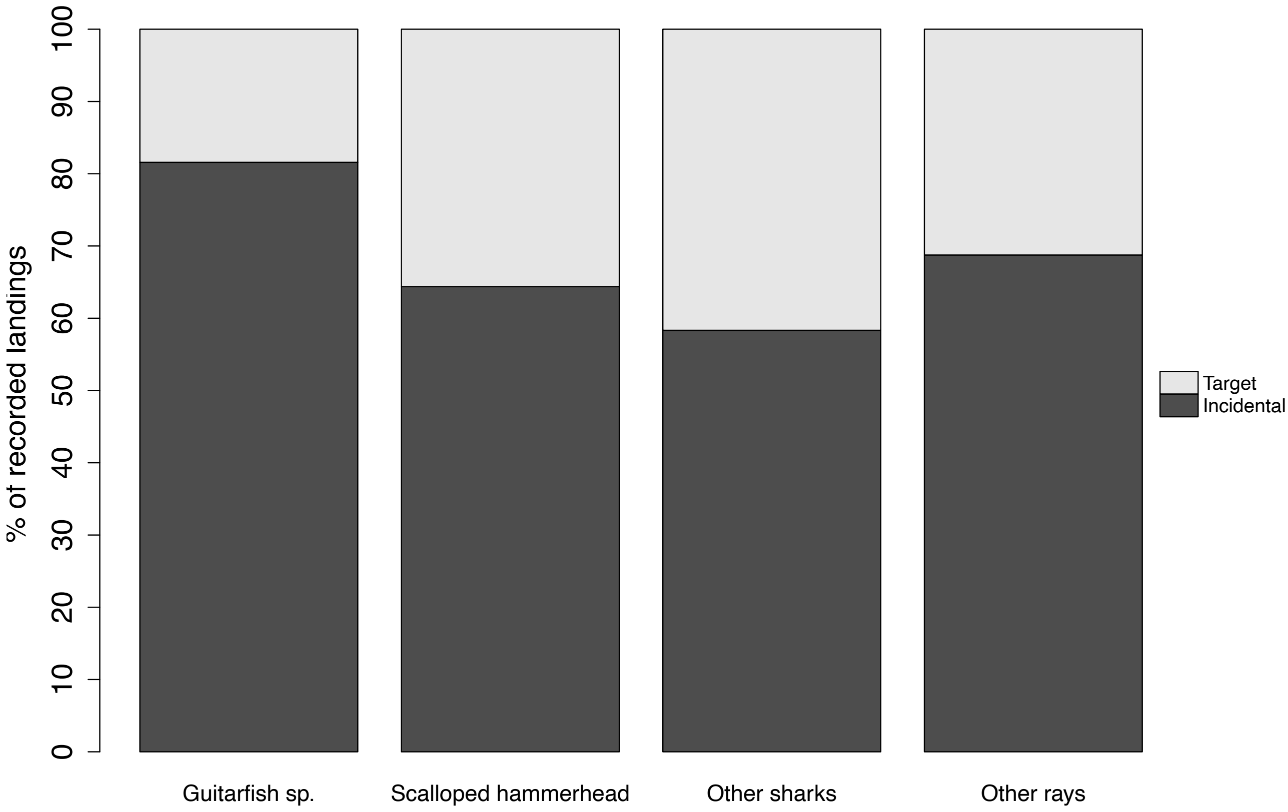

Figure 4. Proportion of landed elasmobranchs targeted and caught incidentally between January and March 2021 (n=300).

5.2 Fin Trade

A small proportion of sharks landed, 19.7%, had or would have their fins removed for sale from 12 taxa identified in Table 1: Arabian smoothounds, dusky sharks, sandbar sharks, scalloped hammerheads, short fin mako sharks, silky sharks, silvertip sharks, smoothound sharks, spinner sharks, spinner or black tip sharks, and tiger sharks. Expected prices for fins at the first point of sale ranged from 2,000 MGA (US$0.53) for a 55 cm unidentified ground shark (carcharhiniforme), to 250,000 MGA (US$66.67) for a 311 cm silky shark, and the median was 100,000 MGA (US$26.67, n=33). Although scalloped hammerheads were the most commonly landed shark species, the minimum reported total length of a scalloped hammerhead with fins removed was 132 cm, and only 4.7% had or would have their fins removed for sale.

