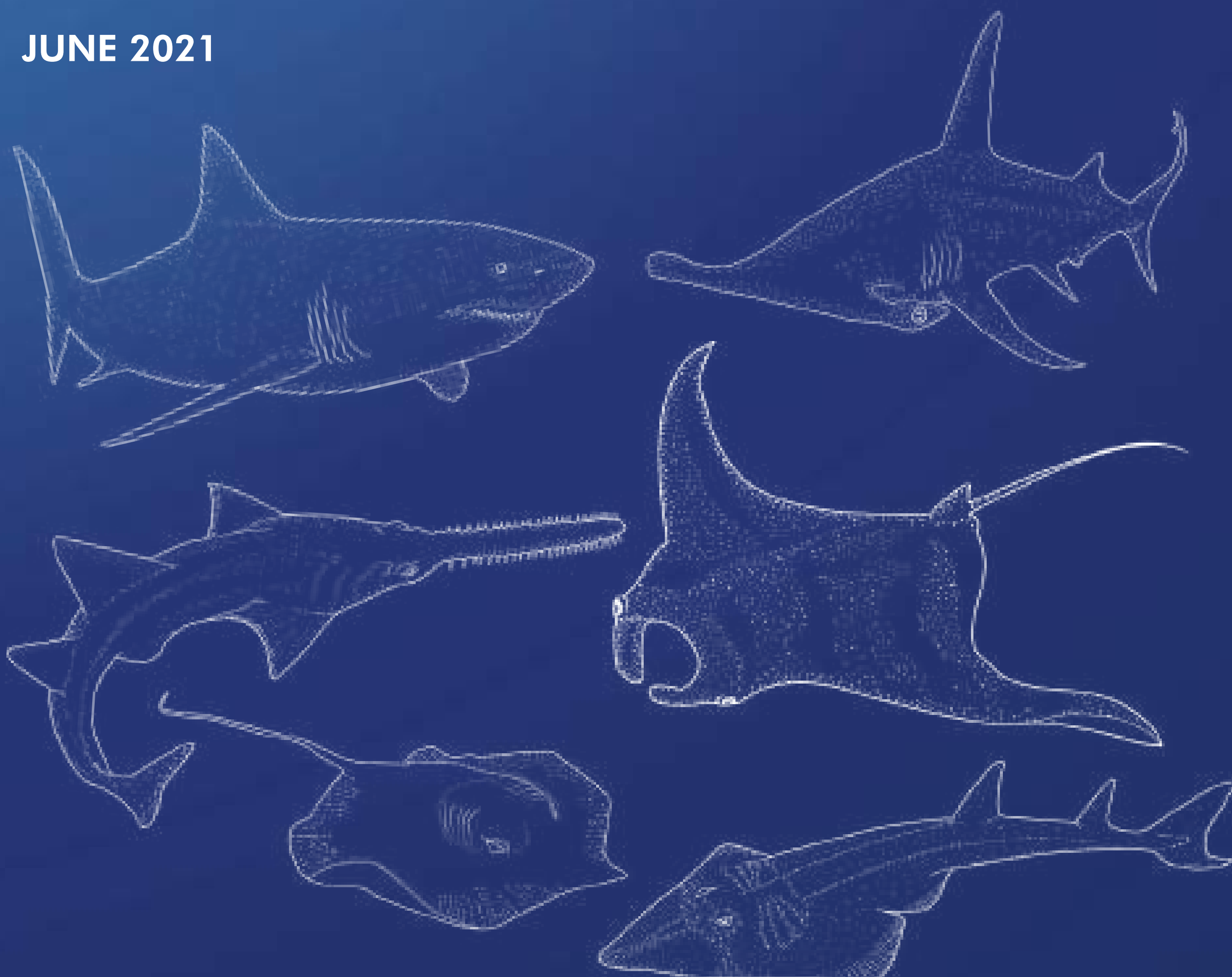
Sustainable Forests & Livelihoods (SUFAL) Project

SHARK AND RAY ASSESSMENT REPORT

Baseline information on the status, threats and governance in Bangladesh

Informed by results from scientific investigations, educational outreach and policy initiatives, and published reports

JUNE 2021



Bangladesh Forest Department
Ministry of Environment, Forest and Climate Change

Shark and Ray Assessment Report:
Baseline information on the status, threats and governance in Bangladesh

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ACKNOWLEDGEMENTS

This comprehensive background document summarizes the current state of knowledge on the status of sharks and rays and threats they are facing in Bangladesh based on results from scientific investigations, citizen science networks, educational outreach and policy initiatives conducted by the Wildlife Conservation Society (WCS) Bangladesh Program, and published reports.

WCS-Bangladesh prepared this document under the consultancy assignment on *Shark and Ray and Associated Species Conservation Strategy Development and Non-Detriment Findings* for the Bangladesh Forest Department's *Sustainable Forests and Livelihoods* (SUFAL) Project. We thank all members of the WCS-Bangladesh citizen science networks for contributing valuable information on shark and ray catches and landings. The WCS research, citizen science, training and educational outreach activities reported herein were financially supported by the Shark Conservation Fund, Rainforest Trust, MacArthur Foundation, Blue Resources Trust, WCS MPA Fund, and USAID's EcoFish Project.

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Acronyms and Abbreviations

AGN	Anchored Gillnet
AUC	Area Under the Curve
BFDC	Bangladesh Fisheries Development Corporation
BFRI	Bangladesh Fisheries Research Institute
BFD	Bangladesh Forest Department
BDT	Bangladeshi Taka
BOB	Bay of Bengal
BOBLME	Bay of Bengal Large Marine Ecosystem Project
BOBP	Bay of Bengal Programme
BLLR	Bottom-unbaited Long Line
CSFSN	Citizen Science Fisherman Safety Network
COFI	Committee on Fisheries
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on Migratory Species
CR	Critically Endangered
DD	Data Deficient
DF	Degree of Freedom
DoE	Department of Environment
DoF	Department of Fisheries
DP	Depth
DO	Dissolved oxygen
EN	Endangered
ESBN	Estuarine Set Bag Net
EEZ	Exclusive Economic Zone
FRSS	Fisheries Resources Survey System
FSU	Fisheries Support Unit
FAO	Food and Agriculture Organization
GPS	Global Positioning System
GoB	Government of Bangladesh
HS	Harmonised Systems
IORA	Indian Ocean Rim Association
IOTC	Indian Ocean Tuna Commission
IPOA	International Plan of Action
IUCN	International Union for Conservation of Nature
LDGN	Large Mesh Drifting Gill Net
LC	Least Concern
LB	Light at Bottom
MFSMU	Marine Fisheries Survey Management Unit
MPA	Marine Protected Area
MSBN	Marine Set Bag Net
MaxEnt	Maximum Entropy Modelling Approach
MDGN	Medium Mesh Drifting Gill Net
MoU	Memorandum of Understanding
MLLR	Mid-water Baited Long-lines
MoEFCC	Ministry of Environment, Forest, and Climate Change
MoFL	Ministry of Fisheries and Livestock
MoFA	Ministry of Foreign Affairs
MCS	Monitoring, Control and Surveillance
NBSAP	National Biodiversity Strategy and Action Plan
NPoA	National Plan of Action
NT	Near Threatened
NI	No Information
NDFs	Non-detriment Findings
NGO	Non-governmental Organization
NA	Not Applicable
NL	Not Listed
PP	Primary Productivity
SCF	Shark Conservation Fund
SL	Salinity
SDGN	Small Mesh Drifting Gill Net
SAARC	South Asian Association for Regional Cooperation
SD	Standard Deviation
SUFAL	Sustainable Forests and Livelihoods Project
SoNG	Swatch-of-No-Ground
TP	Temperature
TAC	Total Allowable Catch
UNCLOS	United Nations Convention on the Law of the Sea
USAID	United States Agency for International Development
USD	United States Dollar
VTMS	Vessel Tracking and Monitoring System
VU	Vulnerable
WCO	World Customs Organization
WCS	Wildlife Conservation Society
WCCU	Wildlife Crime Control Unit

Introduction

As many as 1,250 ecologically and evolutionarily diverse sharks and rays inhabit the marine and fresh waters of our planet (Bräutigam et al. 2015)[1] with more than half considered threatened or near threatened due to over catch (Dulvy et al. 2014)[2]. Growing global concern about population declines has led many countries to develop and adopt National Plans of Action (NPoA) for shark and ray conservation and management.

The Bay of Bengal (BoB) sustains productive fisheries due to the enormous nutrient input from the Ganges-Brahmaputra-Meghna river system and the world's largest mangrove forest in the Sundarbans. A seasonally reversing circular current redistributes these nutrients while a deep submarine canyon upwells and recycles them back into the ecosystem. These extraordinary oceanographic conditions make the northern Bay of Bengal a global "hotspot" for some of the world's most threatened marine megafauna including sharks and rays.

Based on shark and ray species richness, threats to their survival, and the likelihood of achieving successful conservation results, Bangladesh was prioritized in The Global Priorities for Conserving Sharks and Rays, A 2015–2025 Strategy) for (i) Preventing the extinction of the most threatened species; (ii) Investigating the status and conservation needs of poorly known species; and (iii) Taking concerted action and investing in sustainable fisheries management to stop the downward trend in vulnerable populations (Bräutigam et al. 2015).

In response, WCS-Bangladesh launched an initiative to reverse declines in threatened sharks and rays, and significantly reduce their overexploitation and by-catch through science-based, community-informed fisheries management and stakeholder engagement.

Ongoing activities of the initiative include:

- Generating knowledge on the status, ecology, and trade of sharks and rays through spatially explicit catch and bycatch assessments, fish-landing site surveys, targeted interviews, and market-chain analyses.
- Building constituencies among fishers, fish traders and government managers to implement measures to protect threatened sharks and rays and sustainably manage the exploitation of those that are currently not threatened.
- Establishing institutional collaboration and technical capacity to reverse declines of the most threatened species, reduce fisheries-driven overexploitation, and implement international trade control measures to achieve full compliance with CITES obligations for international trade of shark and ray products.
- Developing and providing support to implement a ten-year national strategy to conserve sharks and rays based on sound science and extensive stakeholder input.

Recognizing the need to improve protection for threatened sharks and rays in Bangladesh, the Bangladesh Forest Department (FD) initiated the *Shark and Ray and Associated Species Conservation Strategy Development and Non-Detriment Findings* project under the *Sustainable Forests and Livelihoods* (SUFAL) project. The objectives are to make major contributions towards (1) Protecting sharks and rays threatened by overexploitation from targeted and non-targeted catches; (2) Ensuring that the exploitation of non-threatened sharks and rays is sustainable and does not result in them becoming threatened; (3) Sustaining fishing livelihoods through the conservation of threatened sharks and rays and sustainable exploitation of non-threatened species; (4) Developing an informed public about the critical role of sharks and rays in maintaining a healthy ecosystem through mass awareness programs for species conservation; (5) Establishing a strong capacity among government and community stakeholders for the conservation management of sharks and rays; (6) Achieving compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulating international trade in globally threatened sharks and rays; and (7) Strengthening coordination with the Department of Fisheries regarding shark and ray conservation.

[1] Bräutigam, A., Callow, M., Campbell, I. R., Camhi, M. D., Cornish, A. S., Dulvy, N. K., … Welch, D. J. (2015). Global priorities for conserving sharks and rays: A 2015–2025 strategy. Global Sharks and Rays Initiative.

[2] Dulvy, N. K., Fowler, S. L., Musick, J. A., Cavanagh, R. D., Kyne, P. M., Harrison, L. R., ... & White, W. T. (2014). Extinction risk and conservation of the world's sharks and rays. elife, 3, e00590.

To achieve the objectives described above three priority activities of the SUFAL assignment include (1) developing a *National Conservation Strategy and Plan of Action for the Conservation Management of Sharks and Rays in Bangladesh*, (2) preparing Non-Detriment-Findings (NDFs) for CITES Appendix II listed shark and ray species, and (3) strengthening institutional collaborations.

The FD contracted WCS-Bangladesh for implementing the SUFAL shark and ray assignment, including the formulation of a National Conservation Strategy and Plan of Action for the Conservation Management of Sharks and Rays (NPOA-Sharks) in partnership with government and community stakeholders to serve as the blueprint for government agencies, local communities, NGOs, research institutions, and private enterprises to engage in protecting the most endangered sharks and rays from extinction and ensuring sustainable, productive fishery livelihoods in coastal communities.

This comprehensive background document provides a baseline status report and threat assessment of sharks and rays based on results from scientific investigations, educational outreach, and policy related activities of the WCS-Bangladesh Shark and Ray Initiative conducted between 2016-2019 in partnership with citizen scientists and government agencies, and published reports. It aims to inform the *National Conservation Strategy and Plan of Action for the Conservation Management of Sharks and Rays in Bangladesh* (NPOA-Sharks), with suggested governance frameworks and interventions for improving protection for the most endangered sharks and rays, ensuring that the exploitation of non-threatened species does not result in them becoming threatened, and sustaining productive fishery livelihoods, as well as proposed sustainable financing mechanisms for implementing these actions.

The up-to-date knowledge presented herein serves the formulation of locally practical actions for a National Conservation Strategy and Plan of Action for the Conservation Management of Sharks and Rays in Bangladesh (NPOA-Sharks), with suggested governance frameworks for improving protection for the most endangered sharks and rays, ensuring that the exploitation of non-threatened species does not result in them becoming threatened, and sustaining productive fishery livelihoods, as well as proposed sustainable financing mechanisms for implementing these actions.

The baseline status report and threat assessment of sharks and rays provided herein aim to inform a National Conservation Strategy and Plan of Action for the Conservation Management of Sharks and Rays in Bangladesh (NPoA-Sharks), outlining priority areas of investment for donors and non-governmental organizations (NGOs) for advancing shark and ray conservation and management in Bangladesh, and to assess the effectiveness of interventions in supporting sustainable fisheries and fishing livelihoods for a healthy ocean and healthy people.

Least Concern Bigeye houndshark *Iago omanensis* caught with baited mid-water longlines.

CHAPTER 1

SHARK AND RAY DIVERSITY AND LANDINGS OF SMALL-SCALE COASTAL FISHERIES

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Wildlife Conservation Society Bangladesh

Background

The coastal waters of Bangladesh support a large diversity of marine wildlife including sharks and rays with numerous species considered globally threatened. To inform conservation management that prioritizes the protection of the most endangered species and sustainable exploitation of common species, WCS initiated a citizen science network of data collector to collect information on sharks and rays landed at eight fish landing sites across coastal Bangladesh.

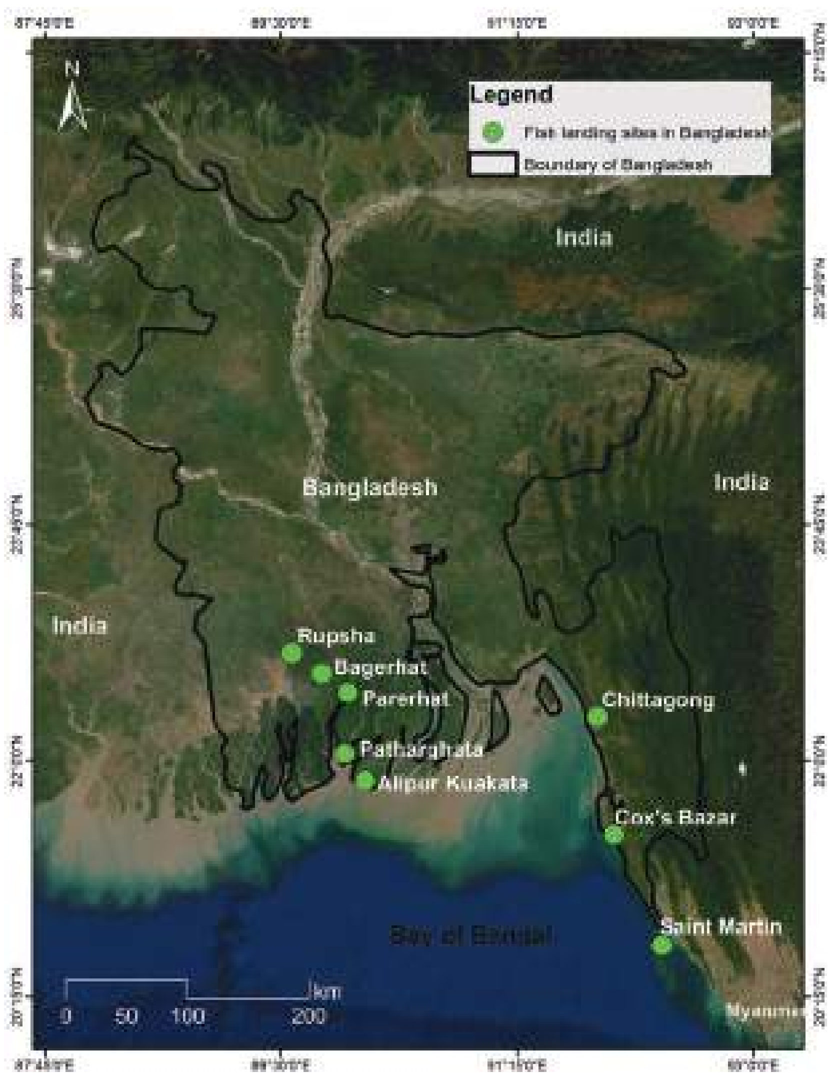

Figure 1. Locations of the eight fish landing sites in Bangladesh where sharks and ray landings were documented between December 2016 and January 2019.

Methods

WCS-Bangladesh trained members from local fishing communities as citizen scientists to collect data on shark and ray landings at eight landing sites (Alipur Kuakata, Bagerhat, Chittagong, Cox's Bazar, Parerhat, Patharghata, Rupsa and Saint Martin's Island) for small-scale fisheries along the coast of Bangladesh (Figure 1).

Data collectors were requested to visit landing sites every day to search for sharks and rays, document landings according to species or genus, take photographs showing dorsal, ventral, and lateral views, and record information on the number of sharks or rays landed, fishing gear that caught the shark or ray, price of sharks and rays sold at the landing site, and weight and length of a typical size specimen from each landing. If there was a range of lengths and weights for a single species/genus, the data collectors divided the sample into three relative sizes (small, medium, and large) and then measured and weighed a typical specimen from each. This was done to obtain a more accurate estimate of the total weight and price paid for the catch.

We analyzed potential differences in the frequency of shark and ray landings as well the number of individuals and total weight of shark and ray landings according to landing site, month, and fishing gear responsible for the catch using non-parametric statistics. We also used generalized linear models to test for the factors (landing site and/or month) determining the species composition of landings, and species accumulation curves to investigate whether more shark and ray species will be discovered as the sample size of our data collection effort increases over time.

To estimate the economic value of shark and ray landings to the fishermen, the product of the price paid per kilogram, weight of a typical specimen and total count of specimens for each species/genus was calculated. Weight calculations were done separately and then summed for landings that were divided into small, medium, and large size classes. Due to the variability in shark and ray landings throughout the year (see below), the mean economic value and standard deviation were calculated for all landings combined for each month. The means and standard deviations for each month were then combined and confidence intervals generated.

Results

Study effort

Between December 2016 and January 2019, WCS citizen scientist data collectors made 2,941 visits to eight fish landing sites. There were large differences in the number of visits to each landing site with a mean of 368 and ranging from 81 in Patharghata to 623 in Cox's Bazar (Table 1). WCS mentors accompanied data collectors on 2.4% of their visits to check that the data were being properly collected.

Table 1. Number of visits by data collectors and WCS, and number and percentage of total visits that sharks and rays were found at eight fish landing sites.

Location	Number of visits by data collectors	Number of visits with WCS staff present	Number and % of visits sharks found	Number and % of visit rays found
Cox's Bazar	623	24	529 (84.9%)	527 (84.5%)
Parerhat	529	7	193 (36.5%)	57 (10.8%)
Bagerhat	416	11	61 (14.7%)	35 (8.4%)
Rupsa	410	15	94 (22.9%)	115 (28.2%)
Alipur Kuakata	370	5	90 (24.3%)	57 (15.4%)
Chittagong	266	2	56 (21.0%)	76 (28.6%)
Saint Martin's Island	246	2	62 (25.2%)	132 (53.9%)
Patharghata	81	4	20 (24.7%)	14 (17.3%)

Sharks

Overall landing characteristics

Shark landing data were skewed (Figure 2). Landings of small numbers of sharks were frequent while landings of large numbers of sharks were much less frequent but comprising most of the total catch (Table 2). More than half of the shark landings included 10 or fewer individuals (55.7%) accounting for only 0.2% of the total number of sharks landed, with landings of >10 but ≤100 individuals comprising 18.1% of the total landings but only 0.9% of the individuals, landings of >100 but ≤1,000 individuals comprising 20.2% of landings but 9.5% of the total individuals, >1,000 but ≤10,000 individuals comprising 4.1% of landings but 18.0% of the total individuals, and >10,000 individuals comprising 1.9% of shark landings but accounting for 71.4% of the individuals.

About one-third (32.5%) of landings were ≤10 kilograms but accounted for only 0.3% of the total weight, and 39.3% of the landings were >10 but ≤100 kilograms but accounted for 2.9% of the total weight. Meanwhile, only 1.8% of landings were >10,000 kilograms but these accounted for more than half (57.1%) of the total weight.

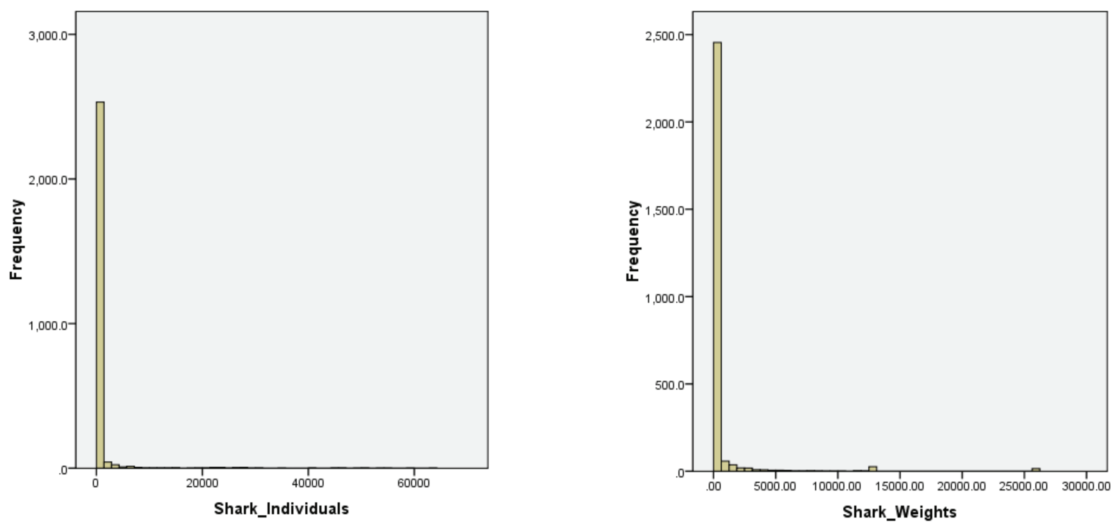

Figure 2. Frequency distribution of the number of shark individuals per landing (left) and weight (kg) per landing (right) from 2,687 shark landings at eight fish landing sites, indicating a positively skewed distribution with many landings of a few sharks weighing little and a much smaller number of landings of many sharks but comprising the majority individuals and total weight landed.

Table 2. Percentage of landings according to the number of shark individuals per landing at eight fish landing sites.

	% landings of shark individuals				
Landing Site	≤ 10	> 10 & ≤ 100	> 100 & ≤ 1,000	> 1,000 & ≤ 10,000	>10,000
Alipur Kuakata	84.9	10.9	4.2	0.0	0.0
Bagerhat	65.6	30.1	4.3	0.0	0.0
Chittagong	77.6	16.4	6	0.0	0.0
Cox's Bazar	51.2	19.3	20.7	6.0	2.9
Parerhat	41.5	15.7	42.3	0.6	0.0
Patharghata	97.7	4.3	0.0	0.0	0.0
Rupsa	94.6	1.8	2.7	0.9	0.0
St. Martin’s	75.7	24.3	0.0	0.0	0.0

Taxonomy and species occurrence

Seven shark families including 11 genera and 19 species were represented in 2,687 shark landings. Catch records were dominated by sharks from the Carcharhinidae and Sphyrnidae families, which represented 77.8% and 21.5% of the total number of shark landings, respectively, with the other families comprising <0.5% of the total landings each (Table 3).

Table 3. Number of landings of seven different shark families recorded during 2,941 visits to eight fish landing sites with the percentage of total shark encounters. Note that multiple shark families were often recorded during a single visit while no sharks were recorded during 62.4% of visits.

Family name	Common name	Number of landings	Percentage of landings
Carcharhinidae	Requiem sharks	2,091	77.8%
Sphyrnidae	Hammerhead sharks	578	21.5%
Hemiscylliidae	Bamboo sharks	11	0.4%
Rhincodontidae	Whale sharks	4	0.2%
Alopiidae	Thresher sharks	1	<0.1%
Hemigaleidae	Weasel sharks	1	<0.1%
Triakidae	Hound sharks	1	<0.1%

For 86.5% of shark landings that included photographs, WCS staff were able to identify 86.3% to species and the remaining 13.7% to genus from the recorded photographs. Due to the strong concordance between the identifications made by the data collectors and those made by WCS staff from photographs, local names provided by the data collectors were used to identify the 13.5% of unphotographed shark encounters to genus.

By a significant margin, Spadenose sharks *Scoliodon laticaudus* were the most landed species comprising 31.6% of the total landings and 95.7% of the total number of shark individuals landed. The second most common species was Scalloped hammerhead sharks *Sphyrna lewini* occurring in 20.7% of the catches and comprising 3.4% of the total individuals caught. Unidentified requiem sharks from the *Carcharhinus* genus were documented in 15.4% of catches comprising 0.3% of the total individuals caught. This genus includes seven species, which were also documented at the eight landing sites: Bull shark, *C. leucas*, Spottail shark *C. sorrah*, Blacktip shark *C. limbatus*, Pigeye shark *C. amboinensis*, Graceful shark *C. amblyrhynchoides*, Spinner shark *C. brevipinna*, and Silky shark *C. falciformis*, listed from most to least frequently recorded during 6.3% to 0.6% of total shark landings. Together, catches of these species comprised <0.5% of the total catch according to the total number of sharks caught. This means that the occurrence and number of the individual requiem shark species landed are slightly greater than they appear in the data.

A generalized linear model using a logit link function indicated that the species composition of shark landings recorded during 10 or more landing site visits (N=2,205) depends on both the landing site (Wald Chi-square = 147.2, $p<0.001$, df=7) and month (Wald Chi-square = 29.9, $p=0.002$, df=11).

A discovery curve of cumulative identifications of new shark species versus sequential day of the 790 days that landing sites were visited indicates that most species (63.2%) were identified during the first 100 days followed by a levelling off in the discovery rate of new species and no new identifications after 19 species had been identified on day 410 (Figure 3). This implies that most or possibly all shark species being landed at the eight landing sites have already been identified. However, it should be recognized that the eight landing sites do not include catches from commercial trawling fisheries that operate in deeper waters where pelagic species, such as Shortfin mako *Isurus oxyrinchus*, Longfin mako *I. paucus*, and Bigeye thresher *Alopias superciliosus*, occur but were not recorded at the eight fish landing sites during our study. Also, some low-value sharks, such as bigeye hound shark *Iago omanensis*, are used for bait which means they may not appear at fish landing sites.

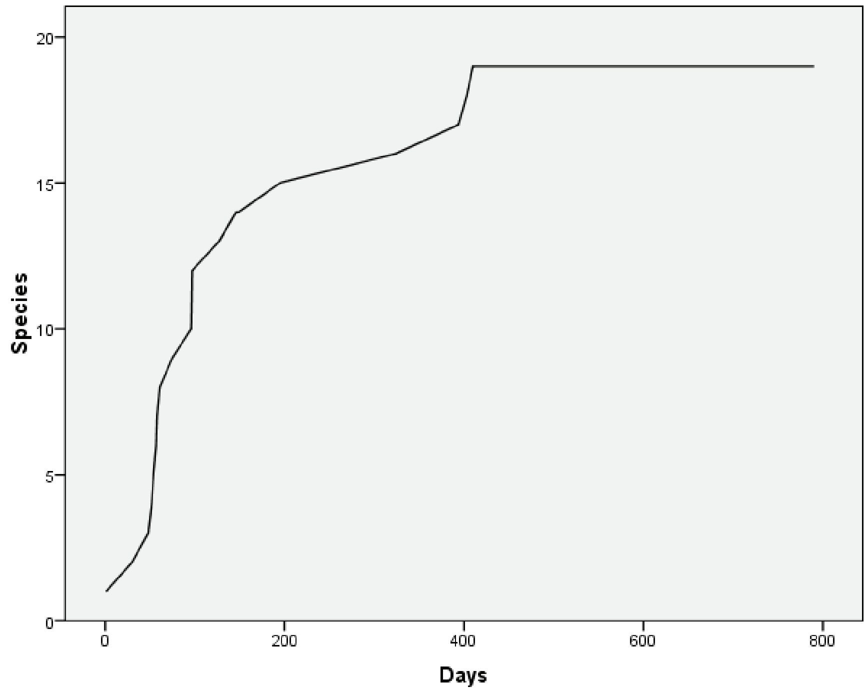

Figure 3. A discovery curve of the cumulative number of shark species identified during the 790 days of the study indicates that most or all species being landed by small-scale coastal fishermen were represented in the 2,687 landings documented at eight sites included in our study.

Landing sites

Data collectors documented one or more sharks during 1,105 or 37.6% of 2,941 visits to eight fish landing sites. There were extreme differences among the frequency of visits when sharks were recorded at the different landing sites (Chi-square = 3.49e3, df=7, p<0.001). Shark landing rates ranged from 84.9% of visits in Cox's Bazar (N=623) but only 21.0% in Chittagong (N=266) and 14.7% in Bagerhat (N=416).

There were also large differences in the number of sharks recorded per landing at different landing sites (N=2,687) (Kruskal-Wallis = 216.9, df=7, p<0.001) with a mean of 1,129.6 individual sharks per landing in Cox's Bazar, 163.8 in Parerhat, and 32.8 in Rupsa. All other sites averaged less than 22.0 sharks per landing. All 55 landings of >10,000 sharks were in Cox's Bazar and 97.3% (or 108) of 111 landings of >1,000 but ≤10,000 sharks were also in Cox's Bazar with two in Parerhat and one in Rupsa.

There were also differences in the weight of sharks per landing in different landing sites (Kruskal-Wallis = 324.9, df=7, p<0.001) with an average of 704.7 kilograms per landing in Cox's Bazar (N=1,807) with the next largest average weight of 106.3 kilograms per landing in Alipur Kuakata followed by 77.6 kilograms per average landing in Parerhat. The remaining sites in Bagerhat, Chittagong, Patharghata, Rupsa and Saint Martin's Island accounted for an average of between 40.9 to 8.9 kilograms per landing.

Observed versus expected frequencies of shark landings and the total number of landed individuals for species that were landed on more than 150 occasions and totalling more than 1,000 individuals indicate major differences among landing sites. Species meeting these criteria included Spadenose sharks (Chi-square=1018.0, p<0.0001 for landings and Chi-square=6,926,537.4, p<0.0001 for individuals), Scalloped hammerhead sharks (Chi-square=993.9, p<0.0001 for landings and Chi-square=257,997.1, p<0.0001 for individuals), Bull sharks (Chi-square=143.0, p<0.0001 for landings and Chi-square=13234.0, p<0.0001 for individuals) and Spottail sharks (Chi-square=315.7, p<0.0001 for landings and Chi-square=3567.0, p<0.0001 for individuals), with seven degrees of freedom (df) for the eight landing sites tested, with Cox's Bazar overwhelmingly accounting for a greater number of landings and individuals than expected for all four species (Figure 4).

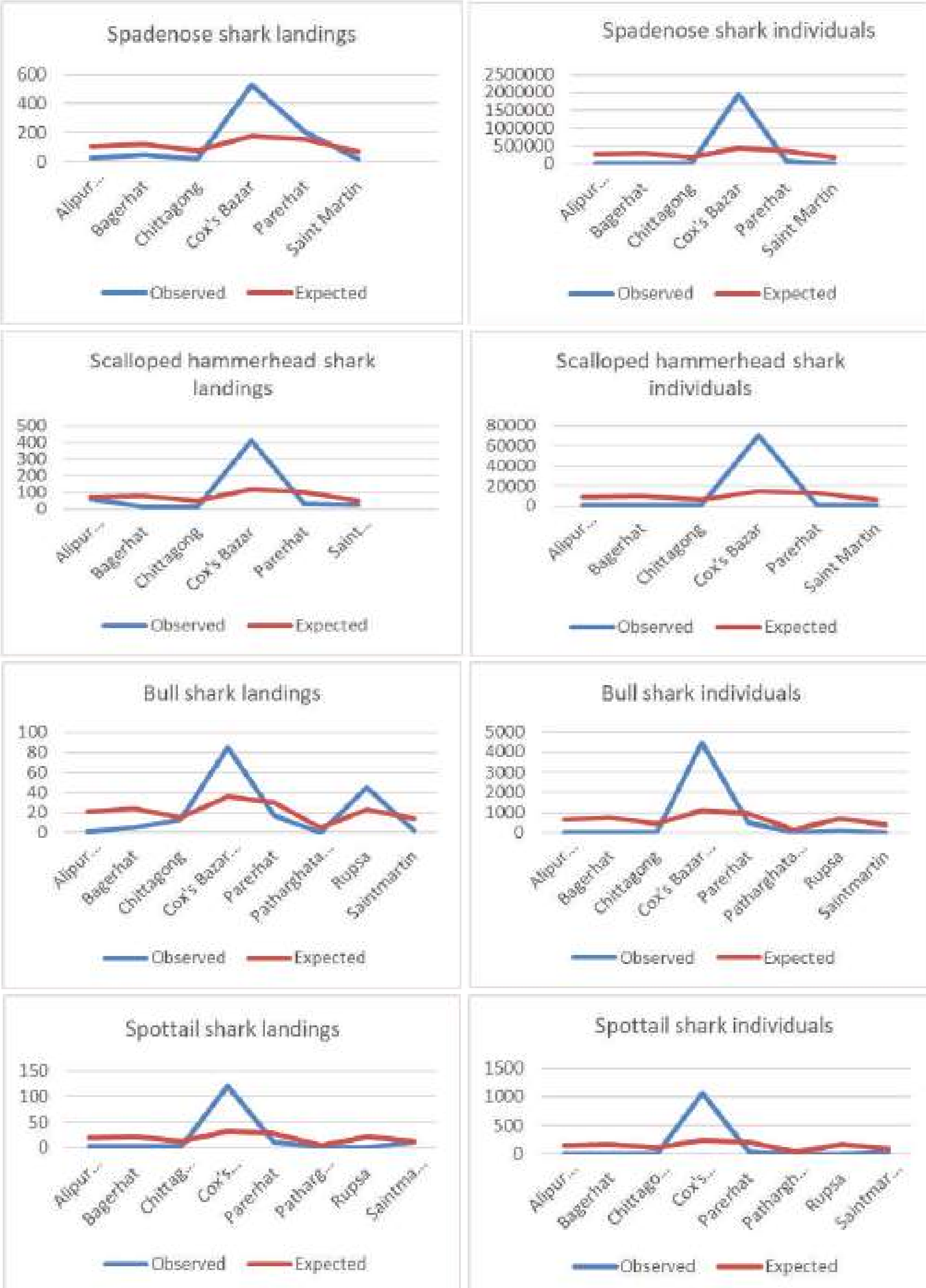

Figure 4. Observed versus expected landings (left) and individuals landed (right) of Spadenose sharks (top), Scalloped hammerhead sharks (middle top), Bull sharks (middle bottom), and Spottail sharks (bottom) if these parameters were distributed equally across landing sites in Alipur Kuakata, Bagerhat, Chittagong, Cox's Bazar, Parerhat, Patharghata, Rupsa, and Saint Martin's Island.

Months

There were significant but relatively small differences in the overall frequency of shark landings during different months (Chi-square=31.3, df=11, p<0.001). The most frequent landings recorded during 43.3 – 50.4% of visits were from August to November (N=57-240) with an additional peak of 45.7% during February (N=173). The least frequent shark landings were in April (N=337) occurring during 29.4% of visits and increasing each month to 37.3% per visit in July (N=271).

Similarly, there were significant differences in the number of sharks landed per month (Kruskal-Wallis=21.365, df=11, p=0.03) with the largest numbers of 888, 2,039, 4,005, 3,936 and 2,965 sharks per landing (N=2,687) in August to November, respectively, and the lowest numbers of 133, 119, 125, 281, 116 and 65 sharks per landing from February to July, respectively.

There were also significant differences among different months in the weight of sharks per landing (Kruskal Wallis=73.2, df=11, p<0.0001). Like the number of shark individuals recorded per landing, the largest mean weights were recorded from August to November of 795, 1,275, 12,639 and 2,445 kilograms per landing, respectively, and the lowest weights recorded between February to July of 207, 410, 340, 156, 115, and 88 kilograms per landing, respectively.

