03332917: Assessing the conservation status of elasmobranchs in the Andaman Islands

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CONTENT

ABSTRACT

Globally, one-third elasmobranch species are threatened with extinction, with the primary threat being overfishing. India has consistently been listed amongst the leading shark fishing nations of the world, with targeted shark fishing still occurring in the Andaman Islands. Despite this, there remains a huge data gap on the diversity, biology, and the drivers behind the fisheries. In order to characterise the elasmobranch fisheries of the islands, we reviewed existing literature, conducted fish landing surveys and interviewed stakeholders to document the diversity, species-specific life history characteristics, socio-economics and attitudes of stakeholders towards the fishery. We documented 57 elasmobranch species, of which 15 are new distribution records for the islands, and three for India. We provide life history information on the most commonly landed elasmobranch species, and provide information on the socio-economic factors driving the fishery. The results are disseminated in the form of outreach material, popular articles and peer-review journals. We also conducted education and awareness programs through interactions, presentations, and workshops, aimed at increasing awareness among local communities in order to contribute to efficient fisheries management. The study provides a baseline on which further studies can be carried out and provides recommendations for enhanced management practices for conservation of elasmobranchs of the islands.

INTRODUCTION

In the past decade, the global decline of elasmobranchs from the world's oceans has been recognized as a significant global environmental concern (Stevens et al. 2000; Blaber et al., 2009). Despite having survived for 400 million years in diverse aquatic ecosystems, their conservative life history characteristics (slow growth, late maturity, low fecundity) make them vulnerable to anthropogenic and natural stressors (Stevens et al. 2000). Stock collapses and local extinctions of several elasmobranch species due to exploitative and unsustainable fishing pratices have been documented worldwide, where stocks have not recovered after several decades (Dulvy et al., 2009; Dulvy & Forrest, 2010; Arunrugstichai et al. 2018). Elasmobranchs are of social and economic importance in many parts of the world, where they contribute to income and dietary protein through fisheries catch and trade as well as income generated through tourism (Barrowclift 2017).

Sharks are apex predators in marine ecosystems and population collapses can not only have cascading impacts on coastal ecosystems but also have trickle down impacts in dependent coastal communities. The decline of apex predator fisheries and the consequent socio-ecological impacts are more pronounce in developing small islands like the Andaman and Nicobar Islands which have seen a massive growth in commercial fisheries since the 1980s.

While the global status of elasmobranchs has come into focus in recent decades, detailed knowledge of the population and conservation status of most of the known species of elasmobranchs remains limited in most regions of the world (Jabado et al. 2018). Furthermore, as elasmobranchs are diverse (consisting of more than 1000 species), their unique life history characteristics renders their management as a group to be difficult and hinders sustainable harvest particularly in tropical regions where multi-gear and multi-species fisheries are common.

In order to feed the increased demand for shark fins from Southeast Asia in 1960s, India has consistently been amongst the leading shark fishing nations of the world for the past decade. Today, the domestic market for meat and international demand for fins, cartilage and oil, drives the elasmobranch fishery of India. The Andaman Islands is one of the few remaining places in India where targeted shark fishing still exists, largely due to the long history of traditional and often sustainable fishing practices adopted by the indigenous and settler communities. However, only in the past five years has there been a rise in demand for ray meat which has led to an initiation of a targeted ray fisheries. While exploitation of elasmobranch from these waters continues at an alarming rate, it is only a matter of time before the islands face the same fate as other coastal regions where elasmobranch populations have declined to near extinction.

Yet despite expanding fisheries, basic information on the diversity and biology of elasmobranchs is still lacking. This has led to lack of suitable policies related to elasmobranch fisheries management. In order to fill this gap, we generated baseline information on the catch composition, species-specific life history information, socio-economics of the fishery and drivers of the fishery. Based on the results, we provide recommendations for management and conservation of elasmobranchs of the islands.

PROJECT MEMBERS

Zoya Tyabji 	**Academic qualifications** Masters in Biodiversity Currently with Wildlife Conservation Society-India **Experience** Has worked in the islands since 2015 where she has led education programs for local, national and international students. Has prior research experience. **Role in the project** Team leader; conduct surveys, compilation, organization and publication of the data; conduct capacity building workshops for various stakeholders.
Tanmay Wagh 	**Academic qualifications:** Masters in Marine Biology Currently working with the Indian Institute of Science, Bengaluru. **Experience:** Has studied and worked in the islands, thus has an understanding of the existing socio-cultural scenario of the islands. Has prior research and outreach experience. **Role in the project** Conduct surveys, analysis of data, dissemination of results through outreach
Mahadev Ganesh 	**Academic qualifications** Secondary school **Experience** Familiar with the area **Role in the project** Assist in field activities, facilitate forming a network of key informants, strengthen the network.

AIM

To efficiently manage elasmobranch fisheries with local stakeholder community involvement in the Andaman archipelago.

