Background for Developing an Integrated Management Plan for the Swatch-of-No-Ground Marine Protected Area

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EXECUTIVE SUMMARY

Bangladesh's first marine protected area (MPA), covering productive shallow waters offshore the Sundarbans mangrove forest and deep waters at the head of the Swatch-of-No-Ground submarine canyon in the northern Bay of Bengal, was declared by the Government of Bangladesh in 2014. The declaration recognized the value of the MPA for protecting globally significant populations of threatened marine wildlife and economically valuable fisheries from increasing anthropogenic and climatic pressures. The declaration also contributed to Bangladesh's national plan and international commitment to protect ten percent of its Exclusive Economic Zone (EEZ) by 2020.

Based on a comprehensive literature review and informed by extensive WCS-led at-sea surveys, fishery investigations, citizen science networks and community consultations, this document compiles current information on the Swatch-of-No-Ground MPA as background for developing a science-based, stakeholder-informed conservation management plan. Topics include (i) physical characteristics, (ii) habitat types, (iii) marine wildlife, (iv) fish and fisheries, and (v) conservation threats. Government agency jurisdictions and mandates are clarified, national legal frameworks for MPA management summarized, and international and regional mechanisms for MPA management discussed. Strategies to reduce threats and sustainable financing opportunities are discussed.

This document serves as an information base to empower adaptive conservation management in the Swatch-of-No-Ground MPA through a transparent and accountable approach that benefits marine wildlife and other biodiversity, productive and sustainable fisheries, and a healthy Blue Economy.

ACKNOWLEDGEMENTS

All persons who have contributed to the development of this background document, including members of the WCS *Citizen Science Fishermen Safety Network*, marine megafauna survey, and fisheries investigations teams are gratefully acknowledged. Special thanks are due to local coastal communities and fishermen who gave their time to participate in consultations. WCS Bangladesh developed this document with financial support from the WCS MPA Fund, the Rainforest Trust, and the John D. and Catherine T. MacArthur Foundation. The USAID ECOFISH project and grants from IUCN Save our Species, Ocean Park Conservation Foundation Hong Kong, Indo-Pacific Cetacean Research and Conservation Fund, Shark Conservation Fund, and the Marine Conservation Action Fund supported WCS research reported in the document.

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ACRONYMS AND ABBREVIATIONS

BCCTF	Bangladesh Climate Change Trust Fund
BFDC	Bangladesh Fisheries Development Corporation
CBD	Convention on Biological Diversity
CCRF	Code of Conduct for Responsible Fisheries
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	Catch per unit effort
CR	Critically Endangered
CMS	Convention on Migratory Species
DD	Data Deficient
DS	Deep-sea blocks
DoF	Department of Fisheries
FD	Forest Department
EEZ	Exclusive Economic Zone
EN	Endangered
EIA	Environmental Impact Assessment
ESBN	Estuarine set-bag net
GoB	Government of Bangladesh
GPS	Global Positioning System
IMO	International Maritime Organization
IUCN	International Union for Conservation of Nature
LC	Least Concern
LDGN	Large-mesh drifting gillnet
MDGN	Medium-mesh drifting gillnet
MSBN	Marine set-bag net
MSP	Marine Spatial Planning
MaxEnt	Maximum entropy modelling approach
MoEFCC	Ministry of Environment, Forest and Climate Change
MoFA	Ministry of Foreign Affairs
MoFL	Ministry of Fisheries and Livestock
MPA	Marine Protected Area
NT	Near Threatened
ONGC	Oil and Natural Gas Corporation
PSSA	Particularly Sensitive Sea Area
RFMO	Regional Fisheries Management Organization
SBN	Set-bag net
SDG	Sustainable Development Goals
SDGN	Small-mesh drifting gillnet
SMART	Spatial Monitoring and Reporting Tool
SOP	Standard Operation Procedures
SS	Shallow blocks
SoNG	Swatch-of-No-Ground
UNCLOS	United Nations Convention on the Law of the Sea

UNEP	United Nations Environment Programme
VU	Vulnerable
VGF	Vulnerable Group Feeding
WCS	Wildlife Conservation Society

INTRODUCTION

In October 2014, the Ministry of Environment, Forest and Climate Change (MoEFCC) of the People's Republic of Bangladesh declared 1,494 square kilometers (km^2)[1] of shallow estuarine waters offshore of the Sundarbans mangrove forest and deep waters at the head of the Swatch-of-No-Ground (SoNG) submarine canyon as the country's first marine protected area (MPA) (Figure 1). The declaration of this MPA (Appendix 1) demonstrates the strong commitment of the Government of Bangladesh (GoB) to marine conservation and sustainable fisheries as well as meeting its international obligations under the Convention on Biological Diversity (CBD) and United Nations Sustainable Development Goals (SDG) to achieve marine protection in 10% of its Exclusive Economic Zone (EEZ) by 2020.