For shark species landed during more than 150 site visits and totalling more than 1,000 individuals landed, differences were found between the observed and expected frequencies of shark landings and the number of individuals landed among different months (Figure 5) for Spadenose sharks (Chi-square=79.3, p<0.0001 for landings and Chi-square=3.64e4, p<0.0001) for individuals landed), Scalloped hammerhead sharks (Chi-square=40.1 p<0.0001 for landings and Chi-square=9.09e4, p<0.0001 for individuals landed), and Spottail sharks (Chi-square=21.1, p=0.032 for landings and Chi-square=1.04e3, p<0.0001 for individuals landed). For Bull sharks, differences were found between the observed and expected frequencies according to the total number of individuals landed (Chi-square=4.08e4, p<0.0001) but not for the number of landings (Chi-square=16.8, p=0.11) among different months. All tests were calculated using df=11 for 12 months.

Spadenose sharks were landed more frequently and in greater numbers than expected in September and November but not October, almost certainly explained by the fishing ban imposed during the government at this time. Scalloped hammerhead sharks indicated an apparent minor peak in landings but no comparable peak in number of individuals landed in May, with another peak of landings in August and September accompanied by an even greater peak in the number of individuals landed, especially in August and to a lesser extent September. Even though the graph in Figure 5 (middle top left) shows an apparent peak in May, as mentioned above, there was no significant difference in observed versus expected landings of Bull sharks according to month. However, there were major differences in the number of individuals landed, with a much greater number of individuals caught in March and October – the latter despite the government fishing ban for most of October mentioned above. Landings of Spottail sharks showed an extended peak from March to June with a similar peak in the number of individuals landed but starting one month later and extending to July.

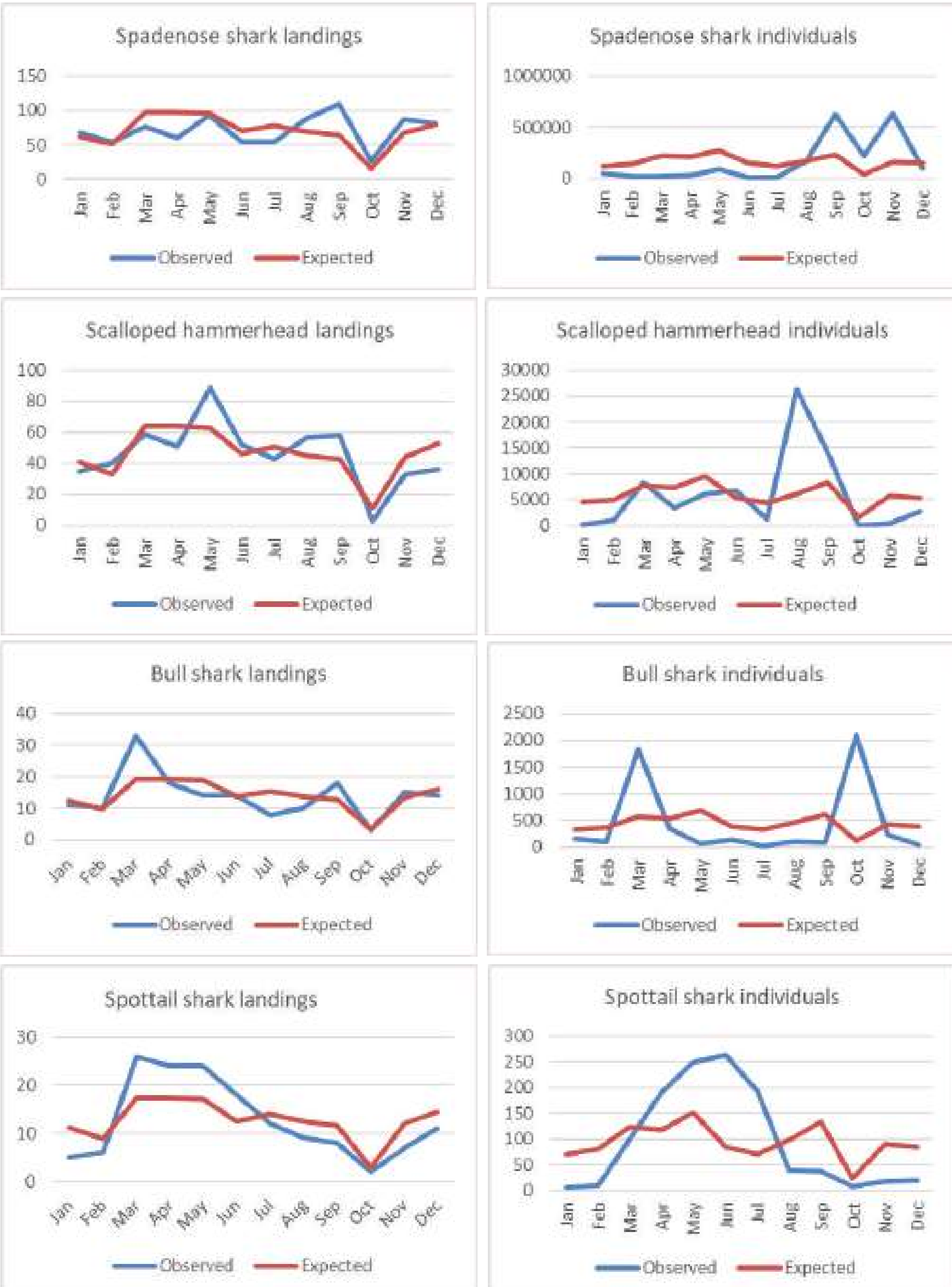

Figure 5. Observed versus expected landings (left) and individuals landed (right), if these parameters were distributed equally across months, of Spadenose sharks (top), Scalloped hammerhead sharks (middle top), Bull sharks (middle bottom), and Spottail sharks (bottom).

Gear types

From 2,442 landings of sharks that included data on the gear type responsible for catching them, there were significant differences in landing frequency among different gears (Chi-square = 3.298e3, df=16, $p<0.001$) with medium mesh Hilsa gillnets responsible for catching almost half (49.5%) and set bag nets responsible for catching almost one quarter (24.2%) of the landings. The remaining quarter was caught in large-mesh gillnets (16.3%), baited mid-water longlines (7.3%), un-baited bottom longlines (1.4%), bottom trawl nets (0.6%) and longshore nets (0.6%).

Similarly, from landings that included data on gear type, there were differences among the gear types responsible for number of individual sharks caught during each landing (Kruskal-Wallis = 118.3, df=6, $p<0.0001$). However, different from the situation of the gear type responsible for largest number of landings, set-bag nets were responsible for catching the largest number of individual sharks (68.3%) followed by medium-mesh gillnets (27.9%) and large-mesh gillnets (2.8%). Each of remaining gears were responsible for catching ~1.0% of the total number of sharks landed.

Like the situation with the gear types responsible for catching shark individuals, there were significant differences in the total weight of sharks caught in different gear types (Kruskal-Wallis = 83.0, df=6, $p<0.0001$) with set-bag nets responsible for catching 60.2% and medium-mesh gillnets responsible for catching 23.6% of the total weight of sharks landed. Baited mid-water longlines and large-mesh gillnets were responsible for 8.8% and 6.9% of the total weight of sharks landed, respectively, with bottom trawl nets, un-baited mid-water long lines and longshore nets responsible for <1.0% each.

Near threatened Spadenose sharks were the most frequently landed shark caught in set-bag nets, occurring in 37.2% of 592 landings and accounting for 96.7% of more than 1.4 million sharks caught in this gear type. The next most commonly occurring species caught in set-bag nets was Scalloped hammerheads accounting for 22.5% of landings and 3.2% of total shark individuals caught in this gear type.

Set-bag nets were responsible for 28.1% of 784 landings of the species and 69.0% of the almost 2 million individual Spadenose sharks landed at landing sites, and 25.9% of 513 landings and 62.8% of more than 70,000 scalloped hammerhead sharks landed with information on fishing gear type. Other threatened sharks reported as caught in set-bag nets include four landings of nine VU silky sharks and a single landing of 50 VU Smooth hammerhead sharks.

Medium-mesh gillnets, primarily targeting Hilsa shad *Tenualosa ilisha*, were responsible for almost half of shark landings and more than a quarter of all individual sharks landed. Like the results from set-bag nets, Spadenose sharks were the most frequently landed shark reportedly caught in medium-mesh gillnets, occurring in 40.2% of 1,208 landings and accounting for 96.2% of almost 600,000 individuals matched with this gear type. Also, like in set-bag nets, the next most commonly occurring species caught in medium-mesh gillnets was Scalloped hammerheads accounting for 25.9% of 513 landings and 2.3% of almost 600,000 individuals caught in this gear type. Medium-mesh gillnets were responsible for 44.8% of the total landings of Scalloped hammerhead sharks and 18.6% of the almost 71,000 individuals landed of this species that included information on gear type. Other threatened species reported as caught in medium mesh gillnets include six of eight landings of a total of 206 Vulnerable Smooth hammerheads, two landings of a total of six CR Great hammerheads, and two landings of a total of two Vulnerable Whale sharks *Rhincodon typus*.

Although large-mesh gillnets were only responsible for 15.4% of the total landings and less than 1.0% of the total individuals identified to species, these nets, which are generally set in deeper waters compared to medium-mesh gillnets, are responsible for many catches and individuals of threatened species. The most landed species caught in large-mesh gillnets was CR Scalloped hammerhead sharks responsible for 28.7% of 310 landings and 5.1% of more than 55,000 individuals reported caught by this gear type. Near threatened Spadenose sharks were reported as occurring in 17.7% of landings and 90.6% of all individuals caught in large mesh gillnets. These nets were also responsible for seven of nine catches and 98.7% of 464 CR Great hammerheads landed, the only catch recorded of a single Pelagic thresher shark *Alopias pelagicus* (although this shark is more likely to appear in the catches of pelagic trawlers which were not represented at the landing sites we sampled), four catches of a total of four Silky sharks, and one landing of a single Whale shark.

Size distribution

Data collected on the size of landed sharks were not suitable for estimating population trends since individuals were measured to determine size classes for estimating economic value. However, a rough indication of population vulnerability can be made from an examination of the frequency distribution of the maximum size of measured individuals and the proportion of landings that included one or more individuals that were sexually mature (Table 4, Figure 6), the latter based on information reported in FishBase (www.fishbase.de).

An assessment of the six most landed sharks at fishing landing sites indicates that the large majority of Spadenose sharks are sexually mature, thereby implying a probable healthy population. However, the population status of Scalloped hammerhead, Bull, Spottail, Tiger and Blacktip sharks are of particular concern with less than 12.0% of landings including one or more sexually mature individuals.

Table 4. Size of sexual maturity, number of landings with information on shark length, and % of landings with maximum size equal or greater than the minimum size of sexual maturity for six shark species commonly landed at eight fish landing sites along the coast of Bangladesh.

Common name	Size at sexual maturity (cm)	Number of landings with information on length	% of landings with max size greater than the size at sexual maturity
Spadenose shark	34	828	98.1
Scalloped hammerhead	225	550	5.3
Bull shark	193	168	11.9
Tiger shark	210-350	149	10.9-0.0
Blacktip shark	165	139	2.8
Spottail shark	130	144	19.1

Piles of immature Critically Endangered hammerhead (*haturi hangor*) and requiem sharks (*boli hangor*) at the fish landing site in Cox's Bazar.

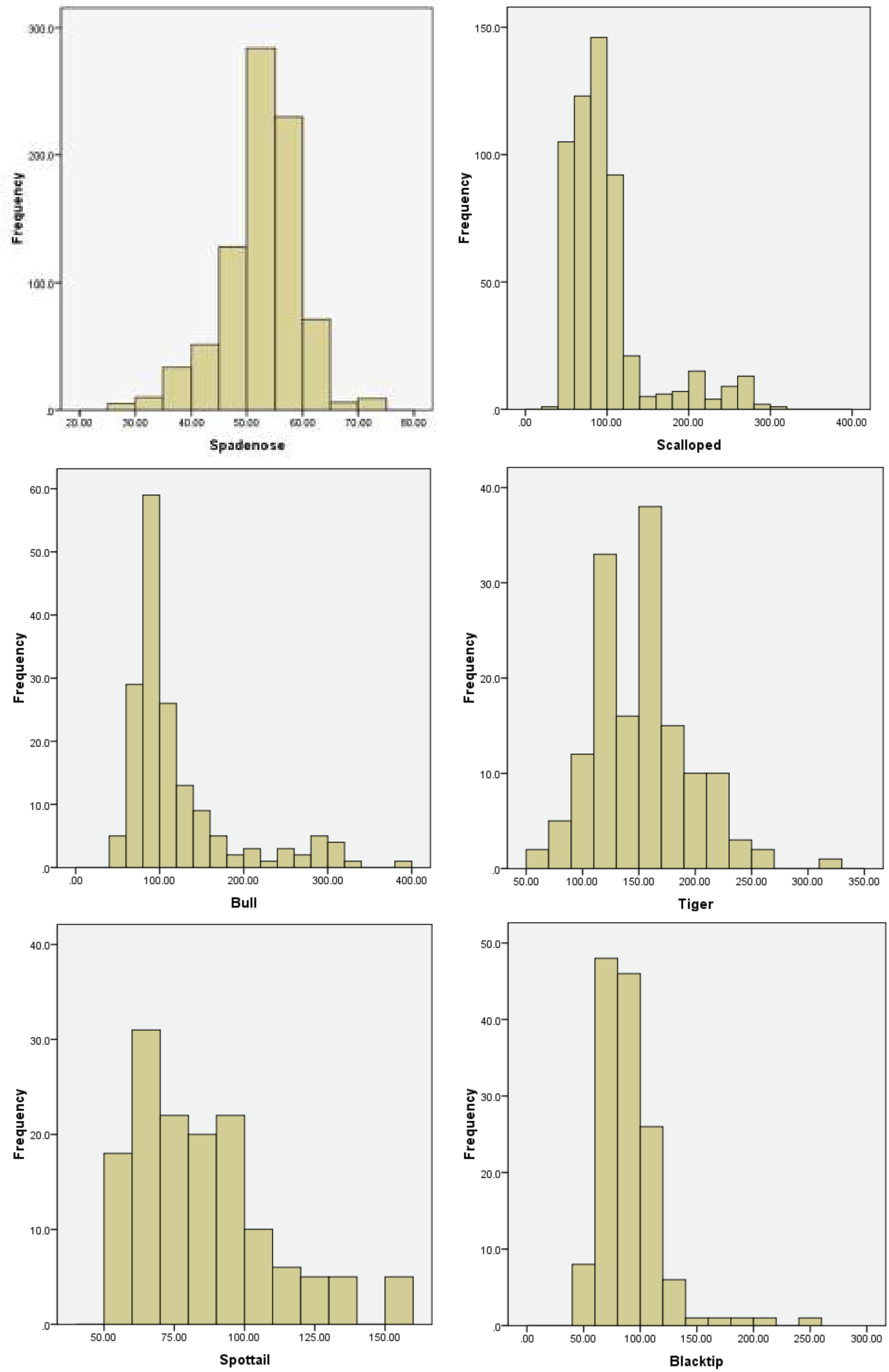

Figure 6. Frequency distribution of the maximum recorded size (cm) for 827 landings of Spadenose sharks (Mean=51.9, SD=7.0) (top left), 550 landing of Scalloped hammerhead sharks (Mean=97.7, SD=51.0) (top right), 168 landings of Bull sharks (Mean=120.9, SD=65.5) (middle left), 147 landings of Tiger sharks (Mean =152.9, SD=42.4) (middle right), 144 landings of Spottail sharks (Mean=85.0, SD=24.8) (bottom left), and 139 landings of Blacktip sharks (Mean=88.9, SD=28.2).

Conservation status

Of the 19 shark species identified at fishing landing sites, eight are considered threatened in the Global IUCN Red List including the Critically Endangered Ganges shark *Glyphis gangeticus*, Scalloped hammerhead *Sphyrna lewini*, and Great hammerhead *S. mokarran*; Endangered Whale shark *Rhincodon typus* and Pelagic thresher shark *Alopias pelagicus*; and Vulnerable Silky shark *Carcharhinus falciformis*, Smooth hammerhead *Sphyrna zygaena*, and Snaggletooth shark *Hemipristis elongata*, with the remaining sharks considered Near Threatened (7), Least Concern (2) and Data Deficient (2) (Table 5).

Altogether these eight threatened sharks accounted for 27.2% of the total landings by frequency, 3.42% by the total individuals and 15.4% by weight. Scalloped hammerhead sharks accounted for the largest portion of catches of these threatened species comprising 25.0% of all landings, 3.4% of all individuals, and 15.1% of the total weight of all shark landings at the eight sampled sites. Note that the proportion of all threatened shark individuals and Scalloped hammerhead individuals is almost the same, which can be explained by the fact that 98.9% of all threatened sharks landed (71,067) were Scalloped hammerheads.

Six of the eight threatened species mentioned above, including all three hammerheads, Pelagic threshers, Silky and Whale sharks are listed in CITES Appendix II. These six sharks accounted for virtually the same percentages as all eight of the threatened species mentioned above because landings of the two other threatened species, not listed in CITES, accounted for only 0.2% of landings by frequency and <0.01% by individual and weight of all threatened species.

Economic value

The total value of shark catches at the eight landing sites was estimated to be at least US$ 1.7 million per year or about 145 million BDT with a 95% confidence interval of about US$ 1.4 million to 2.0 million per year or about 116 to 173 million Taka (Table 6). This amount should be considered a minimum because some sharks were landed before the data collector arrived at the landing site or after they left, or because they were busy examining one shark landing while another group of sharks was brought to the landing site, sold, and taken away before they had a chance to examine the catch.

Small Bengal and Scaly whiprays locally called *paisi* or *faisi* drying at the Nazirtek fish drying center in Cox's Bazar.

Table 5. List of 19 shark species identified at fish landing sites in coastal Bangladesh with information on the percentage of total landings, numbers, weight; their IUCN Red List status (CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient); CITES and CMS Appendix listing, and current and proposed listing in the Bangladesh Wildlife (Conservation and Security) Act, 2012.

Common name	Scientific name	% landings	% numbers	% weight	IUCN Red list	CITES Appendix	CMS Appendix	Current Wildlife Act Listing	Proposed Wildlife Act Listing
Great hammerhead	*Sphyrna mokarran*	0.45	0.02	0.10	CR	II	II	NL	I
Scalloped hammerhead	*Sphyrna lewini*	25.05	3.38	15.12	CR	II	II	I	I
Ganges shark	*Glyphis gangeticus*	0.14	<0.01	<0.01	CR	NL	NL	I	I
Pelagic thresher	*Alopias pelagic*	0.05	<0.01	<0.01	EN	II	II	NL	I
Whale shark	*Rhincodon typus*	0.18	<0.01	0.17	EN	II	I	I	I
Silky shark	*Carcharhinus falciformis*	0.72	<0.01	0.02	VU	II	II	I	II
Smooth hammerhead	*Sphyrna cf. zygaena*	0.54	0.01	0.02	VU	II	NL	I	I
Snaggletooth shark	*Hemipristis elongata*	0.05	<0.01	<0.01	VU	NL	NL	NL	II
Burmese bamboo shark	*Chiloscyllium burmensis*	0.50	<0.01	<0.01	DD	NL	NL	NL	NL
Pigeye shark	*Carcharhinus amboinensis*	3.06	0.02	0.50	DD	NL	NL	NL	I
Grey sharpnose shark	*Rhizoprionodon oligolinx*	0.54	0.01	0.01	LC	NL	NL	NL	NL
Milk shark	*Rhizoprionodon acutus*	0.27	0.02	0.02	LC	NL	NL	I	NL
Blacktip shark	*Carcharhinus limbatus*	6.26	0.12	1.44	NT	NL	NL	I	II
Bull shark	*Carcharhinus leucas*	7.57	0.25	2.44	NT	NL	NL	NL	I
Graceful shark	*Carcharhinus amblyrhynchoides*	1.58	0.01	0.06	NT	NL	NL	NL	II
Spadenose shark	*Scoliodon laticaudus*	38.29	96.07	79.32	NT	NL	NL	I	NL
Spinner shark	*Carcharhinus brevipinna*	1.17	<0.01	0.02	NT	NL	NL	NL	II
Spottail shark	*Carcharhinus sorrah*	6.85	0.05	0.22	NT	NL	NL	I	II
Tiger shark	*Galeocerdo cuvier*	6.76	0.02	0.54	NT	NL	NL	I	II

Table 6. Minimum economic value of shark catches (N=2,687) sold in Alipur Kuakata, Bagerhat, Chittagong, Cox's Bazar, Parerhat, Patharghata, Rupsa and Saint Martin's Island. BDT = Bangladeshi Taka, USD = United States Dollar, SD = standard deviation.

Month	N	Mean BDT per day	Mean USD per day	SD in BDT	SD in USD	Number of days landing site was open	BDT per month	USD per month
Jan	214	20,423	243	93,338	1,111	31	5,064,953	60,297
Feb	173	20,281	241	50,427	600	28	4,543,017	54,084
Mar	333	54,044	643	252,333	3,004	31	13,402,904	159,558
Apr	336	37,182	443	196,823	2,343	30	8,923,690	106,234
May	331	22,631	269	93,323	1,111	31	5,612,527	66,816
Jun	240	6,752	80	21,685	258	30	1,620,400	19,290
Jul	270	3,315	39	13,110	156	31	822,118	9,787
Aug	238	63,716	759	292,839	3,486	31	15,801,473	188,113
Sep	223	200,524	2,387	643,452	7,660	30	48,125,774	572,926
Oct	55	214,486	2,553	656,754	7,818	9	15,442,996	183,845
Nov	229	128,054	1,524	481,267	5,729	31	31,757,426	378,065
Dec	273	15,942	190	55,359	659	30	3,826,022	45,548

Rays

Overall landing characteristics

Like shark landings but less pronounced, ray landings were skewed with frequent landings of small numbers of individuals and much less frequent landings of large numbers of individuals comprising most of the total catch according to the number of individuals and their weight (Figure 7-left, Table 7). More than two thirds of ray landings included 10 or fewer individuals (67.9%) but accounted for only 3.4% of the total number of rays landed, with landings of >10 but ≤100 individuals comprising about one quarter of the total landings (25.8%) but only 13.4% of individuals, landings of >100 but ≤1,000 individuals comprising 5.5% of total landings but accounting for 28.5% of individuals, landings of >1,000 but ≤10,000 individuals comprising 0.7% of total landings but accounting for 27.2% of individuals, and >10,000 individuals comprising 0.1% of total landings but accounting for 27.5% of individuals landed.

The weight of rays recorded per landing was also positively skewed (Figure 7-right). For instance, 28.5% of landings were ≤10 kilograms accounting for only 0.9% of the total weight, 48.8% of the landings were >10 but ≤100 kilograms accounting for 13.7% of the total weight, 20.7% of the landings were >100 but ≤1,000 kilograms accounting for 42.1% of total weight, 1.8% of landings were >1,000 kilograms but ≤10,000 kilograms accounting for 28.1% of the total weight and 0.1% of landings were >10,000 kilograms accounting for 15.1% of the total weight.

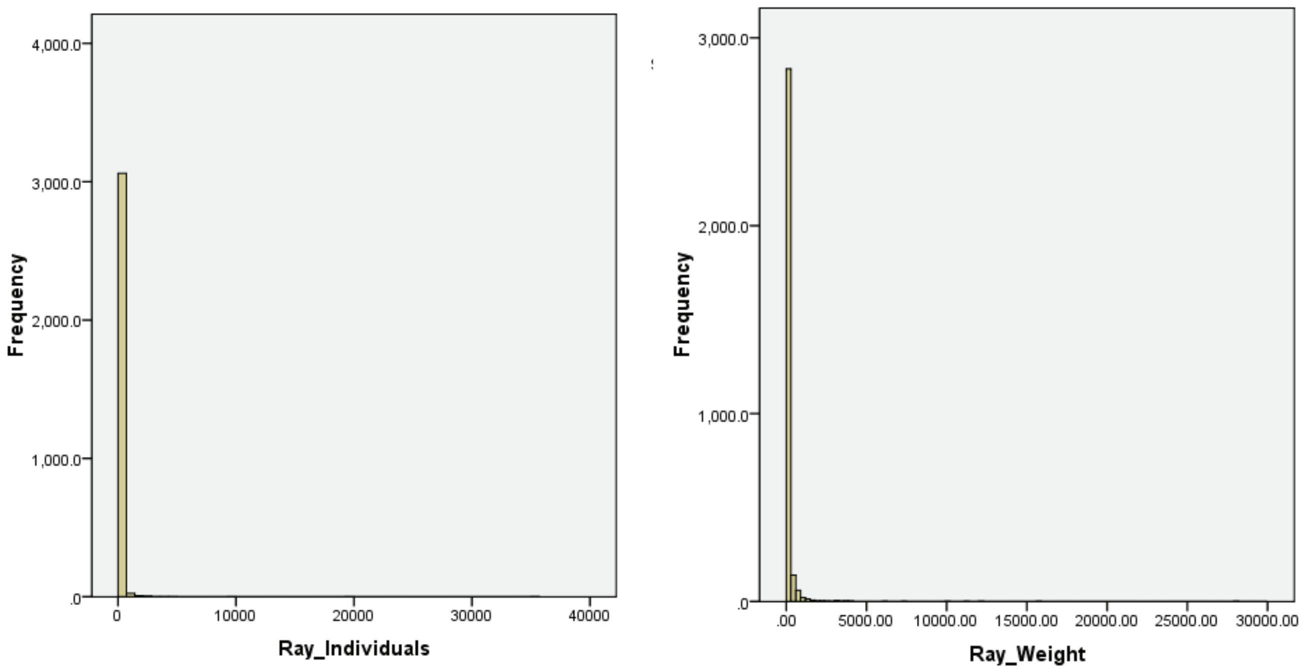

Figure 7. Frequency distribution of the number of ray individuals per landing (left) and weight per landing in kilograms (right) from 3,103 ray landings at eight fish landing sites, both indicating a skewed distribution of many landings of a few rays weighing little and relatively few landings of many rays weighing a lot and accounting for most ray landings by number and weight.

Table 7. Percentage of landings according to the number of ray individuals per landing at eight fish landing sites.

	% landings of shark individuals				
Landing Site	≤ 10	> 10 & ≤ 100	> 100 & ≤ 1,000	> 1,000 & ≤ 10,000	>10,000
Alipur Kuakata	81.0	19.0	0.0	0.0	0.0
Bagerhat	100.0	0.0	0.0	0.0	0.0
Chittagong	92.9	7.1	0.0	0.0	0.0
Cox's Bazar	63.7	28.5	6.8	0.8	0.1
Parerhat	82.7	17.3	0.0	0.0	0.0
Patharghata	93.8	6.3	0.0	0.0	0.0
Rupsa	78.5	14.0	6.4	1.2	0.0
St. Martin's Island	68.7	29.9	1.4	0.0	0.0

Taxonomy and species occurrence

Ten ray families, including 20 genera and 41 species, were represented in 3,103 landings. Slightly more than half of the landings (50.6%) were from the Dasyatidae family with the Gymnuridae, Glaucostegidae, Rhinopteridae and Mobulidae families represented in 17.3%, 13.8%, 8.9% and 6.0% of the landings, respectively, and other families each comprising <2.0% of the total landings (Table 8).

Table 8. Number of landings of ten different ray families during 2,941 visits to eight fish landing sites with the percentage of total ray encounters. Note that multiple ray families were often recorded during a single visit while no rays were recorded on 65.5% of all landing site visits.

Family name	Common name	Number of landings	Percentage of landings
Dasyatidae	Stingrays	1,569	50.6
Gymnuridae	Butterfly rays	536	17.3
Glaucostegidae	Giant guitarfish	429	13.8
Rhinopteridae	Cownose rays	277	8.9
Mobulidae	Manta and Devil rays	185	6.0
Aetobatidae	Pelagic eagle rays	54	1.7
Myliobatidae	Eagle rays	34	1.1
Pristidae	Sawfish	9	0.3
Narcinidae	Electric rays	5	0.2
Rhinidae	Wedgefish	5	0.2

From voucher photographs taken by the data collectors during 84.9% of the ray landings, we identifiied 42.2% of the photographed rays to species, 40.3% to genus and 17.5% to family. Note that rays are much more difficult to identify to the species level compared to sharks. Due to the strong concordance between identifications made by the data collectors and those made from photographs by WCS staff, the local names provided by the data collectors were used to identify the 15.1% of unphotographed ray encounters to genus.

From the 1,142 ray landings identified to species, the Bengal whipray *Brevitrygon imbricata*, Honeycomb whipray *Himantura undulata*, Bleeker's whipray *Pateobatis bleekeri* and Bluespotted maskray *Neotrygon caeruleopunctata* were the most landed species documented in 16.6%, 12.4%, 10.9% and 10.0% of the landings, respectively, with the remaining species documented in <10% of the total landings. However, these results should be considered in the context that the most common rays documented were unidentified stingrays and whiprays from the Dasyatidae family occurring in 18.9% of the landings. This family includes the Bengal whipray, Honeycomb whipray, Bleeker's whipray and Bluespotted maskray, the four most frequently documented species from landing sites. This means that these species are more common than the species-level proportions mentioned above.

The second most commonly occurring rays were unidentified butterfly rays from the *Gymnura* genus, which were identified from 17.1% of the landings. This genus includes the Longtail butterfly ray *G. poecilura*, which was only identified to species in 0.1% or three of the total landings. A similar situation occurred with Guitarfish from the *Glaucostegus* genus, which was the third most common ray documented during 10.5% of the landings. This genus includes the Sharpnose guitarfish *Glaucostegus granulatus*, Giant guitarfish *G. typus*, and Widenose guitarfish *G. obtusus* documented during 1.4%, 1.1% and 0.7%, respectively, of the total landings. Similar situations also occurred with unidentified species from the *Rhinoptera, Brevitrygon, Himantura, Mobula, Aetobatus, Urogymnus, Pastinachus*, and *Narcine* genera which were documented between <0.1 to 7.8% of the total landings. This means that species from the Dasyatidae family and the ten genera mentioned above are also underrepresented to an unknown degree in the data set.

A generalized linear model using a logit link function indicated that the species composition of ray landings recorded during 10 or more landing site visits (N=1,068) depends on landing site (Wald Chi-square = 51.8, $p<0.001$, df=7) but not month (Wald Chi-square = 10.6, $p<0.5$, df=11).

A discovery curve of the cumulative number of ray species encountered for the first time appears to indicate that most rays caught in small-scale coastal fisheries have probably already been identified (Figure 8). Although it is possible that additional species will be discovered in the future, the total species richness of rays in the coastal waters of Bangladesh is probably not very much greater than the 41 species that were recorded at eight fish landing sites between December 2016 and February 2019.

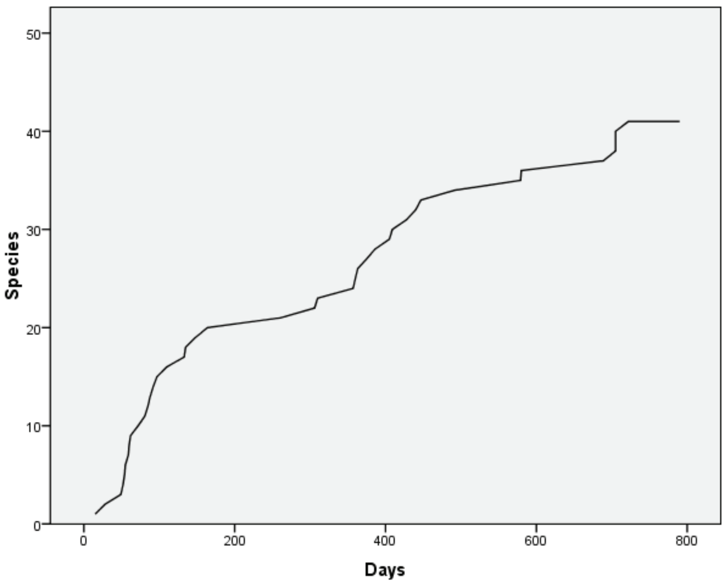

Figure 8. Discovery curve of the cumulative number of ray species identified during the almost 790 days of the study indicate that most species occurring in Bangladesh have been probably identified.

Landing sites

Data collectors documented one or more rays during 34.5% of their visits to fish landing sites (N=2,941). There was a large difference among landing sites in the frequency of ray encounters (Chi-square = 7.0E3, df=7, p<0.001), with the highest encounter rate of 84.5% for encounters per visit in Cox's Bazar (N=624) and the lowest encounter rate of 8.3% per visit in Bagerhat (N=416) (Figure 9).

There were also large differences in the frequency of individual rays per landing at each site (Kruskal-Wallis = 205.0, df=7, p<0.0001) with the largest number of rays per landing (81.4 individuals) in Cox's Bazar (N=2,279) and 52.3 individuals per landing in Rupsa versus only 1.7 individuals per landing in Bagerhat, 3.5 individuals per landing in Chittagong, and 3.7 individuals per landing at Patharghata. The two landings of >10,000 rays were recorded in Cox's Bazar, and 89.5% or 17 of the 19 landings of >1,000 but ≤10,000 rays were also in Cox's Bazar with the other two in Rupsa.

Not surprisingly, there were also differences in the weight of rays per landings in different landing sites (N=2,279) (Kruskal-Wallis = 213.0, df=7, p<0.0001), with the largest average weight per landing of 172.3 kilograms in Cox's Bazar and 145.5 kilograms per landing in Alipur Kuakata, followed by 100.2 kilograms per landing in Parerhat. The remaining sites in Bagerhat, Chittagong, Patharghata, Rupsa and Saint Martin's Island accounted for between 20.3 to 83.4 kilograms for total weight per landing.

Observed versus expected landing frequencies and number of individuals landed for rays landed during more than 20 site visits and totalling more than 400 individuals also indicated major differences among landing sites. There were greater than expected landings and numbers of individuals landed for all four species that met these criteria, with df=7 for eight landing sites, including Bengal whiprays (Chi-square=352.8, p<0.0001 for landings and Chi-square= 1.98e5, p<0.0001 for individuals), Honeycomb whiprays (Chi-square=199.7, p<0.0001 for landings and Chi-square= 2.82e3, p<0.0001 for individuals) , Bluespotted maskrays (Chi-square=410.1, p<0.0001 for landings and Chi-square= 1.02e4, p<0.0001 for individuals) and Bleeker's whiprays (Chi-square=97.3, p<0.0001 for landings and Chi-square=6.28e3, p<0.0001 for individuals).

All four species showed more frequent landings and individuals landed than expected in Cox's Bazar. Bengal whiprays were also landed slightly more than expected at Saint Martin's Island but in low numbers. Honeycomb whiprays were landed slightly more than expected and in much great numbers than expected in Rupsa, while Bluespotted maskrays were landed much more frequently and in slightly greater number of individuals than expected at Saint Martin's Island.

Figure 9. Observed versus expected landings (left) and individuals landed (right) of Bengal whiprays (top), Honeycomb whiprays (second from top), Bluespotted maskrays (second from bottom), and Bleeker's whiprays (bottom) if these parameters were distributed equally across landing sites in Alipur Kuakata, Bagerhat, Chittagong, Cox's Bazar, Parerhat, Patharghata, Rupsa, and Saint Martin's Island.

Monthly differences

There were also significant differences in the frequency of ray landings during different months (Chi-square = 62.3, df=11, p<0.001) with the most frequent landings recorded in September to March and the highest encounter rate in October (54.4%), and the least frequent landings from April to August with the lowest in July (20.2%) (Figure 10).

Similarly, there were significant differences in the number of rays per landing according to month (Kuskal Wallis 106.4, df=11, p<0001) with the highest numbers of 366 and 98 rays per landing (N=3,103) recorded in October and November, respectively, and another peak of 173 rays per landing in May, with the lowest numbers of 21.2, 4.3 and 13.7 rays per landing from June to August, respectively.

There were also significant differences among different months in the weight of rays documented per landing (Kruskal Wallis = 263.2, df=11, p<0.0001). The largest weights were recorded during two peaks, one in October and November of 462.3 and 165.9 kilograms, respectively, and another in February and March of 172.1 and 286.0 kilograms, respectively, with the lowest weights recorded in June and July of 52.4 and 19.8 kilograms, respectively.

Observed versus expected landing frequencies and number of individuals per site visit also indicated major differences among months (DF=11) for Bengal whiprays (Chi-square=45.5, P<0.0001 for landings and Chi-square=404,798, P<0.0001 for individuals), Honeycomb whiprays (Chi-square=33.9, P=0.0004 for landings and Chi-square=3,256, P<0.0001 for individuals), Bluespotted maskrays (Chi-square=53.2, P<0.0001 for landings and Chi-square=12,050, P<0.0001 for individuals). Bleeker's whiprays (Chi-square=24.5, P=0.0106) showed differences among observed versus expected landing frequencies but no difference in the number of individuals landed among different months.

There was also a great deal of variation in the monthly patterns for landings and individuals among and within species. For instance, landings of Bengal whiprays were not higher than expected in October, but the number of individuals landed was much higher (22,500) than expected (1,236). The number of landings of Honeycomb whiprays was highly variable during different months, and slightly less than expected but peaking in numbers by a significant margin in May with 784 individuals landed but only 156 expected. Bluespotted maskrays showed similar variability according to month, but with a major peak in the number of individuals landed in September with 2,153 individuals landed but only 323 expected. Similarly, Bleeker's whiprays showed major peaks in the number of individuals landed in April and October, 604 and 684 individuals, respectively, with 258 and 44 individuals expected, respectively, during these months. At the same time, the number of landings of Bleeker's whiprays was like the number expected according to the number of landing site visits.