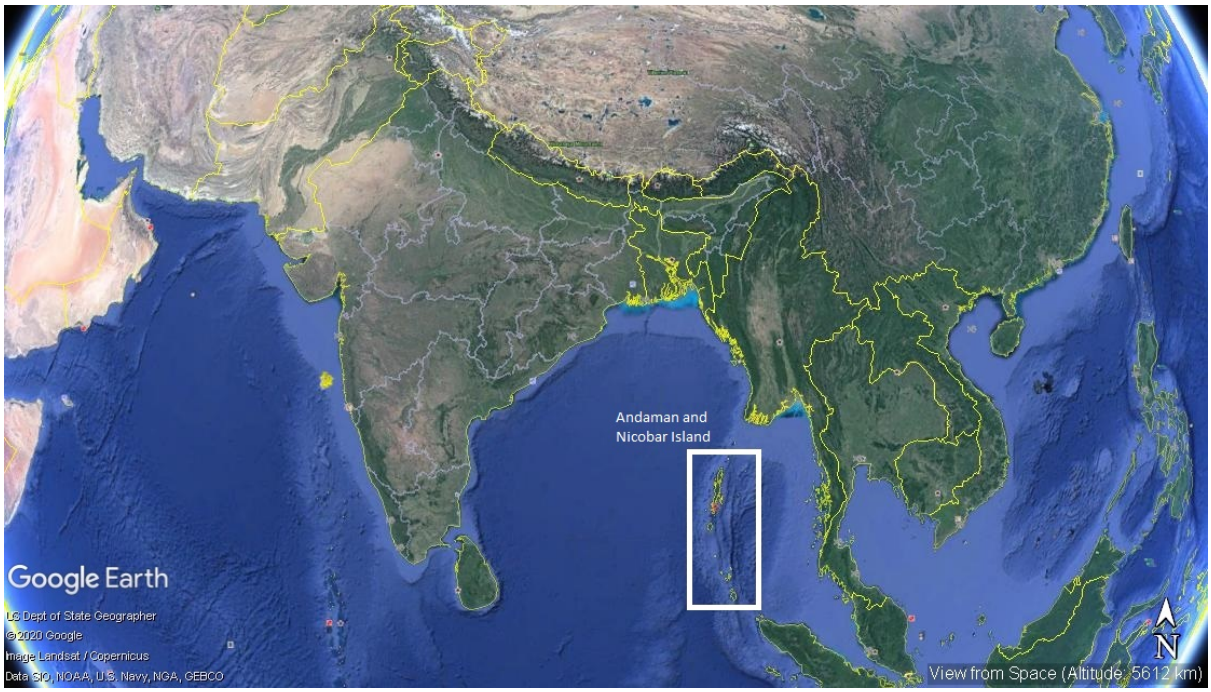
OBJECTIVES

1. To establish baseline information on distribution, demographics, trends, threats and conservation needs of elasmobranch species of the Andamans.
2. To conduct outreach programs and advocate elasmobranch conservation.
3. To initiate a community-based conservation program.

METHODS

Study area:

The Andaman and Nicobar group of Islands are part of the Indo-Burma global biodiversity hotspot and Sundaland hotspot, and were designated by International Union for Conservation of Nature (IUCN) and Mission Blue as 'Hope Spots' due to their high diversity and unique faunal composition of fish and elasmobranch species; habitats encompassing seagrass ecosystems, coral reefs, mangroves, rocky and sandy shores and patches; and their particular importance to the community. The Islands constitute 6% of the total Indian continental shelf, 26.10% of India's coastline and 29.70% of India's Exclusive Economic Zone (EEZ), contributing to a major fisheries resource to be exploited.



Survey method:

1. To establish baseline information on distribution, demographics, trends, threats and conservation needs of the threatened elasmobranch species of the Andamans.

Literature review: During the initial few months of the study, we collated and reviewed information from all published and unpublished sources on elasmobranchs of the Andaman and Nicobar Islands. This included grey literature, peer reviewed publications and media records on sharks which was collected from the Andaman state library, government and non-government organisations, fishery, forest and police department archives and repositories.

Fish landing surveys: Subsequently, a visit to all the landing and cold storage units revealed that majority of elasmobranchs fished from across the islands were landed at Junglighat in Port Blair, South Andaman Islands. Thus, fish landing surveys were undertaken here, in addition to opportunistic surveys at Dignabad and Burmanallah. These fish landing sites were visited every alternate day or when weather permitted, for a total period of a year from July 2017 to May 2018. For each individual species landed, we recorded the species, morphometries, sex and maturity. Further, we asked fishers for fisheries dependent details such as the fishing gear used, time spent fishing, depth of operations, crew size and the fishing grounds.

Interview surveys: We conducted semi-structured questionnaire surveys to collate local knowledge from fishermen, middlemen and processing unit owners on elasmobranch catch, product utility, trends in their population over time, understand the market-supply chain of the targeted elasmobranchs and drivers of the fishery.

2. To conduct outreach programs and advocate elasmobranch conservation.

Through formal and informal interactions with various stakeholders, we conducted outreach programs, disseminated our findings and advocated for elasmobranch management.

3. To initiate a community-based conservation program.

We identified individuals or key informants who were keen to be part of elasmobranch biology and conservation through interactions. Subsequently, we organized discussions and meetings with these key informants, wherein they were made aware of the study and trained them in the methods of data collection. This was a crucial step since the any community driven conservation initiatives are built through sensitising the community and trust building with the researchers. However, this is a slow process based on repeated interactions with the fishers. Thus, we will continue to work closely with the local community in order to encourage participation and initiate forming a network for conservation of elasmobranchs.

Along with fishers, we also interacted dive centers, tour operators and regular sea farers, in order to integrate opportunistic sightings and observations records in our database.

OUTPUTS AND RESULTS

1. **Species composition of sharks and rays sampled at the fish landing sites**

A detailed survey of the existing literature revealed that the available checklists for elasmobranchs species in the ANI are outdated, often with inaccurate information, including species misidentification, and a number of commercially important species that have not been documented.

During our fish-landing surveys, we sampled 5742 individuals representing 36 shark and 21 ray species from South Andaman Islands. A species accumulation curve revealed that while the chance of finding new species of sharks is relatively less (as seen from the flattening line in Fig. 1), more sampling is required to adequately document ray species.