Very few guitarfish, 1.6%, had or would have the fins removed for sale. Although other studies in Madagascar have demonstrated the higher value obtained by fishers for guitarfish fins compared to shark fins (see Cripps et al., 2015) the data suggests that there is less demand for guitarfish fins in the southeast. Although the exact reason for this is unclear, possible explanations include landing guitarfish of an insufficient size or collector preference for purchasing shark fins. There was no evidence that non-guitarfish ray fins were sold and there was also no evidence of a mobula ray gill trade.

5.3 Meat Trade

96.9% of sharks, 99.4% of guitarfish and 93.0% of non-guitarfish rays were identified as being sold for their meat whilst 11.4% of sharks, 0.3% of guitarfish and 0.0% of non-guitarfish rays were identified for personal consumption. The higher proportion of elasmobranchs identified as being landed for meat for local trade compared to fins and meat for personal consumption suggests that elasmobranchs are landed primarily for meat, which is supported by data from fisher interviews (see Savage, 2021). The median price at the first point of sale for meat (whole body) was 3,000 MGA ($.80, range: 1,000 – 250,000 MGA, n = 340) for sharks, was 6,000 MGA ($1.60, range: 1,000 – 35,000 MGA, n=305) and 25,000 MGA ($6.67, range: 1,000 – 150,000 MGA, n=71) for non-guitarfish rays.

6 Discussion

This study has provided an insight into the diversity of elasmobranchs caught in southeast Madagascar with at least 30 different taxa identified, including species threatened with extinction according to the IUCN Red List of Threatened Species and are protected under CITES. This study confirms that elasmobranchs are caught incidentally in the wider finfish fishery. Further studies should monitor elasmobranch fishing effort and improve on species identification. The existence of local markets for meat and export markets for shark fins drives exploitation, which is of conservation concern. This has likely compounded growing fishing effort due to the high reliance on marine resources for livelihoods and lack of suitable alternative livelihoods in this region. Legislation for elasmobranch fisheries in Madagascar is lacking and state capacity for monitoring and enforcement is limited, particularly in the southeast where the regional fisheries ministry does not have access to a functioning patrol boat (Baker-Médard & Faber, 2020; Long et al., 2019). Available data suggest declines in lobster stock, and if in the future the lobster fishery were to completely collapse, small-scale elasmobranch fishing effort may increase which is effectively unregulated across Madagascar (Cripps et al., 2015; Long et al., 2019; Sabatini et al., 2008).

Scalloped hammerheads are particularly vulnerable to overfishing due to their life history traits. They are slow growing, mature late, have a long gestation period and produce few offspring (IOTC, 2015; IOTC Secretariat, 2007). There are a number of possible explanations for the high number of juvenile scalloped hammerheads landed. The timing of this study may be aligned with life-history of this species. Life cycles stages of scalloped hammerheads are spatially segregated, with young juveniles occupying shallow inshore nursery grounds and older juveniles migrating offshore as they mature. Mature females then return to coastal areas for parturition (Clarke 1971, Coiraton and Amazcua 2020). Whilst it is known that the reproductive cycle of scalloped hammerheads is annual, the pupping season in Madagascar is unknown. However, in South Africa the pupping season is thought to occur in the summer months (i.e. January and December) which occurred during the pilot and immediately prior to the second data collection period (Miller et al., 2013). A longer study would detect if there is seasonality in the size-class structure of catch.

It is also worth noting that inshore habitats, including mangroves, are well established as pupping and nursery grounds for scalloped hammerheads (CMS, 2018; Zanella et al., 2016). Mangroves are sparsely distributed in southeast Madagascar with Sainte Luce - one of the three communities in which this study was conducted - being home to one of the larger and more intact areas of mangrove in the region (Moat & Smith, 2007). It may be that these inshore habitats targeted by fishers serve as important nursery and pupping grounds for juvenile sharks. Furthermore, the previous removal of larger adult sharks may have removed top-down pressure in the food-web, allowing the proliferation of smaller sharks in the absence of predation (van der Elst, 1979). The high number of scalloped hammerheads may also relate to fishing gear. Both handlines and gill nets are used widely in this fishery (Savage, 2021). Handlines may not be capable of (frequently) landing larger sharks, whilst scalloped hammerheads are known to be particularly vulnerable to gill nets (Gallagher & Klimley, 2018). These possible explanations are not mutually exclusive. Irrespective of the explanations above, a high rate of removal of Critically Endangered juvenile scalloped hammerheads is of conservation concern (Rigby, Dulvy, et al., 2019).