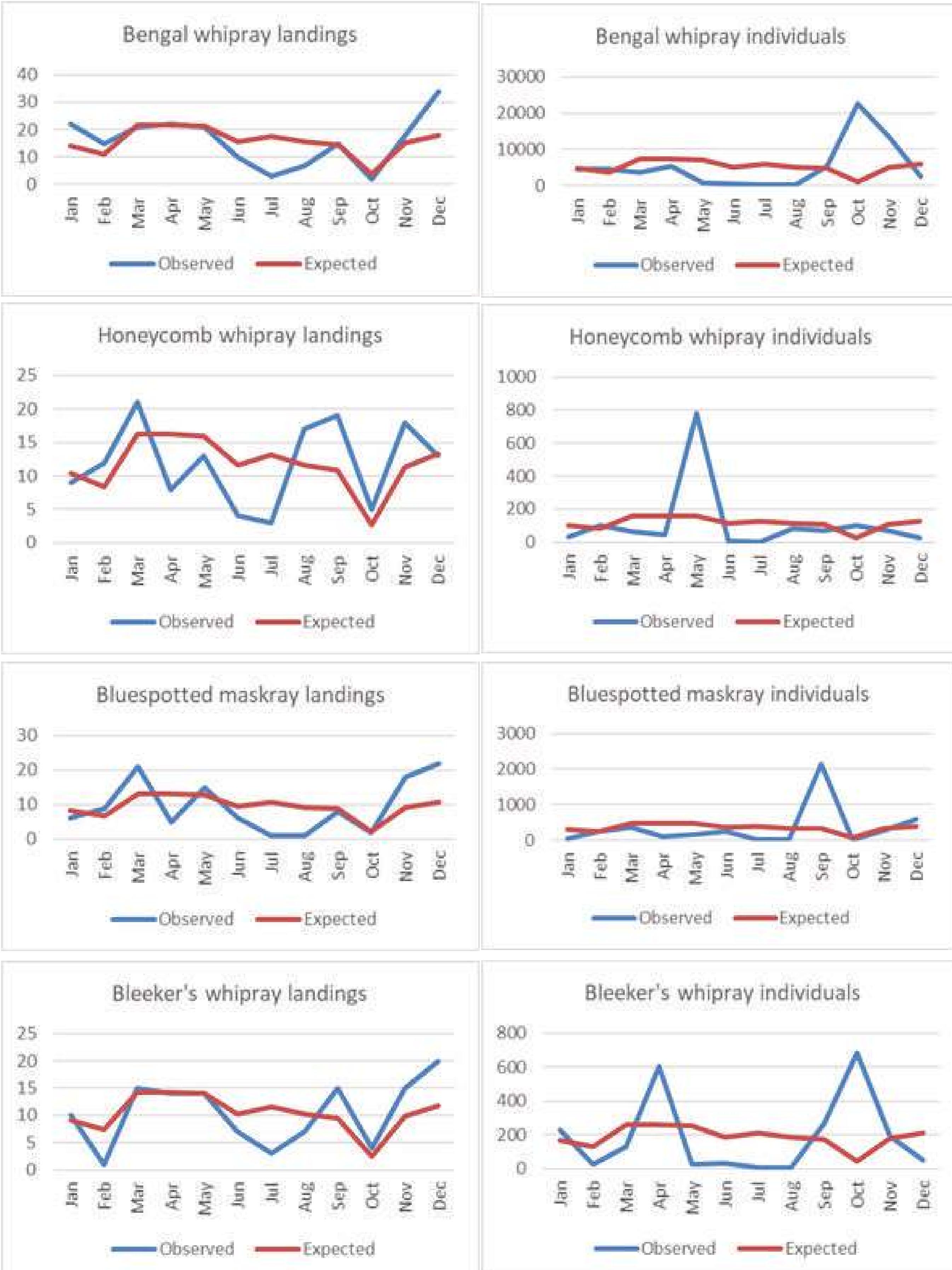

Figure 10. Observed versus expected landings (left) and individuals landed (right), if these parameters were distributed equally across months, of Bengal whiprays (top), Honeycomb whiprays (second from top), Bluespotted maskrays (second from bottom), and Bleeker's whiprays (bottom) if these parameters were distributed equally across months.

Gear types

From landings of rays that included data on the gear type responsible for the catches (N=2,756), there were differences among gears (Chi-square = 2,135.8, df=6, p<0.001) with medium-mesh gillnets and set-bag nets accounting for 32.0% and 32.4% of the total ray catches, respectively; longlines with baited hooks and large-mesh gillnets accounting for 16.3% and 13.6% of total ray catches, respectively, with the remaining 5.7% of rays caught in a bottom trawling and long-shore nets and longlines with unbaited hooks.

Similarly, there were also differences among the number of ray individuals caught in different gear types (Kruskal-Wallis = 113.3, df=6, p<0.001) with longlines with baited hooks accounting for 84.5% of the individuals, set-bag nets accounting for 8.6% of the individuals and bottom trawling nets, large-mesh gillnets, medium-mesh gillnets and longlines with unbaited hooks accounting together for <5% of the total individuals each.

Like the situation with the gear types responsible for catching ray individuals, there were significant differences in the weight of ray landings caught in different gears (Kruskal-Wallis = 242.3, df=6, p<0.0001), with large-mesh gillnets catching the largest weight per landing of 31.0 kilograms, followed by longlines with baited hooks with 19.6 kilograms, and longlines with unbaited hooks with 11.8 kilograms per landing. Set-bag nets were responsible for catching 60.2% and medium-mesh gillnets for 23.6% of the total weight of rays landed. Longlines with baited hooks and large-mesh gillnets were responsible for 8.8% and 6.9% of the total weight of rays landed, respectively, with bottom trawling, longlines with unbaited hooks, and long-shore nets responsible for <1.0% each.

Size distribution

Like sharks, data collected on the size of landed rays were not suitable for making quantitative estimates of populations trends. However, a rough indication of the population vulnerability can be made from an examination of the frequency distribution of maximum size in each landing (Figure 11) and the proportion of landings that include one or more individuals that were sexually mature based on information on length at sexual maturity for the species (Table 9) as reported in *FishBase*. An assessment of rays landed on 25 or more occasions at landing sites indicates that the large majority of Bengal whiprays are sexually mature, thereby implying a probable healthy population. However, the population status of Vulnerable Honeycomb whiprays and Bluespotted maskrays of particular concern with only about one-third and slightly less than one quarter of landings, respectively, including sexually mature individuals. Information on the length at sexual maturity was not available for Bleeker's whiprays.

Table 9. Size at sexual maturity, % landed below size at sexual maturity, and maximum length recorded of the six ray species commonly landed at eight landing sites along the coast of Bangladesh.

Common name	Length at sexual maturity (cm)	Landings with information on length	% landings with maximum length greater than size at sexual maturity
Bengal whipray	19	25	84.0
Honeycomb whipray	85 - 90	27	33.3*
Bluespotted maskray	31	114	23.7
Bleeker's whipray	?	125	?

*Using 87.5 cm as the criteria for the length of sexual maturity.

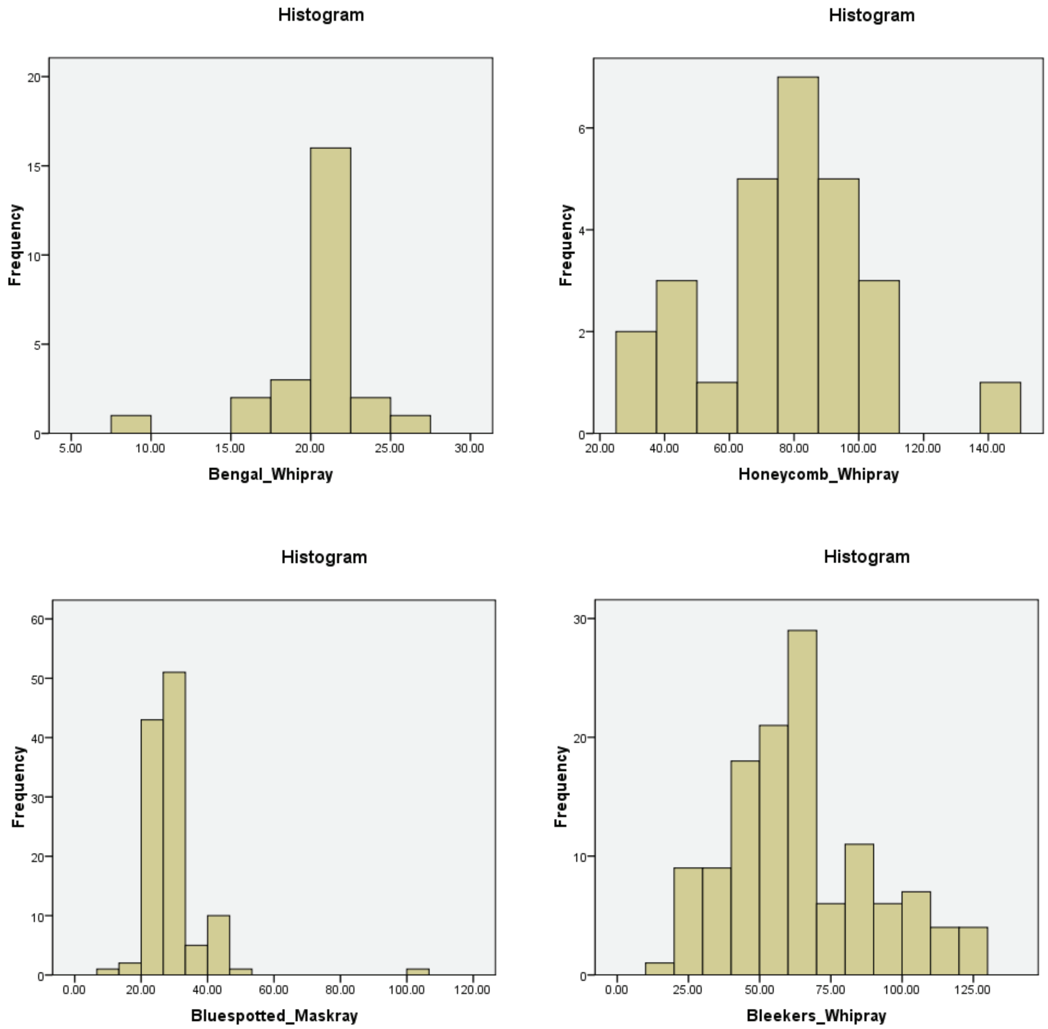

Figure 11. Frequency distribution of the maximum recorded size (cm) for 25 landings of Bengal whiprays (Mean=20.5 cm, SD=3.2) (top left), 27 landings of Honeycomb whiprays (Mean=77.1 cm, SD=25.1) (top right), 114 landings of Bluespotted maskrays (Mean=29.4 cm, SD=9.4) (bottom left), and 125 landings of Bleeker's whiprays (Mean=63.9 cm, SD=26.0).

Conservation status

Of the 41 ray species identified at fish landing sites, 27 are considered threatened in the IUCN Global Red List. These include the Critically Endangered Largetooth sawfish, Bowmouth guitarfish, Giant guitarfish, Sharpnose guitarfish, and Widenose guitarfish; Endangered Bentfin devilray, Chilean devilray, Giant devilray, Kuhl's devilray, Giant freshwater whipray, Longhead eagle ray, Mottled eagle ray, and Ocellate eagle ray; and 14 other Vulnerable ray species (Table 10). Altogether these 27 threatened rays accounted for 60.2% of the total landings by frequency, 5.8% by total individuals and 55.2% by total weight, indicating a strong link between the threatened status of rays, large body size and low number of individuals landed. The most landed of the threatened rays according to frequency was the Vulnerable Honeycomb whipray, recorded in 12.4% of the total landings, followed by the Endangered Giant devilray in 9.0% of total landings. The Honeycomb whipray also accounted for the largest proportion by number of individuals of threatened rays, accounting for 1.9% of the total individuals and 13.3% of the total weight landed.

Economic value

The total value of ray catches at the eight landing was estimated to be US$ 986,022 per year or about 83 million BDT with a 95% confidence interval of US$ 742,081 to 1,229,964 or between around 62 and 103 million Taka. Similar to the situation with sharks, this is an underestimate because some ray landings may have been missed during the visits, either because rays were landed before the data collector arrived at the site or after they left, or because the data collectors were busy examining one group of rays while another group was brought to the landing site and taken away before they had a chance to examine the catch. However, it provides a minimum value for rays landed at the eight landing sites. Month-wise economic values of the ray fishery at the eight landing sites are described in the Table 11.

Huge numbers of guitarfishes (*Glaucostegus spp*) locally known as *pitambori* or *nangla* for sale at the BFDC fish landing center in Cox's Bazar.

Table 10. List of 41 ray species identified at fish landing sites in coastal Bangladesh with information of the percentage of total landings, numbers and weight for those landings identified to species (N=1,142 and their IUCN Red List status (CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient)

Common name	Scientific name	% landings	% numbers	% weight	IUCN Red list	CITES Appendix	CMS Appendix	Current Wildlife Act Listing	Proposed Wildlife Act Listing
Bowmouth guitarfish	*Rhina ancylostoma*	0.44	0.01	0.11	CR	NL	NL	NL	II
Giant guitarfish	*Glaucostegus typus*	2.89	0.21	0.86	CR	NL	NL	NL	II
Largetooth sawfish	*Pristis pristis*	0.79	0.01	1.11	CR	I	I	I	I
Sharpnose suitarfish	*Glaucostegus granulatus*	3.85	0.58	4.03	CR	NL	NL	I	II
Widenose guitarfish	*Glaucostegus obtusus*	1.93	0.2	0.24	CR	NL	NL	NL	II
Bentfin devilray	*Mobula thurstoni*	0.61	0.03	0.28	EN	II	I	NL	I
Chilean (Sicklefin) devilray	*Mobula tarapacana*	0.18	0.01	0.33	EN	II	I	NL	I
Giant devilray	*Mobula mobular*	9.02	0.56	10.77	EN	II	I	NL	I
Giant freshwater whipray	*Urogymnus polylepis*	3.77	0.21	6.54	EN	NL	NL	NL	I
Kuhl's (Shortfin) devilray	*Mobula kuhlii*	2.63	0.26	1.07	EN	II	I	NL	I
Longhead eagle ray	*Aetobatus cf. flagellum*	0.09	<0.01	0.05	EN	NL	NL	NL	I
Mottled eagle ray	*Aetomylaeus maculatus*	0.18	<0.01	0.01	EN	NL	NL	NL	I
Ocellate eagle ray	*Aetomylaeus milvus*	2.8	0.08	0.54	EN	NL	NL	NL	I
Roughnose cowtail ray	*Pastinachus solocirostris*	0.18	0.01	0.02	EN	NL	NL	NL	I
Blotched stingray	*Taeniurops meyeni*	0.53	0.01	0.24	VU	NL	NL	NL	II
Coach (Reticulated) whipray	*Himantura uarnak*	4.64	0.34	2.83	VU	NL	NL	NL	II
Giant manta ray	*Mobula birostris*	0.09	<0.01	0.63	VU	II	I	NL	I
Honeycomb whipray	*Himantura undulata*	12.43	1.85	13.34	VU	NL	NL	NL	II
Javan cownose Ray	*Rhinoptera javanica*	2.45	0.2	0.65	VU	NL	NL	NL	I
Jenkins' whipray	*Pateobatis jenkinsii*	0.09	<0.01	<0.01	VU	NL	NL	NL	II
Leopard whipray	*Himantura leoparda*	0.53	0.04	0.57	VU	NL	NL	NL	II
Mangrove whipray	*Urogymnus cf. granulatus*	1.14	0.36	1.92	VU	NL	NL	NL	II

Table 10 continued.

Common name	Scientific name	% landings	% numbers	% weight	IUCN Red list	CITES Appendix	CMS Appendix	Current Wildlife Act Listing	Proposed Wildlife Act Listing
Porcupine ray	*Urogymnus asperrimus*	0.26	<0.01	0.19	VU	NL	NL	NL	II
Shortlip numbfish	*Narcine cf. brevilabiata*	0.09	<0.01	<0.01	VU	NL	NL	NL	II
Spotted eagle ray	*Aetobatus ocellatus*	2.19	0.07	0.62	VU	NL	NL	NL	II
Tubemouth whipray	*Urogymnus cf. lobistoma*	1.93	0.08	1.81	VU	NL	NL	NL	II
Whitespotted Whipray	*Maculabatis gerrardi*	4.29	0.73	6.43	VU	NL	NL	NL	I
Longtail butterfly ray	*Gymnura poecilura*	0.26	0.04	0.03	NT	NL	NL	II	NL
Scaly whipray	*Brevitrygon cf. walga*	0.09	0.02	<0.01	NT	NL	NL	NL	NL
Pelagic stingray	*Pteroplatytrygon violacea*	0.09	<0.01	<0.01	LC	NL	NL	NL	NL
Bengal guitarfish	*Rhinobatos annandalei*	0.35	0.01	<0.01	DD	NL	NL	NL	II
Bengal whipray	*Brevitrygon imbricata*	16.64	85.14	12.48	DD	NL	NL	NL	NL
Bennett's stingray	*Hemitrygon cf. bennetti*	0.35	0.11	0.12	DD	NL	NL	II	NL
Bluespotted maskray	*Neotrygon caeruleopunctata*	9.98	5.63	2.48	DD	NL	NL	II	NL
Brown numbfish	*Narcine timlei*	0.09	<0.01	<0.01	DD	NL	NL	NL	II
Smallspot numbfish	*Narcine maculata*	0.09	<0.01	<0.01	DD	NL	NL	NL	NL
Smoothback guitarfish	*Rhinobatos lionotus*	0.09	<0.01	<0.01	DD	NL	NL	NL	II
Spot-tail sleeper ray	*Narke dipterygia*	0.09	<0.01	<0.01	DD	NL	NL	NL	NL
Bleeker's whipray	*Pateobatis bleekeri*	10.95	3.01	29.06	NL	NL	NL	NL	I
Narrow cowtail ray	*Pastinachus gracilicaudus*	0.26	<0.01	0.02	NL	NL	NL	NL	NL
Shorttail cownose ray	*Rhinoptera cf. jayakari*	0.7	0.17	0.63	NL	NL	NL	NL	I

Table 11. Minimum economic value of the ray fishery in Alipur Kuakata, Bagerhat, Chittagong, Cox's Bazar, Parerhat, Patharghata, Rupsa and Saint Martin's Island. BDT = Bangladeshi Taka, USD = United States Dollar, SD = standard deviation. Note that the fish landing sites are open every day of the year except during the 22-day ban period to protect Hilsa spawning generally in October.

Month	N	Mean BDT per day	Mean USD per day	SD in BDT	SD in USD	Number of days landing site was open	BDT per month	USD per month
Jan	216	33,943	404	128,118	1,525	31	8,417,761	100,211
Feb	173	47,035	560	159,528	1,899	28	10,535,940	125,428
Mar	336	78,251	932	482,256	5,741	31	19,406,341	231,028
Apr	336	23,935	285	92,131	1,097	30	5,744,340	68,385
May	331	15,114	180	69,587	828	31	3,748,267	44,622
Jun	241	5,560	66	27,382	326	30	1,334,518	15,887
Jul	272	1,727	21	7,263	86	31	428,293	5,099
Aug	240	14,215	169	46,363	552	31	3,525,412	41,969
Sep	225	34,491	411	101,617	1,210	30	8,277,768	98,545
Oct	57	150,447	1,791	674,306	8,027	9	10,832,168	128,954
Nov	234	33,122	394	121,926	1,452	31	8,214,283	97,789
Dec	277	16,490	196	53,945	642	30	3,957,559	47,114

Discussion

Challenges

This study faced some key challenges including uncertainty among shark traders about the legal status of sharks and rays in trade, which resulted in our citizen science data collectors not being allowed to collect data at certain landing sites after raids and confiscations were made by law enforcement agencies. Also, particularly in Cox's Bazar and Chittagong, sharks and rays are frequently sold to traders who operate from separate vessels at sea, meaning the catches never reach the landing site to be recorded by the data collectors.

One shortcoming of the study was that it was limited to small-scale fisheries landing their catches at the eight coastal landing sites and it did not include information on shark and ray landings by pelagic trawl fisheries that generally fish in deeper offshore waters. Our analyses of shark and ray fisheries therefore underestimates landings of pelagic sharks in Bangladesh, such as CITES Appendix II listed thresher and mako sharks that occur where industrial trawl fisheries generally operate.

Common species

Landings of sharks and rays were dominated by a few relatively common species with far fewer landings, total individuals, and weight of a larger number of rarer species. Of the total shark landings identified to species (N=2,319), Spadenose sharks and Scalloped hammerheads together accounted for 63.4% of total landings, 99.5% of individuals and 94.4% of total weight, while the other 17 species accounted for the remainder. Of the total ray landings identified to species (N=1,309), Bluespotted maskrays and Bengal, Honeycomb and Bleeker's whiprays accounted for almost half (49.8%) of total landings, 95.6% of individuals and 57.4% of total weight, while the other 37 species accounted for the remainder. Of the most landed shark and ray species, the large number of Scalloped hammerhead sharks and Honeycomb whiprays being landed are of particular concern due to their Critically Endangered and Vulnerable status, respectively, in the IUCN Global Red List.

Although accounting for <1.0% of the total individuals landed, relatively common landings of Critically Endangered Giant, Sharpnose and Widenose guitarfish, accounting for between 1.9% and 3.9% landings each, and Endangered Giant devilrays, Giant freshwater whiprays, Kuhl's devilrays and Ocellate eagle rays, accounting for between 2.6% to 9.0% landings each, are concerning.

Rare species

Four shark species were encountered on less than five occasions. These include Whale, Ganges, Pelagic thresher, and Snaggletooth sharks, all of which are considered threatened with Ganges sharks Critically Endangered. Meanwhile 19 ray species were encountered on less than five occasions, of which nine are considered threatened, including Jenkin's whipray, Longhead eagle ray, Giant manta ray, Shortlip numbfish, Roughnose cowtail ray, Mottled eagle ray, Chilean (Sicklefin) devilray, Porcupine ray, and Bowmouth guitarfish, with Bowmouth guitarfish considered Critically Endangered.

New confirmed species

This study confirmed the identification of three new shark species, including Spinner, Burmese Bamboo and Snaggletooth sharks, and 11 new ray species, including Smallspot numbfish, Smoothback guitarfish, Giant freshwater whipray, Ocellate eagle ray, Roughnose cowtail ray, Bentfin devilray, Shorttail whipray, Giant manta ray, Round whipray, Shortlip numbfish, and Tubemouth whipray in Bangladesh. This indicates the strong value of this study in terms of better understanding the full range of elasmobranchs occurring in the country's waters. As indicated by the species discovery curves (Figures 3 and 8), we expect that the large majority of shark and ray species that occur in these waters have already been identified.

Landing sites

Fishing vessels generally land shark and ray catches at landing sites nearest to their fishing grounds or where they can get a high price for their catch. This explains the large number of sharks and rays landed at Cox's Bazar with well-established processing and marketing channels. By a significant margin, Cox's Bazar accounted for the large majority of shark and ray landings (67.2% for sharks and 73.4% for rays), number of individuals landed (96.7% for sharks and 92.8% for rays) and weight of landings (96.2% for sharks and 88.7% for rays).

Cox's Bazar is close to a wide variety of ocean habitats including the Meghna and Naf River mouths, reefs and islands, and a steep drop off to deep water. There is also a strong demand for shark fins and ray gill plates for export to China via at-sea transfer to vessels coming from Myanmar, and for shark and ray meat to supply local markets especially in the neighboring Chittagong Hill Tracts. Due to higher prices paid in Cox's Bazar, larger sharks and rays are often landed here even though other landing sites may be closer.

From the perspective of monitoring shark and ray fisheries, Cox's Bazar is clearly the most important landing site to focus on. However, it is important to also monitor fish landing sites close to other ocean habitat types, where rare species of particular conservation concern may be landed at higher rates. For example, 56.5% of 283 Vulnerable Smooth hammerhead sharks were landed in Rupsa while all five Critically Endangered largetooth sawfish landings were in Bagerhat and Rupsa, and 10 of 16 landings of Endangered Giant devilrays were in Alipur Kuakata.

Seasonality

The results of this study indicate great variability in the number of shark and ray landings and the number of individuals landed according to month, which may be connected to life history patterns including potential migration and seasonal reproduction patterns. Also affecting monthly landing patterns is a fishing ban period to protect Hilsa spawning which ran from 1-22 October in 2017 and 7-29 October in 2018. However, peaks in the number of Bull shark and Bengal and Bleeker's whipray individuals landed in October, versus the number expected according to site visits, indicate that the government fishing ban is not completely effective.

Fishing gears

A major finding of this study was that medium-mesh gillnets and set-bag nets are responsible for a large majority of shark landings. Together these gears accounted for about three quarters of all shark landings and more than 96% of all shark individuals landed. Sharks are not targeted by these gears, which means that reducing the demand for shark products through strengthened enforcement of laws regulating trade and consumption will not substantially reduce fishery related mortality. Interestingly, while medium-mesh gillnets and set-bag nets accounted for about 65% of the total ray landings, longlines with many hooks (both baited and unbaited) accounted for about 85% of the total number of rays landed. Longlines specifically target rays, thus implying that enforcement of laws regulating trade and consumption on rays would be more effective at reducing fishery related mortality compared to sharks. Clearly, the large proportion of non-target catches of both sharks and rays in medium-mesh gillnets and set-bag nets indicate that direct measures to reduce fishery related mortality, such as gear restrictions and area closures in MPAs, are needed along with enforcement of laws on trade and consumption.

Conclusion

This study revealed that the shark and ray fishery in Bangladesh is complex, involving many species (although dominated by a few) and gear types (both as targeted and non-targeted catches), and with a great deal of variation in the number of landings and individuals documented at different landing sites and during different months. The study also found that Bangladesh is a stronghold for several species of Critically Endangered and Endangered sharks and rays in need of urgent protection, including Great and Scalloped hammerhead sharks, Giant and Sharpnose guitarfish, Ocellate eagle rays, Giant devilrays and Giant freshwater whiprays. Meanwhile, the study also documented frequent landings of large numbers of individuals of other relatively common and non-threatened species, including Spadenose, Bull, Blacktip, Spottail and Tiger sharks, and Bengal and Bleeker's whiprays and Bluespotted maskrays, that provide opportunities for developing a sustainable shark and ray fishery based on rigorous science and in compliance with national wildlife laws and international obligations under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Convention on Migratory Species (CMS).

Requiem sharks (*Carcharhinidae spp*) locally known as *boli hangor* for sale at the BFDC fish landing center in Cox's Bazar.

A huge bull shark *Carcharhinus leucas* locally called *boli hangor* is hauled to the BFDC fish landing and processing center in Cox's Bazar.

CHAPTER 2

PREDICTIVE MAPPING AND A SPATIAL ASSESSMENT OF BYCATCH RISK FOR SHARKS AND RAYS FROM DATA COLLECTED BY A CITIZEN SCIENCE NETWORK OF GILLNET FISHERMEN IN BANGLADESH

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Background

In 2015 the Wildlife Conservation Society initiated a *Citizen Science Fisherman Safety Network* (CSFSN) that engaged 37 gillnet and, in 2017, seven bottom set un-baited longline fishers in Bangladesh to record geo-referenced and photo-verified data on their fishing practices and catches in exchange for providing them with a Global Positioning System (GPS) and training to increase their navigational safety. A strong focus of the network is to understand the spatial ecology and catch characteristics of sharks and rays in gillnet fisheries in the northern Bay of Bengal and then to apply this knowledge to conservation management that aims to prevent the extinction of threatened species and ensure that catches of non-threatened species are sustainable.

Gillnet fisheries in Bangladesh can be divided into two broad categories. The first uses medium mesh size nylon nets (9-10 cm). Locally called *chandi or lash jals*, these nets are 3-5,000 m long and used from May to December targeting Hilsa shad *Tenualosa ilisha*, a fishery that directly or indirectly employs about 2.5 million people and generates more than 1.3 billion USD for the national economy (Islam et al. 2016). The second is large-mesh size nylon nets (30-35 cm). Locally known as boro *nakura jals* or *koral/lakkha jals*, these nets have a thicker thread size compared to medium mesh nylon nets, are as long as 4,000 m, and normally used from January to April targeting large finfish such as the threadfin sea catfish *Arius arius*, four-finger threadfin *Eleutheronema tetradactylum*, snappers (family Lutjanidae), croakers (family Sciaenidae) and groupers (family Serranidae). Unbaited long lines use weights and sharp hooks with floats, locally known as *hazari borshi*. These nets are about 600-800 m long and operated in waters 3-12 m deep. They target rays and are normally operated from December to April.

Methods

Field

All gillnet and longline fishing vessel captains participating in the CSFSN were provided with a GPS, a digital waterproof camera, standardized data sheets and a richly illustrated handbook in Bengali language on recording information on their fishing practices and catches. They were also given training on how to use a GPS for safe navigation and recording a geographic position, identifying common shark and ray species, estimating their size and weight, and photographing dorsal, ventral, and lateral views of representative specimens of each species caught.

For each gillnet or longline set, fishermen recorded their geographic position at the locations of net deployment and retrieval, identifications to species or genus, and numbers and estimated weight of each species catch. Data were periodically collected from the fishermen by WCS staff who also mentored them on any questions they had and on improving the quality of the data recorded in the field.

Analyses

All data collected by the fishermen were entered into an Excel file database and then quality checked for errors. All species identification of sharks and rays were verified from photographs taken by the fishermen. Due to the close concurrence between the genus identifications made by the fishermen and identifications made by WCS staff from photographs taken in the field, for catches that did not include photographs we accepted the genera identifications of the fishermen. All species identifications were made directly from photographs by experienced WCS staff.

Maps of the predicted distribution of sharks and rays were generated for all georeferenced catch records combined and for species or genera/families that were caught in 10 or more gillnet or longline catches. Genera and families were analyzed for species groups that are particularly difficult to identify to species from photographs.

The predicted distribution of sharks and rays was modeled using a maximum entropy modelling approach (MaxEnt) that predicts species occurrence by finding the most widespread distribution based on presence-absence data and considering environmental variables of known locations of the species (Phillips et al. 2006, Kumar & Stohlgren, 2009). The MaxEnt model generated a probability estimate of species occurrence of 0 to 1, with 0 being the lowest and 1 the highest probability derived from the area under the curve (AUC) value. Environmental variables in the model included temperature, primary productivity, salinity, pH, light at the bottom and dissolved oxygen which was extracted from Bio-oracle website for marine data layers developed for ecological modelling (Assis et al. 2017). We also used depth collected from the NOAA ETOPO1 1 Arc-Minute global relief model bathymetry dataset (Amante & Eakins, 2009). Environmental variables were resampled from the raw dataset into a unique cell size (0.083 x 0.083 degrees) and clipped from the global range to the geographic extent of Bangladesh EEZ using ArcMap and R packages.

The intensity of fishing operations was mapped from the spatial distribution of gillnet sets generated from the GPS waypoints recorded by the fishermen and using a kernel density estimation technique. To estimate relative bycatch risk, we then calculated the overlap between the species distribution and fishing intensity using a raster calculator implemented in ArcMap to determine the overlap of species suitability and fishing intensity. The model generated a bycatch risk probability for the species ranging from 0 to 1, with 0 being the lowest and close to 1 the highest probability of bycatch risk.

Results

Summary of net sets and catches

Medium mesh nets

Data on fishing practices and catches were collected during 463 fishing trips and 3,559 net sets using medium mesh size nets. Medium mesh size net sets were concentrated mainly offshore of the Sundarbans mangrove forest with the majority (60%) set in the Swatch-of-No-Ground (SoNG) Marine Protected Area (MPA) mostly around the perimeter of the head of the submarine canyon in waters less than 500 m deep. Sharks were caught in 15.3% of medium mesh size net sets with six species recorded (Table 1). Most sharks (71%) were caught in the SoNG MPA in waters 10 to 100 m deep (Figure 1).

Table 1. Six shark species caught in medium mesh size gillnets in coastal waters of Bangladesh during October 2015 to August 2019.

Common name	Scientific Name	Number of catches	% of net sets species caught	Number of individuals caught when species recorded			Weight (kg) of individuals caught		
				Mean	SD	Range	Mean	SD	Range
Spadenose shark	*Scoliodon laticaudus*	326	9.2	34.7	121.5	1-2010	0.4	0.4	0.1-1.5
Blacktip shark	*Carcharhinus limbatus*	85	2.4	6.4	13.8	1-100	3.6	2.9	0.1-10.0
Pigeye shark	*Carcharhinus amboinensis*	42	1.2	11.7	14.4	1-60	2.1	1.8	0.5-8.0
Bull shark	*Carcharhinus leucas*	28	0.8	6.4	17.2	1-90	9.2	5.4	1.0-20.0
Scalloped hammerhead	*Sphyrna lewini*	20	0.6	9.7	22.2	1-100	8.5	21.5	0.4-80.0
Tiger shark	*Galeocerdo cuvier*	17	0.5	6.6	7.5	1-30	8.2	8.4	0.5-20.0

Rays were caught in 1.6% of medium mesh size net sets with seven species recorded (Table 2). Due to the difficulties in identifying rays to species, most of the catches (74%) were only identified to five genera and one family which were not represented in the species identifications. Most (69%) of the medium mesh gillnets that caught rays were set inside the SoNG MPA in waters 10 to 200 m deep (Figure 1).

Table 2. Seven ray species and five genera and one family that could not be identified to species from photographs caught in medium mesh size gillnets in coastal waters of Bangladesh during October 2015 to August 2019. SD=standard deviation, NA=not applicable.

Common name	Scientific Name	Number of catches	% of net sets species caught	Number of individuals caught when species recorded			Weight (kg) of individuals caught		
				Mean	SD	Range	Mean	SD	Range
Family									
Stingrays	Dasyatidae	13	0.4%	3.7	3.8	1-20	2.1	3.9	0.75-5.0
Genus									
Cownose rays	*Rhinoptera* spp	10	0.3%	1.6	3.7	1-4	5.9	26.9	1-15.0
Whiprays	*Himantura* spp	8	0.2%	3.4	3.5	1-10	5.6	24.5	0.5-12.0
Butterfly rays	*Gymnura* spp	8	0.2%	1.0	3.8	1	0.7	4.08	0.65-0.8
Eagle rays	*Aetobatus* spp	2	0.1%	NA	NA	NA	NA	NA	NA
Guitarfish	*Rhinobatus* spp	1	NA	NA	NA	NA	NA	NA	NA
Species									
Longtail butterfly ray	*Gymnura poecilura*	7	0.2%	1.3	2.1	1-2	27.6	NA	0.5-NA
Whitespotted whipray	*Maculabatis gerrardi*	2	0.1%	NA	NA	NA	NA	NA	NA
Bengal whipray	*Brevitrygon imbricata*	2	0.1%	NA	NA	NA	NA	NA	NA
Sharpnose guitarfish	*Glaucostegus granulatus*	1	0.0%	2.0	NA	2	NA	NA	NA
Giant devilray	*Mobula mobular*	1	0.0%	1.0	NA	NA	NA	NA	NA
Giant freshwater whipray	*Urogymnus polylepis*	1	0.0%	NA	NA	NA	NA	NA	NA
Bengal guitarfish	*Rhinobatos annandalei*	1	0.0%	NA	NA	NA	NA	NA	NA

Large mesh nets

Data on fishing practices and catches were collected during 85 fishing trips and 688 sets using large mesh size nets targeting large finfish (Table 3). Large mesh gillnet sets targeting large finfish were concentrated in waters deeper and farther offshore than medium mesh gillnet sets although there was substantial overlap with a large portion (48%) also occurring in the SoNG MPA. Nets were set in waters generally deeper than 20 m with a few in waters deeper than 200 m inside the submarine canyon.

Table 3. Nine shark species caught in large mesh size gillnets in coastal waters of Bangladesh during October 2015 to August 2019. SD=standard deviation, NA=not applicable.

Common name	Scientific Name	Number of catches	% of net sets species caught	Number of individuals caught when species recorded			Weight (kg) of individuals caught		
				Mean	SD	Range	Mean	SD	Range
Scalloped hammerhead	*Sphyrna lewini*	44	6.4%	10.5	20.0	1-110	8.0	13.5	3.0-70.0
Pigeye shark	*Carcharhinus amboinensis*	35	5.1%	6.8	10.0	1-50	10.3	16.8	0.4-60.0
Tiger shark	*Galeocerdo cuvier*	30	4.4%	2.6	5.2	1-29	9.2	9.0	3.0-45.0
Blacktip shark	*Carcharhinus limbatus*	21	3.1%	7.7	11.6	1-44	4.8	2.3	0.6-8.0
Spadenose shark	*Scoliodon laticaudus*	15	2.2%	6.1	7.5	1-20	0.4	0.1	0.1-0.6
Bull shark	*Carcharhinus leucas*	11	1.6%	5.0	8.4	1-30	8.9	4.7	4.0-20.0
Spottail shark	*Carcharhinus sorrah*	5	0.7%	5.7	4.0	2-10	7.2	6.8	2.4-12.0
Spinner shark	*Carcharhinus brevipinna*	2	0.3%	4.0	NA	4	NA	NA	NA
Graceful shark	*Carcharhinus amblyrhynchoides*	2	0.3%	NA	NA	NA	NA	NA	NA

Nine shark species were caught in 27.6% (190) of 688 large mesh gillnet sets. Most of the large mesh gillnet sets which caught sharks (74%) were located around the southern and deeper part of the SoNG MPA in waters 10 to 200 m deep (Figure 1).