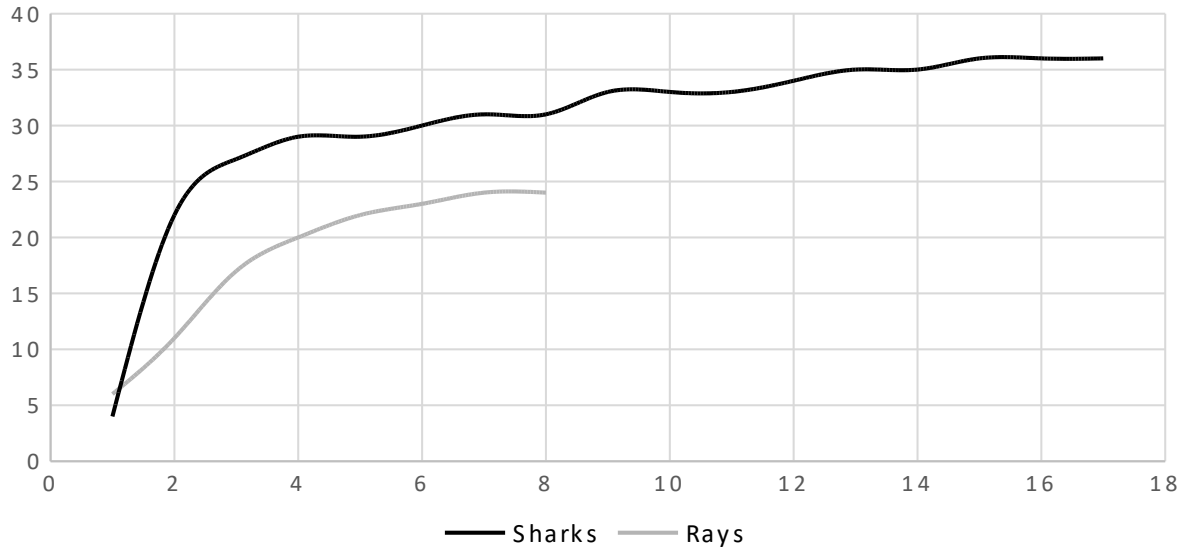


Figure 1: Species accumulation curve for sharks and rays landed in the Andaman Islands

1.1 ***IUCN status***

Of the 36 shark species, 15 species (21.89 %) are listed on the IUCN Red List of Threatened Species as threatened (Critically Endangered, Endangered, or Vulnerable), 14 species (40.69 %) as Near Threatened, four species (1.07 %) as Data Deficient, two species (36.29 %) as Least Concern and one species (0.04 %) as Not Evaluated

Of the 19 ray species identified, 15 species (85.17 %) are listed on the IUCN Red List of Threatened Species as threatened (Critically Endangered, Endangered, or Vulnerable), one species (0.4 %) as Near Threatened, one species (1.08 %) as Data Deficient, and two species (13.33 %) have not been evaluated.

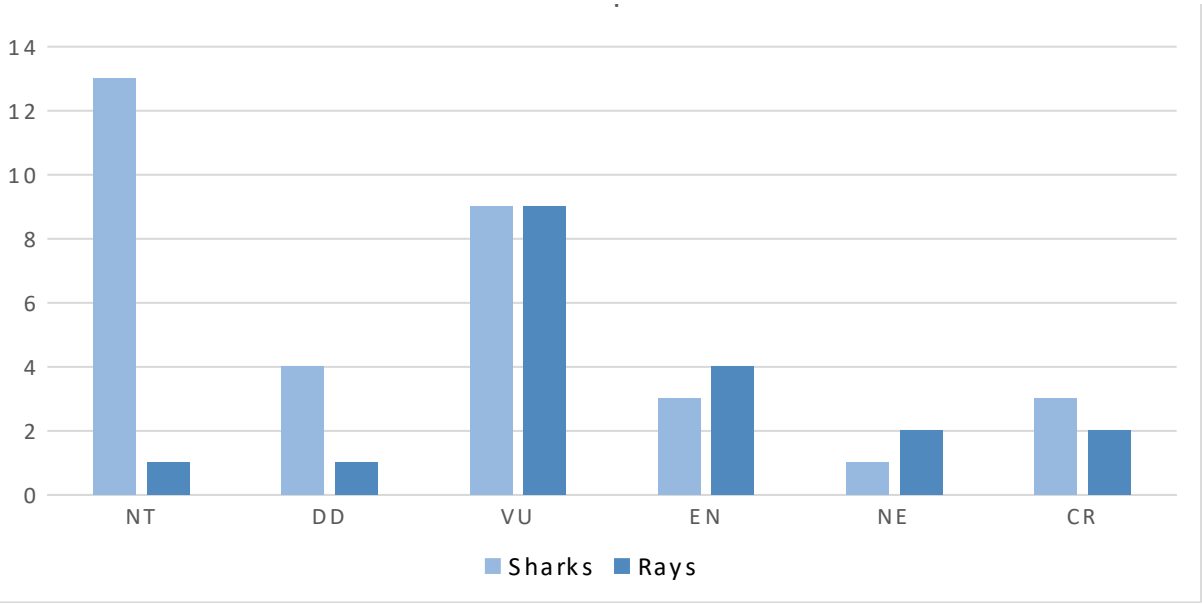


Figure 2: IUCN status of shark and ray species landed

1.2. New records

We recorded 15 new distributional records for the Andaman Islands, including three for india.

Ten previously unreported shark and ray species for the islands include: the bignose shark (*Carcharhinus altimus*), pigeye shark (*Carcharhinus amboinensis*), bull shark (*Carcharhinus leucas*), snaggletooth shark (*Hemipristis elongata*), slender weasel shark (*Paragaleus randalli*), Arabian smoothhound shark (*Mustelus mosis*), sand tiger shark (*Carcharias taurus*), Indonesian bambooshark (*Chiloscyllium hasseltii*), tawny nurse shark (*Nebrius ferrugineus*), dwarf gulper shark (*Centrophorus atromarginatus*), Pink whipray (*Pateobatis fai)* and Long-headed eagle ray (*Aetobatus flagellum).*

Ten previously unreported shark and ray species for India include: Indonesian houndshark (*Hemitriakis indroyonoi*), Indonesian shortsnout spurdog (*Squalus hemipinnis*), and Fine-spotted whipray (*Himantura tutul).*

1.3. Size extensions

Size extension for eight shark species were recorded from the islands for Hasseltiis bambooshark (*Chiloscyllium hasseltii*), slender weasel shark (*Paragaleus randalli*), tawny nurse shark (*Nebrius ferrugineus*), pigeye shark (*Carcharhinus amboinensis)*, silky shark (*Carcharhinus falciformis)*, blacktip shark (*Carcharhinus limbatus)*, spot-tail shark (*Carcharhinus sorrah)*, sliteye shark (*Loxodon macrorhinus*).