Objectives of the SoNG MPA include (i) protect globally threatened marine wildlife including dolphins, porpoises, whales, sharks, rays and marine turtles and their habitat through a marine spatial planning approach, (ii) sustain productive fisheries and fishing livelihoods and provide economic benefits for local communities; and (iii) support a sustainable blue economy for the benefit of local resource users and the nation.

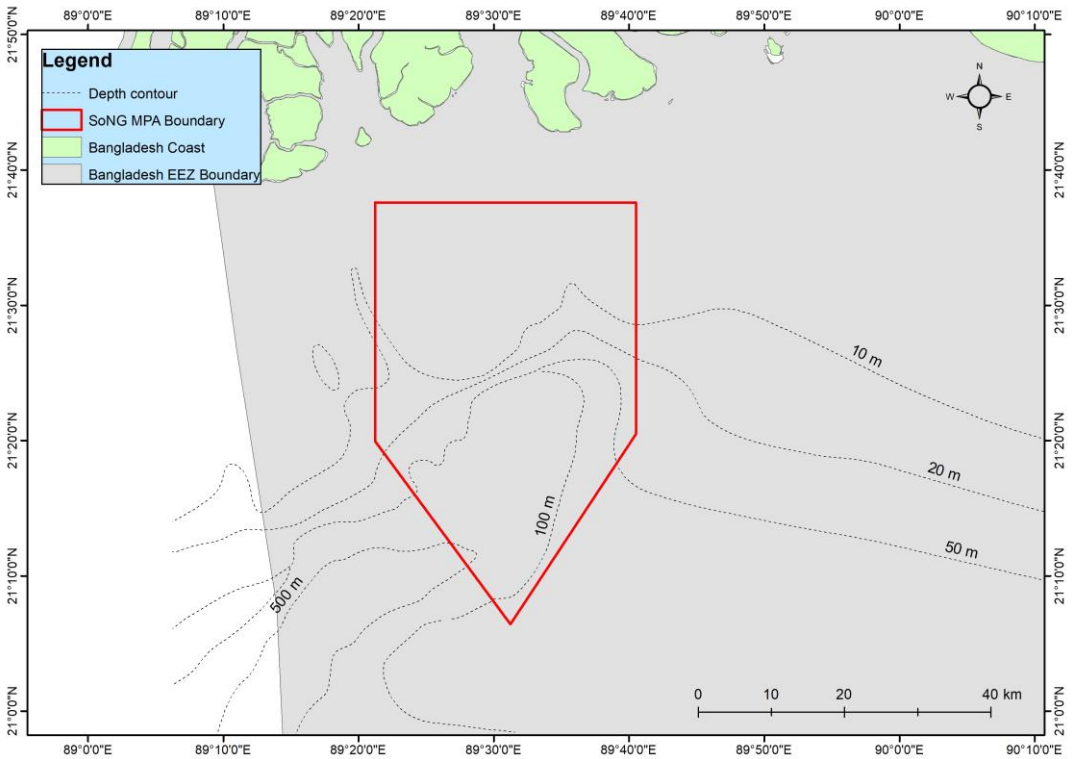

Figure 1. Map showing the location and boundaries of the Swatch-of-No-Ground MPA, which includes shallow estuarine waters offshore the Sundarbans and deep waters at the head of the submarine canyon from which the MPA gets its name.

The SoNG MPA is fed by the Ganges-Brahmaputra-Meghna, the world's third largest river system flowing through the world's largest mangrove forest and eroding a deep submarine canyon, which maintains the world's largest sediment fan. The canyon upwells nutrients that are redistributed and recycled by seasonally reversing currents and their associated eddies.