Four ray species were caught in 3.5% of 688 large mesh gillnet sets (Table 4). Most catches (63%) were only identified to genus or family. Two genera and one family were identified that were not represented in the species identifications. Most of the large mesh gillnet sets which caught rays (45%) were located around the SoNG marine protected area between 50 to 200 m deep as well as in nearshore waters (Figure1).

Table 4. Four ray species and two genera and one family that could not be identified to species from photographs caught in large mesh size gillnets during October 2015 to August 2019. SD=standard deviation, NA=not applicable.

Common name	Scientific Name	Number of catches	% of net sets species caught	Number of individuals caught when species recorded			Weight (kg) of individuals caught		
				Mean	SD	Range	Mean	SD	Range
Family									
Stingrays	Dasyatidae	6	0.9	8.33	10.78	1-25	1.65	0.21	1.5-1.8
Genus									
Cownose rays	*Rhinoptera* spp	8	1.2	3.67	1.78	3-5	4.9	NA	NA
Butterfly rays	*Gymnura* spp	1	0.1	4.00	NA	NA	2.3	NA	NA
Species									
Longtail butterfly ray	*Gymnura poecilura*	5	0.7	4.40		3-7	2.0	NA	NA
Bengal whipray	*Brevitrygon imbricata*	2	0.3	NA	NA	NA	NA	NA	NA
Sharpnose guitarfish	*Glaucostegus granulatus*	1	0.1	2.00	NA	NA	NA	NA	NA
Spotted eagle ray	*Aetobatus narinari*	1	0.1	1.00	NA	NA	3.00	NA	NA

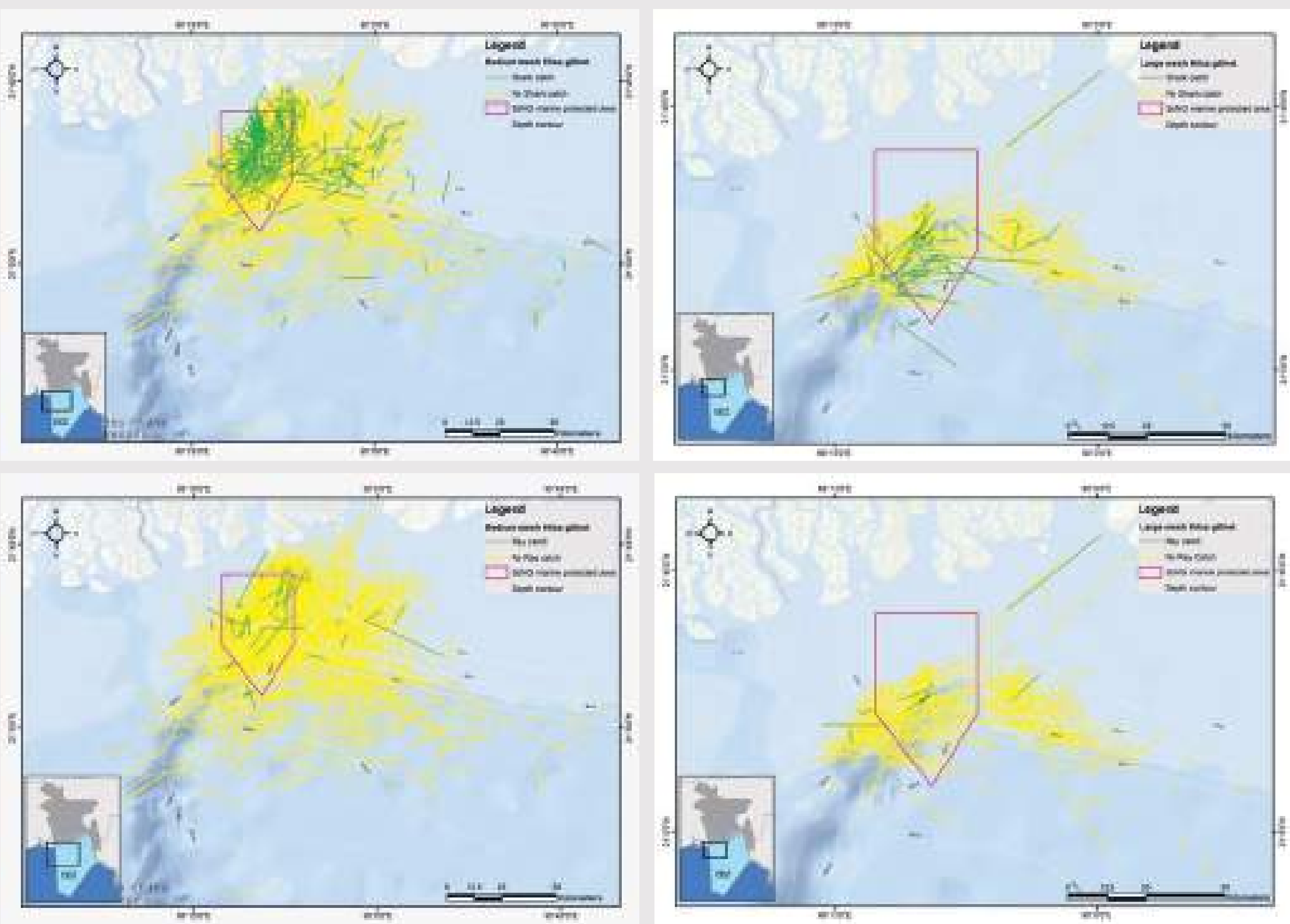

Figure 1. Locations of medium mesh (left) and large mesh (right) net sets indicated in yellow and shark catches (top) and ray catches (bottom) indicated in green.

Predicted distribution of sharks and rays

Sharks

The combined model for all shark catches combined (N=677) predicted that the most suitable habitat is in the nearshore shallow waters offshore the Sundarbans mangrove forest in waters generally less than 100 m deep but also occurring in deeper waters (> 500 m) at the head of the SoNG (Figure 2, Table 5). The Meghna estuary (in the central-northern most open area) shows low suitability of shark habitat. Lack of data on shark catches in that area could be the reason behind the low suitability ranking.

Using data on 620 shark catches with geographic positions, maps were generated of the predictive distribution of six species (Figure 3). These included Spadenose (N=309), Blacktip (N=95), Pigeye (N=71), Scalloped hammerhead (N=60), Tiger (N=47) and Bull (N=38) sharks. Four species (Spadenose, Blacktip, Pigeye and Bull shark) exhibited habitat preferences for estuaries, mangroves, or inshore areas. Depth preferences varied slightly among species. Other shark species with different habitat preferences that were not identified during this study may inhabit waters identified as low probability for shark and ray occurrence in these maps.

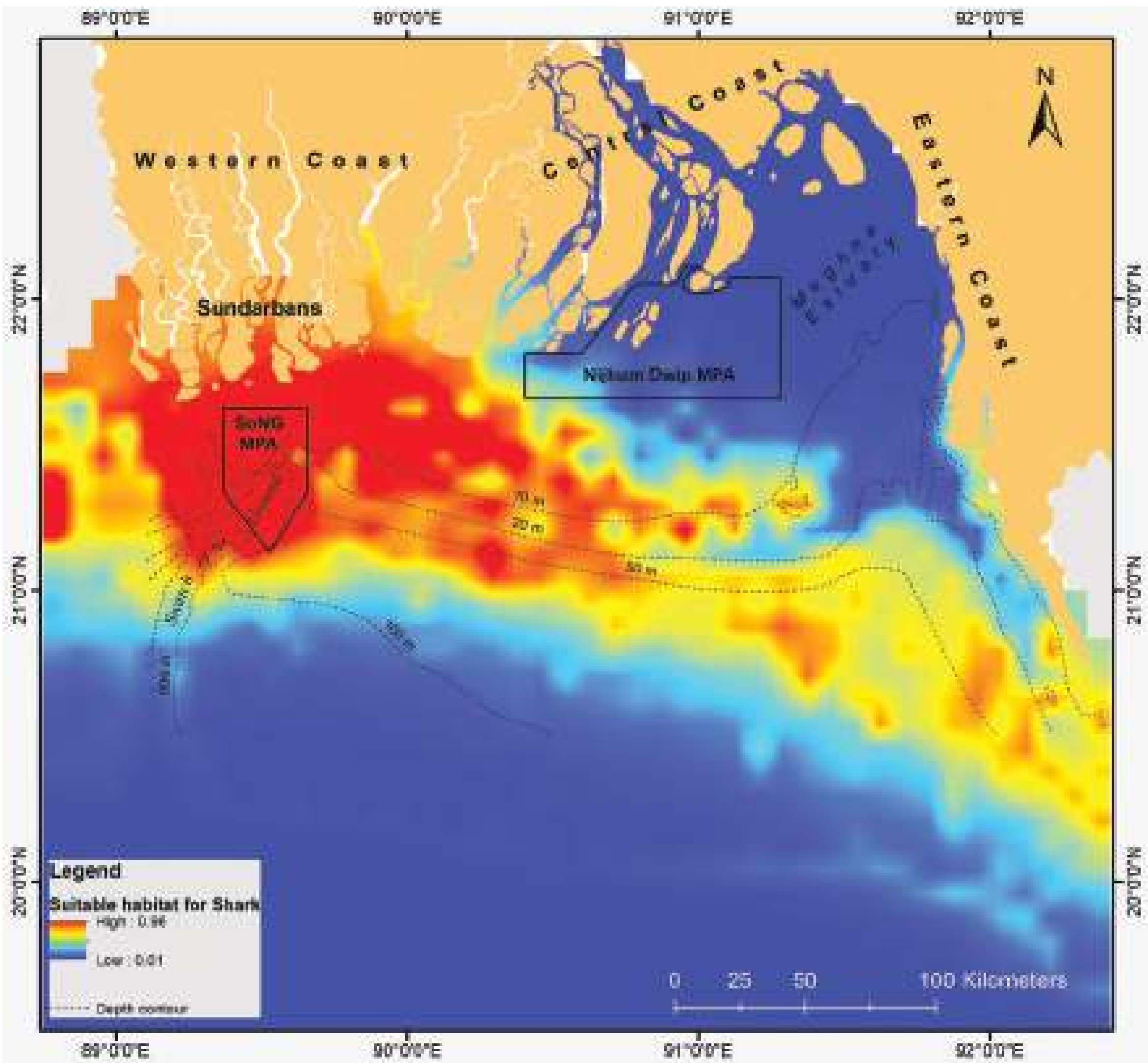

Figure 2. Predicted distribution of all sharks combined (N=677) based on catch data from gillnet fishermen.

Table 5. Core range, number of catches, % probability of seven environmental parameters (DP = depth, PP = primary productivity, DO = dissolved oxygen, SL = salinity, TP = temperature, PH = pH, and LB = light at bottom, SD=standard deviation) that explains the predicted distribution of all shark catches and species recorded in 10 or more occasions, and the average area under the curve (AUC) value from maps generated for all sharks combined and species recorded in at least 10 occasions in the northern Bay of Bengal.

Species	Number of catches	Core range	% Environmental parameters							AUC value
			DP	PP	DO	SL	TP	PH	LB	
All sharks combined	677	Estuaries and nearshore shallow waters offshore the Sundarbans in waters generally <100 m deep but also as deep as 1,000 m in the head of the SoNG.	3.4	27.9	5.4	1.1	26.1	34.2	2.1	0.91 (SD = ± 0.03)
Spadenose shark	309	Inside the mangrove estuary which extends from the Sundarbans to southern offshore to the SoNG, mostly <50 m deep along the coast but also as deep as 500 m.	3.0	35.6	9.3	1.3	13.9	31.9	5.0	0.94 (SD= ± 0.03)
Blacktip shark	95	Extends from near shore and offshore Sundarbans area to the SoNG MPA, mostly 10 to 100 m deep along the coast but also as deep as 1,000 m.	0.9	11.3	2.4	0.7	31.4	44.1	9.3	0.95 (SD= ± 0.03)
Pigeye shark	71	Extends from near shore and offshore Sundarbans area to the SoNG MPA, mostly at 10 to 50 m deep along the coast but also as deep as 1,000 m.	2.7	46.1	0.9	1.6	1.9	32.8	14.0	0.94 (SD= ± 0.04)
Scalloped Hammerhead	60	Sundarbans southern offshore area to the SoNG MPA, mostly 10 to 100 m deep along the coast but also as deep as 1,000 m.	1.9	9.2	4.6	5	33.5	36.2	9.6	0.90 (SD= ± 0.12)
Tiger shark	47	Sundarbans southern offshore area to the SoNG MPA, mostly <100 m deep along the coast but also as deep as 1,000 m.	3.2	9.3	3.8	6.5	27.5	42.9	6.6	0.94 (SD= ± 0.04)
Bull shark	38	Sundarbans southern offshore area to the mangrove estuary and around the SoNG MPA, mostly 10 to 100 m deep along the coast but also as deep as 500 m.	11.5	57.6	2.1	0.8	0.9	20.9	6.2	0.92 (SD= ± 0.06)

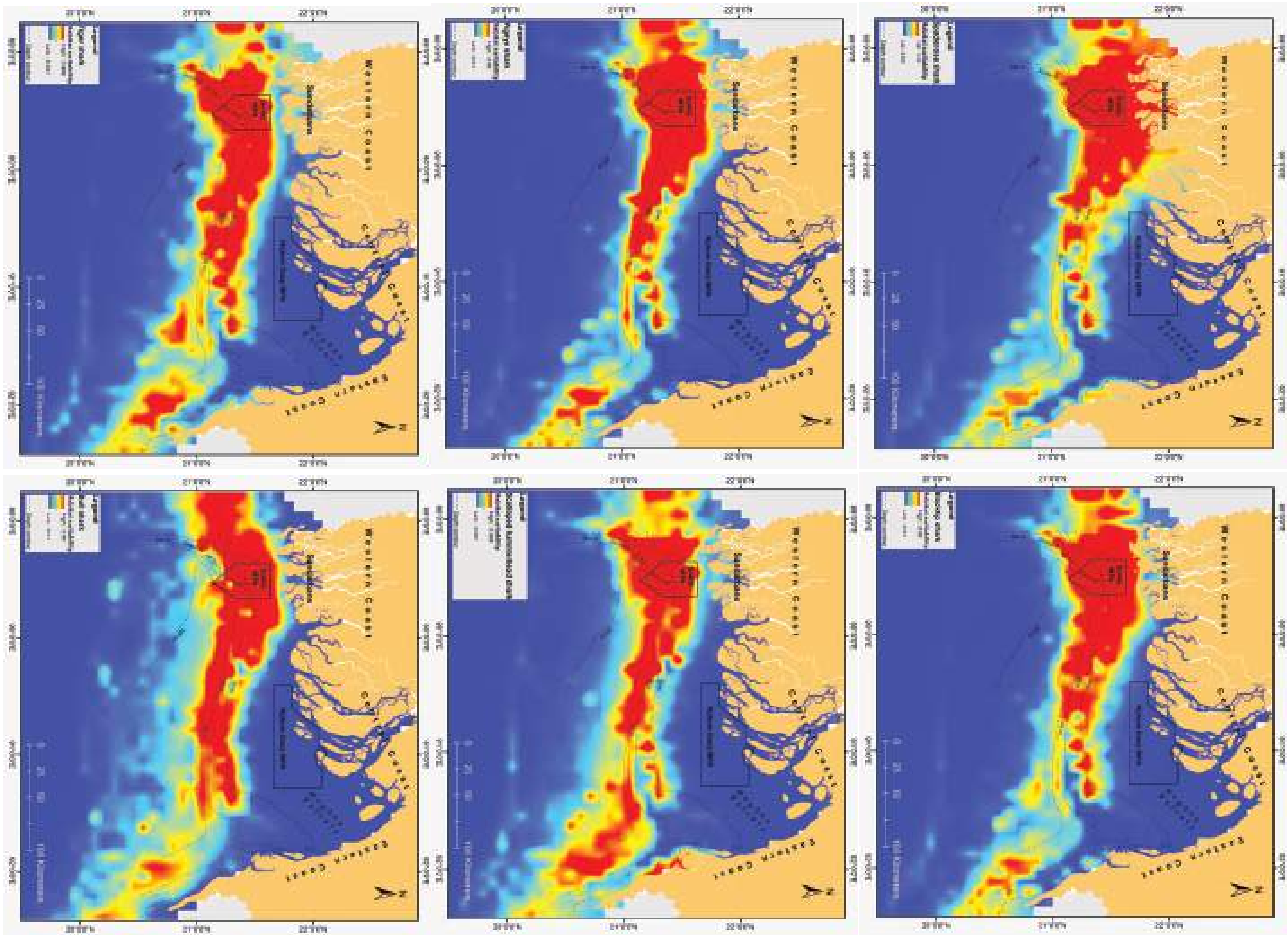

Figure 3. Predicted distribution of Spadenose (N=309), Blacktip (N=95), Pigeye (N=71), Scalloped hammerhead (N=60), Tiger (N=47) and Bull (N=38) sharks according to habitat suitability models based on environmental parameters of catch locations in the coastal waters of Bangladesh.

Rays

We extracted spatial information of ray catch (N=381) by combining total catches documented by gillnet fishermen and bottom unbaited longline fisheries specifically targeting rays. The combined model for all rays predicted the most suitable habitat in the estuaries and nearshore shallow water extending from the western to central coast including inside the fringe areas of the Sundarbans (Figure 4). The Meghna River mouth showed the lowest suitability for rays.

Rays are more difficult to identify to species compared to sharks and the total number of ray catches was low (N=381) compared to the total shark catches (N=677). We were able to generate maps of the predicted distribution of seven species: Longtail butterfly ray (N=18), Bleeker's whipray (N=32), Giant freshwater whipray (N=57), Honeycomb whipray (N=21), Narrow cowtail ray (N=15), Sharpnose guitarfish (N=53) and Shorttail stingray (N=17), one genus: Cownose rays *Rhinoptera* sp. (N=17), and one family: Stingrays Dasyatidae (N=19) (Figure 5 and Table 6).

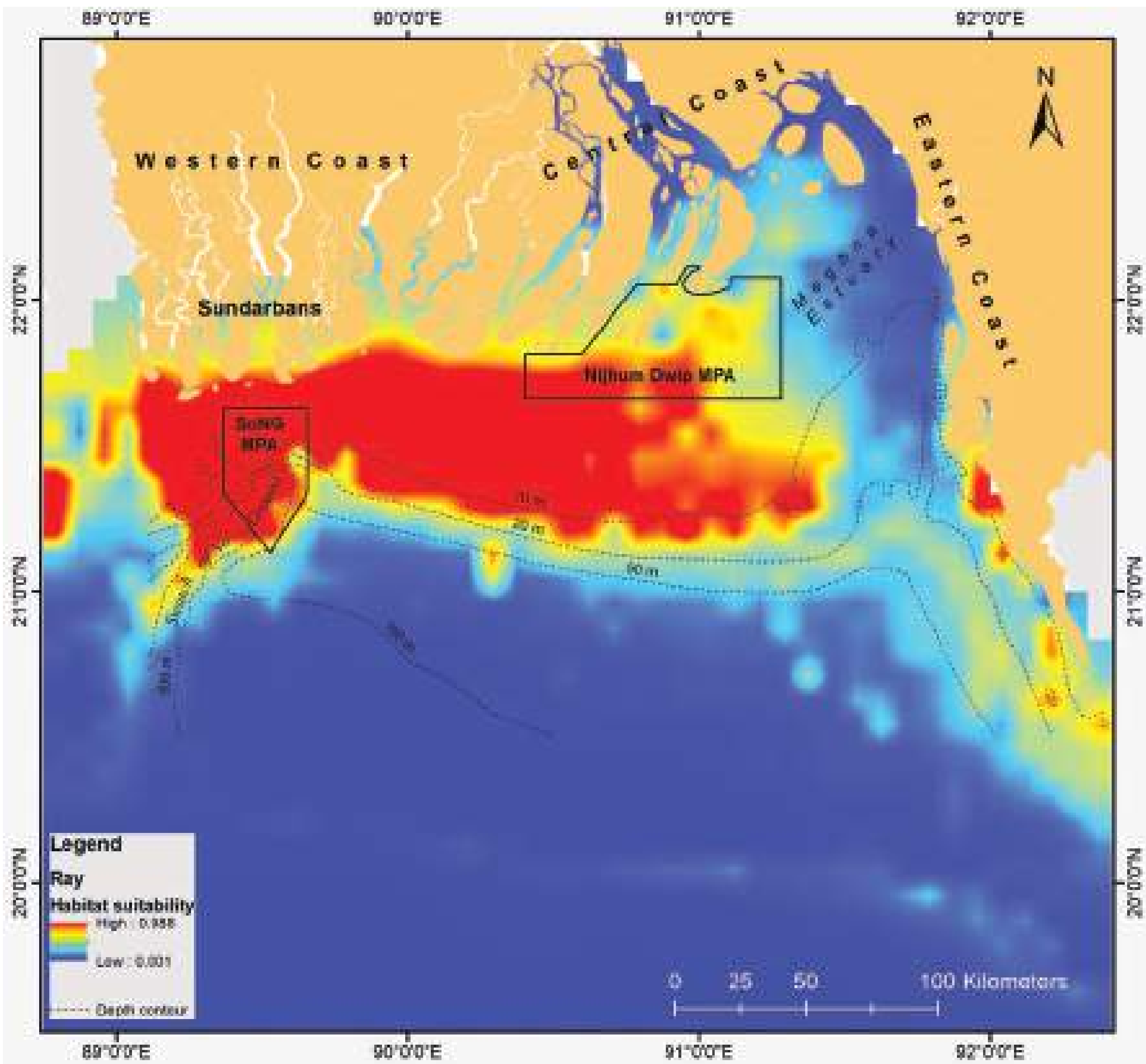

Figure 4. Predicted distribution of all rays combined based on catch data from gillnet and unbaited bottom set longline fishermen (N = 381).

Table 6. Core range, number of catches, % probability of seven environmental parameters (DP = depth, PP = primary productivity, DO = dissolved oxygen, SL = salinity, TP = temperature, PH = pH, and LB = light at bottom, SD=standard deviation) that explains the predicted distribution of recorded in 10 or more occasions, and the average area under the curve (AUC) value from maps generated for all rays combined, seven species, and one genus and one family that could not be identified to species based on photographs.

Taxa	Number of catches	Core range	% Environmental parameters							AUC value
			DP	PP	DO	SL	TP	PH	LB	
All rays combined	381	Estuaries and nearshore shallow water extending from the western to central coast with patches in the Sundarbans and extending offshore to waters generally <20 m deep but as deep as 500 m in the head of the SoNG.	10.8	42.6	4.8	3.8	17.3	15.4	5.3	0.92 (SD= ± 0.04)
Family										
Stingrays (Dasyatidae)	19	Estuaries and nearshore shallow water extending from the western to eastern coast and the northern part of SoNG MPA, except Meghna estuary and generally 10m to 20 m deep waters.	34.7	16.5	-	18.2	28.0	1.8	-	0.90 (SD= ± 0.13)
Genus										
Cownose rays (*Rhinoptera* spp)	17	Estuaries and nearshore shallow water extending from the western to eastern coast with patches in the Sundarbans and extending offshore to waters generally 10 to 100 m deep along the coast.	70.4	11.6	-	0.4	-	10.8	6.8	0.91 (SD= ± 0.07)
Species										
Giant freshwater whipray	57	Inshore, estuaries and nearshore shallow water extending from the central to the eastern coast with patches in the Sundarbans, Nijhum Dwip MPA and the northern of SoNG MPA, including the Meghna estuary. Mostly at <10 m deep.	-	85.6	-	-	-	0.5	13.9	0.92 (SD= ± 0.05)
Sharpnose guitarfish	53	Estuaries and nearshore shallow water extending from the western to central coast with patches in the Sundarbans, Nijhum Dwip MPA and northern SoNG MPA, and extending offshore to waters generally <20 m deep along the coast.	5.1	66.6	-	4.5	2.3	11.9	9.5	0.94 (SD= ± 0.05)

Table 6 continued.

Taxa	Number of catches	Core range	% Environmental parameters							AUC value
			DP	PP	DO	SL	TP	PH	LB	
Bleekers whipray	32	Inshore, estuaries and nearshore shallow water extending from the western to the eastern coast with patches in the Sundarbans and the Nijhum Dwip MPA, including the Meghna estuary. Mostly <10 m of depth along the coast.	3.8	13.1	-	64.4	11.9	4.5	2.3	0.95 (SD= ± 0.04)
Honeycomb whipray	21	Inshore, estuaries and nearshore shallow water extending from the western to the central coast with patches in the Sundarbans and Nijhum Dwip MPA, including the Meghna estuary. Mostly at <10 m of depth along the coast.	-	0.7	0.1	97.1	-	0.7	1.4	0.90 (SD= ± 0.04)
Longtail butterfly ray	18	Estuaries and near shore shallow water extending from the western to the eastern coast and the northern of SoNG MPA, except the Meghna estuary. Mostly <20 m deep but also as deep as 500 m.	69.8	7.7	-	9.6	7.1	2	3.8	0.87 (SD= ± 0.15)
Shorttail stingray	17	Inshore, estuaries and nearshore shallow water extending from the western to the eastern coast with patches in the Sundarbans, Nijhum Dwip MPA and the northern of SoNG MPA, excluding the Meghna estuary. Mostly <10 m deep.	-	-	-	100	-	-	-	0.90 (SD= ± 0.01)
Narrow cowtail ray	15	The Meghna estuary and the western mangrove patches, Nijhum Dwip MPA and the northern of SoNG MPA, also including inshore, estuaries and nearshore shallow water extending from the western to the eastern coast. Mostly <10 m deep.	-	-	-	100	-	-	-	0.93 (SD= ± 0.02)

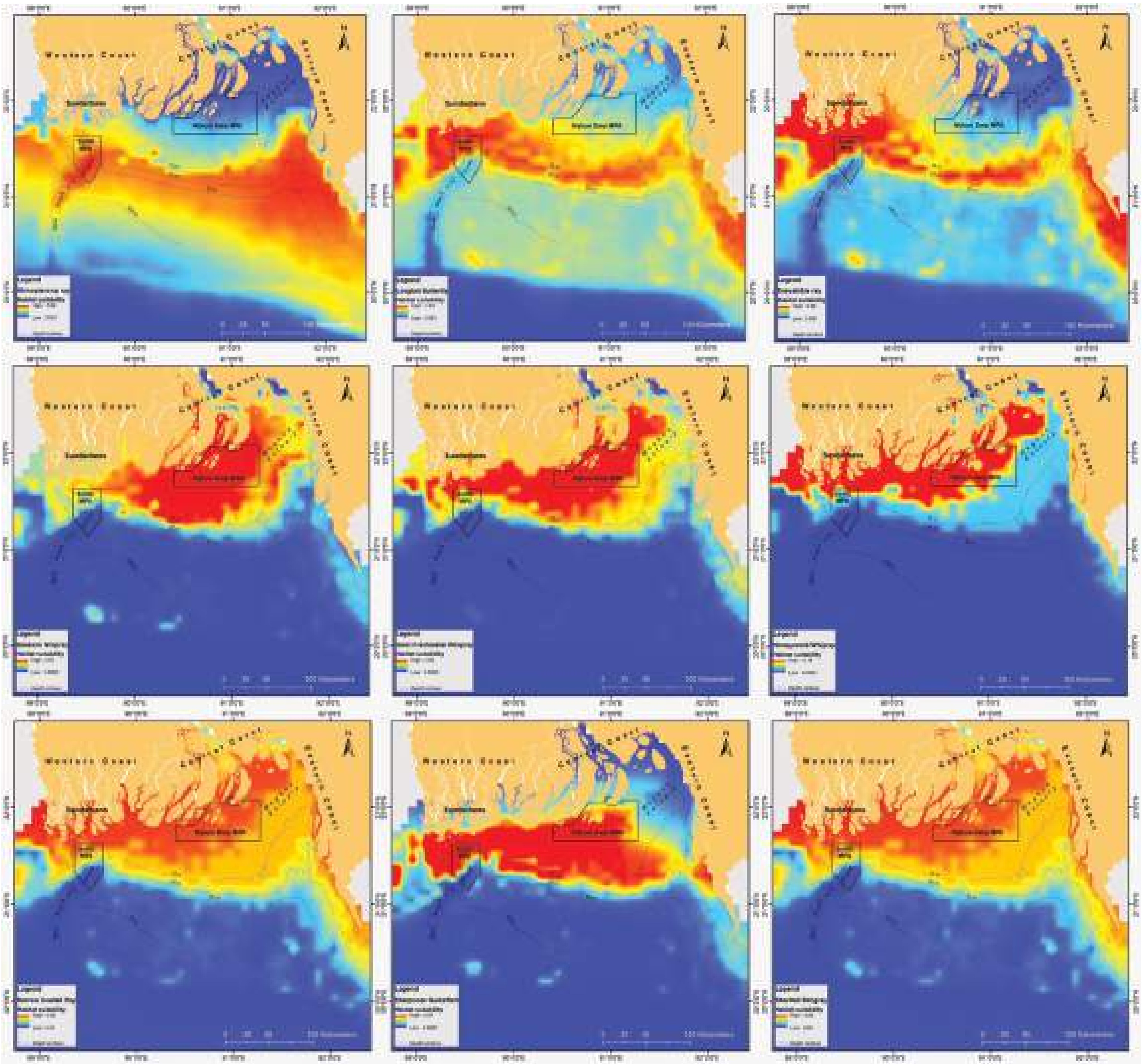

Figure 5. Predicted distribution of Cownose rays (N=17), Longtail butterfly rays (N=18), Stingrays (N=19), Bleeker's whipray (N=32), Giant freshwater whiprays (N=57), Honeycomb whiprays (N=21), Narrow cowtail rays (N=15), Sharpnose guitarfish (N=53) and Shorttail stingrays (N=17) according to habitat suitability models.

Spatial risk of shark and ray catches

Shark catches

High risk areas for shark bycatch in medium and large-mesh fishing gears are mainly concentrated along the south facing western coast offshore of the Sundarbans mangrove forest and extending to waters as deep as 100 m at the head of the SoNG (Figure 6, Table 7). Medium risk areas surround of the western high-risk patch diminishing towards offshore the Meghna River mouth towards the eastern coast in waters less than 100 m deep. The Meghna River mouth and waters more than 100 m deep shows low risk for shark bycatch from medium and large mesh gillnets. The entire SoNG MPA shows the high risk of shark bycatch, whereas the Nijhum Dwip MPA shows low risk.

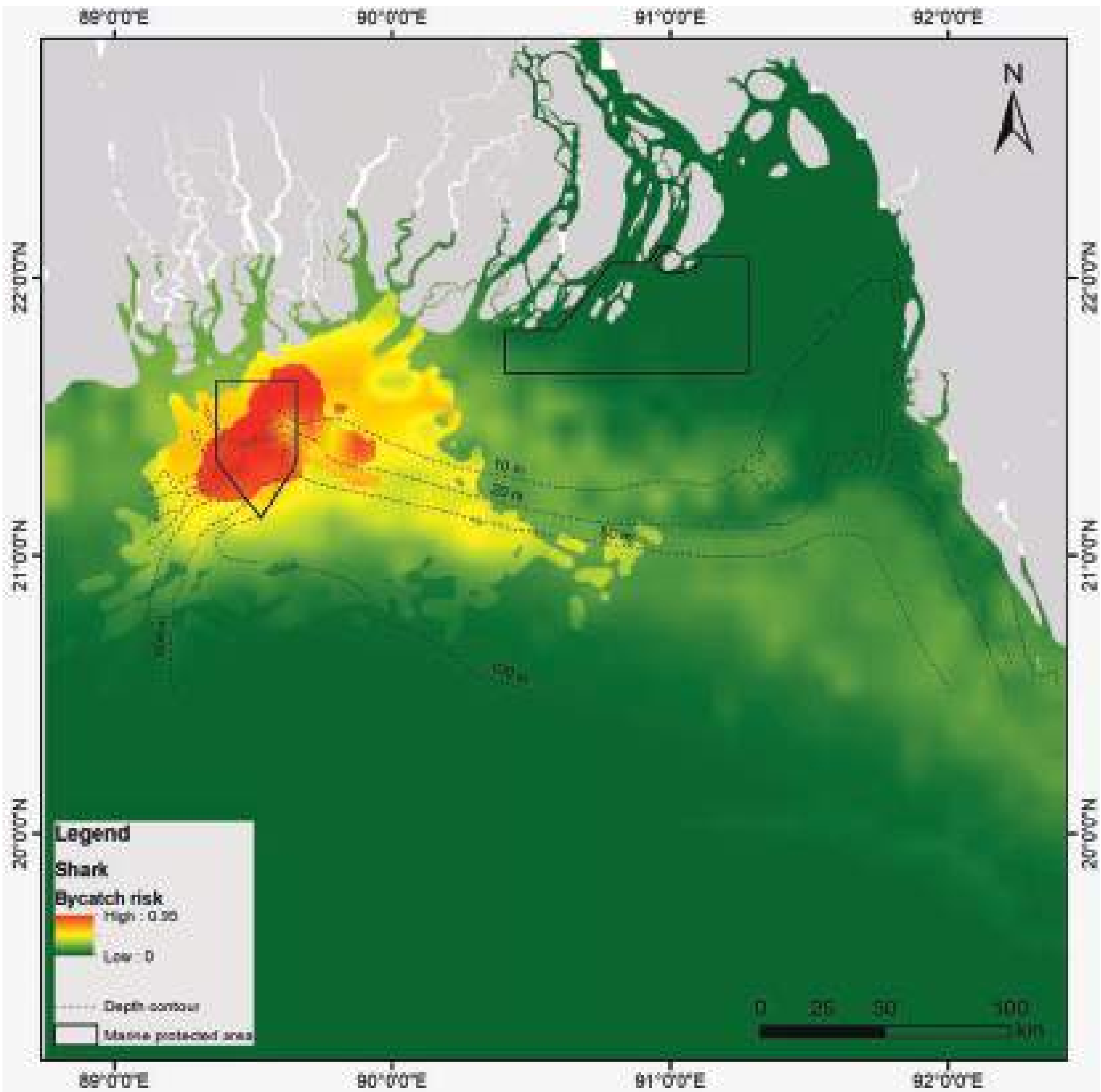

Figure 6. Bycatch risk modelling of sharks based on the overlap of their predictive distribution and gillnet fishing activity.

Bycatch risk models for the six shark species with sufficient data to model their habitat distribution, including Spadenose, Blacktip, Pigeye, Scalloped hammerhead, Tiger and Bull shark, showed roughly similar pattern to the combined model thus demonstrating the potential for protecting multiple species with marine spatial planning and fisheries management that concentrates bycatch reduction measure in high-risk areas (Figure 7, Table 7).

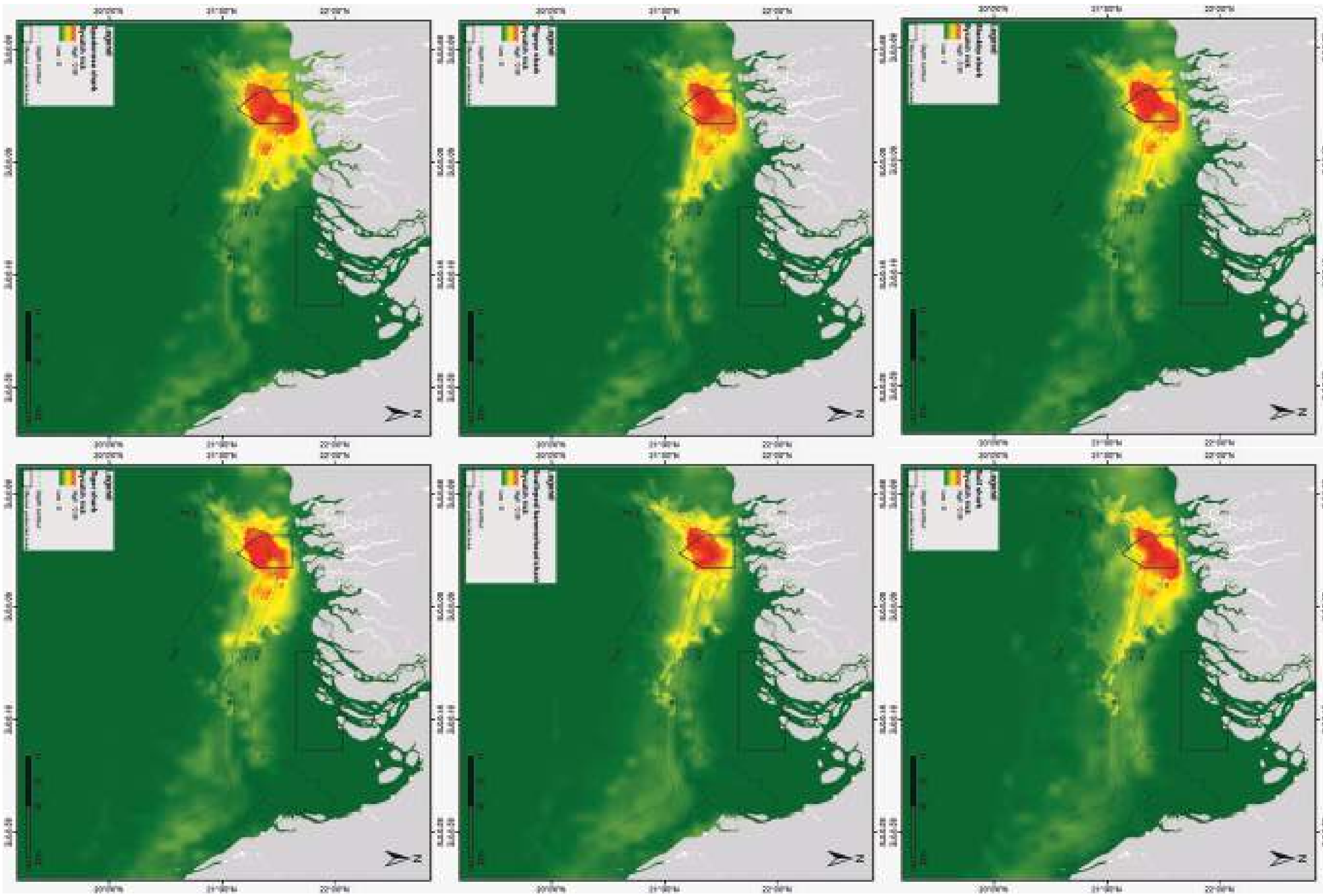

Figure 7. Bycatch risk modelling of six shark species based on the overlap of predictive distribution and gillnet fishing activity.