1.4. Gear catch:

Sharks:

Twenty-one species were recorded interacting with gillnets, hook and line, and pelagic longlines each, 18 species were recorded interacting with demersal longlines, 14 species with trawl nets and two species (Centrophorus atromarginatus (n=1) and C. granulosus (n = 6)) with deep-sea longlines.

Certain species were only recorded in one type of gear. For example, Alopias pelagicus (n = 230), A. superciliosus (n = 6), C. longimanus (n = 19) and Hemitriakis indroyonoi (n = 2) were only associated with pelagic longlines; Mustelus mosis (n = 7) were only recorded from hook and line; and S. mokarran (n = 2) were only recorded in trawl nets.

Further, there was a significant difference between the TL of sharks caught depending on the type of fishing gears used ($f(5, 2{,}146) = 88.66$, $p < 0.005$). Sharks landed in pelagic longliners had a high TL range from 21.5 to 376.5 cm (mean of 124.90 ± 49.83); those in demersal longlines had a TL range from 42 to 214.5 cm (mean 18.81 ± 93.76); those in deep-sea longlines (>200 m) had a TL range from 72.5 to 103 cm (mean of 88.3 ± 10.80); those in gillnets had a TL range from 25 to 312.5 cm (mean of 97.49 ± 34.26); those in trawl nets had a TL range from 50 to 297.9 cm (mean of 47.67 ± 97.65); and those from hook and line had a TL range of 46 to 266.7 cm (mean of 47.67 ± 97.65) (Fig 3).

Rays:

Sixteen species of rays were captured in demersal longlines, 14 species in trawl nets, ten in gill 374 nets, seven in hook and line, and two in pelagic longlines. No rays were captured in deep-sea longlines. Certain species were caught exclusively in certain gears. For example, *A. vespertilio* (n = 2), and *Maculabatis gerrardi* (n = 13) were only caught in trawl nets.

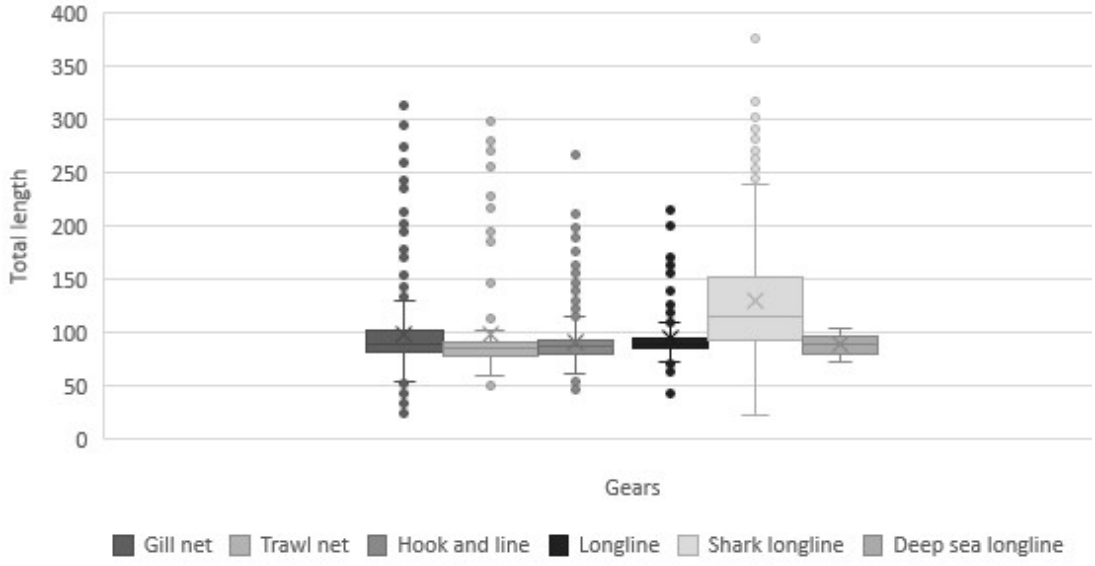


Figure 3: Shark length across various fishing gears

1.5. Species composition and biological data

Table 1: Biological information for all elasmobranch species landed in the Andaman Island is provided in Appendix 4.10

Table 2: Maximum likelihood estimates of length and weight regression parameters for the most commonly landed shark species.

Species	Sex	n	TL range (cm)	Weight range (kg)	a	b	R2	SE
Loxodon macrorhinus	Combined	931	42 - 103.2	0.29 - 3.63	1.037E-06	3.197	0.658	0.233
	Male	498	42 - 102	0.3 - 3	2.468E-06	2.997	0.613	0.232
	Female	433	48.5 - 103.2	0.29 - 3.63	4.292E-07	3.401	0.707	0.230
Carcharhinus amblyrhynchos	Combined	590	58.6 - 186.5	1.21 - 46	8.967E-07	3.392	0.948	0.175
	Male	277	58.6 - 174	1.21 - 34	1.396E-06	3.291	0.926	0.192
	Female	313	65 - 186.5	1.3 - 46	6.713E-07	3.458	0.962	0.157
Sphyrna lewini	Combined	240	35.5 - 245	0.47 - 100	1.276E-05	2.749	0.813	0.252

	Male	96	35.5 - 213.5	0.47 - 56	2.460E-05	2.609	0.759	0.334
	Female	144	50.5 - 245	0.54 - 100	6.049E-06	2.912	0.878	0.176
Carcharhinus albimarginatus	Combined	144	74.5 - 173	1.2 - 35	3.183E-07	3.606	0.881	0.189
	Male	65	74.5 - 173	1.2 - 35	4.125E-07	3.551	0.857	0.211
	Female	79	77 - 156	1.5 - 25	2.582E-07	3.650	0.902	0.171
Carcharhinus brevipinna	Combined	75	60.4 - 187.5	1.11 - 44	1.644E-06	3.223	0.948	0.161
	Male	46	62.6 - 187.5	1.25 - 44	1.581E-06	3.232	0.953	0.161
	Female	29	60.4 - 178.5	1.11 - 33	1.775E-06	3.206	0.937	0.168
Paragaleus randalli	Combined	115	76 - 104.5	1.2 - 3.5	9.953E-07	2.737	0.460	0.167
	Male	68	76 - 104.5	1.2 - 3.46	1.868E-05	2.590	0.528	0.150
	Female	47	79 - 95.8	1.2 - 3.5	1.477E-05	2.657	0.303	0.185