[1]According to the coordinates from the Gazette Notification (Appendix 1) and using the WGS 1984 UTM Zone 45N projected coordinate system and a transverse Mercator projection. In the gazette and in previous reports an incorrect area for the MPA (1,738 km^2) was used.

This extreme infusion and redistribution of biological productivity is a rare condition defined by unusual geomorphic and oceanographic features that support abundant marine diversity.

Iconic marine wildlife in the SoNG MPA include globally significant populations of cetaceans (the scientific grouping of dolphins, porpoises, and whales), sharks, rays and marine turtles, many of which are threatened with extinction. While the SoNG MPA is characterized by comparatively greater productivity and biodiversity compared to most other regions in the Bay of the Bengal, it is also vulnerable to environmental threats especially increasing fishing pressure and climate change.

The boundaries of the SoNG MPA were determined according to the locations of 114 sightings of Irrawaddy dolphins, 43 sightings of finless porpoises, 104 sightings of Indo-Pacific humpback dolphins, 412 sightings of Indo-Pacific bottlenose dolphins, 128 sightings of Bryde's whales, 34 sightings of spinner dolphins and 29 sightings of pantropical spotted dolphins made during surveys conducted by the Wildlife Conservation Society (WCS) between 2004-2014 along almost 13,000 km of transect lines in shallow coastal waters bordering the Sundarbans mangrove forest and waters as deep as 500 m in the SoNG submarine canyon.

A nearest neighbor approach was used to identify sighting clusters and generate a minimum convex polygon that encompassed 90% of all sightings of bottlenose, spinner, and spotted dolphins and Bryde's whales in the smallest possible space, and 50% of all sightings of Irrawaddy and humpback dolphins and finless porpoises (Figure 2 - left). The lower threshold for the latter species was used due to their more extensive distribution in the coastal waters of Bangladesh compared to the former species, whose distribution is limited to the head of the submarine canyon. Polygons for all seven species were then overlaid and a single five-sided polygon was created around the perimeter to designate the MPA boundaries. As a cross check, a point density map using 867 sightings of all cetacean species combined was overlaid on the single polygon for designating the boundaries of the SoNG MPA (Figure 2 - right).

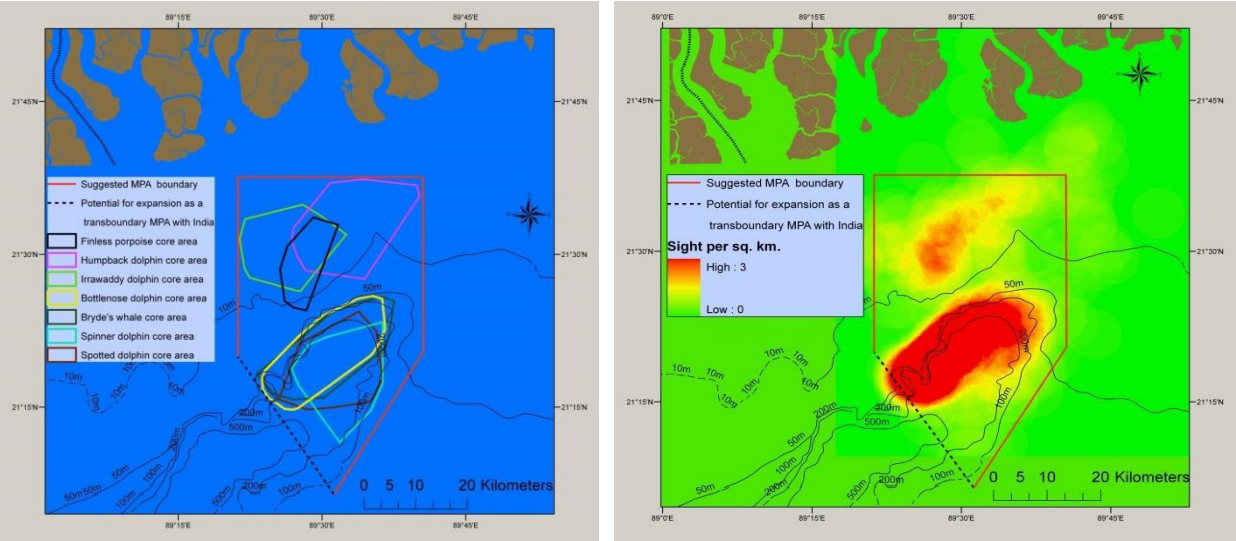

Figure 2. Maps from the SoNG MPA proposal (WCS 2014) showing polygons encompassing priority habitat for all seven cetaceans commonly found in coastal and submarine canyon waters of Bangladesh, and a single polygon that covers the total area of priority habitat and the boundaries for the SoNG MPA (left), and a density map of all cetacean sightings combined overlaid with the boundaries of the SoNG MPA (right).