Table 7. Description of high, medium and low risk areas for shark bycatch for all catches combined and for six species.

Species	High risk areas	Medium risk areas	Low risk areas
All sharks combined	Concentrated in western water at 10m to 500m of depth, southern to the mangrove forest which extends to the mouth of SoNG.	Mostly surrounding western high-risk area in waters >500 m deep and in waters <100 m along the central coast and offshore the Meghna River mouth in waters <100m deep and along the east coast.	The Meghna River mouth and waters > 100 m deep along the southwestern coast.
Spadenose shark	Same as all sharks combined	Same as above	Same as all sharks combined
Blacktip shark	Same as all sharks combined	Same as all sharks combined	Same as all sharks combined
Pigeye shark	Same as all sharks combined	Same as all sharks combined	Same as all sharks combined
Scalloped hammerhead	Same as all sharks combined but the patch farther offshore from the mangrove forest.	Same as all sharks combined but farther offshore compared to other sharks.	Same as all sharks combined
Tiger shark	Same as all sharks combined	Same as all sharks combined	Same as all sharks combined
Bull shark	Same as all sharks combined	Mostly surrounding western high-risk areas >500m, and the areas <500m deep along the central and east coast.	Same as all sharks combined

Ray catches

High risk areas for ray bycatch in medium and large-mesh fishing gears are mainly concentrated along the western coast offshore to the Sundarbans mangrove forest (Figure 8 and Table 8). This includes just outside to the mangrove shallow water to almost 200 m deep at the mouth of the SoNG. The medium risk area surrounds the western high-risk patch extending east to the central and eastern coasts in the deeper waters <50 m deep. The medium risk area also includes waters > 200 m deep in the SoNG as well as areas just inshore the Sundarbans. low risk areas include waters >100 m deep. The entire SoNG MPA shows the high risk of ray bycatch, whereas the Nijhum Dwip MPA shows medium to low risk.

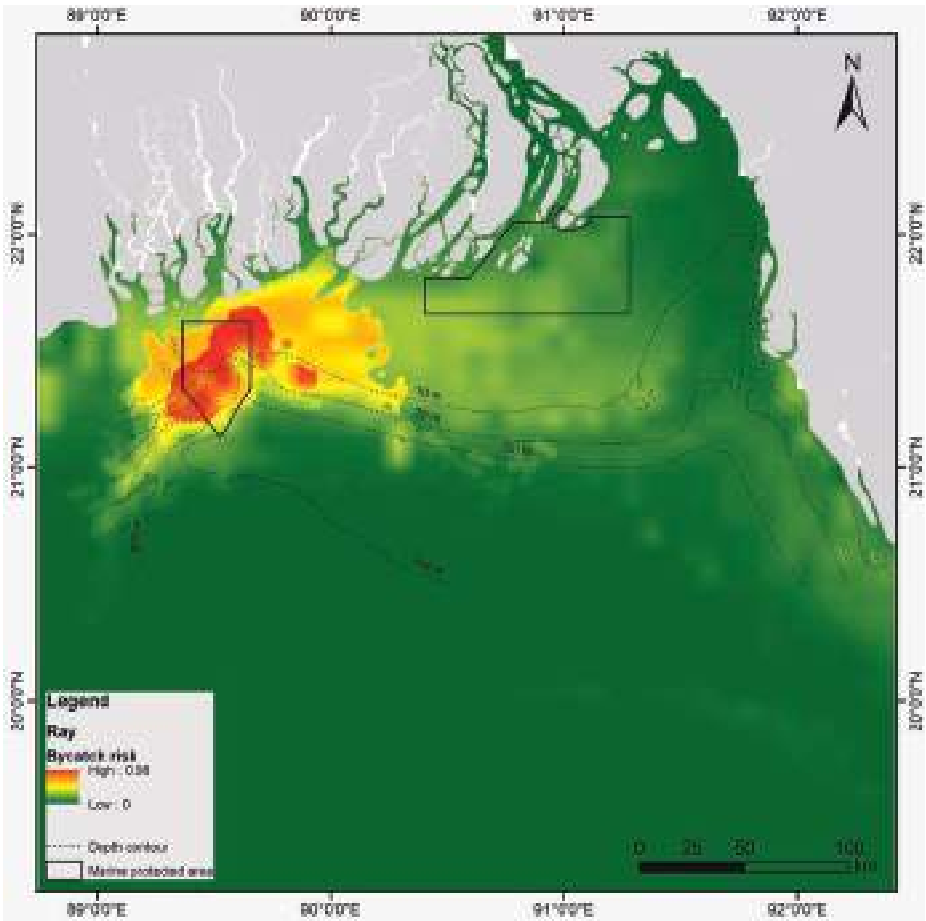

Figure 8. Bycatch risk modelling of rays based on the overlap of their predictive distribution and gillnet fishing activity.

High risk areas for ray bycatch were more variable for models generated separately for seven species as well as one genus and one family that could not be identified to species from photographs (Figure 9 and Table 8).

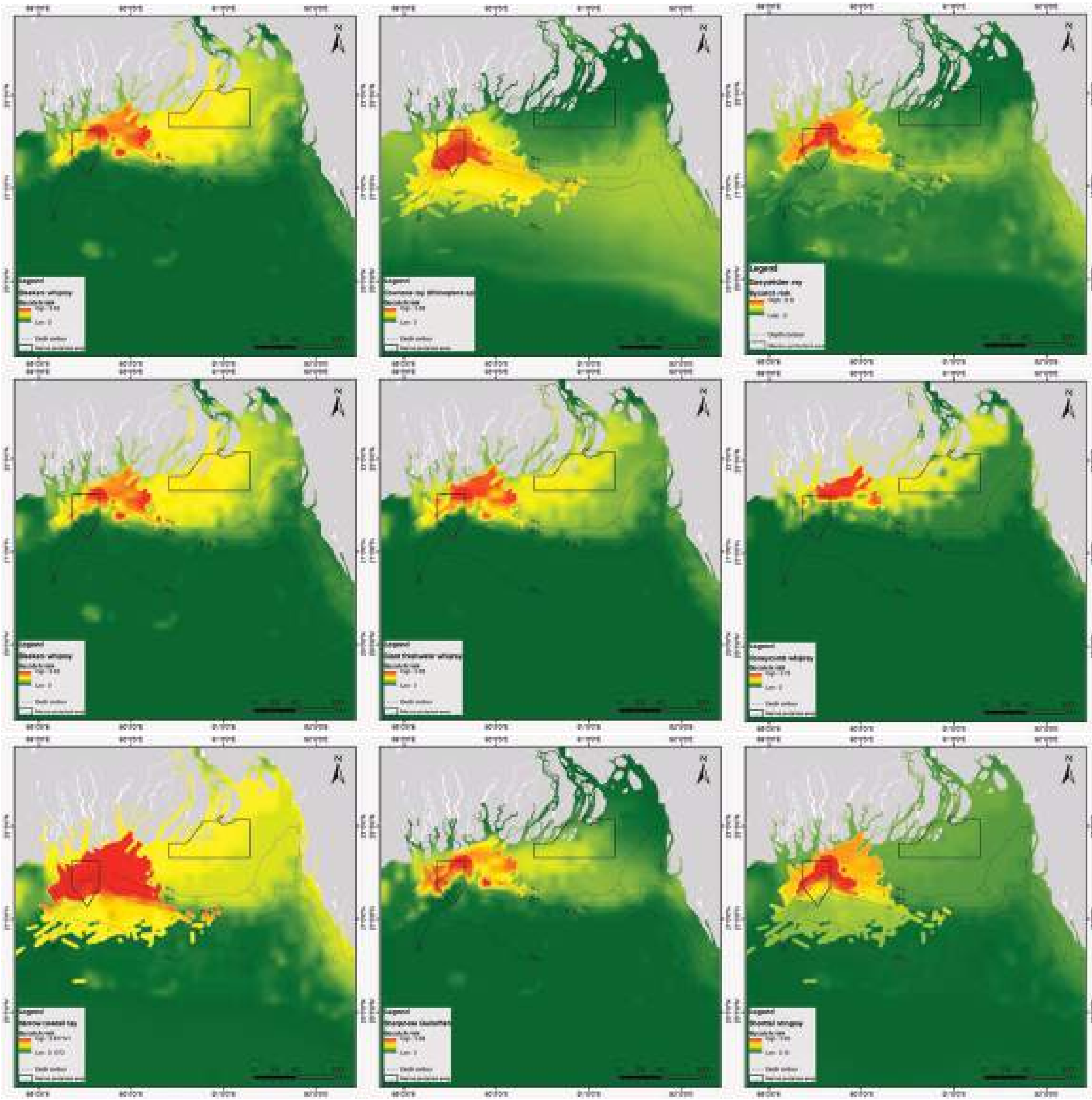

Figure 9. Bycatch risk modelling of Longtail butterfly ray (top left), Cownose ray (top middle), Stingray (top right), Bleekers whipray (second row left), Giant freshwater whipray (second row middle), Honeycomb whipray (second row right), Narrow cowtail ray (Bottom left), Sharpnose guitarfish (bottom middle) and Shorttail stingray (bottom right) based on the overlap of predictive distribution and gillnet fishing activity.

Table 8. Description of high, medium, and low bycatch risk areas for all rays combined, seven species and one family and one genus that could not be identified to species from photographs.

Family/Genus/Species	High risk areas	Medium risk areas	Low risk areas
All rays combined	Concentrated along the western coast offshore the Sundarbans mangrove forest, to < 500 m deep in the mouth of the SoNG.	Surrounds western high-risk patch in waters less than 500 m deep in the SoNG) to the central and eastern coast in inshore channels extending offshore to waters mostly <50 m deep.	Offshore waters >100 m of depth.
Family			
Stingrays (Dasyatidae)	Same as all Rays combined but in waters < 50 m deep.	In areas <500 m along the entire coast.	Same as all Rays combined but in waters < 500 m deep.
Genus			
Cownose rays (*Rhinoptera* spp)	Same as all Rays combined.	Same as stingrays.	The shallower (<10 m) Meghna estuary and the areas having depth > 500m.
Species			
Longtail butterfly ray	Same as stingrays.	Same as stingrays.	Same as stingrays.
Bleeker's whipray	Similar to Stingrays but extends more to east and in waters <20 m.	Surrounding western high-risk areas, extends to eastern coast having depth up to 20 m including the inshore areas along the entire coast.	Offshore areas having depth of more than 50 m.
Giant freshwater whipray	Same as Bleeker's whipray	Same as Bleeker's whipray	Same as Bleeker's whipray.
Honeycomb whipray	Same as Bleeker's whipray but in waters <10 m.	Same as Bleeker's whipray.	Same as Bleeker's whipray but >20 m.
Narrow cowtail ray	Same as all rays combined but covering much more area from mangrove forest to SoNG at the depth of up to 500 m.	Surrounding western high risk areas which extend >500 m depths. Also includes central and eastern coast having depth up to 100 m including inshore rivers along the entire coast.	Same as all Rays combined.
Sharpnose guitarfish	Same as Bleeker's whipray	Same as Bleeker's whipray	Same as Bleeker's whipray
Shorttail stingray	Same as stingrays.	Same as stingrays but <100 m at east coast including inshore rivers.	Same as stingrays, but in more than 100 m deep areas.

Discussion

Effort and Catches

Both large and medium mesh gillnets were deployed in and around the SoNG submarine canyon in waters shallower than 100 m except at the head of the canyon. Despite their longer net length and width, medium mesh gillnets (N=3,559) had a lower catch rate of 15.3% for sharks and 1.6% for rays compared to large mesh gillnets (N=688) with a catch rate of 27.6% for sharks and 3.5% for rays. A positive relationship between mesh size and catch/bycatch rates has been documented for other marine megafauna such as common bottlenose dolphins *Tursiop truncatus* (Palka and Rossman 2001), harbor porpoises *Phocoena phocoena* (Palka 2000, Orphanides 2010) and loggerhead turtles *Caretta caretta* (Murray 2009). Also, a review of over 600 published and unpublished studies of gill bycatch of marine mammals, marine turtles and seabirds found that large mesh size was positively associated with bycatch rates for all three species groups (Northridge et al. 2017).

Species diversity and conservation importance

Among the nine sharks documented in the catches of medium and large mesh gillnets, one is Critically Endangered (Scalloped hammerhead) and another (Spinner shark) is Vulnerable according to the global IUCN Red List. Among the 14 rays documented in the catches of medium and large mesh gillnets and bottom set unbaited longlines, one is Critically Endangered (Sharpnose guitarfish), four Vulnerable (Bengal whipray, Longtail butterfly ray, Spotted eagle ray and Leopard whipray) and seven are Endangered (Whitespotted whipray, Giant freshwater whipray, giant devilray, Bleeker's whipray, Honeycomb whipray, Narrow cowtail ray, and Round whipray). The number of species recorded during this study was relatively low compared to the 39 shark and 61 ray species confirmed as occurring in Bangladesh. This may be explained by the fact that (i) the overall abundance of sharks and rays is dominated by a few species (see Chapter I *Shark and ray diversity and landings of small-scale coastal fisheries*), (ii) some species that have low economic value to the fishermen may have been discarded and/or not recorded, and (iii) most net and long-line sets were made in waters offshore of the Sundarbans and in and around the SoNG submarine canyon which did not include all habitat types occurring in Bangladesh.

Habitat

Habitat suitability modelling is an effective approach to predict the distribution of sharks and rays with limited data. Both the integrated and species-specific models show that the most suitable habitat for shark and rays occurs offshore the Sundarbans mangrove forest to the SoNG submarine canyon. The Sundarbans may provide breeding and nursery grounds for juvenile sharks and rays that depend on mangrove habitat for reproduction such as Blacktip sharks (Burgess and Branstetter, 2009, Castro, 1996, Keeney et al. 2003 and 2005), Pigeye sharks (Knip et al. 2011 a & b), Scalloped hammerhead (Duncan, 2006, Compagno, 1998, Jorgensen et al. 2009, Vidthayanon, 2005), Cownose rays (Last et al. 2016), and Honeycomb whiprays (Last et al. 2009, White et al. 2006, Ferrari, 2002, Rigby, 2012). Species-specific shark models show similar habitats among species with some small differences in the depth while species-specific ray models show much greater variance in their habitat preferences including depth, pH, salinity, temperature, and primary productivity.

Bycatch risk

Sharks and rays are widely distributed in the Bay of Bengal. However, there are specific areas where catch probability is particularly high. Bycatch risk models showed the high-risk areas concentrated around the SoNG for both sharks and rays. Rays were also at high risk of being caught in shallow nearshore and inshore estuarine waters. This suggests rays could be vulnerable to bottom set fishing gears in shallow water such as set bag nets, bottom set long lines, and small mesh gillnets.

Challenges and opportunities

Data collected by gillnet and bottom set unbaited longline fishers were limited to the northwestern coast offshore of the Sundarbans south to the SoNG submarine canyon and east to Nijhum Dwip. This leaves a significant gap in coverage from the central and east coast as well as southern offshore areas in Bangladesh's EEZ. To better understand the ecology, distribution and habitat preference of sharks and rays, additional data from these areas are needed. To better understand the full complexity of the spatial distribution of sharks and rays and their vulnerability to being caught in fisheries operating in Bangladesh, data are also needed from other small-scale fisheries including set bag nets, baited midwater long lines, and commercial trawlers.

Conclusion

Most shark and ray studies are based on documenting catches at fish landing sites which does not provide empirical data on where the catches were made and with what fishing gear type. These data are needed to understand species habitat and evaluate the spatial distribution of bycatch risk. This study used data collected by citizen scientists in a predictive framework to identify the highest priority areas for focusing shark and ray protection efforts. One key result is that the study confirmed the importance of the SoNG MPA for protecting threatened sharks and rays and the Nijhum MPA for protecting threatened rays.

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A member of the *WCS Citizen Science Fishermen Safety Network* assists our researcher in recording details of a scalloped hammerhead *Sphyrna lewini* caught by a baited mid-water longliner encountered during an at-sea fisheries investigation.

CHAPTER 3

AT-SEA INVESTIGATION OF ELASMOBRANCH CATCHES OF COASTAL SMALL-SCALE FISHERIES IN BANGLADESH

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Methods

Fisheries investigations were conducted in the coastal waters of the northern Bay of Bengal in the winter season between December and January of 2017-18 and 2018-19 covering almost 3,500 km (Figure 1). Sampling locations were recorded using a hand-held GPS and water depth with a depth sounder.

For gillnets and long-lines, the total gear length was calculated by measuring the distance between floats and counting the total float numbers. Width and mesh size of gill nets were measured. For set bag nets the mouth circumference, funnel length and cod end mesh size were recorded according to information provided by the fishing vessel captain.

Species identifications were confirmed using Ebert (2013) for sharks and Last (2016) for rays. Voucher photographs were taken for verification. If a species could not be identified in the field, detailed photographs of the specimen and its key characteristics were taken for determining later identification.

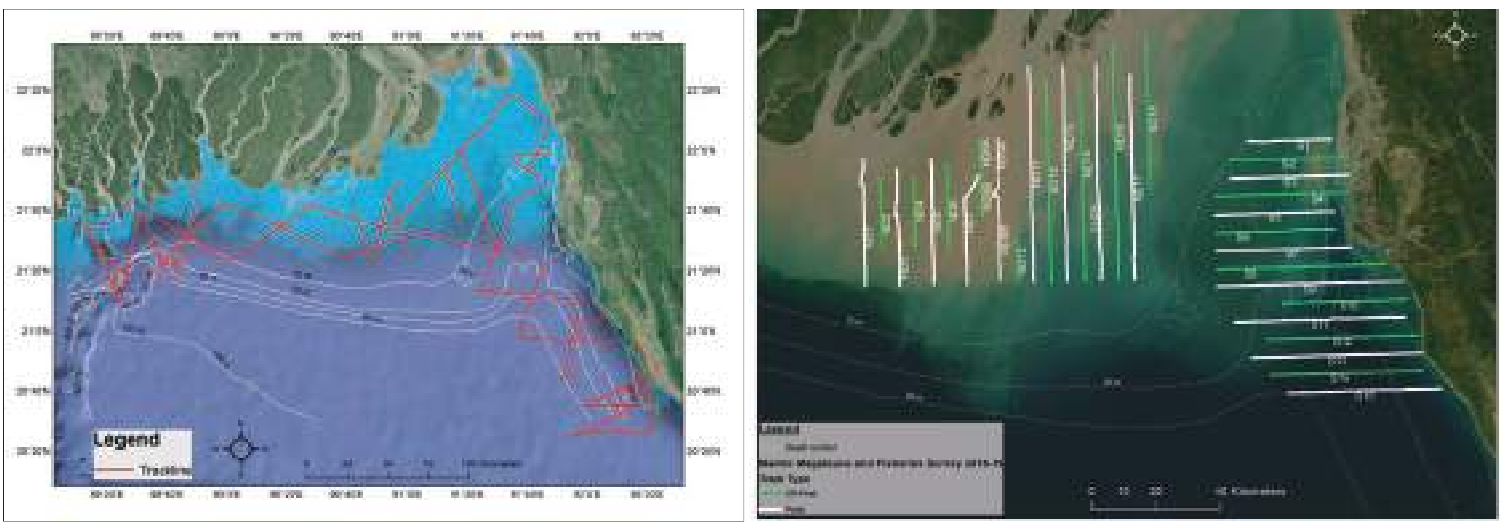

Figure 1. Tracks of the survey vessel followed systematic transect lines which were roughly followed for fisheries investigations in 2017-18 covering the entire coast (left) and in 2018-19 covering the western side of the Ganges-Meghna-Brahmaputra river estuary and the southeastern coast of Bangladesh (right).

Results

Fisheries Investigation and Gear Information

Catches of 57 fishing vessels using eight different gear types were investigated during the two surveys (Figure 2). Data were collected from 16 medium-mesh (MDGN, mesh = 8.1-13.0 cm), 13 small-mesh (SDGN, mesh = 2.5-7.6 cm), five large-mesh (LDGN, mesh = 16.0-19.1 cm) and one anchored gillnet (AGN); six un-baited bottom (BLLR) and three baited mid-water long-lines (MLLR); and eight offshore/marine (MSBN) and five estuarine/nearshore (ESBN) set-bag nets (Table 1). Approximately half (52%) of the sampled fishing gears were deployed in coastal waters 3-10 meters deep, with only two catches sampled from gears deployed at depths of >30 meters.

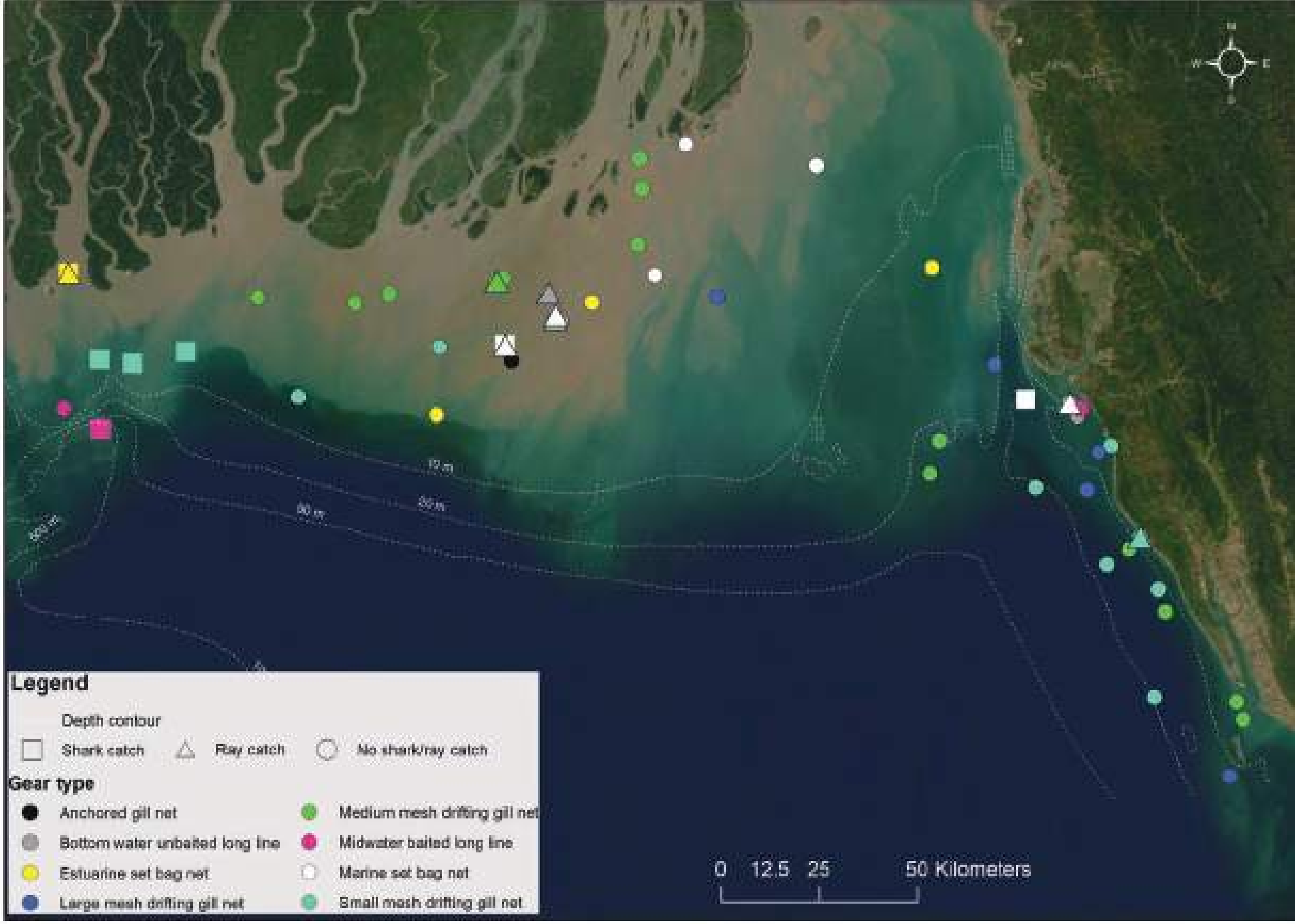

Figure 2. Locations of the at-sea catch sampling of medium-mesh, small-mesh gillnet, large-mesh gillnet, anchored gillnet, baited mid-water long-lines, un-baited bottom long-lines, estuarine set-bag nets, and marine set-bag nets with different colors indicating different gear types and different shapes indicating shark and/or ray catch on no shark or ray catch.

Catch Characteristics

Seventy-six sharks from four species and one shark that could only be identified to genus were recorded in eight or about 14% of the 57 sampled catches (Table 2). Mid-water baited long-lines (MLLR) targeting sharks and large finfish were responsible for half of all recorded shark catches and almost 60% of all individuals despite only three catches being sampled from this gear (Table 2). Sharks recorded in MLLR included all four specimens identified to species including Critically Endangered (CR) Scalloped hammerhead *Sphyrna lewini* as well as Near Threatened (NT) Spadenose *Scoliodon laticaudus* and Tiger *Galeocerdo cuvier* sharks, Least Concern (LC) Bigeye houndshark *Iago omanensis*, and one unidentified Bamboo shark *Chiloscyllium* sp. Two shark catches were also sampled in MSBNs and one catch each in SDGN and ESBN.

Eighteen rays from 10 species and 13 rays that could only be identified to three genera were recorded in 17 or 29.8% of the sampled catches (Table 2). Of the rays identified to species, half are listed in the IUCN Red List as CR, EN or VU. This does not include one guitarfish that could not be identified to species from the *Rhinobatos* genus, which is among the most globally threatened ray groups. BLLRs were responsible for the largest number or about 29.4% of all ray catches and 32.0% of individuals while MSBN and SDGN were both responsible for 23.5% of all ray catches and 42.0% and 13.0% of all ray individuals caught, respectively. MSBNs were responsible for catches of one CR Sharpnose *Glaucostegus granulatus* and one Widenose guitarfish *Glaucostegus obtusus* while two EN Giant freshwater whipray *Urogymnus polylepis* were caught in one catch of MDGN and one catch of BLLR, respectively.

Table 1. Information on sampled fishing gears including deployment depth and recorded sharks and rays in sampled catches. Mesh sizes for ESBN and MSBN are measured from the cod end, while the mesh size range for anchored gill nets reflects large mesh near the bottom of the net gradually decreasing in size towards the float line. NA=Not Applicable.

Gear Type	Sampled catches	Length/Funnel length (m)		Mesh/Hook size (cm)		Depth of operation (m)		Catches (individuals) of sharks and rays	
		Mean	Range	Mean	Range	Mean	Range	Shark	Ray
Medium mesh drifting gill net (MDGN)	16	2,926	94-6,800	11.0	8.1 – 13.0	12	3.7-26.7	0(0)	3(3)
Small mesh drifting gill net (SDGN)	13	2,877	890-9,230	5.0	2.5-7.6	14	7.7– 28.5	1(20)	4(4)
Marine set bag net (MSBN)	8	24	5-41	2.3	0.5-10.0	14.3	5.5– 23.1	2(10)	4 (13)
Bottom unbaited long line (BLLR)	6	4,021	3,712-4,806	5.0	5.0	11.8	2.0–33.4	0(0)	5(10)
Large mesh drifting gill net (LDGN)	5	3,080	274-5,049	17	16.0-19.1	14	8.9 – 18.8	0(0)	0(0)
Estuarine set bag net (ESBN)	5	29	9-48	3.1	0.5-10.0	10.2	4.5–21.4	1(2)	1(1)
Mid water baited long line (MLLR)	3	1,449	1,360-27,625	4.0	4.0	5.3	5.3 – 125.0	4(45)	0(0)
Anchored gill net (AGN)	1	NA	643	NA	1.3-11.9	NA	12.5	0(0)	0(0)

Table 2. Sharks and rays caught by small-scale fisheries in the coastal waters of Bangladesh with information on the number of catches and individuals gear type and IUCN Global Red List status (CR= Critically Endangered, EN= Endangered, VU=Vulnerable, NT= Near Threatened, LC=Least Concerned, DD= Data Deficient, NL=Not listed).

Common name	Scientific name	Catches	Individuals	Gear type	IUCN Red List Status
Shark					
Spadenose shark	*Scoliodon laticaudus*	7	35	ESBN MSBN MLLR SDGN	NT
Bigeye houndshark	*Iago omanensis*	1	38	MLLR	LC
Scalloped hammerhead	*Sphyrna lewini*	1	2	MLLR	CR
Tiger shark	*Galeocerdo cuvier*	1	1	MLLR	NT
Bamboo shark	*Chiloscyllium* sp	1	1	ESBN	NL
Ray					
Butterfly rays	*Gymnura* spp	4	7	MSBN BLLR	NL
Bleeker's whipray	*Pateobatis bleekeri*	2	5	BLLR MDGN	NL
Whiprays	*Brevitrygon* spp	2	5	MSBN	NL
Giant freshwater whipray	*Urogymnus polylepis*	2	2	BLLR MDGN	EN
Scaly whipray	*Brevitrygon imbricata*	2	2	ESBN SDGN	DD
Honeycomb whipray	*Himantura undulata*	1	2	BLLR	VU
Jenkin's whipray	*Pateobatis jenkinsii*	1	2	BLLR	VU
Sharpnose guitarfish	*Glaucostegus granulatus*	1	1	MSBN	CR
Widenose guitarfish	*Glaucostegus obtusus*	1	1	MSBN	CR
Whitespotted whipray	*Maculabatis gerrardi*	1	1	SDGN	VU
Longtail butterfly ray	*Gymnura poecilura*	1	1	SDGN	NT
Smallspot numbfish	*Narcine maculata*	1	1	SDGN	DD
Guitarfish	*Rhinobatos* spp	1	1	MDGN	NL

Size Distribution

Sample sizes for sharks were only sufficient to assess the sexual maturity of Bigeye hound and Spadenose sharks of which 47.4% and 71.4% were sexually mature which may indicate a relatively healthy population of these species (Table 3). However, these calculations were based on only a single catch of a total of 38 Bigeye hound sharks and seven catches of a total of 35 Spadenose sharks, which means that more information is needed, especially for Bigeye hound sharks, to test this hypothesis. Also, both these sharks are relatively low value and small species compared to many other sharks targeted in Bangladesh, such as Scalloped hammerhead and Tiger sharks of which we had information on only three individuals, none that were sexually mature. No inferences can be made about the size distribution of rays due to small sample sizes. However, it is encouraging that more than half were sexually mature (Table 4). More information is clearly needed on the size class distribution of rays.

Table 3. Size distribution and sexual maturity of sampled sharks. NA= Not Applicable.

Common name	Size of sexual maturity (cm)	Number of measured individuals	Number of sexually mature individuals	Size range of sexually mature individuals (cm)
Bigeye houndshark	55	38	18	65.0
Spadenose shark	34.3	35	25	44-53
Scalloped hammerhead	225	2	0	NA
Tiger shark	210 - 350	1	0	NA

Table 4. Size distribution and sexual maturity of sampled rays. NA= Not Applicable.

Common name	Size of sexual maturity (cm)	Number of measured individuals	Number of sexually mature individuals	Size range of sexually mature individuals (cm)
Giant freshwater whipray	110	2	0	NA
Honeycomb whipray	60-70	2	2	67
Jenkin's whipray	70	2	1	70
Scaly whipray	15	2	1	22
Bleeker's whipray	51	2	1	78
Sharpnose guitarfish	98	1	1	110
Widenose guitarfish	48	1	1	105
Whitespotted whipray	48-58	1	0	NA
Longtail butterfly ray	35	1	1	41
Smallspot numbfish	28	1	1	50

Discussion

The largest number of sharks were caught in baited longlines and the largest number of rays in unbaited bottom set longlines. According to Government records, 2,500 mechanized fishing vessels deploying more than 10,000 long line gears operate along the coast of Bangladesh (DoF, Fisheries Statistics Yearbook, 2017-18). The proportion of mid-water baited (targeting large fish and sharks) versus bottom unbaited longlines (targeting rays) in this estimate is unknown. The Government of Bangladesh is planning to increase the number of industrial offshore baited longline fishing vessels for targeting tuna *Thunnus* spp.[1] This study indicates that both mid-water baited and bottom un-baited longliners catch relatively large numbers of sharks and rays, respectively, including CR, EN and VU species.

Out of five ESBNs and eight MSBNs recorded, only one each met legal requirements in the *Marine Fisheries Rules1983*, under the *Marine Fisheries Ordinance1983 (Marine Fisheries Act 2020)* that mesh size at the cod end of the net should be >45 mm. In our study, set bag nets were responsible for catching the second largest number of sharks and rays including CR guitarfish. Although the number of set bag nets sampled during our study was small, information from WCS surveys indicates that these gears account for 37.2% of the total fishing gears operated along the coast. To protect sharks and rays, as well as sustainable fisheries, the number of both ESBNs and MSBNs should be reduced and the rule requiring a mesh size >45 mm be enforced.

[1]https://www.thedailystar.net/business/big-plan-tuna-fishing-1465681

Although we had insufficient data to evaluate the size distribution of the larger, economically valuable sharks, such as CR Scalloped hammerheads, a separate study conducted by WCS at fish landing sites found that only 5.3% of Scalloped hammerheads in Bangladesh were sexually mature which may indicate a declining population. Conversely, a large portion of the smaller much less valuable shark species, including Bigeye houndsharks and Spadenose sharks, were sexually mature potentially indicating healthy populations of these species. The results on the size distribution of rays were inconclusive due to small sample sizes.

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WCS researchers provide fishermen encountered at sea with pamphlets depicting protected sharks and rays of Bangladesh and booklets explaining the importance of protecting endangered sharks, rays and other marine wildlife.

CHAPTER 4

PERCEPTIONS OF SMALL-SCALE FISHERS ON SHARK AND RAY IN THE COASTAL WATERS OF BANGLADESH

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Background

Directed and accidental catches of sharks and rays catch in fisheries can pose significant threats to species and populations. Many small-scale fishing vessels are not registered which means that national fisheries statistics may not provide an accurate understanding of fishing effort and catches of marine wildlife (Moore et al. 2010). Researchers can benefit from the knowledge of fishermen to better understand small scale fisheries and their interactions with coastal ecosystems and to establish conservation priorities (Aragones et al. 1997, Close and Hall 2006, Anadón et al. 2009). Interview surveys can help identify areas where conservation efforts should be focused, such as places with intensive fishing activity and significant catches of threatened marine wildlife (Moore et al. 2010). Information from these surveys can also be used to assess attitudes toward marine wildlife conservation, such as awareness of laws and other conservation initiatives (Aragones et al. 1997).

Methods

Two at-sea interviews were conducted during a total of 52 days in December/January 2017/2018 and 2018/19. During the 2017/18 survey, the entire coast of Bangladesh was searched covering 1,895 km of track line. During the 2018-19 survey, coastal waters offshore of Nijhum Dwip and Sonadia Islands, which were identified as potential sites for Marine Protected Areas (MPAs), were prioritized (WCS 2018) (Figure 1).

A systematic questionnaire for interviewing the captains and crews was pre-approved by the Wildlife Conservation Society (WCS) Internal Review Board (IRB). This is required prior to the beginning of data collection or recruitment of any human subject to ensure data confidentiality and consent of the human subject. All interviewers completed training on basic social and behavioral research through the Collaborative Institutional Training Initiative (CITI Program).

The interviews were conducted on the research vessel to avoid other members of the crew manipulating their responses. The most experienced crew member or the captain of the fishing boat was chosen for the interview. Questions were asked to the fishers about fishing gear, number of trips, seasonal and geographical patterns of gear sets, targeted and non-targeted catches, sustainable fisheries, and understanding of MPAs.