2. Status of the fishery through interview surveys:

In the ANI, there is a targeted shark fishery along with an emerging fishery for rays. This harvest combined with accidental by-catch in multi-gear and multi-species fisheries has put elasmobranch populations under severe pressures. Harvest primarily occurs for shark fins, gill plates, meat and liver oil. Presently, there are 1528 registered traditional boats, 1358 motorized boats and 69 mechanized boats across the Andaman and Nicobar archipelago (Fisheries Department 2016), with a population 22188 fishers (Marine fisheries census 2010) of which 7503 fishing permit identification cards have been acquired (Fisheries Department 2016). Sixty-eight of the 69 mechanized boats operate from South Andamans, and one runs from Nancowry in Nicobar Islands. Skilled shark fishers are brought from the *Thoothoor* community from Tamil Nadu in South India during shark season, which is from November to April, to conduct targeted shark fishing. Targeted shark fishing is carried out for 25-30 days using J-shaped hooks on longlines in pelagic waters from South Andamans to Nicobar. According to the boat owner and trader of two 20-meter longline vessels, his boats alone caught 1200 tonnes of sharks in one season (October to April). Elasmobranch fins are auctioned and sold according to size and species, with different sizes of fins having different prices. Some species such as guitarfish have a higher price than any other elasmobranch as they have more set of fins and are thicker.

Thicker fins provide more yield as the traders believe that these are used for surgical purposes and dissolve naturally in the human body. The sharks are transported to Kanyakumari where they are processed. The fins are salted, dried and exported from Chennai and there on to Singapore and further to China or Japan; whereas rest of the sharks are stored in a processing unit till further demand.

Additionally, Telugu communities settled in Burmanallah, South Andaman, conduct deep sea shark fishing close to the coast where an aggregation ground for deep sea sharks exists. Due to the unique topography of the Andaman and Nicobar archipelago, there are variations in depth gradients close to the coast making it an ideal habitat for diverse species.

Rays were initially caught as bycatch and discarded till a decade ago. However, nowadays since the past 7 years, there has been a rise in targeted ray catches especially when catches of other target species are less. This is due to the rising demand for ray meat as well as the use of this meat as feed for the poultry industry. Similarly, targeted fishing for gill rakes of Mobula rays is also carried out, primarily during the seasonal ban on shark fishing in March-April.

While shark fishing started due to the demand for its fins in the early 1960's, where only the fins were used but the rest of the body discarded; today, every part of the sharks caught is used, including the fins which is as a delicacy in China; the cartilage is dried, crushed and sold in Southeast Asia for medicinal purposes; liver oil which is macerated, sold and used for various purposes ranging from tonic to cosmetic products; and the meat is consumed in other parts of India. However, in 2015, a ban on export of fins was implemented which has led to an emerging black market for fins. Since most parts of the sharks are used or exported with very little waste; the fishers, traders and processing unit owners perceive this to be a loss to them as the part of the shark which could get them the most profit, now has to be discarded. Furthermore, according to the traders, a few cities in India allow export of fins abroad, such as Mumbai as opposed to Delhi, Kerala or Chennai, therefore it is now a larger loss to transport the fins to those particular cities from Tamil Nadu after the processing of the sharks, for further export.

Due to its proximity to the cold storage centers and cargo transport, all elasmobranchs in the islands are landed in Junglighat in Port Blair. While, Port Blair has access to facilities such as ice for cold storage, infrastructures and easier access to cargo facilities; these facilities are absent in other parts of the Andamans (Middle and North) and Nicobars. Till 2015, there used to be a targeted ray fishing occurring in middle Andaman with other elasmobranchs caught as bycatch. The rays used to then be transported to Junglighat, after which it would be sent to a cold storage centre or for export depending on the demand. However, after the fishing bans for some protected species and ban on

export of fins, the fishing costs and transport costs led to a loss which is why these fishers shifted to another target species. According to the fishers of Middle and North Andamans, all shark species, guitarfish, wedgefish and a few ray species are perceived to be protected and thus cannot be harvested. Therefore, all fishers in North and Middle Andamans now cut the sting of the rays and release stingrays from their fishing gears. Similarly, sharks are also either released from the fishing gears or are used as bait due to these regulations.

2.1. Fisheries policies

As the fisheries sector continues to expand along with the opening of the islands for South east Asian markets, management of apex predator fisheries is of prime conservation significance. There is confusion amongst various stakeholders on which elasmobranch species are protected and when these laws were implemented. While there are 10 species of elasmobranchs protected according to the Indian Wildlife Protection Act (1972), 6 of the species are found in these waters, with rare occurrences in the islands. A few fishers in middle and north Andamans believe that all sharks are banned and most fishers do not catch guitarfish and wedgefish as these are protected in the islands. Furthermore, while there exists a 45-day shark fishing ban from 15th April to 31st of May, only targeted shark fishers and trawlers in Junglighat are informed about this ban as it applies predominantly to them. Therefore, all the other fishers deploying other fishing gears catch elasmobranch species during this time. This lack of clarity in different fishing villages regarding laws and regulations creates a mixed profiling of elasmobranch fisheries. This lack of clarity Is further compounded by the non-selective nature of most fishing gear. This means that although protected species or species perceived to be protected are not landed, the chances that they are caught and thrown back in the water also exist. This could affect fishery resource and population estimates of threatened species, making their management challenging.