PHYSICAL CHARACTERISTICS

Bathymetry

Nearshore waters of the SoNG MPA are shallow with sandbars and sea-bed ridges. The SoNG submarine canyon is eroded by sedimentation discharged by the Ganges-Brahmaputra-Meghna river system and it is the most prominent bathymetric feature in the northern Bay of Bengal (Figure 3 - left). The head of the canyon lies within about 35 km of the edge of the Sundarbans mangrove forest at the 50-m depth contour, continuing towards the sea in a southwest direction ranging between 900-1,460 m deep (Subrahmanyam 2008). The canyon is cone shaped (Figure 3 - right), ranging from about six km wide at its head to 40 km wide at its mouth. The walls are relatively steep (12-15°) with plateaus on both sides (Sengupta 1992). The bottom of the canyon floor is mainly mud and coastal silt with turbidity currents forming complex channel-levees (Subrahmanyam 2008).

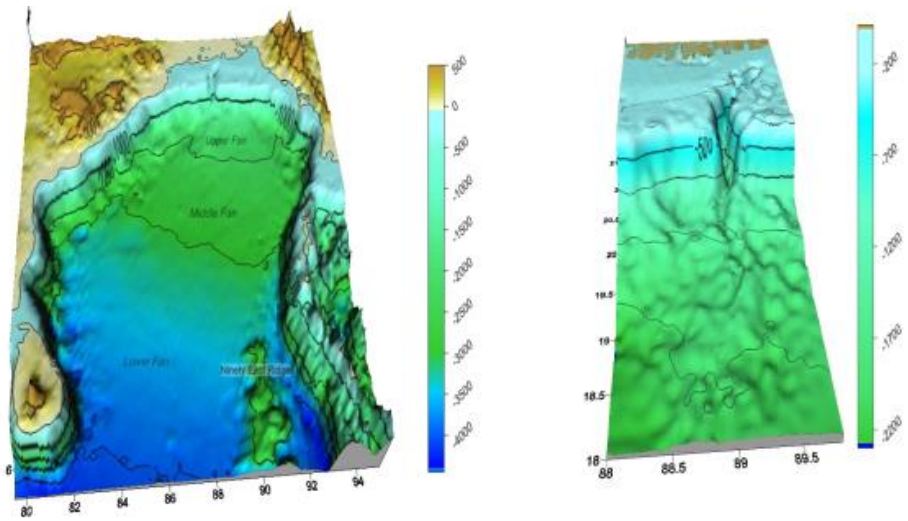

Figure 3. 3D bathymetric model of Bay of Bengal (left) and Swatch-of-No-Ground (right) from Kader et al. 2013.

Climate, currents and tides

Climate at the head of the Bay of Bengal is characterized by a seasonally reversing monsoon system mirrored by a seasonally reversing cyclonic ocean current with associated meso-eddies that retain nutrients. From May to September, the southwest or summer monsoon system is characterized by heavy wind and rain originating from the Arabian Sea. From December to February, a high-pressure system over the Tibetan plateau initiates the normally calm and dry northeast or winter monsoon (Kuehl 1997).

Strong southeast winds during the summer monsoon drive counterclockwise currents while relatively light northeast winds drive clockwise currents during the winter monsoon (Kottke 2003). Frequent cyclones, which are increasing in frequency and magnitude, occur particularly in May and October, which are transition months between the two different seasons (Kudrass et al. 1998).