For questions about catches the research team showed the fishers a photo identification guide. When the species identified by fishermen was available, we also photographed a voucher specimen for documentation.

During interviews, the research team also recorded information on gears specifications including length and net mesh sizes. Gear length was calculated according to the measured gear distance between floats multiplied by the number of gear segments between floats.

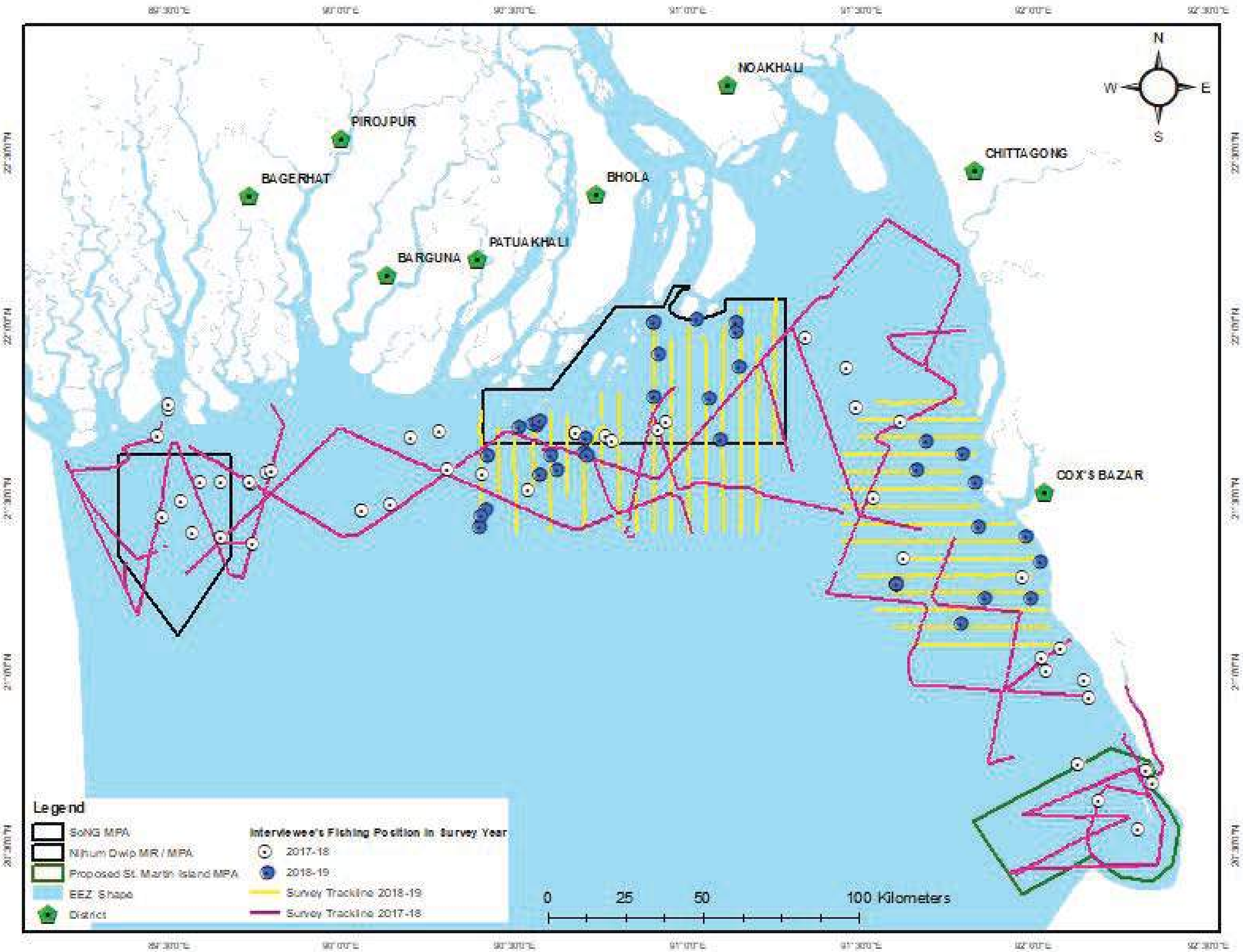

Figure 1. Track lines covered during the 2017/18 and 2018/19 fishery investigations and interview/fishing locations.

Results

Interviews

Eighty-eight fishermen from 88 fishing vessels were interviewed with 75% working as captain, 19% as crew, 5% as boat owners, and 1% as vessel engine driver. Their home districts included Cox's Bazar (N=33), Patuakhali (N=20), Bhola (N=11), Barguna (N=8), Noakhali (N=6), Bagerhat (N=4), Pirojpur (N=4) and Chattogram (N=2) (Figure 2). Most of the interviewees from Bagerhat, Barguna and Pirojpur were fishing offshore of the Sundarbans mangrove forest and in or near the Swatch-of-No-Ground (SoNG) MPA while interviewees from Patuakhali and Bhola were fishing between the Baleswar River mouth and the western half of the Nijhum Dwip MPA, Noakhali in the eastern half of the Nijhum Dwip MPA, Chattogram widespread in the eastern side of the Bay of Bengal, and Cox's Bazar widespread in coastal waters offshore of the southwestern coast of Bangladesh.

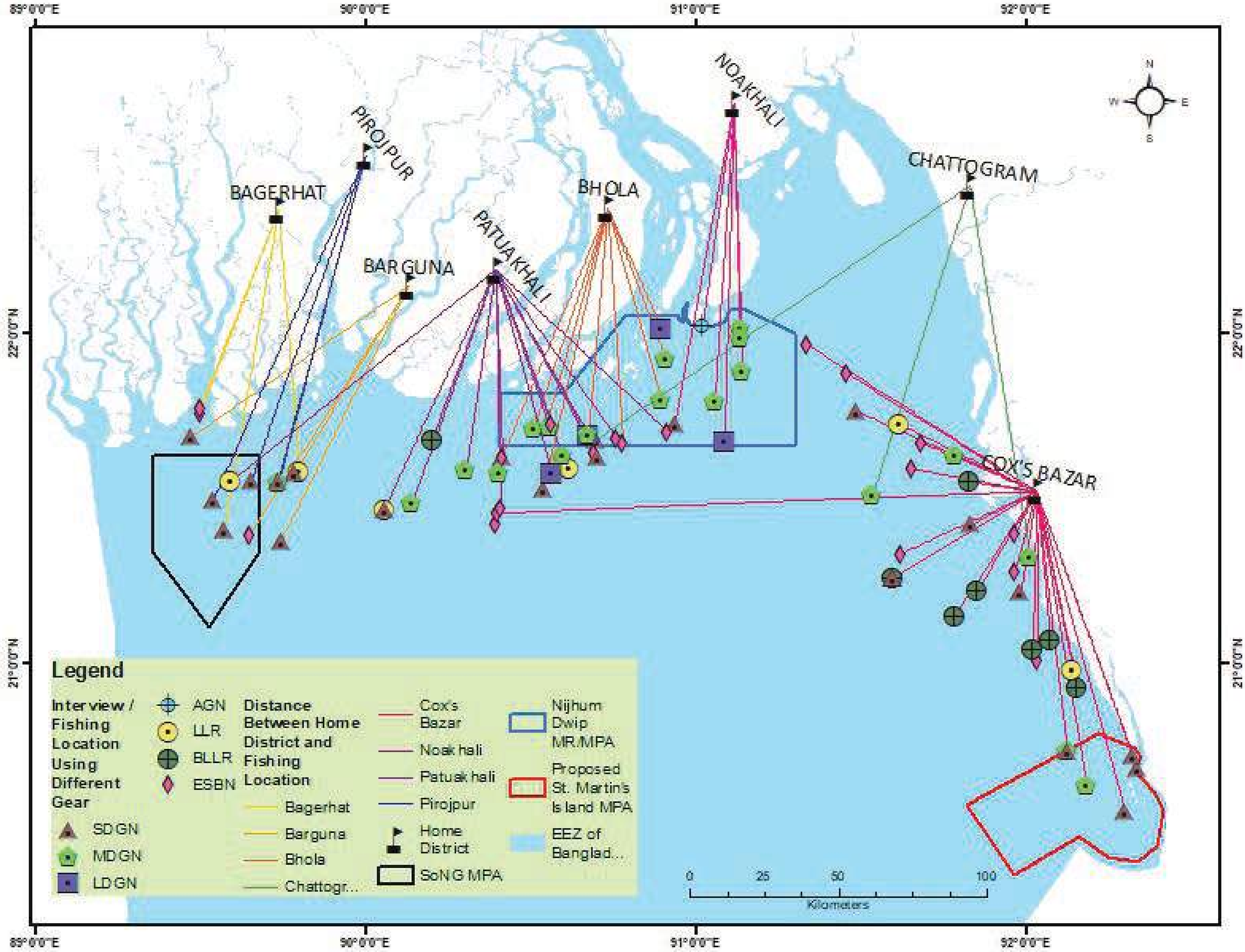

Figure 2. Map of the coast of Bangladesh showing the locations of interviews of 88 fishers interviewed and their home ports.

Fishing vessels and gears

Interviewed fishers used seven different fishing gear types including small-mesh drifting gillnet (SDGN, N=25), medium-mesh drifting gillnet (MDGN, N=22), large-mesh drifting gillnet (LDGN, N=4), anchored gill net (AGN, N=2), baited mid-water long-lines with many hooks (LLR, N=6), un-baited bottom-set long-lines (BLLR, N=9), and estuarine set bag nets (ESBN, N=20). Nets were set in waters between 2.0 - 42.7 m deep. Estuarine set bag nets had the smallest mesh size of all gear types. Un-baited bottom-set long-lines had the longest gear length of all gear types while small-mesh drifting gillnet had the smallest gear length. Fisher experience with these seven different types of gears ranged from 1 to 30 years. Engine power ranged from 10 to 125 horsepower with variation both among gears and within gears. Vessels deploying small-mesh drifting gillnet had the most powerful engines while vessels deploying baited mid-water long lines had the least powerful engines. (Table 1)

Fishing effort

Fishers go to sea for one to 16 days per trip for a total of between 60 to 270 days per year. The Government of Bangladesh (GoB) mandated 65-day fishing ban from 20 May to 23 July and 22-day hilsa fishing ban between the Bengali month of Ashwin and Kartik (mid-September and mid-November) are generally followed by fishers. Gear sets during a single fishing trip varied between one and 58. (Table 2)

Table 1. Gear specification for small mesh gill nets (SDGN), medium mesh gill nets (MDGN), large mesh gill nets (LDGN), anchored gill nets (AGN), baited long-lines with many hooks (LLR), un-baited bottom long-lines (BLLR), and estuarine set bag net (ESBN). NA=Not Applicable.

Gear name	Mesh/hook size (cm)		Gear length (m)		Experience of gear use (year)		Depth of fishing location (m)		Engine power (HP)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
SDGN	5	1.9 – 8.1	3966	178 – 21946	11	1 – 25	12.0	2.7 – 42.7	37	12 - 125
MDGN	10	8.9 – 12.0	4490	677 – 23760	15	1 – 35	15.2	2.7 – 27.6	38	14 - 110
LDGN	14	13.0 - 15.2	3387	2975 – 3625	19	10 – 30	14.6	10.9 - 18.3	35	31 - 45
AGN	NA	11.4 – NA	NA	NA	NA	6 – NA	NA	12.5 - NA	NA	75 – NA
LLR	NA	4.0 - NA	NA	NA	13	1 – 32	5.3	5.3 - NA	26	10 - 36
BLLR	8	3.8 - 17.8	14617	3852 – 27625	11	4 – 20	11.8	2.0 - 33.8	37	22 – 95
ESBN	1.5	0.1 – 2.5	NA	NA	15	3 – 30	10.9	4.5 – 23.1	30	22 – 74

Table 2. Average trip duration, gear set per trip, trip per year and fishing days per year, and range for each fishing gear. NA=Not Applicable.

Gear name	Trip duration (days)		# of gear sets per trip		# of trip per year		# of fishing days per year	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
SDGN	7	1-13	10	1 - 26	5	1 - 12	167	90 - 270
MDGN	7	1-12	10	1 - 24	5	1 - 12	215	90 – 270
LDGN	8	6-10	15	8 - 21	3	2 - 5	150	90 - 210
AGN	5	3-7	9	4 – 14	7	4 - 9	180	90 - 270
LLR	8	3-13	16	6 – 28	6	3 - 15	155	90 - 240
BLLR	8	2-12	12	7 – 24	9	1 - 35	180	120 - 270
ESBN	7	1-16	20	2 - 58	16	2 - 83	168	60 - 270

Sharks and rays

During interview surveys eight shark and 25 ray species were identified by fishers as caught in the seven different fishing gear types. Of the reported sharks, one species, the Scalloped hammerhead *Sphyrna lewini* is considered Critically Endangered with the remaining species considered Near Threatened (4), Least Concern (2) or Data Deficient (1).

Of the reported rays, four are considered Critically Endangered, including the Sharpnose guitarfish *Glaucostegus granulatus*, Clubnose guitarfish *G. thouin*, Bowmouth guitarfish *Rhina ancylostoma* and Whitespotted wedgefish *Rhynchobatus djiddensis;* ten are Endangered, including the Whitenose whipray *Pateobatis uarnacoides*, Bleeker's whipray *P. bleekeri*, Giant freshwater ray *Urogymnus polylepis*, Honeycomb whipray *Himantura undulata*, Round whipray *Maculabatis pastinacoides*, Roughnose cowtail ray *Pastinachus solocirostris*, Longhead eagle ray *Aetobatus flagellum*, Whitespotted eagle ray *A. narinari*, Mottled eagle ray *Aetomylaeus maculatus* and Whitespotted whipray *Maculabatis gerrardi*, and eight are Vulnerable including the Leopard whipray *Himantura leoparda*, Coach whipray *H. uarnak*, Bengal whipray *Brevitrygon imbricata*, Sharpnose Ray T*elatrygon acutirostra*, Longtail butterfly ray *Gymnura poecilura*, American cownose ray *Rhinoptera bonasus*, Sharpnose ray T*elatrygon acutirostra*, and Porcupine ray *Urogymnus asperrimus*, with the remaining one Near Threatened, one Least Concern, and one Data Deficient. (Table 3)

Almost three-quarters of the fishers interviewed said they had caught sharks and rays. Sixteen reported that the most frequent catches were made in SDGN and MDGN, 13 in ESBN, eight in BLLR, six LLR, four in LDGN, and two in AGN.

All eight shark species were caught in SDGN, followed by six in LLR, four in ESBN and MDGN, three in LDGN and BLLR, and one in AGN. Fourteen of the 25 ray species were reported caught in SDGN, followed by ten in BLLR, nine in LLR, six in ESBN, three in MDGN, LDGN, and AGN.

Sawfish

Ten fatal entanglements of sawfish were reported between 2006-2019 by nine fishers. All were in MDGs. Seventy-nine fishers reported that they had no sawfish entanglements in their fishing nets between 2006-2019. For some fishers, it had been 20 years since they had seen a sawfish.

Five of the fishermen identified six entanglements of sawfish as the Critically Endangered Largetooth sawfish *Pristis pristis*. Fishers reported that the average length of these species was 3.5 meters (range = 0.6 – 6.6 meters) and the average weight was 191 kilograms (range = 4 - 400 kilograms).

Four of the sawfish were sold in Mohipur/Patuakhali, two in Cox's Bazar and one in Noakhali, at an average price of BDT 621 (US$ 7.3) per kilogram and the highest price of 1,100 BDT (US$ 13.0) per kilogram. Two fishers were unwilling to share information on the question about where they sold sawfish and their selling price. One fisher produced oil from his entangled sawfish rather than selling it fresh. He was also unwilling to share information on how he produced the oil, its uses, if it was sold, and its selling prices.

Table 3. Sharks, and rays reported caught by fishermen using large mesh gill nets (LDGN), medium mesh gill nets (MDGN), small mesh gill nets (SDGN), estuarine set bag net (ESBN), estuarine set bag net (ESBN), bottom long line (BLLR), long lines with many hooks (LLR) and anchored gill nets (AGN) with information on global IUCN Red List status.

Common Name	Scientific Name	IUCN Red List Status	# of times identified by fishers	SDGN	MDGN	LDGN	AGN	LLR	BLLR	ESBN
Sharks										
Spadenose shark	*Scoliodon laticaudus*	NT	25	12	3	1	0	3	2	4
Pigeye shark	*Carcharhinus amboinensis*	DD	15	5	4	0	0	1	2	3
Bull shark	*Carcharhinus leucas*	NT	12	2	5	0	0	2	2	1
Tiger shark	*Galeocerdo cuvier*	NT	9	1	3	1	1	2	0	1
Scalloped hammerhead	*Sphyrna lewini*	CR	6	4	0	1	0	1	0	0
Bigeye houndshark	*Iago omanensis*	LC	2	1	0	0	0	1	0	0
Spottail shark	*Carcharhinus sorrah*	NT	1	1	0	0	0	0	0	0
Milk shark	*Rhizoprionodon acutus*	LC	1	1	0	0	0	0	0	0
Rays										
Leopard whipray	*Himantura leoparda*	VU	12	2	2	0	1	4	2	1
Bengal whipray	*Brevitrygon imbricata*	VU	8	4	0	1	0	0	1	2
Brown whipray	*Maculabatis toshi*	LC	7	3	0	0	0	3	1	0
Clubnose guitarfish	*Glaucostegus thouin*	CR	5	0	0	0	0	2	3	0
Whitenose whipray	*Pateobatis uarnacoides*	EN	5	1	0	1	0	0	3	0
Giant freshwater ray	*Urogymnus polylepis*	EN	4	0	1	0	0	1	2	0
Bleeker's whipray	*Pateobatis bleekeri*	EN	3	1	1	1	0	0	0	0
Coach whipray	*Himantura uarnak*	VU	3	0	0	0	0	3	0	0
Honeycomb whipray	*Himantura undulata*	EN	3	0	0	0	0	3	0	0
Round whipray	*Maculabatis pastinacoides*	EN	3	0	0	0	0	2	0	1
Roughnose cowtail ray	*Pastinachus solocirostris*	EN	3	0	0	0	0	0	2	1
Bowmouth guitarfish	*Rhina ancylostoma*	CR	3	2	0	0	0	1	0	0
Bengal guitarfish	*Rhinobatos annandalei*	DD	3	2	0	0	0	1	0	0
Longhead eagle ray	*Aetobatus flagellum*	EN	2	2	0	0	0	0	0	0

Table 3 continued.

Common Name	Scientific Name	IUCN Red List Status	# of times identified by fishers	SDGN	MDGN	LDGN	AGN	LLR	BLLR	ESBN
Whitespotted eagle ray	*Aetobatus narinari*	EN	2	1	0	0	1	0	0	0
Mottled eagle ray	*Aetomylaeus maculatus*	EN	1	1	0	0	0	0	0	0
Sharpnose ray	*Telatrygon acutirostra*	VU	1	0	0	0	0	0	1	0
Sharpnose guitarfish	*Glaucostegus granulatus*	CR	1	1	0	0	0	0	0	0
Longtail butterfly ray	*Gymnura poecilura*	VU	1	1	0	0	0	0	0	0
Whitespotted whipray	*Maculabatis gerrardi*	EN	1	0	0	0	0	0	0	1
American cownose ray	*Rhinoptera bonasus*	VU	1	0	1	0	0	0	0	0
Whitespotted wedgefish	*Rhynchobatus djiddensis*	CR	1	1	0	0	0	0	0	0
Sharpnose ray	*Telatrygon acutirostra*	VU	1	0	0	0	0	0	1	0
Sharpnose stingray	*Telatrygon zugei*	NT	1	1	0	0	0	0	0	0
Porcupine ray	*Urogymnus asperrimus*	VU	1	0	0	0	0	0	1	0

*** Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), and Data Deficient (DD)

Changes in catching sharks and rays

Of the 28 fishers who responded to the question about the status of shark catches, 14 reported declining catches of Spadenose sharks, four of Tiger sharks, three of Bull sharks and Scalloped hammerhead sharks, two of Pigeye sharks, and one of Spottail sharks and Bigeye houndsharks (Figure 3).

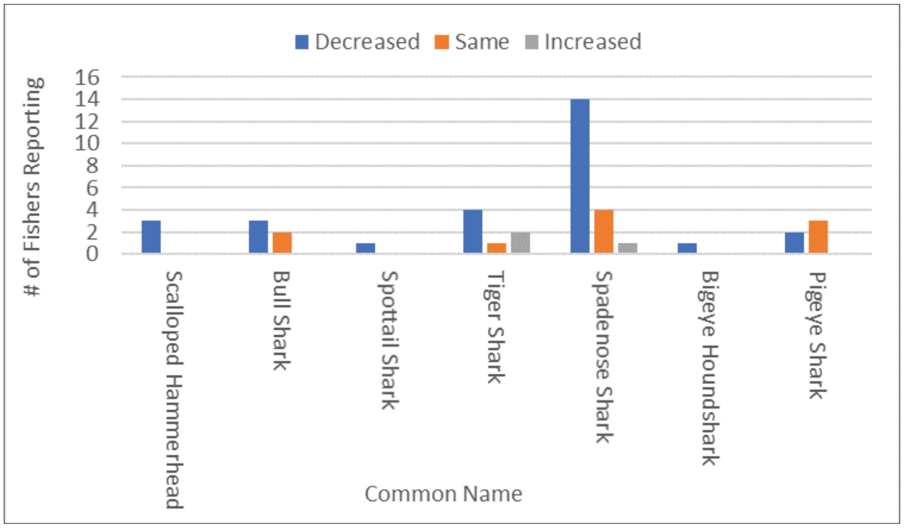

Figure 3. Reported trends in the catch of seven shark species.

Of the 37 fishers who responded to the question about the status of ray catches, nine reported declines in Leopard whipray; five Bengal whipray; four Clubnose guitarfish; three Round whipray and Whitenose whipray; two Longhead eagle ray, Spotted eagle ray, Reticulate whipray, Honeycomb whipray, Brown whipray, Roughnose cowtail ray and Giant freshwater stingray; and one Sharpnose ray, Sharpnose guitarfish, Bleeker's whipray, Whitespotted whipray, Bengal guitarfish, Cownose ray, Sharpnose ray and Porcupine ray compared to 10 years ago. None of these 37 fishers believed that ray catches are increasing (Figure 4).

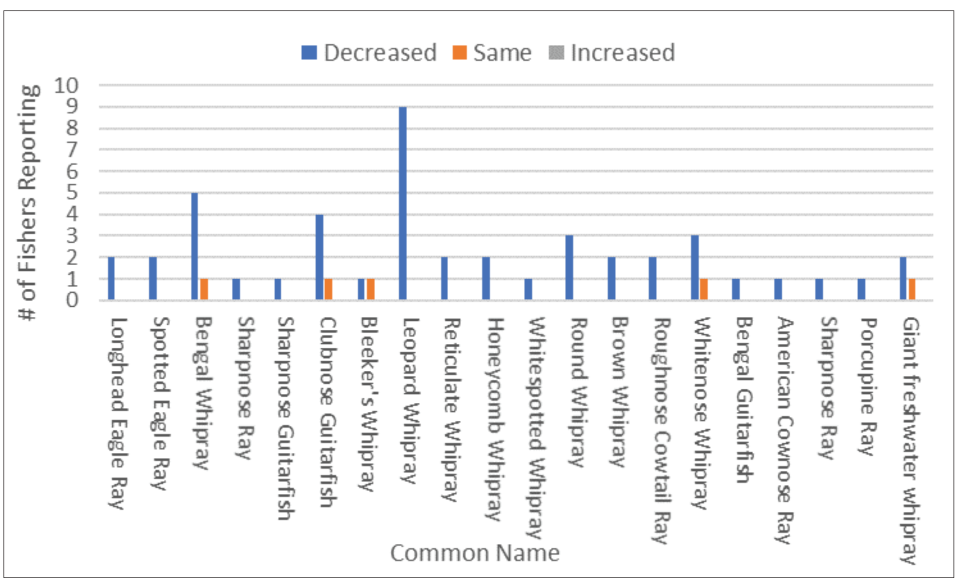

Figure 4. Reported trends in the catch of 20 ray species.

Sustaining fisheries and protecting threatened marine megafauna

Forty-one fishermen answered questions about sustainable fisheries and protecting marine megafauna. Nearly half (46%) had no idea how to ensure sustainable fisheries. However, 39% said that sustainable fisheries could be achieved, and threatened sharks and rays protected by obeying current fisheries laws and rules including catching legal-size fish, stopping the use of illegal monofilament gill nets, stopping the use of fixed/set bag nets, using estuarine set bag nets with a 45 mm mesh size at the cod end, and following fishery bans in a particular area and/or time. Apart from following laws and rules the remaining fishers said that sustainable fisheries could be achieved by reducing non-target catches, raising awareness about illegal industrial trawler fishing, protecting brood fish, and providing authorities with information on illegal activities.

Marine Protected Areas

Forty-one fishermen answered questions about MPAs. Ninety percent of the respondents had never heard of MPAs before the interview. The remaining 10% were aware that Bangladesh had an MPA, but they had no idea where it is located or what it is.

After explaining the concept of MPAs, 95% of the interviewed fishermen agreed that they could be beneficial for increasing fish stocks, protecting threatened sharks and rays, and improving socio-economic conditions. Most (92%) fishermen expressed a willingness to release threatened marine megafauna species entangled in fishing gear, and 78% said they would endorse a "no take zone" in the MPA.

Discussion

This survey documented a wide variety of fishing gears operating in the Bay of Bengal. Most were unselective. Gill nets were the most common gear type.

The study was conducted during the winter season. For this reason, the number of small mesh drifting gill nets and estuarine set bag nets was greater than if we had conducted our interviews during a different season. Illegal fishing gears included monofilament gillnets (12.5% of fishing gears), as specified in the *Protection and Conservation of Fish Act, 1950* (Section 4A), and estuarine set bag nets (22.7% of fishing gears) with a mesh size of less than 45 mm at the cod end, as specified in the *Marine Fisheries Rules, 1983* (Rule 14e).

The use of non-selective gear, including monofilament gillnets and estuarine set bag nets with a small mesh size at the cod end, is concerning because these nets catch small individuals that never have an opportunity to reproduce. Small mesh drifting gillnets reportedly caught the largest number of species of the seven different gear types including almost two-thirds of the 33 shark and ray species reported caught by the interviewed fishermen. Estuarine set bag nets are also particularly destructive because they catch a large variety of species at all their life history stages from fry to adult.

According to Hossain et al. (2015) sawfish were formerly abundant in Bangladesh but are now rapidly decreasing with the principal cause of overfishing. Sawfish are not targeted, but their rostra with toothlike projections makes them particularly vulnerable to becoming entangled in fishing nets. All ten sawfish entanglements reported by interviewees were caught in medium mesh size drifting gill nets.

Marine Protected Areas (MPAs) are among the most widely used management tools for conserving marine species and habitats, maintaining ecosystem function, and ensuring the sustainable use of marine resources (Sarker et al. 2019). Globally, MPAs have nearly doubled in just five years (McCauley 2014, Lubchenco & Grorud-Colvert 2015). Many of these have prioritized shark and ray conservation (Koldewey et al. 2010, Davidson 2012, Dulvy 2013) including protection of their reproduction and feeding habitat (Escalle et al. 2015, Norse 2010).

Bangladesh has two MPAs. One is located at the head of the SoNG and offshore of the Sundarbans mangrove forests, and the other in the waters offshore of Nijhum Dwip. Engaging fishermen is vital for the protection of threatened sharks and rays in MPAs. The lack of knowledge of the interviewees about the role of MPAs and their existence in Bangladesh is concerning.

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Shark fins drying in the sun at Mogchita Para near the Cox's Bazar fish landing and processing center.

CHAPTER 5

DOMESTIC AND INTERNATIONAL TRADE OF SHARK AND RAY PRODUCTS IN BANGLADESH

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Background

In this chapter we summarize information from published reports and from traders interviewed by WCS on Bangladesh's domestic and international shark and ray trade, and identify potential opportunities to protect globally endangered species, support sustainable shark and ray fisheries and increase Government revenue and livelihood earnings from legally obtained shark and ray products. It should be noted that catch and export statistics published by the Government of Bangladesh (GoB) do not distinguish between sharks and rays or shark fins and fish swim bladders which limits our understanding and ability to make science-based recommendations on shark and ray trade.

Catch and export volume

Bangladesh ranked among the top twenty shark fin exporting countries according to 2000-2011 FAO trade data (Mundy-Taylor and Crook 2013, Dent and Clarke 2015), but the country was not among the top twenty shark catching nations. Official statistics report gradual declines in shark and ray landings from 6,234 metric tons of in 2001-2002 to 3,373 metric tons in 2019-2020 (DoF 2018 and 2019, Barua 2020).

According to official records, Bangladesh exported between zero and nearly one thousand metric tons of dried shark fins annually between 1990 - 2010, almost none between 2011-2018, and then over 2,000 metric tons in 2018/2019 (DoF 2006, 2010, 2017, 2018 and 2019). It is interesting that the adoption of the Wildlife (Security and Conservation) Act, 2012, which currently protects 18 shark and 11 ray species, roughly coincides with a gap in export records.

For comparison, during the time when Bangladesh reported almost no shark exports, Hong Kong customs alone recorded 25.6, 45.0, 1.8, and 6.8 metric tons of shark fins imported from Bangladesh in 2016, 2017, 2018, and 2019, respectively, but only 0.4 metric tons in 2020 (Appendix 1). A possible explanation for this drop could be a reduction in trade during the global Covid-19 pandemic[1], and restrictions on gatherings in restaurants and for wedding celebrations in Hong Kong where shark fins are primarily consumed in shark fin soup.

Although Bangladesh reportedly also exports liver oil, dried meat, teeth, jaws, and skins of sharks and rays (Haroon 2010, Roy et al. 2014a), no other shark or ray products were found listed in the export statistics of the Government of Bangladesh. This lack of information on exports of these products could be due to countries not using standardized customs tariff codes recommended by the World Customs Organization[2] which makes international trade difficult to track.

[1] https://thefinancialexpress.com.bd/views/navigating-through-the-coronavirus-crisis-and-uncertainty-1599926328

[2] Harmonized System (HS) codes were developed by the World Customs Organization as an international tool to describe commodities being shipped across international borders.

Commonly traded shark and ray parts, their processing and use

Fins

Shark fin soup, which uses cartilaginous fin needles (ceratotrichia) extracted from shark and ray fins, is a luxury food in China, Hong Kong, and Singapore. Dorsal, pectoral and caudal fins from sharks or rays over 1.5 meters in length are commercially traded (Kreuzer et al. 1983) for upwards from one thousand USD per kilogram (Vannuccini 1999), making them among the highest valued seafood in the world. Sawfish and wedgefish fins are highly sought after (Dulvy et al. 2014, Jabado 2019) because of their large number of fin needles. This high market value and demand creates an incentive for fishermen to target valuable sharks and rays, many which are at risk of extinction, in directed fisheries and to retain sharks and rays that are not targeted but caught incidentally in fisheries targeting bony fish. In Bangladesh, shark and ray fins are generally cut off at landing, salted and sun dried for export (Figure 1). Dried fins are graded according to size with a value of around 1,000 BDT/kg (11.8 USD/kg) for fins between two to four inches in length, increasing with every two inches in size to over 8,000 BDT/kg (94.4 USD/kg) for fins over 20 inches in length (Bahadur 2010, Hasan et al. 2017) (Figure 2).

Figure 1. Fins of sharks (left) and guitarfishes (right) are laid out to dry in the sun.

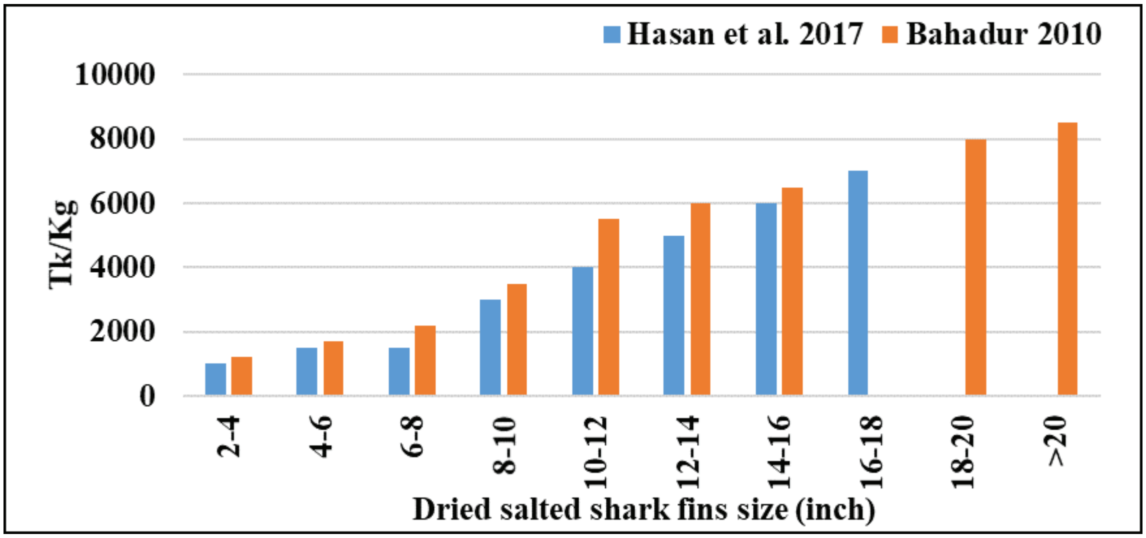

Figure 2. The market price of dried shark fins increases according to size according to Hasan et al. (2017) and Bahadur (2010).

Gill plates

Dried gill plates of filter-feeding manta and devil rays are highly valued for their use in 'health tonics', particularly in southern China. The average price of dry gill plates in a Sri Lankan fish market was 96–228 USD/kg (8,140-19,340 BDT/kg) (Fernando and Stevens 2011, Croll et al. 2016). Demand for gill plates is globally the largest driver for manta and devil ray fisheries (Heinrichs et al. 2011).

According to shark and ray traders interviewed by WCS in Cox's Bazar (2) and Alipur Kuakata (1) during December 2020, only gill plates from giant manta rays (*Mobula birostris*) are large enough to meet international demand. They purchase fresh gill plates above twelve inches in length at landing sites for 8,000-9,000 BDT/kg (94.4-106 USD/kg) and sell them dried for 30,000-35,000 BDT/kg (354-413 USD/kg) for export (Figure 3). The 26 traders questioned by Haque et al. (2020) reported prices of smaller dried mobulid gill plates for export between 4.8-19.2 USD (410-1,630 BDT) for 1-6 inches and 8.4-24 USD (710-2,040 BDT) for 8-10 inches in length. Haque et al. (2020) states that demand for gill plates has increased in the last five years.

Figure 3. Dried ray gill plates are exported for high prices to China.

Meat

According to traders questioned by WCS, the meat of small sharks and rays is consumed locally fresh or salted and dried (Figure 4), but the dried meat from larger species is sold to Myanmar. Small sharks, such as spadenose shark *Scoliodon laticaudus* or hound shark (*Iago* spp) sell fresh for 60-130 BDT/kg (0.7-1.5 UDS/kg) and dried for about 500 BDT/kg (5.9 USD/kg). The fresh meat of medium sized sharks, such as spottail shark *Carcharhinus sorrah* or milk shark *Rhizoprionodon acutus* sell for about 120 BDT/kg (1.4 USD/kg) or about 600 BDT/kg (7.1 USD/kg) when dried. The fresh meat from larger sharks, such as bull shark *Carcharhinus leucas*, pigeye shark *Carcharhinus amboinensis* or hammerhead sharks *Sphyrna* sp is sold fresh for about 250 BDT/kg (2.9 USD/kg) and dried for about 800-950 BDT/kg (9.4 – 11.2 USD/kg).

As with shark meat, the price for ray meat varies according to species and size. Smaller rays, like the bengal whipray *Bretrygon imbricata*, blue spotted maskray *Neotrygon caeruleopunctata*, kuhl's maskray *Neotrygon kuhlii*, or scaly whipray *Brevitrygon walga* are sold fresh for local consumption for 50-80 BDT/kg (0.6-0.9 USD/kg), while larger fresh rays to sell to local traders or buyers mainly from Myanmar for 120-320 BDT/kg (1.4-3.8 USD/kg). Salted dry ray meat sells for about 250 BDT/kg (2.9 USD/kg) for whole small rays and up to 750 BDT/kg (8.8 USD/kg) for pieces of larger.

While mobula ray meat is generally not highly valued in most parts of South Asia (Couturier et al. 2012, Dulvy et al. 2014, Thorrold et al. 2014), there is demand for local consumption and export in Bangladesh. According to the traders, the market value of fresh devil ray meat *Mobula* sp consumed locally is 120-180 BDT/kg (1.4-2.1 USD/kg), while dried and salted meat sells for 300-450 BDT/kg (3.5-5.3 USD/kg) to traders exporting it mostly to Myanmar. The relatively low price for meat from mobulids compared to other rays is apparently due to it turning black when dried (Figure 4).

Figure 4. Fresh meat of guitarfish (left top) and small dried guitarfish (right top) are sold to local consumers while dried meat from mobula rays is exported to Myanmar (bottom).