Further, the lack of communication and understanding of the species that are protected or not, creates losses and conflict amongst various stakeholders. For example, a fisherman was apprehended up by the fisheries authorities as he had caught a ray that was protected. However, till then, none of the fishers in the fishing villages had been informed about the particular ban and were clueless about it. On the other hand, most fishers from Middle and North Andamans believe that getting into the elasmobranch business is a lot of hard work and effort with more damage to gears resulting in loss, whereas to catch other fish species requires a lot less effort and is more profitable. Therefore, it is largely fishers coming from the mainland to fish in the waters of the islands, or traders who profit from elasmobranch fisheries.

2.2. ***Threats***

All fishers throughout the islands agree that there has been a decline in elasmobranchs in the waters of the Andaman Islands. In the past decade, they would have to fish in coastal and shallower waters for fish, in the recent past however, they have to venture into far and deeper waters and despite doing so, on some days, they would come back empty handed. In North Andamans, the fishers blame the tsunami for this declining trend whereas the rest of the islands reason that it is due to overfishing. Many subsistence and small-scale fishers using smaller boats and gears blame the increase of targeted shark fishing, use of *ring jaal* (modified purse seine), and trawlers for the decline in fish stocks closer to the shores.

The scale of fishing carried out by mechanised fishing vessels from peninsular India and the facilities they get (in terms of training, subsidies, etc) greatly affect catches by local fishers especially from Middle and North Andamans, most of who carry out small scale fishing. Firstly, due to a decline in catch and secondly, despite catching elasmobranchs as bycatch, with the unclear ban on sharks and ray fisheries they cannot sell it and are either used as bait or are thrown back in the sea. When they do get an opportunity to sell it, it is at prices of 100rs. per piece however big the ray may be.

Due to a demand for elasmobranchs in South Andamans, many fishers have identified aggregation grounds for various species across the islands and seasonally target these areas to maximise catch and profit. This in turn could have negative repercussions both to the populations of the species, ecosystem and the future of elasmobranch fisheries. There have already been noted local extirpations such as sawfish species have not been seen after the tsunami, while most fishers claim that they were once common in the islands. Similarly, reef sharks and sandbar sharks that were once commonly caught are now rarely caught (Advani et al. 2013). Similarly, in the fishing village of Burmanallah, South Andamans, fishers from the *Telugu* community harvest deep sea sharks from aggregating grounds near the area and have already noticed declines in the past two years. While their fishing grounds were in South Andamans earlier, they have now started fishing in the middle and north Andamans as the deep-sea sharks in South Andamans are showing a steep decline. Therefore, an urgent precautionary measure to ensure that their harvest does not lead to a rapid collapse of the fisheries like it had on the west coast of India and Maldives (Akhilesh et al. 2011).

The 2019 fisheries policy draft stresses on bringing expertise and investment from mainland India by offering them subsidies to start fishing in the islands. It also mentions an increase in fishing mechanized boats by these skilled fishers from the mainland. This will jeopardize the livelihoods and resources of the local fishers even more and create conflict between fishing zones and fish resources. The policy further states that there is a need to establish connections with neighboring Southeast

Asian countries. This could be a serious cause of concern for the already decimating stock populations of elasmobranchs.

Achievements and Impacts:

The project has succeeded in documenting the species composition, species-specific life history traits, species interactions with gear, while also gathering information on the drivers of the fishery and the attitude, perception and socio-economic importance of the fishery to the various stakeholders involved. We have published two peer-reviewed articles on the new records of sharks and elasmobranch catch composition and life history information.

The results of the study were presented at various platforms including informal interactive sessions, education programs for locals, national and international students, and scientific conferences. The results were communicated to the stakeholders, and have already garnered interest due to our prolonged/continued engagement with them (>2 years). It has also helped form a network of key informants. Most stakeholders have informed us that this was the first time when someone came regularly and showed persistence and passion for understanding their issues rather than blindly forming opinions in the form of policies which affected them directly. The results have also garnered interest from the field of conservation and management authorities, including the Forest Department and the Fisheries Department, who we will be working with in the long term. This engagement with fishers, traders, authorities and members from the research and conservation sector, could potentially lead to better elasmobranch fisheries management in the ANI.

Lastly, the project has contributed towards providing a baseline study on which future studies can be based and which can inform management for elasmobranch populations.

Capacity Development and Leadership capabilities:

Through the project, we developed technical expertise on sharks and rays, learning how to communicate efficiently and effectively with various stakeholders and learning how to deal with obstacles in the project.

We also learnt how to lead and work in a team, brainstorming through obstacles that arose, taking advantage of opportunities that arose and move past barriers and obstacles that we could not break

down. The project also provided plenty of opportunities and mistakes to learn from, and to change the way we did things, be it communicating to certain stakeholders or sampling.

This skillset will help us in the future as most of us plan to pursue a path in fisheries research and conservation. Additionally, it also provided us a baseline to build upon for our future studies.

CONCLUSION

This is the first systematic study carried out for elasmobranchs fisheries in the Andaman Islands, providing valuable information from this data-poor region. With this study, we record a total of 15 elasmobranch species that were previously unreported from the Island and two for India. It is worthwhile to note that two of the most dominantly landed species, *Paragaleus randalli* and *Pateobatis jenkinsii* were new records for the Islands indicating either a lack of systematic data collection or inaccurate species documentation for this region.

In most heavily fished regions of the world, a mean size reduction has been observed for dominantly landed species of sharks, largely due to overfishing. However, a limited scale of operations and the recent development of fisheries, mean that this is not yet the case in the ANI. This is evident from the fact that four of the six dominantly landed species are large sharks. Thus, he elasmobranch populations of the islands could be healthier in comparison to the global dataset and offers opportunity for timely interventions before stock are depleted to a point of no recovery.