Little is known about guitarfish (family: Rhinobatidae), although they have been described as one of the most vulnerable families of elasmobranchs apart from sawfish (family: Pristidae) (Dulvy et al., 2014).Though it was not possible to identify guitarfish to species level, a common problem encountered when identifying guitarfish species, the guitarfish landed were thought to belong to the genera Acroteriobatus and Rhinobatos (Last et al., 2016; Moore, 2017). Of the seven species of Acroteriobatus listed on the IUCN Red List occurring in the Western Indian Ocean, three are threatened with extinction, two are Near Threatened, and two are Data Deficient (IUCN, 2021). Of the five species of Rhinobatos listed on the IUCN Red List occurring in the Western Indian Ocean, one is Near Threatened and the remainder are Data Deficient (IUCN, 2021). It is also possible that guitarfish landed may also belong to a currently undescribed Acroteriobatus species endemic to Madagascar (Weigmann et al. in press). Future studies should seek to confirm the species of guitarfish(es) landed, possibly through genetic analysis. The majority of guitarfish species inhabit coastal areas, a trait shared with sawfish, which are easily exploited by inshore fishers in southeast Madagascar (Moore, 2017). This makes the high rate of removal of guitarfish of possible conservation concern.

7 Acknowledgements

A special thanks must go to the community data collectors and fishers surveyed for participating in this study. Thanks must also go to Stephen D. Long for his support in methodological design and data analysis and interpretation, to Dave Van Beuningen, Rhett Bennet and David Ebert for their support in species identification and to Blue Ventures for training data collectors in mobile data collection. This study was funded by the UK Government through the Darwin Initiative.

8 References

Baker-Médard, M., & Faber, J. (2020). Fins and (Mis)fortunes: Managing shark populations for sustainability and food sovereignty. *Marine Policy*, *113*(February 2019). https://doi.org/10.1016/j.marpol.2019.103805

Burgess, H. G., & Branstetter, S. (2009). Carcharhinus limbatus. *The IUCN Red List of Threatened Species 2009: E.T3851A10124862.* https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T3851A10124862.en

CITES. (2021). Appendices I, II & III (14/02/2021). Retrieved from https://cites.org/eng/app/appendices.php

Clarke, T, A. (1971). The ecology of the scalloped hammerhead shark Sphyrna lewini in Hawaii. *Pacific Sciences*, *25*, 133–144.

CMS. (2018). *Memorandum of Understanding on the Conservation of Migratory Sharks.Great and Scalloped Hammerhead Sharks Fact Sheet. CMS/Sharks/MOS3/Inf.15.c*.

Coiraton, C., & Amazcua, F. (2020). In utero elemental tags in vertebrae of the scalloped hammerhead shark Sphyrna lewini reveal migration patterns of pregnant females. *Scientific Reports*, *10*(Aricle number: 1799).

Compagno, L. J. . (1984). *FAO Species Catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2 - Carcharhiniformes. FAO Fish. Synop. 125(4/2)*. Rome: FAO.

Cripps, G., Harris, A., Humber, F., Harding, S., & Thomas, B. (2015). *A Preliminary Value Chain Analysis of Shark Fisheries in Madagascar. Report SF/2015/3*. Ebene, Mauritius.

Dudley, S. F. ., Kyne, P. M., & White, W. T. (2006). Rhinoptera javanica. *He IUCN Red List of Threatened Species 2006: E.T60129A12310446*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2006.RLTS.T60129A12310446.en

Dulvy, N. K., Fowler, S. L., Musick, J. A., Cavanagh, R. D., Kyne, P. M., Harrison, L. R., … Valenti, SarahWhite, W. T. (2014). Extinction risk and conservation of the world's sharks and rays. *ELife*, *3*, 1–34. https://doi.org/10.7554/eLife.00590

Duncan, K. ., & Holland, K. N. (2006). Habitat use, growth rates and dispersal patterns of juvenile scalloped hammerhead sharks Sphyrna lewini in a nursery habitat. *Marine Ecology Progress Series*, *312*, 211–221.