Skins

Shark and ray skins are used primarily in the leather industry (Durga et al. 2020). When polished, shark or ray leather is known as highly valued shagreen. Haroon (2010), Roy et al. (2014b), and Uddin et al. (2018) report that ray and shark skins or hides are made into shoes, wallets, belts, handbags, and purses in Bangladesh. WCS was unable to confirm any domestic processing of shark or ray leather, and traders claimed that skins are not used domestically but exported, mainly via Myanmar to Hong Kong or China (Figure 5).

Reported market prices for sundried skins in Bangladesh vary considerably. While most skins referred to are from rays, traders informed WCS that salted and dried skins from pigeye and bull sharks are also exported to Myanmar for re-export to China, selling for 100-170 BDT/kg (1.2-2.0 USD/kg). Bahadur (2010) reported sundried shark skins selling for 350 BDT/kg (4.1 USD/kg) in Cox's Bazar, with prices for stingray skins below 150 grams for 300 BDT/kg (3.5 USD/kg) and above for 770 BDT/kg (9.1 USD/kg), while Haroon (2010) reported sundried shark skins selling prices of 2,500-3,000 BDT/kg (29.5-35.4 USD/kg) to Middle Eastern and European buyers. Hasan et al. (2017) reported smaller shark skins selling for 700 BDT/kg (8.3 USD/kg) and larger ones for 1,200 BDT/kg (14.2 USD/kg) in Cox's Bazar and Chattogram for export to Myanmar.

Figure 5. Skins from whip and stingrays.

Liver oil

Sharks and rays have large oily livers to keep them afloat. Their liver oil is rich in Vitamin-A, used in skincare products due to its hydrating and antioxidant properties, and squalene, used as a boosting agent in vaccines. There is concern that the global demand for squalene used in Covid-19 vaccines for improving immune system response could further worsen the status of already threatened sharks (Macdonald and Soll 2020). Crude shark and ray liver oil is used as lubricant in tanning and textile industries (Haroon 2010).

Shark oil is extracted by chopping and boiling the liver in metal containers (Haroon 2010, Bahadur 2010, Hasan et al. 2017). Once all water has evaporated, the crude oil floating on the surface is ladled off and strained through a cloth. Haroon (2010) reported liver oil also being separated using a centrifuge after the chopped pieces are soaked in 1-2% sodium hydroxide or 2-5% of sodium carbonate at 82-85°C.

According to Hasan et al. (2017), 200 kg of shark livers yield approximately 120 kg of crude liver oil. In 2010, shark liver oil sold for 15-17,000 BDT (USD 176.9-200.5) per 250-kg drum depending on its purity (Bahadur 2010), reportedly increasing to 22-25,000 BDT (USD 259.5-294.9) in 2014. Haque et al. (2020) stated that liver oil from mobula rays is sold to fish-feed producers and occasionally to pharmaceutical companies, while Haroon (2010) reported shark oil being exported.

Cartilage

Dried cartilage of sharks and rays (Figure 6) is believed to have anti-inflammatory and antioxidant properties. Ray cartilage sold for between 200 BDT/kg (2.4 USD/kg) and 500 BDT/kg (5.9 USD/kg), and shark cartilage at 250 BDT/kg (2.9 USD/kg) in Cox's Bazar (Bahadur 2010), with prices as high as 450 BDT/kg (5.3 USD/kg) reported from Cox's Bazar and Chattogram in 2017 (Hasan et al. 2017). According to Haque et al. (2018), cartilage from sharks and rays landed in Bangladesh is traded locally and exported to China, Hong Kong and Singapore (Hasan et al. 2017).

Figure 6. Dried guitarfish cartilage

Teeth and jaws

Shark jaws and teeth are used in various regions of the world as ceremonial objects (Rose 1996), trinkets and jewelry (Vannuccini 1999). Between 2010-2017, prices for sun dried shark teeth increased from 500 BDT/kg to 20,000 BDT/kg (5.9-235.9 USD/kg) in Bangladesh (Bahadur 2010, Hasan et al. 2017). Some of these teeth are reportedly exported to Myanmar. (Hasan et al. 2017). According to Bahadur (2010), the dried rostrum of a sawfish sells for 500 to 1,000 BDT (5.9-11.8 USD) per piece at Cox's Bazar. According to more recent information collected by WCS, dried sawfish rostra can be sold for as much as 25,000 BDT (294.9 USD) for large ones.

Guts and left-over parts

Shark and ray body parts are sold to fish or poultry feed producers for 2,000 BDT (23.6 USD) per 250-kg drum (Bahadur 2010, Haque et al. 2020). It is also reported that indigenous communities consume unsalted, sun-dried shark guts bought for 150 BDT/kg (1.8 USD/kg) (Bahadur 2010, Hasan et al. 2017).

Trade channels and routes for shark and ray products from Bangladesh

Sharks

Traders buy processed shark fins, meat, and skins, and then export them to Myanmar for re-export to Singapore, Hong Kong, China, and USA (Roy et al. 2007). Roy et al. (2015) estimated that only 10-20% of this trade follows proper legal procedures. According to information from an international media survey and interviews with shark traders in Bangladesh shark fins are transported by boat from Chattogram and Cox's Bazar to Myanmar and then on to Yangon and China (WCS 2018). Shark liver oil is sold to wholesalers in Dhaka and Chattogram (Hasan et al. 2017).

Rays

The majority of the dried ray meat is exported to Myanmar along with other elasmobranch products. Along with other ray parts, including fresh meat, mobulid gill plates, liver oil, and left-over parts, these products are shipped from Chattogram and Cox's Bazar to Teknaf, across the border to Myanmar and on to China and Thailand. Chinese buyers often contact middlemen or traders in Bangladesh to order products that are then sent via Myanmar. Some products are also transported by truck or bus from Chattogram or Cox's Bazar to Khagrachari, Dhaka, Rangpur and Rajshahi (Haque et al. 2020).

Domestic Consumption

In 2018, WCS conducted standardized interviews with 305 fishers, traders and consumers in nine locations with major fish landing sites (Khulna, Bagerhat, Parerhat, Kuakata, Patharghata, Chittagong, Cox's Bazar, Teknaf, and St. Martin's Island). Of the 166 fishers questioned, 80% have been fishing for over 10 years and 72% do not have income sources other than fishing. Nearly half (49%) were unaware of laws protecting sharks and rays. Of the 100 shark and ray consumers questioned, 63% eat sharks or rays at least once a month and 37% every week. Most consumers (85%) were Hindus, Buddhists, Christians, or ethnic minorities, with the remaining being Muslim. Of the 39 shark and ray traders interviewed, most buy directly from fishermen (87%) and have been trading sharks and rays for more than 10 years (73%), while 46% were unaware of laws protecting sharks and rays.

Potential for increasing Government revenue and improving livelihoods from legal shark and ray products

While domestic and international trade of shark and ray products in Bangladesh is substantial, most trade is undocumented. Official catch and export statistics do not differentiate shark or ray species, or shark and ray products from fish swim bladders. The mandated use of World Customs Organization codes specifying shark and ray parts and products would enable the tracking of international trade. Enforcement of existing licensing and business regulations, including for on-line traders, could increase Government revenue and incentivize traders to comply with national and international trade regulations and species protection laws. As a next step, technical training on quality control and product diversification could increase financial benefits from legally obtained non-threatened species.

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Appendix 1. Quantity of landed sharks and rays, exported sharks fin and fish maw (combined) from Bangladesh according to published Government of Bangladesh statistics, and Hong Kong customs records on imported dried sharks fins from Bangladesh. NI = No information

Year	BD Catch Sharks & Rays in metric tons	BD Export (shark fins & fish maw) in metric tons	Hong Kong imported shark fins from Bangladesh in metric tons
2001-2002	6,234	263	NI
2002-2003	5,063	172	NI
2003-2004	4,946	4	NI
2004-2005	4,085	1	NI
2005-2006	4,448	78	NI
2006-2007	4,790	244	NI
2007-2008	4,767	266	NI
2008-2009	3,933	276	NI
2009-2010	4,794	955	NI
2010-2011	4,205	0	NI
2011-2012	3,865	0	NI
2012-2013	5,017	1	NI
2013-2014	5,648	0	NI
2014-2015	5,093	0	1
2015-2016	4,622	0	18.9
2016-2017	4,495	0.16	25.6
2017-2018	3,974	0.5	45
2018-2019	4,274	2,134	1.8
2019-2020	3,373	NI	6.8 (2019), 0.4 (2020)

WCS empowers law enforcement officers through the provision of training, mentoring support and tools to identify protected sharks, rays and their commonly traded parts and to develop legal cases for the successful prosecution of illegal shark and ray traders.

CHAPTER 6

INSTITUTIONAL AND LEGAL FRAMEWORKS FOR THE CONSERVATION AND MANAGEMENT OF SHARKS AND RAYS IN BANGLADESH

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Background

Institutional and legal frameworks are the foundation for marine conservation and management and are critical for achieving sustainable ocean development (Tarmizi 2010; FAO 2020). Numerous laws and rules aim to regulate Bangladesh's fisheries, but their implementation frequently encounters conflicts and non-compliance resulting in poor governance (Islam et al. 2017). The existing institutional and legal framework for shark and ray conservation and management is fragmented, with different laws, regional mandates, and international commitments covering different aspects. The purpose of this document is to summarize the institutional and legal frameworks that govern shark and ray conservation and management.

Mandates of National Agencies

The protection of threatened sharks and rays in Bangladesh is a shared responsibility of the Forest Department (FD), which is responsible for protecting threatened wildlife, and the Department of Fisheries (DoF), which is responsible for managing marine fisheries, with additional assistance mandated from the Navy, Coast Guard, and River Police responsible for enforcing fishery regulations, as well as from Customs, Police, and Border Guard Bangladesh responsible for enforcing trade laws and rules.

Under the Ministry of Environment, Forests and Climate Change (MoEFCC), the FD has gradually shifted its focus from maximizing productivity and profitability of natural resource extraction to a dual function of also protecting threatened biodiversity including wildlife listed in Schedule I and II of the *Wildlife (Conservation and Security) Act 2012*. The FD's Wildlife Crime Control Unit (WCCU) leads the combat against illegal wildlife trade in collaboration with other law enforcement agencies.

The Ministry of Fisheries and Livestock (MoFL) manages inland and marine fisheries through the Department of Fisheries (DoF). The Marine Fisheries Survey Management Unit (MFSMU) under the DoF conducts catch assessment surveys. The Bangladesh Fisheries Research Institute (BFRI) coordinates and conducts research and training aimed at maximizing production and utilization of living aquatic resources through improved management and technology. The Fisheries Resources Survey System (FRSS) prepares the annually published DoF *Yearbook of Fisheries Statistics of Bangladesh*. The DoF's Fish Inspection and Quality Control wing ensures internationally required safety standards for exported fisheries products, and provides processing licenses, and export and traceability certificates. The Bangladesh Fisheries Development Corporation (BFDC) supports processing and marketing of fishery catches by managing fish landing sites, cold storage, auction, and processing centers as well as transportation.

The Bangladesh Navy protects the nation and its maritime resources from external maritime threats such as smuggling and trafficking with a fleet that includes 17 offshore patrol vessels. In addition to providing security assistance to seaports and conducting relief and rescue operations in the coastal areas after natural calamities, the Bangladesh Coast Guard supp orts the Navy with its own fleet of patrol vessels in securing maritime borders, controlling piracy and illegal trafficking, protecting fishery, oil, gas, forest resources, and preventing pollution. Major rivers, including Sundarbans waterways, are also under the jurisdiction of the Coast Guard. The *Bangladesh Coast Guard Act 2016* prohibits illegal fishing in territorial waters of Bangladesh.

The River Police, a specialized unit of the Bangladesh Police, patrols inland waterways and supports the DoF with enforcing fisheries regulations including temporal and spatial fishing bans.
Mandates of the Bangladesh Customs, Police, and Border Guard Bangladesh include the enforcement of domestic and international trade regulations, including those pertaining to sharks, rays, and their products.

National Laws and Policies

The *Constitution of the People's Republic of Bangladesh* directs the state to safeguard natural resources, biodiversity, and wildlife for the present and future citizens.

Bangladesh adopted the *Territorial Waters and Maritime Zones Act 1974* enabling the establishment of conservation zones to maintain the productivity of living marine resources with appropriate measures to prevent indiscriminate exploitation, depletion and destruction (Iqbal 2019).

The *Wildlife (Conservation and Security) Act 2012* provides the legal basis for conservation and management of wildlife and biodiversity, including protection for threatened sharks and rays. An amendment for listing eight genera and 23 species of sharks and rays under Schedule I and one genus and 29 species under Schedule II is currently under consideration by the MoEFCC. While definitions for the schedules are not provided in the act, current interpretation is generally that Schedule I provides complete protection from exploitation, while capturing, killing, trading, or displaying (e.g., sharks or rays in aquaria) of Schedule II listed species require an official permit from the FD.

The Forest Act 1927 (Act XVI of 1927) Section 2(4) (b) (iii) defines wild animals as 'forest produce'. Section 26(1) (d) prohibits the removal of any forest produce other than timber from the Sundarbans Reserved Forest. As aquatic wildlife, all sharks and rays are fully protected in the Sundarbans.

The *Marine Fisheries Act 2020* (*Marine Fisheries Ordinance 1983*) is the primary law governing marine fisheries in Bangladesh. It does not specifically regulate shark or ray fisheries, but it does empower the MoFL to declare multi-use Marine Protected Areas (MPAs)[1], regulate the number of licensed fishing vessels for conservation and sustainable fishery management[2], and issue gear-specific fishing licenses[3].

The *Marine Fisheries Ordinance1983* requires the reporting of shark and ray catches[4]. The *Protection and Conservation of Fish Act 1950*[5] prohibits the use, production, sale, or possession of monofilament gillnets as a punishable offence with imprisonment of up to five years and a fine of up to 10,000 Bangladesh Taka.

The *Protection and Conservation of Fish Rules 1985* prohibits the use of explosives, poison, fine-mesh mosquito nets (fry or post-larvae catch), the use of any net with mesh size below 45 mm (2 inches), and the use of set-bag nets in waters less than ten meters deep. An overview of applicable fishing gear regulations is provided in Appendix 1. Additional rules will be enacted under the *Marine Fisheries Act 2020* (*Marine Fisheries Ordinance 1983*).

The *Biological Diversity Act 2017* defines activities adversely affecting threatened animals or biological resources as punishable offences and enables the Government to enact protective regulations for any living resources that it considers vulnerable or endangered. It differs from other legislation in that it promotes a multi-sectoral approach by mandating a multi-agency national committee rather than a single ministry or agency.

The *National Fisheries Policy 1998* enables the MoFL and the DoF to issue rules, policies and administrative orders pertaining to the marine environment to increase fish production for improved socio-economic conditions of fishers.

[1]Section 29 (i)

[2]Section 4

[3]Section 28

[4]Section 14

[5]East Bengal Act No. XVIII of 1950 and subsequent amendments of 1963, 1970, 1982, 1985, 1987, 1995, 2002, 2005, 2006, 2007, 2011

The *Export Policy 2015-2018* refers to Section 29 of the *Wildlife (Conservation and Security) Act 2012* for regulations on export of wild animals or their body parts.

Import and Export Policy Orders issued by the Ministry of Commerce triennially under the *Imports and Exports (Control) Act, 1950* (Act No. XXXIX of 1950) specify the use of Harmonised Systems (HS) Codes including product-specific commodity codes for sharks and rays[6]. HS Codes were developed by the World Customs Organization (WCO) to classify products in trade and enable traceability with appropriate data recording.

National Strategies and Action Plans

The *Vision-2021* of the Government of Bangladesh prioritizes conservation through systematic protection and environmentally sound management of wetlands, open water, and marine fisheries.

As per the *Eighth Five Year Plan 2020 – 2025* of the Government of Bangladesh, marine fisheries are a priority sector for national blue economy initiatives coordinated by the Ministry of Foreign Affairs (MoFA). Exploring blue economy-related activities, include capacity development for deep-sea fishing. Although the marine fisheries sub-strategy does not directly address shark and ray fisheries, management recommendations include the introduction of a Vessel Tracking and Monitoring System (VTMS), strengthening interagency cooperation and capacity building for monitoring, control and surveillance (MCS), and establishing MPAs.

The *National Biodiversity Strategy and Action Plan of Bangladesh* (NBSAP 2016-2031) provides recommendations for improving protection of the country's biodiversity aligning with international commitments including the UN Convention on Biological Diversity and UN Sustainable Development goals. It aims to achieve this through effectively managed protected areas; integrating biodiversity into cross sectoral policies; improving public awareness about biodiversity protection; reducing pressure on biodiversity; promoting sustainable use; and undertaking stock assessments to inform ecosystem- and community-based management, avoid overfishing, and conserve threatened species and vulnerable ecosystems. Specific technical solutions proposed in the *NBSAP 2016-2021* include turtle excluder devices, tracking devices for deep-sea fishing vessels, and predictive modeling of sustainable exploitation levels for fisheries resources.

The *National Fisheries Strategy 2006* endorsed by the MoFL aims to ensure sustainable use and management of fishery resources, recognizing a largely uncontrolled increase in fishing effort, lack of resource management, and a shift of resource ownership from fishermen to wealthy businessmen and traders. In the *Marine Fisheries Sub-Strategy (2006)* sustainable management of marine fisheries is linked to marine fisheries development for poverty reduction, co-management and resource conservation through systematic monitoring and information sharing, allocating fishing rights and fisheries management to communities and relevant fishing groups, and by providing a regulatory management framework. Although the sub-strategy does not directly address shark and ray fisheries, relevant recommendations include (a) monitoring all fishing vessels (non-mechanized, mechanized, and industrial), (b) registering fishing vessels and fishermen according to gear type, (c) defining legal mesh sizes and areas of operations, and (d) enforcing restrictions or bans on destructive gears.

According to the *Marine Fisheries Sub-strategy 2006*, all fishing should be prohibited in areas less than five meters deep or within five kilometers from shore to allow uninterrupted migration of juvenile fish. The sub-strategy also suggests that waters beyond ten kilometers offshore and less than 40 meters deep should be allocated to mechanized boats operating drifting gillnets, marine set bag nets and long-lines.

The Quality Control Strategy 2006 provides guidelines for issuing licenses for processing plants, export certificates, and improving the traceability of fish and fisheries products. The DoF quality control wing could apply these guidelines to improve traceability and determine the legality of exported shark and ray products.

[6]http://www.bangladeshcustoms.gov.bd/first_schedule/BCT-2019-2020.pdf

Regional Organizations, Associations and Programmes

The Indian Ocean Tuna Commission (IOTC) promotes cooperation among the 31 contracting parties, including Bangladesh, to ensure the conservation and optimum use of stocks and encouraging the sustainable fisheries through appropriate management. IOTC urges members to prepare and implement a National Plan of Action (NPOA) for sharks to facilitate estimation of catches, appropriate management measures, and the collection of bycatch data and compliance with IOTC Resolutions.

As Bangladesh's IOTC focal point, the DoF provides annual reports on marine fisheries, including details on sharks and rays. A NPOA for shark is being developed which may incorporate the IOTC requirements to introduce key national strategies related to sharks, including the status of the NPOA-sharks.[7]

Member states of the *South Asian Association for Regional Cooperation* (SAARC), including Bangladesh, promote welfare of people of South Asia, accelerate economic growth and increase collaboration and mutual assistance in economic, social, culture, technology, and scientific fields. Since the region is a major contributor to global fisheries production, the mandate of SAARC includes regional fisheries policies, reporting and management, which could benefit the conservation management of shared sharks and rays.

The *Indian Ocean Rim Association* (IORA) aims to strengthen regional cooperation and sustainable development within the Indian Ocean region. Bangladesh is one of the 22 member states and will assume the role of Chair in December 2021. IORA proposes that fisheries management, as one of its focal areas, along with environmental concerns should be integrated into maritime policies. The IORA Fisheries Support Unit (FSU) aims to enhance cooperation within the fisheries sector, through better utilization of fisheries resources, expertise exchange and conducting joint research activities. This could be a potential platform for collaboration on Indian Ocean range species threatened from overfishing.

The *Bay of Bengal Programme* (BOBP) promotes and facilitates the long-term development and use of marine fisheries resources of the Bay of Bengal based on responsible fishing practices and environmentally sound management programs. Transferring suitable technologies and techniques for the growth of small-scale fisheries; developing skills through training and education; and encouraging women's involvement in coastal fisheries development are core objectives of the BOBP relevant to shark and ray conservation management.

International Conventions and Agreements

Bangladesh is party to the *United Nations Convention on the Law of the Sea* (UNCLOS), considered the global legal framework for maritime and marine activities and exploitation of natural resources beyond national jurisdiction. As such, Bangladesh is committed to protecting living resources within its EEZ and to work with transboundary governments either directly or through regional organizations in protecting shared stocks and highly migratory species including sharks and rays.[8]

Bangladesh has signed but not ratified the *UN Fish Stocks Agreement (1995)*, which focuses on highly migratory transboundary fish stocks within EEZs and the adjacent high seas, in response to a worldwide resource management crisis.

The *Convention on Biological Diversity* (CBD) is an international legally-binding treaty ratified by 196 nations, including Bangladesh, with three main goals: conservation of biodiversity; sustainable use of biodiversity; and the fair and equitable sharing of the benefits arising from the use of genetic resources. The Primary National Focal Point for the CBD in Bangladesh is in the MoEFCC, while the Protected Areas Focal Point is in the FD. Bangladesh has formulated numerous conservation strategies to achieve CBD biodiversity targets including the *Bangladesh Bird Management Plan 2015, Bangladesh Herpetofauna Management Plan 2015, Mammal Management Strategy 2015-2025, Tiger Action Plan, Bangladesh Vulture Conservation Action Plan 2016-2025,* and *Bangladesh Elephant Conservation Action Plan 2018-2027*.

[7] https://www.iotc.org/documents/SC/23/NR02

[8] UNCLOS Article 65, 116-120

Bangladesh is a member of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), which regulates international trade and mandates adoption of national legislation to improve the management of threatened wildlife, including sharks and rays. During the last two Conferences of Parties (CoP17 and CoP18), Bangladesh co-sponsored successful proposals to list Silky sharks *Carcharhinus falciformis*, Thresher sharks *Alopias* spp., Mobula rays *Mobula* spp., Mako sharks *Isurus* spp., Giant guitarfishes *Rhynchobatus djiddensis* and Wedgefishes *Rhynchobatus* spp. in CITES Appendix II. Bangladesh is also taking steps to amend national legislation (see National laws and policies above) and to increase the capacity of its law enforcement agencies to detect, report and prosecute illegally traded wildlife, including sharks, rays and their body parts, to comply with CITES commitments.

The FD is the national CITES management authority, authorized to issue CITES import and export permits for Appendix II listed for species that have been assessed with a positive finding under the CITES Non-Detriment Finding (NDF) process. To date, no NFDs have been developed for any shark or ray species in Bangladesh – although two are planned to be developed as part of the World Bank funded *Sustainable Forests and Livelihoods* Project implemented by the Bangladesh Forest Department.

Bangladesh is a member of the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), which aims to conserve terrestrial, aquatic, and avian migratory species throughout their range. However, Bangladesh has not signed the *CMS Memorandum of Understanding on the Conservation of Migratory Sharks* (CMS Sharks MoU), which aims to improve the conservation status of migratory sharks listed in Appendices I and II of the Convention. The CMS National Focal Point for Bangladesh is in the FD under the MoEFCC.

The *FAO Code of Conduct for Responsible Fisheries* was adopted globally in 2000 to ensure responsible and sustained fisheries. The code outlines international standards of behavior for responsible practices to ensure conservation, management, and development of living aquatic resources, ecosystem, and biodiversity. The code aims to strengthen institutional collaboration among states, regions, and sub-regional agencies in consideration of nutritional, economic, social, environmental, and cultural importance of fisheries and fishery sector stakeholders. The code is a voluntary instrument that addresses many aspects of fisheries, and it represents a common commitment by Member States to minimum standards and creates a moral obligation for governments and other stakeholders to act in a responsible manner and to address urgent fisheries management issues.

As a member of the FAO Committee on Fisheries (COFI), Bangladesh endorsed the *International Plan of Action on Sharks* (IPOA-Sharks) developed by the *United Nations Food and Agriculture Organization* (FAO) in 1999, committing to develop and implement a *National Plan of Action* (NPOA) to reverse shark population declines and improve their conservation and management. A first NPOA was drafted in 2014 by the Bangladesh Fisheries Research Institute (BFRI) with support from the *Bay of Bengal Large Marine Ecosystem* Project (BOBLME). The plan was never adopted, and substantial new information on sharks and rays has become available since 2014.

Gaps in legislation and regulatory frameworks

It was not until the passage of the *Wildlife (Conservation and Security) Act 2012*, that shark or ray species were legally protected in Bangladesh. To date there is considerable confusion among law enforcement officers regarding the legal protection of sharks and rays.

The proposed *Shark and Ray Amendment 2021* (Appendix 2), which lists eight genera and 23 species of sharks and rays under Schedule I, and one genus and 29 species of sharks and rays under Schedule II, brings clarity for law enforcement officials. It also aligns national legislation with CITES, CMS and IOTC commitments and recent IUCN Red List conservation status assessments. However, the *Wildlife (Conservation and Security) Act 2012* currently lacks legal definitions for the respective schedules and guidance on penalties resulting from infractions.

A key challenge faced in combatting illegal shark and ray trade is the difficulty of arresting and prosecuting criminals. If a wildlife criminal is arrested and a case is filed, successful prosecutions are rare, and the penalties are relatively minor. One significant impediment is a provision in the *Wildlife (Conservation and Security) Act 2012* that makes FD officials criminally liable if a judge finds there is insufficient evidence to prosecute an arrested violator. The implication of this provision is that, instead of using this law to arrest and prosecute wildlife criminals, the FD often uses the *Forest Act (1927)* to arrest wildlife traders. The relatively minor penalties of this law provide little deterrence for criminals.

The current recording and reporting on shark and ray catches and landings lacks spatial coverage, geo-spatial information and details on genera or species that are crucial for quantifying fishery impacts on shark and ray stocks and reporting to IOTC, CMS and CITES. Information particularly on pelagic sharks and rays caught by industrial long-liners, bottom, or mid-water trawlers as well as the at-sea transshipment trade is likely under reported and largely uncontrolled. Furthermore, shark and ray catches are frequently landed, processed, and traded at unofficial landing and processing sites, which further inhibits monitoring and enforcement.

Dried shark fins and rays gill plates are often mixed with dry fish or frozen seafood shipments lacking species or product specific HS customs codes. Official catch and export statistics do not differentiate shark or ray species, or shark and ray products from fish swim bladders. This reduces the traceability of shark and ray products originating from Bangladesh, and results in revenue loss for the Government. Enforcement of existing licensing and business regulations, including for on-line traders, would inform the sustainability of the shark and ray trade and could increase Government revenue and incentivize traders to comply with national and international trade regulations and species protection laws.

Awareness about laws and rules regulating trade in sharks and rays was found to be low among domestic consumers (WCS 2018). Increasing consumption of shark and ray meat has been observed across the country which means that the retention of sharks and rays is not only being driven by the global market but also increasingly by domestic demand.

Regulatory recommendations in published references and the BOBLME NPOA

Hoq et al. (2014) recommended updating the 'Fishery Act' with strong rules and proper monitoring, control, and surveillance for restricting indiscriminate exploitation of sharks and rays, and for gaining a better understanding of the economics of shark fisheries in Bangladesh.

The BOBLME NPOA Sharks Draft (2014) recommended:

- Promoting gear modifications to mitigate elasmobranch bycatch and discard mortality.
- Standardized recording of shark and ray catches and increased reporting of discard mortality.
- Adopting tri-national (Bangladesh, India & Myanmar) fishery management agreements for shared elasmobranch stocks including Total Allowable Catch (TAC) limitations.
- Review and update the NPOA at least every four years based on regular assessments.

Badhon et al. (2019) recommended:

- Developing long-term studies on taxonomic identification, distribution, and population of sharks facilitated by Government agencies (DoF, BFRI) with a consortium of experts to guide shark conservation and management.
- Transforming the single sector approach of regulatory agencies into an integrated approach.
- Inclusion of new data attributes for shark and ray species-specific records in the Fisheries Resources Survey System (FRSS) to initiate the process of national species status assessments.
- Facilitating an NDF process, led by the FD, to regulate the trade of shark products with technical assistance from the DoF.
- Building capacity and infrastructure for the FD to identify shark species from products and monitor trade for CITES compliance.
- Signing the CMS Sharks-MoU as an opportunity to develop fisheries bycatch reduction.
- Integrating shark conservation into fisheries policies and management (e.g., National Fisheries Policy Article 8 and 8.2) with clear directives for legal processes in the marine fishing industry, and bycatch regulations on sharks and other marine megafauna.
- Investing in strategies to manage bycatch in artisanal and industrial fisheries, (e.g., modifications of gear, safe handling and releasing of bycatch, reducing post-release mortalities).

- Establishing a multi-agency national committee under the Bangladesh Biodiversity Act to initiate a national status assessment for shark species.
- Providing legal protection for threatened aquatic species by listing them under the Protection and Conservation of Fish Act 1950.
- Allocating resources for enhancing institutional capacity and trained human resources of the DoF to improve the protection of threatened sharks and other marine megafauna through engagement with the fishing industry.

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Appendix 1. Overview of currently applicable fishing gear regulations for marine waters of Bangladesh

Net Type	Local Name (s) (As per legislation)	Description (As per legislation)	Prohibition	Section, Rule, Clause	Marine Fisheries Act 2020 (Previous Marine Fisheries Ordinance 1983)	Date of Gazette Notification
Monofilament gillnet	Current; Japani Current; Fandi; Fash; Kapa; Badha; Kathi Jal	Fishing net made of single filament synthetic nylon fibre of different mesh sizes.	No person shall manufacture, fabricate, import, market, store, carry, transport, own, possess or use Current Jal.	Section 4A (1)	Protection and Conservation of Fish Act, 1950	September 21, 2002
			Current Jal or any net with 45 mm mesh size or with less than 45 mm are prohibited.	Rule 12	Protection and Conservation of Fish Rules, 1985	January 25, 1988
Small-mesh gillnet	Zero Sutar; Dui Sutar; Tin Sutar; Nylon; Sutar; Bhasan; Ilish/Ilse; Poket/Poka; Candi/Chandi; Kona; Gulti/Khota; Sain; any other jal for Hilsha harvest	Small-mesh nylon or twine nets targeting primarily Hilsa	Use of any nets with less than 65 mm mesh size for catching Hilsa is prohibited as specified in the local name.	Section 3, Subsection 3, Clause (iii), Rule 12 (a) (b)	Protection and Conservation of Fish Rules, 1985	July 15, 2020
Large-mesh drift net, Small-mesh drift net	Bhasa Jal; Bara Vasajal – Lakhyajal		The minimum mesh size for large mesh drift net shall be 200 mm, and the minimum mesh size for small mesh drift net shall be 100 mm.	Rule 14 (c) (d)	Marine Fisheries Rules, 1983 Marine Fisheries Rules, 1983	September 12, 1983 September 12, 1983
			Area of fishing with drift net (Bhasa Jal for Hilsha and like fishes, and Bara Vasajal – Lakhyajal) are earmarked up to 40 meters depth of marine waters at its highest tide.	Section 15, Subsection (3) (4)		

Appendix 1 continued.

Net Type	Local Name (s) (As per legislation)	Description	Prohibition	Section, Rule, Clause	Act/Rule	Date of Gazette Notification
Set bag nets (*Fixed funnel net, marine*)	Behundi Jal		Area of fishing with set bag net is earmarked up to 40 meters depth of marine waters at its highest tide.	Section 15, Subsection (1)	Marine Fisheries Rules, 1983	September 12, 1983
			The minimum mesh size at the cod end shall be 45 mm.	Rule 14 (e)	Marine Fisheries Rules, 1983	May 31, 2004
Estuarine Set Bag Net-ESBN (Fixed funnel net, estuarine)	Badha; Pekua; Bingi; Gara; Chingri Pona Dhora; Khuti/ Khuta; Tong; Bindi Jal	Any type of cotton, nylon, or synthetic net	The use of estuarine set bag nets of any size, type or mesh size in any freshwater areas or coastal waters up to 10 meters depth at high tide is prohibited year-round.	Rule 12, Sub-Rule 4 (b)	Protection and Conservation of Fish Rules, 1985	April 07, 2013
Mechanized trawl net targeting fish or shrimp	Boom		Mesh size for fish trawl net at the cod end shall be 60 mm, and for shrimp trawl net, with low opening, the minimum mesh size shall be 45 mm at the cod end.	Rule 14 (a) (b)	Marine Fisheries Rules, 1983	September 12, 1983
			Area for fishing with trawlers are earmarked for operation beyond 40 meters of marine waters at its highest tide.	Section 15, Subsection (5)	Marine Fisheries Rules, 1983	September 12, 1983
Fine-mesh drag, seine or set-bag net, Mosquito nets	Katha; Ver; Jagat Ver; Bhim Jal (Moshari/Chot Jal)	Any type of cotton, nylon, or synthetic net up to 10 mm length or diameter.	Banned from the Bengali months of Falgun to Sravan (mid-February to mid-August).	Section 3, Sub-section (3), Clause (iii), Rule I2 (a) (b)	Protection and Conservation of Fish Rules, 1985	April 07, 2013
			No person shall catch or cause to be caught fry or post larvae of fish, shrimp, and prawns of any kind, in any form and in any way in the estuary and coastal waters of Bangladesh.	Rule 8 (1A)	Protection and Conservation of Fish Rules, 1985	September 21, 2000
Longline	Borshi; Hazari borshi		Area of fishing with hook and lines is earmarked up to 40 meters depth of marine waters at its highest tide.	Section 15, Subsection (2)	Marine Fisheries Rules, 1983	September 12, 1983

Appendix 2. List of sharks and rays proposed to be included in Schedule I and II of the *Bangladesh Wildlife (Conservation and Security) Act, 2012*.