However, gravid females and juveniles of large shark species are being fished out, which is a reason to be cautious as these may reduce the productivity and resilience of the system. These are also aggregating species, such as *Carcharhinus albimarginatus, Carcharhinus amblyrhynchos,* and *Sphyrna lewini*. Therefore, it is possible that nursery grounds could be fished out. Further, during our interaction at the landing-sites, fishermen repeatedly emphasized that nursery grounds for *Sphyrna lewini* were harvested as the juveniles and gravid females would come closer to the shore in large numbers just before and during the monsoons, making them vulnerable to inshore fisheries. Similarly, aggregating grounds for *Mobula* sp. were harvested, which are the main areas for targeted fisheries during monsoons when it is difficult to catch and get a good price for other species.

Despite the smaller number of deep-sea sharks recorded during the study, there is atargeted deep-sea shark fishery carried out in some parts of the Islands. Deep sea sharks, targeted for their oil, are known to have the least productivity and thus are most vulnerable to even the slightest fishing pressures. As seen from previous evidences from the Maldives and west coast of India, the deep-sea fishery declined in a relatively short time (Akhilesh et al. 2011, Jabado et al. 2018). Thus, it is imperative to regulate deep sea fishing so as to not overexploit our deep-sea shark stocks.

The lack of landings during the monsoons could be ascribed to the 45-day shark fishing ban and the unfavourable conditions of the sea. During these 45 days, pelagic longlines and trawlers are banned from fishing. However, other fishers operating motorised and non-motorised vessels perceive that all shark species are banned during this time frame and therefore do not land sharks at the landing site.

Anecdotal evidence suggests that accidental catches of sharks occasionally get transported directly to the storage centre when the authorities are not present.

The islands, due to their geographic location, are also prone to seasonal cyclonic depressions leading to torrential rains, high winds and waves, leading to unfavourable conditions for faring out into the sea. Most fishers catch and stock up on *Amblygaster sirm* (Walbaum) (spotted sardine, locally called *kappa tarni*) during this time, which is used as as bait for targeting other bigger fish during the rest of the year. The seasonality in landings of species along with their sizes and sex could be attributed to a number of factors including seasonal gear selection, fishing locations encompassing the different types of habitats or geographic region, species movements, sexual segregations, size of the sampled populations and growth phase (Anderson and Ahmed 1993, Jabado et al. 2016).

Additionally, species that were previously thought to be very common from the archipelago, including the sandbar shark *Carcharhinus plumbeus*, whitetip reef shark *Triaenodon obesusus,* (Advani et al. 2013) Great hammerhead shark *Sphyrna* mokarran, were rarely recorded, whereas other species such as the winghead hammerhead shark *Eusphyra blochii*, three species of Sawfish - *Anoxypristis cuspidata*, *Pristis pristis* and *Pristis zijsron*, and Blue shark *Prionace glauca*, may potentially be locally extinct as they have not been sighted in the waters for nearly a decade. The absence of a few shark and ray species at the landing site could also be attributed to the misunderstanding and perception of fishers towards species that are banned. The tiger shark *Galeocerdo cuvier* that was thought to have not been encountered in over 20 years (Advani et al. 2013), is perceived to be banned and thus not landed. According to the fishers on pelagic longline, it is one of the most commonly encountered shark species in the high seas, contributing to depredation and accidental catch on longlines. Although the whale shark *Rhyncodon typus* is a protected species and is not caught, most fishers do not catch them either as they perceive them to be whales or because they think they are tiger sharks due to the markings on the body and thus protected. Some fishers also believe it to be the most dangerous shark. In South Andamans, only *Glaucostegus typus* (Giant guitarfish) is caught with occasional reports of wedgefish being caught but not landed at the landing sites due to being perceived as a banned item. This creates a black market where stocks go undetected and unmonitored, leading to a lacuna in the exploitation status and population status of the species.

Moving forward, we require additional studies on the spatial and temporal patterns in distribution of elasmobranchs, their life history characteristics, in order to identify critical habitats, seasonality of their habitat-use and vulnerability of the habitats to anthropogenic impacts (D'Alberto et al. 2019). As the islands are also developing infrastructure and capacity-building in order to expand their

fisheries, it is imperative to use science-based management techniques with the inclusiveness of stakeholders involved in order to avoid overexploitation of elasmobranchs and aid their conservation.

Problems encountered and lessons learnt:

Which project activities and outcomes went well and why?

Most of the objectives and outcomes went well due to the persistence and passion of the team. This was also a stepping stone and learning opportunity for all of us, and therefore we had to make the best use of this opportunity.

Which project activities and outcomes have been problematic and in what way, and how has this been overcome?

Studying sharks and rays often has a glamour aspect to it, however, our study was based at the fish-landing site, and was quite taxing since we had to sample early in the hours. Further, our field base was 45 mins away from the fish-landing site. Therefore, many volunteers and team members also struggled with this. We resolved this by encouraging the samplers to focus on the information we were getting which was worth the effort, and to focus on the engagement with stakeholders, which was always fruitful and fun.

On a technical aspect, ray taxonomy needs to be resolved through genetics which was not possible due to the limited resources available to us. However, we did identify rays which were possible to differentiate morphologically. Rays were also difficult to ID because they are usually stored with their ventral section facing top making it hard to photograph identifying factors.

In the future:

While most published and grey literature is focused on taxonomic work with some fisheries related research, there is a gap in research addressing the ecology of species involved and socio-economics of fishermen, traders and processing unit owners. Further, the current management of species across a multi-cultural society creates conflict and needs better clarity and engagement across a multi-stakeholder platform.