Espinoza, M., González-Medina, E., Dulvy, N. K., & Pillans, R. D. (2016). Carcharhinus albimarginatus. *The IUCN Red List of Threatened Species 2016: E.T161526A68611084*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T161526A68611084.en

Ferreira, L. C., & Simpfendorfer, C. (2019). Galeocerdo cuvier. *The IUCN Red List of Threatened Species 2019: E.T39378A2913541*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T39378A2913541.en

Gallagher, A. J., & Klimley, A. P. (2018). The biology and conservation status of the large hammerhead shark complex: the great, scalloped, and smooth hammerheads. *Reviews in Fish Biology and Fisheries*, *28*, 777–794. https://doi.org/https://doi.org/10.1007/s11160-018-9530-5

Healy, T. (2018). *The Deep South: Socio-Economic, Historic, Cultural, Political, Anthropological and Environmental Analysis of Madagascar's Southern Region*. Antananarivo, Madagascar. Retrieved from http://documents1.worldbank.org/curated/en/587761530803052116/pdf/127982-WP-REVISED-deep-south-V27-07-2018-web.pdf

Humber, F., Andriamahefazafy, M., Godley, B. J., & Broderick, A. C. (2015). Endangered, essential and exploited: How extant laws are not enough to protect marine megafauna in Madagascar. *Marine Policy*, *60*, 70–83. https://doi.org/10.1016/j.marpol.2015.05.006

IOTC. (2015). *Status of the Indian Ocean Scalloped Hammerhead Shark (SPL: Sphyrna lewini). IOTC-2015-SC18-ES19.* https://doi.org/https://doi.org/10.5281/zenodo.3263421

IOTC Secretariat. (2007). *Compilation of information on blue shark (Prionace glauca), silky shark (Carcharhinus falciformis), oceanic whitetip shark (Carcharhinus longimanus), scalloped hammerhead (Sphyrna lewini) and shortfin mako (Isurus oxyrinchus) in the Indian Ocean. I OTC-20*. Retrieved from https://www.iotc.org/documents/compilation-information-blue-shark-prionace-glauca-silky-shark-carcharhinus-falciformis

IUCN. (2021). The IUCN Red List of Threatened Species. Version 2021-1. Retrieved May 13, 2021, from https://www.iucnredlist.org

Kyne, P. ., & White, W. . (2015). Taeniurops meyeni. *The IUCN Red List of Threatened Species 2015: E.T60162A68646736*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T60162A68646736.en

Kyne, P. M., Dudgeon, C. L., Ishihara, H., Dudley, S. F. J., & White, W. T. (2016). Aetobatus ocellatus. *He IUCN Red List of Threatened Species 2016: E.T42566169A42566212*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T42566169A42566212.en

Kyne, P. M., & Finucci, B. (2018). Neotrygon kuhlii. *The IUCN Red List of Threatened Species 2018: E.T116847578A116849874*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T116847578A116849874.en

Last, P. R., White, W. T., Carvalho, M. R., de, Séret, B., M.F.W., S., & Naylor, G. J. P. (2016). *Rays of the World*. Melbourne: CSIRO Publishing.

Long, S. (2017). Short-term impacts and value of a periodic no take zone (NTZ) in a community-managed small-scale lobster fishery, Madagascar. *PLoS ONE*, *12*(5), 1–23. https://doi.org/10.1371/journal.pone.0177858

Long, S., Thurlow, G., Jones, P. J. S., Turner, A., Randrianantenaina, S. M., Gammage, T., … Ndriamanja, J. R. (2019). Critical analysis of the governance of the Sainte Luce Locally Managed Marine Area (LMMA), southeast Madagascar. *Marine Policy*. https://doi.org/10.1016/j.marpol.2019.103691

Manjaji Matsumoto, B. M., Fahmi, & White, W. T. (2020). Pateobatis jenkinsii (amended version of 2016 assessment). *The IUCN Red List of Threatened Species 2020: E.T161744A176850023*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T161744A176850023.en

Marshall, A., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M. P., … Sherley, R. B. (2019). Mobula alfredi. *He IUCN Red List of Threatened Species 2019: E.T195459A68632178*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T195459A68632178.en

Miller, M. H., Carlson, J., Cooper, P., Kobayashi, D., Nammack, M., & Wilson., J. (2013). *Status review report: scalloped hammerhead shark (Sphyrna lewini). Report to National Marine Fisheries Service, Office of Protected Resources. March 2013*.