(১) তফসিল-১ এ উল্লিখিত 'মৎস্য (FISHES)' শীর্ষক ছকের ক্রমিক নং ১ হইতে ২৫ এবং উহার বিপরীতে কলাম ২, ৩ ও ৪ এ উল্লিখিত এন্ট্রিসমূহের পরিবর্তে যথাক্রমে নিম্নরূপ ক্রমিক নং ও এন্ট্রিসমূহ প্রতিস্থাপিত হইবে, যথা :

ক্রমিক নং	বাংলা নাম	ইংরেজি নাম	বৈজ্ঞানিক নাম
		বর্গ- কার্চারিনিফর্মিজ (হাঙ্গর) Carcharhiniformes পরিবার-স্ফিরনিডি (Sphyrnidae)	
০১	পাখমাথা হাতুড়ি হাঙ্গর/ জুলিয়া মাগর/কাইন্যা/কাউন্যা	Winghead/ Hammerhead shark	*Eusphyra blochii*
০২	হাতুড়ি হাঙ্গর/ জুলিয়া মাগর/ কাইন্যা/কাউন্যা	Hammerhead sharks	*Sphyrna spp.*
		পরিবার- কার্চারিনিডি (Carcharhinidae)	
০৩	ভোঁতা বলি হাঙ্গর	Pigeye shark	*Carcharhinus amboinensis*
০৪	সাদাগাল হাঙ্গর/ কামোট	Whitecheek shark	*Carcharhinus dussumieri*
০৫	পন্ডিচেরী হাঙ্গর	Pondicherry shark	*Carcharhinus hemiodon*
০৬	ঘ-বলি হাঙ্গর	Bull shark	*Carcharhinus leucas*
০৭	সাদাটুপি হাঙ্গর	Oceanic whitetip shark	*Carcharhinus longimanus*
০৮	গাঙ্গেয় চিনারি হাঙ্গর	Ganges shark	*Glyphis gangeticus*
০৯	বড়পাখ চিনারি হাঙ্গর/সিনারি হাঙ্গর	Broadfin shark	*Lamiopsis temminckii*
১০	তীক্ষ্ণদাঁত লেমন হাঙ্গর	Sharptooth lemon shark	*Negaprion acutidens*
		বর্গ- ওরেক্টোলোবিফর্মিজ (Orectolobiformes) পরিবার- স্টেগোস্টোমাটিডি (Stegostomatidae)	
১১	বাঘা হাঙ্গর/জেব্রা হাঙ্গর	Leopard shark/Zebra shark	*Stegostoma fasciatum*
		পরিবার- রিংকোডনটিডি (Rhincodontidae)	
১২	তিমি হাঙ্গর	Whale shark	*Rhincodon typus*
		বর্গ-ল্যামনিফর্মিজ (Lamniformes) পরিবার – ওডোন্টাসপিডিডি (Odontaspididae)	
১৩	ধূসর বাঘা হাঙ্গর	Sand tiger shark	*Carcharias taurus*
		পরিবার - অ্যালোপিডি (Alopiidae)	
১৪	কাস্তে হাঙ্গর	Thresher sharks	*Alopias spp.*
		পরিবার - ল্যামনিডি (Lamnidae)	
১৫	মাকো হাঙ্গর	Mako sharks	*Isurus spp.*
		বর্গ- রাইনোপ্রিস্টিফর্মিজ (রে ফিস) Rhinopristiformes পরিবার - প্রিস্টিডি (Pristidae)	
১৬	করাত মাছ/খান্দা মাগর/খটক/করাতি হাঙ্গর/আইশা	Sawfishes	*Pristis spp.*

১৭	ছুরি করাত মাছ/ খান্দা মাগর/ খটক/আইশা	Pointed sawfish	*Anoxypristis cuspidata*
		পরিবার- রিনিডি (Rhinidae)	
১৮	ধনুকমুখী পিতাম্বরি/ব্যাঙ হাঙ্গর	Bowmouth guitarfish	*Rhina ancylostoma*
১৯	পিতাম্বরি/ নাঙলা	Guitarfishes/Wedgefishes	*Rhynchobatus spp.*
		পরিবার- রাইনোব্যাটিডি (Rhinobatidae)	
২০	পিতাম্বরি/ নাঙলা	Guitarfishes/Wedgefishes	*Rhinobatos spp.*
		পরিবার- গ্লকোস্টেজিডি (Glaucostegidae)	
২১	পিতাম্বরি/ নাঙলা	Guitarfishes/Wedgefishes	*Glaucostegus spp.*
		বর্গ – মাইল্যোব্যাটিফর্মিজ (**Myliobatiformes**) **পরিবার – ইটোব্যাটিডি** (**Aetobatidae**)	
২২	বড়মাথা ঠোট্যা/টুইটা ঘাপরি	Longhead eagle ray	*Aetobatus flagellum*
		পরিবার - মোবুলিডি (**Mobulidae**)	
২৩	শিংচোয়াইন/দেউ মাছ/লুইমনি	Devil rays	*Mobula spp.*
		পরিবার- মাইলিয়োব্যাটিডি (**Myliobatidae**)	
২৪	চিত্রা ঠোট্যা/টুইটা ঘাপরি	Mottled eagle ray	*Aetomylaeus maculatus*
২৫	ফুল ঠোট্যা/টুইটা ঘাপরি	Ocellate eagle ray	*Aetomylaeus milvus*
		পরিবার- রাইনোপটেরিডি (Rhinopteridae)	
২৬	ভোঁতা ঘাপরি	Javan cownose ray	*Rhinoptera javanica*
২৭	ছোটলেজী ভোঁতা ঘাপরি	Shorttail cownose ray	*Rhinopetra jayakari*
		পরিবার - ডাসিয়াটিডি (Dasyatidae)	
২৮	ফুল শাপলাপাতা/জাতি শাপলাপাতা	White spotted whipray	*Maculabatis gerrardi*
২৯	রাম্মি/চুনি শাপলাপাতা	Bleeker's whipray	*Pateobatis bleekeri*
৩০	থ্যাবড়া নাক থাইন/ হাঙরাইল	Roughnose cowtail ray	*Pastinachus solocirostris*
৩১	মিঠাপানির শাপলাপাতা/পাইন্যা/বাইল্যা	Giant freshwater whipray	*Urogymnus polylepis*

(২) তফসিল-২ এ উল্লিখিত 'মৎস্য (FISHES)' শীর্ষক ছকের ক্রমিক নং ১ হইতে ২৭ এবং উহার বিপরীতে কলাম ২, ৩ ও ৪ এ উল্লিখিত এন্ট্রিসমূহের পরিবর্তে যথাক্রমে ক্রমিক নং ও এন্ট্রিসমূহ প্রতিস্থাপিত হইবে, যথা :

ক্রমিক নং	বাংলা নাম	ইংরেজি নাম	বৈজ্ঞানিক নাম
		বর্গ- কার্চারিনিফর্মিজ (হাঙ্গর) **Carcharhiniformes** **পরিবার-কার্চারিনিডি** **Carcharhinidae**	
০১	মুইট্ট্যা হাঙ্গর/সাদা লতা বলি/বলি হাঙ্গর	Graceful shark	*Carcharhinus amblyrhynchoides*
০২	ঘূর্ণি হাঙ্গর/কালা লতা বলি হাঙ্গর	Spinner shark	*Carcharhinus brevipinna*
০৩	রেশমি/সিল্কি হাঙ্গর	Silky shark	*Carcharhinus falciformis*
০৪	ইলিশা বলি/কালা লতা বলি হাঙ্গর	Blacktip shark	*Carcharhinus limbatus*
০৫	কালাটুপি রিফ হাঙ্গর/কালা লতা বলি হাঙ্গর	Blacktip reef shark	*Carcharhinus melanopterus*
০৬	ফোঁটালেজী/কালা লতা বলি হাঙ্গর	Spottail shark	*Carcharhinus sorrah*
০৭	বাঘা হাঙ্গর	Tiger shark	*Galeocerdo cuvier*
০৮	নীল হাঙ্গর	Blue shark	*Prionace glauca*
০৯	সাদাটুপি রিফ হাঙ্গর/সাদা পাখনা হাঙ্গর	Whitetip reef shark	*Triaenodon obesus*
		পরিবার- হ্যামিগ্যালিডি **(Hamigaleidae)**	
১০	বড়শিদাঁতী হাঙ্গর	Hooktooth shark	*Chaenogaleus macrostoma*
১১	শাঁখাদাঁতী/শিয়াল-বলি হাঙ্গর	Snaggletooth shark	*Hemipristis elongata*
		বর্গ-ল্যামনিফর্মিজ **(Lamniformes)** **পরিবার - ল্যামনিডি (Lamnidae)**	
১২	সাদা হাঙ্গর	White shark	*Carcharodon carcharias*
		বর্গ- ওরেক্টোলোবফর্মিজ **(Orectolobiformes)** **পরিবার-জিংলিমসটোমাটিডি** **(Ginglymostomatidae)**	
১৩	টনি নার্স হাঙ্গর	Tawny nurse shark	*Nebrius ferrugineus*
		বর্গ-টর্পেডিনিফর্মিজ **(Torpediniformes)** **পরিবার- নারসিনিডি (Narcinidae)**	
১৪	ভোঁতামুখ কারেন্ট মাছ	Shortlip numbfish	*Narcine brevilabiata*
১৫	চীনা কারেন্ট মাছ	Chinese numbfish	*Narcine lingula*

১৬	বাদামি কারেন্ট মাছ	Brown numbfish	*Narcine timlei*
		বর্গ-মাইলিয়োবেটিফর্মিজ (Myliobatiformes) **পরিবার- জিম্নুরিডি (Gymnuridae)**	
১৭	প্রজাপতি/বাদুড়/পদুনি/পদ্মমামনি	Butterfly rays	*Gymnura spp.*
		পরিবার - ডাসিয়াটিডি (Dasyatidae)	
১৮	বাঘা/চিতা শাপলাপাতা	Leopard whipray	*Himantura leoparda*
১৯	জালি/বাঘা/চিতা শাপলাপাতা	Coach (Reticulated) whipray	*Himantura uarnak*
২০	বাঘা/হরিণা/চিতা শাপলাপাতা	Honeycomb whipray	*Himantura undulata*
২১	ক্ষুদেচোখা শাপলাপাতা	Smalleye stingray	*Megatrygon microps*
২২	সাদানাক শাপলাপাতা/ হাউশ	Whitenose whipray	*Pateobatis uarnacoides*
২৩	জাকিনের ঘন্টি/ ঘুড়ি শাপলাপাতা	Jenkins' whipray	*Pateobatis jenkinsii*
২৪	কালি/কালাফোটা শাপলাপাতা	Blotched stingray	*Taeniurops meyeni*
২৫	সজারু শাপলাপাতা	Porcupine ray	*Urogymnus asperrimus*
২৬	গোল শাপলাপাতা	Round whipray	*Maculabatis pastinacoides*
২৭	বাদা শাপলাপাতা	Mangrove whipray	*Urogymnus granulatus*
২৮	চোঙ্গামুখ/চুনি শাপলাপাতা	Tubemouth whipray	*Urogymnus lobistoma*
		পরিবার – ইটোব্যাটিডি (Ateobatidae)	
২৯	চিত্রা ঠোট্যা/ফুল টুইটা ঘাপরি	Spotted eagle ray	*Aetobatus ocellatus*
		পরিবার- মাইলিয়োব্যাটিডি (Myliobatidae)	
৩০	ডোরাকাটা ঠোট্যা/টুইটা ঘাপরি/শঙ্খচিল	Banded eagle ray	*Aetomylaeus nichofii*

The exhibition *Ocean Guardians: Protecting Threatened Sharks and Rays in Bangladesh* developed by WCS engages visitors through sensory experiences to learn fascinating facts about sharks and rays and to understand their critical role in maintaining a healthy ocean ecosystem and about the laws and rules governing their exploitation and trade.

CHAPTER 7

EDUCATIONAL OUTREACH FOR PROTECTING THREATENED SHARKS AND RAYS IN BANGLADESH

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Introduction

Since 2016, WCS has been building constituencies for shark and ray conservation in Bangladesh. WCS outreach initiatives and tools target coastal fishers, fish traders and Government officers. Our innovative and cost-effective outreach encourages positive behavior changes among stakeholders by improving their knowledge about the ecological value of sharks and rays in maintaining a healthy ocean supporting healthy people, and about laws and rules to protect them. The initiative also instills pride in fishers, traders, and law enforcement officers as ocean guardians.

Education and capacity building for sharks and rays conservation and management are guided by a Theory of Change (Figure 1) and supported by communication tools developed and successfully implemented by WCS.

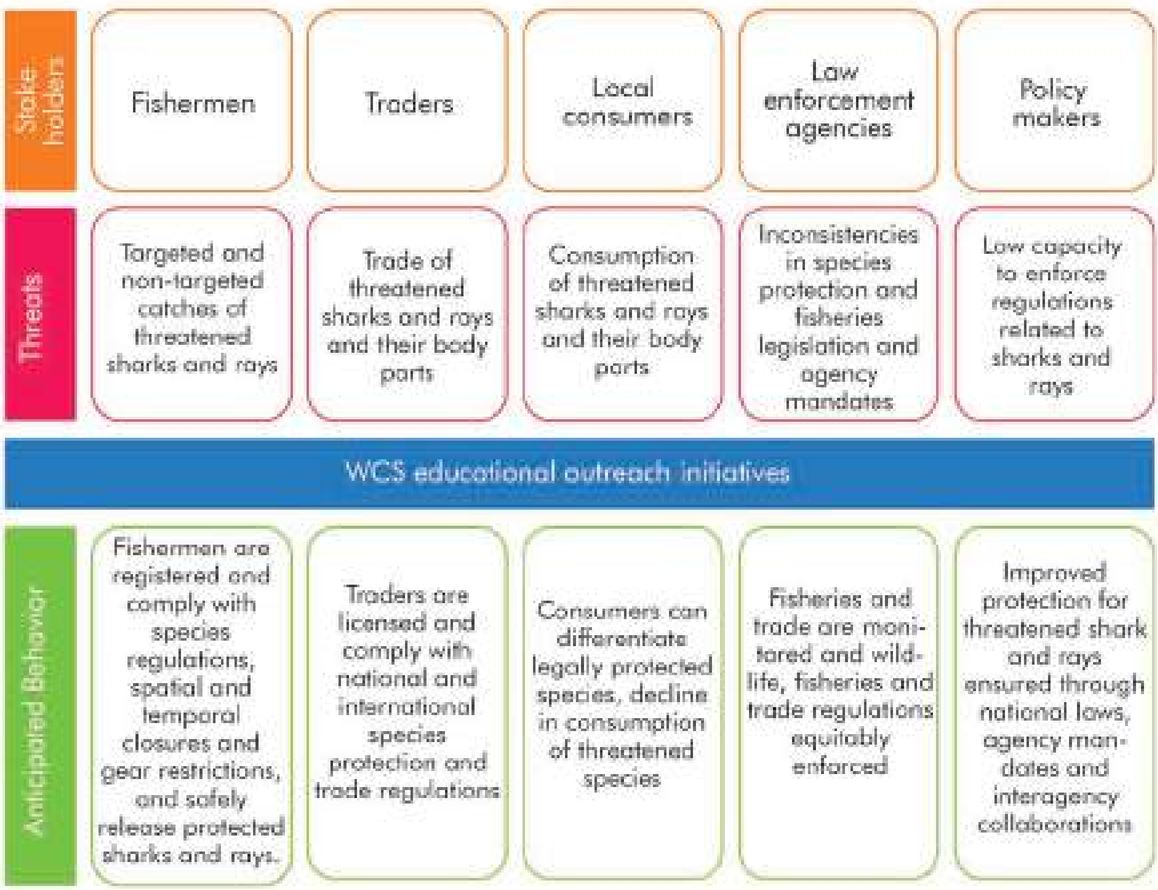

Figure 1. WCS Theory of Change to improve the protection of threatened sharks and rays in Bangladesh by reducing mortalities in fisheries, implementing trade regulations, and reducing domestic consumption.

Developing targeted educational outreach initiatives

Building on over a decade of experience in educational outreach for wildlife conservation in Bangladesh, WCS has developed an effective educational outreach initiative for sharks and rays, including mobile exhibitions and community radio programs, documentary films, training manuals, species identification guides and compliance tools[1]. In addition to communicating fascinating facts about the diverse sharks and rays occurring in Bangladesh and their vulnerability to overfishing driven by domestic and international demand, WCS raises awareness on species protected by the Bangladesh *Wildlife (Conservation and Security) Act 2012* and whose trade is regulated by the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES)[2].

Defining Key Messages

Communicating content in concise key messages is a crucial first step for educational outreach and capacity building. To access audiences with low literacy levels and increase knowledge retention, WCS formulates key messages in rhymes and uses symbols or pictograms for visual representation.

Three key messages are communicated through WCS educational outreach:

- Bangladesh supports a large diversity of sharks and rays that sustain a healthy ocean and healthy people.
- National and international demand for shark and ray products threatens many shark and ray species with extinction because they grow and reproduce slowly and too many are killed.
- International commitments and national laws prohibit the killing and trading of threatened sharks and rays or their parts in Bangladesh. Violations of these regulations can result in high fines or imprisonment.

Educational outreach events to reach remote fishing communities

Mobile educational outreach events

To reach remote fishing communities as well as urban audiences, WCS creates mobile exhibitions that can easily be transported by truck, rickshaw van or boat, and set up in local cyclone shelters, schools, Government offices or temporary tents. Each exhibition is tailored to focal topics and builds on previous outreach efforts.

Many of the exhibition concepts are based on the *Ocean Literacy Framework* developed by a global ocean science education community, informed by results from WCS marine research, and tailored to inspire people to protect marine wildlife for a healthy ocean supporting healthy people.

Communication is visually enhanced with high-quality photographs, informative panels, and illustrations to ensure access to key information for all visitors, including those with low literacy. Attractive displays combine life-size animal models, short documentary movies, captivating photographs, and fascinating facts. Much of the information is communicated through interactive games to maximize retention while assessing understanding in a fun manner.

[1]https://medium.com/wcs-marine-conservation-program/changing-fishery-practice-in-the-worlds-largest-mangrove-forest-7d5714c397f9
https://medium.com/wcs-marine-conservation-program/ocean-guardians-pave-the-way-to-save-threatened-sharks-and-rays-in-bangladesh-10fc79acfbad

[2]Copies of these materials are available at bangladesh.wcs.org and reproduction for educational purposes is encouraged.

Trained interpreters guided visitors through the exhibition, explain the games and engage visitors in informal discussions. Facilitators have proven to be a key part of successful educational outreach activities, because they not only ensure active participation but also provide an opportunity for WCS to gain a better understanding of local attitudes and practices.

The traveling exhibition Healthy Ocean - Healthy People showcases how the ocean provides us with critical resources and how we are damaging marine ecosystems. It highlights current efforts to create marine protected areas that aim to support sustainable fisheries and protect threatened marine wildlife (Figure 2).

Another WCS educational outreach initiative is called *Ocean Guardians: Protecting Threatened Sharks and Rays* (Figure 3). This initiative aims to inform small-scale fishers, shark and ray traders and consumers and field-level law enforcement officers about threatened sharks and rays of Bangladesh and their vulnerability, and to raise awareness about national laws and international obligations to regulate their exploitation and trade. The exhibition highlights efforts made by the Government of Bangladesh to improve shark and ray protection through enforcement of national legislation aligned with international commitments.

Figure 2. Between 2016 and 2020, sixteen Healthy Ocean - Healthy People exhibitions were arranged in eight coastal upazilas (Bagerhat, Kalapara, Patharghata, Hatiya, Ramgati, Zianagar, Cox's Bazar, and Teknaf) and Dhaka, reaching over 30,000 visitors.

Figure 3. Since 2020, the Ocean Guardians: Protecting Threatened Sharks and Rays in Bangladesh exhibition has been visited by over 250 Government officers and about 1,300 students in Khulna and Dhaka. Due to restrictions on travel and social gatherings during the global Covid19 pandemic, plans for the exhibition to visit major coastal shark and ray landing sites were postponed.

Community Radio Program

WCS collaborated with local radio stations to produce four episodes in local dialects of the *WCS Ocean Guardian Radio Program* about Government efforts to protect sharks and rays (Figure 4). These episodes incorporated statements from government officials about laws and rules related to the exploitation and trade of sharks and rays, doctors debunking local myths about their medicinal properties, marine biologists explaining their ecological value, and inspiring accounts of fishermen who successfully released live turtles, dolphins, and a whale shark from their nets. The episodes potentially reached about two million people living in coastal fishing communities with almost 3,500 positive comments received by the stations via phone calls, text, and Facebook messages (Figure 5).

Figure 4. Eleven radio station managers and producers finalized four episodes of the *WCS Ocean Guardians Radio Program* conceptualized by the WCS Bangladesh Educational Outreach Program during an intensive workshop.

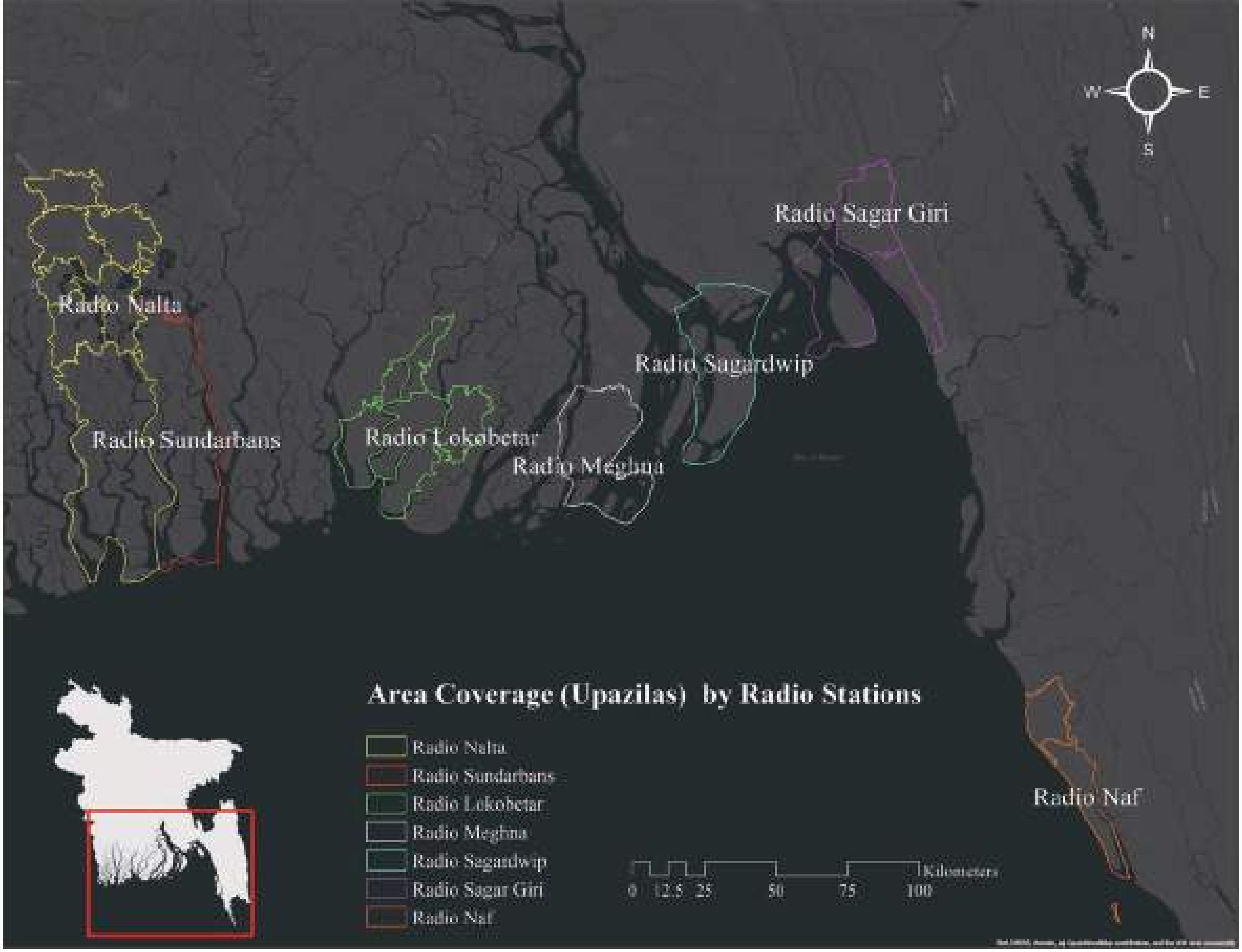

Figure 5. Area coverage of the seven community radio stations that produced and aired the *WCS Ocean Guardian Radio Program*.

The first episode was *Saving the World's Biggest Fish* which promoted improved protection for threatened whale sharks and their safe release from fishing nets which includes a personal account of a WCS *Citizen Science Fishermen Safety Network* member who released a whale shark from his net. The second episode *Saving the World's Last Sawfish* highlights Critically Endangered sawfish including ecological facts with a fisherman reporting population declines, a marine biologist discussing the safe release of sawfish entangled in fishing gears, a medical doctor debunking local myths about the medical value of sawfish meat, and a fisheries officer reminding listeners that killing, trading or eating sawfish is a punishable offence. In the third episode *Saving the Graceful Ocean Flyers*, fish traders and fishers discussed how the increasing demand for mobula rays gill plates and meat is a serious threat to the survival of these globally endangered species, and included a play-acted scene to inspire fishers to safely return these ocean giants if they are caught in fishing gears. The fourth episode *Keeping Our Ocean Healthy with A Hammer and A Sickle* focuses on two groups of threatened sharks: hammerhead and thresher sharks. Hammerhead sharks are landed in huge quantities in Bangladesh and both species groups are protected from international trade under CITES requiring a special permit for exporting their products. This episode focused on the value of these sharks to maintain an ecological balance for a healthy ocean and healthy people. WCS continues to collaborate with the participating community radio stations to produce additional episodes focusing on safeguarding marine wildlife and sustainable fisheries for a healthy ocean and healthy people.

Outreach tools

Diversity of sharks and rays in Bangladesh and their legal protection

To visualize Bangladesh's amazing shark and ray diversity, WCS uses gallery quality photographs as well as life-size models of focal species (Figure 6). The models, built by students of fine arts, show life-like features.

WCS outreach initiatives familiarize audiences with species that are protected under the *Bangladesh Wildlife (Conservation and Security) Act 2012* and international conventions (Figure 7).

Figure 6. Life-size models of sharks, rays, turtles, and dolphins displayed in exhibitions and training events enhance sensory experiences and enable close-up views of characteristic features.

Figure 7. To help recognize protected shark and ray species, WCS uses common handyman tools to represent species groups commonly recorded at fish landing sites.

Key information and fun facts on shark and ray biology and ecology covered in the exhibition enable visitors to distinguish sharks and rays from other fish, appreciate their special senses, understand their life cycles, and vulnerability due to low reproduction rates and slow growth. Visitors also learn about the importance of sharks and rays in maintaining a healthy ocean that benefits healthy human communities. They also learn about national laws and rules and international obligations protecting sharks and rays.

Threats to sharks and rays

To enhance the understanding of sharks and rays as soft bone fish that mature late and reproduce slowly and are vulnerable to overfishing, WCS developed a series of discovery towers (Figure 10) which provide visitors with information along with opportunities for sensory experiences that enhance their understanding and knowledge retention.

Each of these towers show specialized features that enable sharks and rays to live and hunt in the water. Visitors can touch different body parts and learn about their functions. The towers feature (1) Feeding (comparing teeth of dolphins, porpoise, sharks and humans and gill plates of filter-feeding mobula rays), (2) Protective armor (explaining the benefits of skin covered in the tiny pointed scales for fast swimmers), (3) Moving fast (function of fins, liver instead of swim bladder providing buoyancy, active motion to provide oxygen to gills), and (4) Special senses (electroreceptors allowing these expert hunters to sense living organisms) (Figure 8).

Figure 8. WCS developed four discovery towers to enhance the experiences of visitors by touching different sharks and ray body parts and learning about their functions and senses.

To introduce shark and ray as a special fish, two overlapping circles in the form of a Venn Diagram are pasted on a board on which cards depicting characteristics that sharks and rays share with bony fish or that set them apart need to be placed in the right section. (Figure 9).

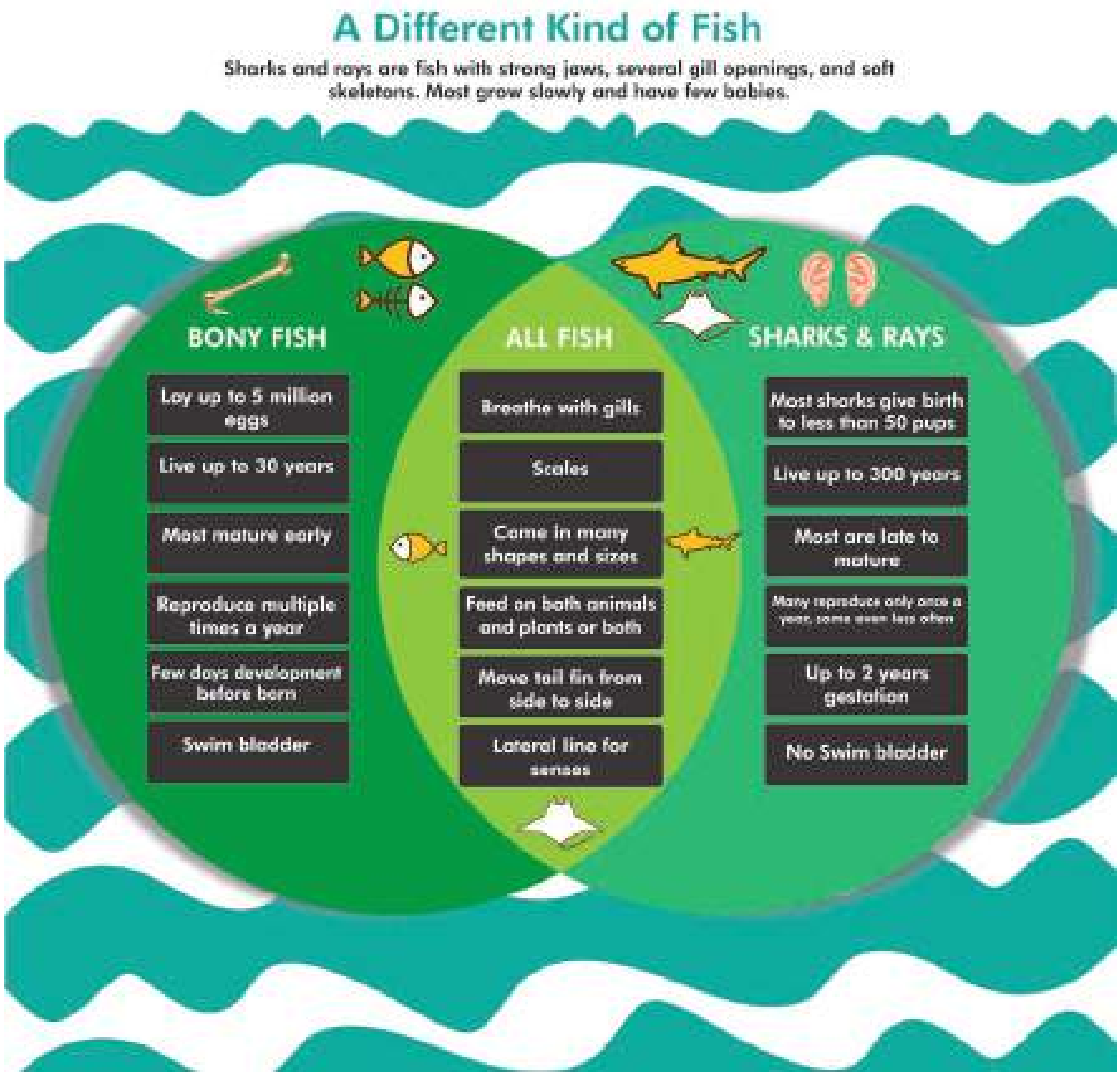

Figure 9. WCS uses a matching game to introduce sharks and rays as a different kind of fish that grow slowly and have fewer babies.

To introduce the distinct features of sharks and rays, WCS uses a game with a light that signals the correct connection between a body part description and the corresponding image. Visitors learn that sharks and rays come in various shapes and sizes, and that rays have fins connected to their head with gills on their underside (Figure 10).

Figure 10. WCS uses a touch and play game to learn about different physical features of sharks and rays and their functions in an interactive way.

A metal detector disguised as a sawfish rostrum demonstrates how electro-sensors allow sharks and rays to detect their prey on the sea bottom or buried under the sand (Figure 11).

Figure 11. WCS uses a metal detector game where the visitors must find metal pieces buried under sand. This way they learn about the feeding mechanism of sharks and rays by using electric sensors.

Infographs show that although sharks and rays appeared on earth long before humans, they are under grave threat today (Figure 12).

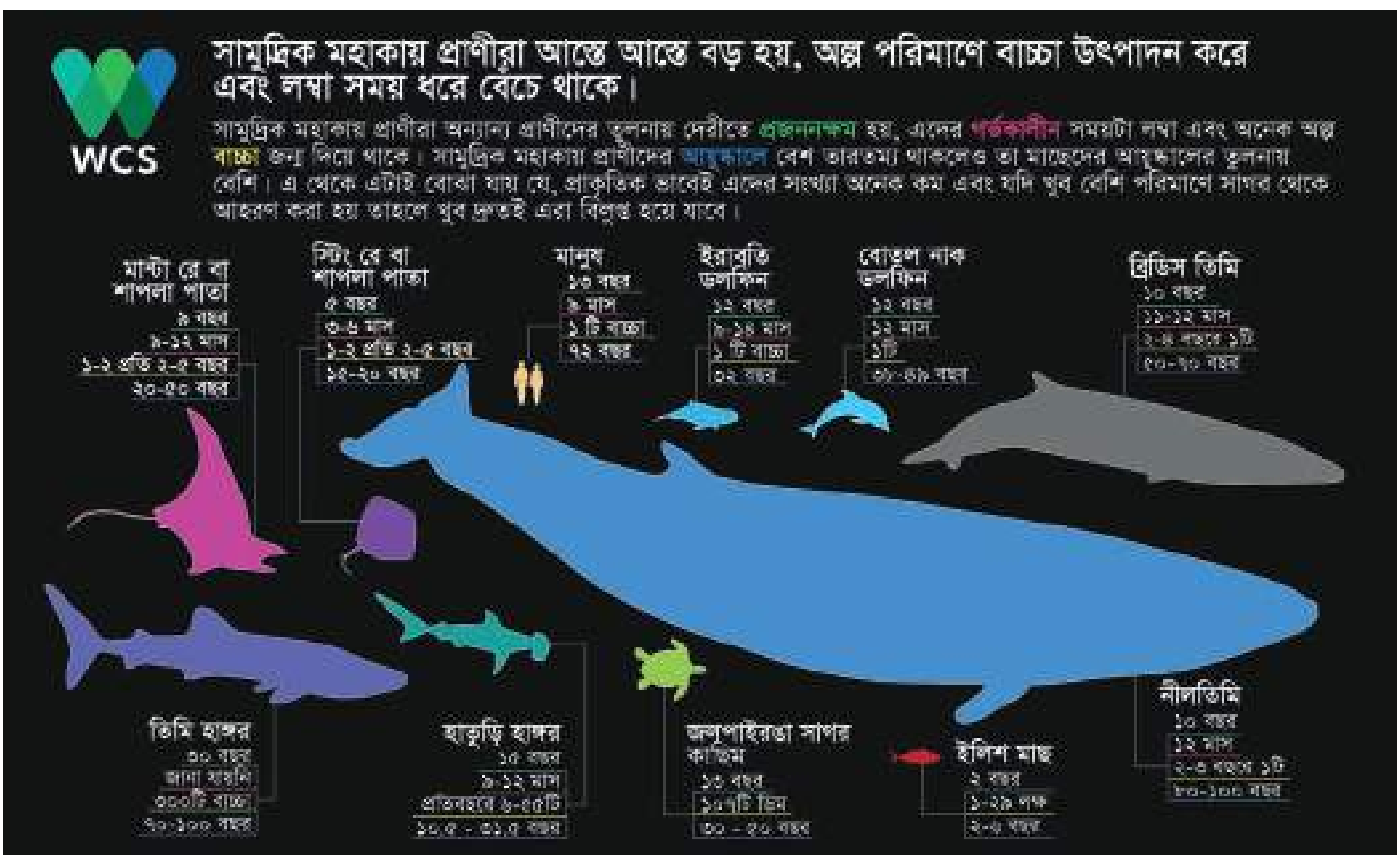

Figure 12. Infographs in English and Bengali languages on interesting facts about the ocean giants.

WCS developed an animated video showing the role of sharks in maintaining a healthy ocean supporting healthy people. Photographs with explanatory text communicate how overfishing, bycatch and the demand for shark and ray products are endangering global shark and ray populations.

Protecting threatened sharks and rays

Government efforts to protect threatened sharks and rays were highlighted through game stations such as a *Catch and Release Game* where participants release protected species caught in their gears and an interactive model on how marine protected areas to protect threatened marine species and benefit local and national economies (Figure 13).

Figure 13. Facilitated by trained interpreter, WCS uses a model with layers of maps showing distribution of Ocean Giants and associated threats to depict the marine spatial planning approach (left) and a catch and release game where visitors can only catch non-protected species and must safely release protected species to earn points and win the game.

Documentary Films

The short documentary film *Discover and Protect Ocean Giants* features the diversity of Ocean Giants (sharks, rays, dolphins, porpoises, whales, and marine turtles) in the Bay of Bengal, shark and ray fisheries, local and international demands for shark and ray products, and importance of Marine Protected Areas to safeguard Ocean Giants.

An additional short documentary film *Protecting Threatened Sharks and Rays in Bangladesh* highlights efforts by the Government of Bangladesh to improve the protection of threatened sharks and rays by regulating domestic and international trade, establishing science-based marine protected areas and strengthening sustainable fisheries management.

Species Identification Tools

WCS developed printed media on sharks and ray for distribution during training and outreach events including stickers (Figure 14), a brochure (Figure 15) and posters (Figure 16). These water-resistant tools aim to improve knowledge about and compliance with national wildlife and fisheries laws and international trade regulations protecting threatened sharks and rays. Copies of posters and brochures were distributed to offices of the Forest Department, Department of Fisheries and other law enforcement agencies during meetings and trainings, while the stickers were disseminated in coastal fishing communities during educational outreach and consultation events. To strengthen the capacity of Government law enforcement officers for identifying wildlife or their body parts, including sharks and rays, that are illegally traded in, from and through Bangladesh, WCS developed the easy-to-use S*pecies Identification Guide to Commonly Traded Wildlife and Their Body Parts in Bangladesh* (Figure 17).

Figure 14. Waterproof stickers featuring protected sawfish (top left), mobula rays (top right), hammerhead sharks (bottom left) and whale shark (bottom right) aim to motivate their safe release from entangling fishing gears

Figure 15. A laminated brochure introduces commonly landed sharks and rays of Bangladesh including descriptions of their characteristics, their IUCN Global Red List status and CITES and Bangladesh Wildlife Act listing.

Figure 16. Two water-resistant posters provided to Government offices and landing sites show CITES protected sharks (top) and rays (bottom) of Bangladesh and include information on the legal regulations protecting them.

Figure 17. WCS uses *a Species Identification Guide to Commonly Traded Wildlife and Their Body Parts in Bangladesh* (top left) and *a Handbook on Identifying Dried Fins of CITES-listed Sharks* (top right) during the trainings for combating illegal wildlife trade.

In addition to the WCS species identification guides, WCS obtained permission and reproduced posters in Bengali language on Identifying Dried Fins of *CITES-listed Sharks and Identifying Dried Gill Plates of Mobula Rays* developed by the PEW Charitable Trust (Figure 18). These posters serve as quick references for law enforcement officers for distinguishing commercially traded CITES listed shark and ray species based on distinctive characteristics of their dorsal fins and gill plates, respectively. These identification tools are introduced during training workshops and mentoring visits conducted by WCS and the Forest Department for law enforcement agencies on combatting illegal trade of sharks and rays in Bangladesh.

Figure 18. WCS displays posters on *Identifying Dried Shark Fins* during the trainings for combating illegal wildlife trade in Bangladesh and disseminated copies to the relevant agencies.

Members of the WCS Citizen Science Fishermen Safety Network haul in their medium-mesh drifting gillnet and record details on their fishing effort and catch, including on sharks and rays.