We provide some recommendations that would contribute to the better management and conservation of elasmobranch populations in the Andaman and Nicobar Islands:

1. Regular fisheries monitoring – Regular fisheries profiling focusing on the species harvested and their biology, bycatch and discards, stock structure, fishing effort, catch per unit effort, exports and the supply chain of the elasmobranch fisheries can help in understanding trends in populations and identify urgent management measures. This can be carried out with the aid of the fisheries department who can be trained for this purpose so that the methods are standardized and the data is robust.
2. Identification and management of critical habitats - Since elasmobranchs show diverse life history characteristics, a fixed ban for a 45-day period can be ineffective to conserve populations. Our initial surveys revealed potential breeding and nursery grounds in the islands. However, this is currently speculative and needs more detailed fisheries dependent and independent measures. Fishers should also be sensitized to this aspect and should be involved so as to bring about a bottom-up approach for management.
3. Elasmobranch Ecology - There is a dearth of research on the population ecology, trophic structures, habitat use and movements, migratory patterns, reproductive biology, fisheries resource, stock structure, etc. of elasmobranchs which can feed into better management policies. Further, while there is increased attention on sharks for management, there is little to no focus for management on rays.
4. Fisheries policies and better communication amongst stakeholders - Management practices and policies need to be developed using sound socio-ecological research. This needs to include a combination of bottom-up and top-down approaches involving multiple stakeholder groups with the focus on ensuring sustainable resource harvest which doesn't threaten elasmobranch populations as well as local livelihoods. Implementation needs to be ensured by communicating policies with stakeholders regarding fishing bans, gear restrictions, protected species, etc.. Gears can be modified, for example, in targeted fishing longline gears, J-shaped hooks should be replaced with circular hooks so as to reduce bycatch of other species. Local fishers should also be included in any development of the fisheries sector so that there is capacity building and revenues that feed into the islands rather than outside.

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APPENDICES

Appendices

Please include important additional information not required in the main text along with:

Appendix 4.1: CLP M&E measures

Output	Number	Additional Information
Number of CLP Partner Staff involved in mentoring the Project	3	Dr. Vardhan Patankar, Stuart Paterson, Christina Imrich
Number of species assessments contributed to (E.g. IUCN assessments)	-	We conducted regional population assessments including species-specific life history information. One of our mentors is a member of the IUCN Shark Specialist Group (Regional Group and Regional Vice-Chairs of the Indian Ocean) and is aware of the project and their results.
Number of site assessments contributed to (E.g. IBA assessments)	-	
Number of NGOs established	-	
Amount of extra funding leveraged ($)	-	
Number of species discovered/rediscovered	15	12 shark species and 3 ray species are new records for the Andaman and Nicobar Islands. Three of these species are new records for India. There are many more species that are new species, however due to limited resources – constraints of conducting genetic studies, we were unable to identify them and listed only the genus in most cases.
Number of sites designated as important for biodiversity (e.g. IBA/Ramsar designation)	-	
Number of species/sites legally protected for biodiversity	-	
Number of stakeholders actively engaged in species/site conservation management	5	Stakeholders including fishers, traders and processing unit owners were actively engaged. Officials from the Forest Department and Fisheries Department were also involved.

Number of species/site management plans/strategies developed	-	
Number of stakeholders reached	7	Stakeholders including fishers, traders and processing unit owners; Forest Department, Fisheries Department, NGOs and institutes
Examples of stakeholder behaviour change brought about by the project.	3	1) Fishers more open towards releasing gravid females, juveniles that was not used including stingrays and guitarfish 2) More awareness amongst authorities and policy makers that a simple shark ban will be problematic and non-effective for fishers that actually depend on them for their livelihoods. A holistic measure is required and involvement from all stakeholders 3) Due to this, all stakeholders are willing to discussing ways forward for effective management and conservation measures
Examples of policy change brought about by the project	-	1) The project informs decision makers about management changes required 2) It also brings about behavioural change in the local stakeholders involved 3) It has built capacity of the team, wherein we are at a position of bringing about policy change in the future, having learnt from the experience of the project
Number of jobs created	-	We have trained 16 people on sampling for elasmobranchs. In addition, we have taught 12 people to identify elasmobranchs for continuous monitoring.
Number of academic papers published	3	1) Tyabji Z, Jabado R, Sutaria D (2018) New records of sharks (Elasmobranchii) from the Andaman and Nicobar Archipelago in India with notes on current checklists. https://doi.org/10.3897/BDJ.6.e28593 2) Tyabji et al. 2020. Catch composition and life history characteristics of sharks and rays (Elasmobranchii) landed in the Andaman and Nicobar Islands, India 3) We are analysing data for a manuscript based on the interview data on drivers and attitudes towards elasmobranch fisheries in the Andaman Islands.

Number of popular articles published	2	Tyabji Z. 2020. The on-ground realities of shark fisheries in India. WCS Medium, August web archive. Tyabji Z. 2020. Secrets from the dead: studying sharks at fish-landing sites. Current Conservation: Volume 14, Issue 1, 28-31.
Number of conferences where project results have been presented	4	Student Conference on Conservation Science - Bangalore 2018 – won best presentation, Rufford Small Grant Conference (Goa 2018 and Andamans 2019)
Number of other platforms where results have been presented	7	Parikrma Science Festival - India 2020 Webinars 2020: Parikrma school, NINOX, SSI-India, St. Joseph College, ICES school of Science, Thicket Tales

Appendix 4.2: Financial report

Appendix 4.3: Scientific paper published: Tyabji Z, Jabado R, Sutaria D (2018) New records of sharks (Elasmobranchii) from the Andaman and Nicobar Archipelago in India with notes on current checklists. https://doi.org/10.3897/BDJ.6.e28593

Appendix 4.4: Report submitted based on the status of elasmobranchs in the Andaman Islands, India

Appendix 4.5: Scientific paper published: Tyabji et al. 2020. Catch composition and life history characteristics of sharks and rays (Elasmobranchii) landed in the Andaman and Nicobar Islands, India

Appendix 4.6*: Popular article.* Tyabji Z. 2020. Secrets from the dead: studying sharks at fish-landing sites. Current Conservation: Volume 14, Issue 1, 28-31.

Appendix 4.7: Educating the local students about elasmobranchs. http://www.andamanchronicle.net/index.php?option=com_content&view=article&id=13462:rotary-cgz-organises-biodiversity-awareness-workshop-at-anet&catid=37&Itemid=142

Appendix 4.8: Images of sampling at the fish landing site, team discussions, presentations and workshops.

Appendix 4.9: *Popular article.* Tyabji Z. 2020. The on-ground realities of shark fisheries in India. WCS Medium, August web archive.

Appendix 4.10*: Biological information of elasmobranch species landed in the Andaman Islands*