Moat, J., & Smith, P. . (2007). *Atlas of the vegetation of Madagascar*. Kew: Royal Botanic Gardens.

Moore, A. B. M. (2017). Are guitarfishes the next sawfishes? Extinction risk and an urgent call for conservation action. *Endangered Species Research*, *34*, 75–88. https://doi.org/https://doi.org/10.3354/esr00830

Musick, J. A., Stevens, J. D., Baum, J. K., Bradai, M., Clò, S., Fergusson, I., … Vooren, C. . (2009). Carcharhinus plumbeus. *The IUCN Red List of Threatened Species 2009: E.T3853A10130397*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T3853A10130397.en

Pollom, R., Jabado, R. W., Bennett, R., Elhassan, I., Fernando, S., Kuguru, B., … Spaet, J. (2019). Mustelus mosis. *The IUCN Red List of Threatened Species 2019: E.T161480A139617441*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T161480A139617441.en

Rigby, C. L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M. P., … Winker, H. (2019). Carcharhinus obscurus. *He IUCN Red List of Threatened Species 2019: E.T3852A2872747*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T3852A2872747.en

Rigby, C. L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M. P., … Winker, H. (2019). Isurus oxyrinchus. *Surus Oxyrinchus. The IUCN Red List of Threatened Species 2019: E.T39341A2903170*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T39341A2903170.en

Rigby, C. L., Carlson, J., Smart, J. J., Pacoureau, N., Herman, K., Derrick, D., & Brown, E. (2020). Carcharhinus brevipinna. *The IUCN Red List of Threatened Species 2020: E.T39368A2908817*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T39368A2908817.en

Rigby, C. L., Dulvy, N. K., Barreto, R., Carlson, J., Fernando, D., Fordham, S., … Winker, H. (2019). Sphyrna lewini. *He IUCN Red List of Threatened Species 2019: E.T39385A2918526*.

Rigby, C. L., Sherman, C. S., Chin, A., & Simpfendorfer, C. (2017). Carcharhinus falciformis. *The IUCN Red List of Threatened Species 2017: E.T39370A117721799*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T39370A117721799.en

Sabatini, G., Salley, S., & Ramanamanjato, J. (2008). A Review of the Spiny Lobster Fishery in the Tolagnaro (Fort-Dauphin) Region. In J. Ganzhorn, S. Goodman, & M. Vinclette (Eds.), *Biodiversity, Ecology and Conservation of Littoral Ecosystems in Southeastern Madagascar, Tolagnaro* (pp. 299–308). Washington D.C., U.S.A: Smithsonian Institution.

Savage, J. (2021). *Characterising the Elodrato and Sainte Luce Elasmobranch Fisheries. A report for the Darwin Initiative. SEED Madagascar.*

Savage, J. (2020). *A Baseline Socioeconomic Assessment of Lobster Fishing Communities in Southeast Madagascar.* Retrieved from https://madagascar.co.uk/application/files/7515/8684/3984/Baseline_Socioeconomic_Assessment.pdf

Simpfendorfer, C. A., & Stevens, J. (2003). Loxodon macrorhinus. *The IUCN Red List of Threatened Species 2003: E.T41831A10575744*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2003.RLTS.T41831A10575744.en

Simpfendorfer, C., & Burgess, G. H. (2009). Carcharhinus leucas. *The IUCN Red List of Threatened Species 2009: E.T39372A10187195*. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T39372A10187195.en

van der Elst, R. P. (1979). A proliferation of small sharks in the shore-based Natal sport fishery. *Environmental Biology of Fishes*, *4*, 349–362. https://doi.org/https://doi.org/10.1007/BF00005524

Weigmann, S., Ebert, D. A., & Seret, B. (n.d.). Resolution of the Acroteriobatus leucospilus species complex, with a redescription of A. leucospilus (Norman, 1926) and descriptions of two new western Indian Ocean species of Acroteriobatus (Rhinopristiformes, Rhinobatidae). *Marine Biodiversity*.

Zanella, I., Lopez-Garro, A., McComb-Kobza, D. ., Golfin-Duarte, G., Perez-Montero, M., & Morales, J. (2016). First record of young-of-the-year Scalloped hammerhead shark, Sphyrna lewini (Carcharhiniformes: Sphyrnidae) from Isla del Coco National Park, Costa Rica. *Revista de Biología Tropical*, *64*, 201–204.