The SoNG submarine canyon plays an important role in protecting the Sundarbans mangrove forest by changing the angle of waves and lowering their strength as they reach close to the

shore. Tidal currents are as strong as 3.5 m per second, and tides are highest in the northeastern part of the Bay of Bengal reaching up to 6 m (Barua 1990)**.**

HABITAT TYPES

The SoNG MPA includes two major habitat types in a relatively small space. These include (i) shallow open estuarine waters where freshwater, sediments and nutrients and rivers draining the Sundarbans mangrove forest mix with seawater in a seasonally reversing current and (ii) deep, upwelled marine waters at the head of the SoNG submarine canyon. These habitat types promote diverse biological communities including marine wildlife such as cetaceans, sharks, rays, and marine turtles. The relative rarity of this magnitude of freshwater inputs, combined with a seasonally reversing current and upwelling at the head of the SoNG submarine canyon, makes this MPA globally unique.

Estuarine waters

Discharge from the Ganges-Brahmaputra-Meghna river system passes an estimated freshwater flow of 1,400 km^3/year (Shiklomanov 1993) and more than 10^9 tons of sediment per year (Milliman and Syvitski 1992). The average monthly water flow varies from 190 m^3/sec in March to 7,650 m^3/sec in August. Sedimentation is greatest (~50 cm/year) in estuarine waters and at the head of the SoNG submarine canyon, decreasing substantially in deeper water (Michels et al. 2003).

There is a great deal of variability in salinity during different times of the year, which is linked to seasonal precipitation, evaporation, river discharge and tidal patterns. During the southwestern monsoon season salinity ranges between 5-18 parts per thousand (ppt) in the estuarine waters adjacent to Sundarbans mangrove forest (Aziz and Paul 2015). During at sea in investigations conducted in the northeast monsoon season in 2010-2013, WCS recorded a salinity between 10-28 ppt and sea surface temperature between 20-28^o Celsius in shallow waters (4-23 m) at the northern edge of the MPA.

Submarine canyon waters

The SoNG canyon supports the world's largest submarine fan that transports more than one quadrillion tons of sediment (Wasson 2003) to its outer regions by strong turbidity currents (Kudrass et. al 1998, Subrahmanyam 2008) (Figure 4). WCS collected surface temperature and salinity data from 79 locations in the SoNG MPA on 24 December 2017 and 27 January 2018, recording an average surface water temperature of 23.5^o C (range = 21.6-25.6 ^{o} C) and an average salinity level of 26.9 ppt (range=16.1-30.4 ppt) in the northeastern monsoon season. Information on salinity and surface water temperature during southwestern monsoon is not available from the SoNG MPA area.

Figure 4. WCS team surveying for cetaceans at the head of the SoNG submarine canyon where an abrupt change in the watercolor indicates the meeting of currents with upwelled cool clear water at the head of the canyon.

MARINE WILDLIFE

Cetaceans

The SoNG MPA supports a large diversity of cetaceans, including species at immediate risk of extinction but in numbers generally much greater compared to neighboring populations of the same species. Cetacean distribution is closely tied to environmental gradients, with Irrawaddy dolphins and finless porpoises occurring most often in nearshore, turbid, low-salinity waters, Indo-Pacific humpback dolphins in slightly deeper waters where the color turns from brown to green, and Indo-Pacific bottlenose, pantropical spotted, and spinner dolphins, and Bryde's whales in deep, clear, high-salinity waters at the head of the SoNG submarine canyon. Elevated cetacean diversity and abundance has been associated with the steep topography of submarine canyons. These areas are also important for fish prey especially when biological productivity is reduced in surrounding waters (Smith et al. 2008).

Irrawaddy dolphins

Irrawaddy dolphins are found in near- and inshore waters of the western Pacific and eastern Indian Ocean generally associated with river mouths. They also occur far upstream in three large rivers, including the Ayeyarwady, Mekong and Mahakam. Irrawaddy dolphins are considered Endangered (EN) in the Global IUCN Red List due to a 50% or greater decline in three generations of their range-wide population. Populations generally number in the 10s to low 100s with the single exception of Bangladesh, which supports by far the largest populations with an estimated 450 individuals in the Sundarbans (Smith et al. 2006) and 5,400 in the coastal waters (Smith et al. 2008) (Figure 5). Irrawaddy dolphins are caught and die in gillnets in all areas where they have been studied. Their habitat is particularly affected by climate change.

Figure 5. Map from the SoNG MPA proposal (WCS 2014) (left) showing that the SoNG MPA covers 233 km^2 of priority habitat for Endangered Irrawaddy dolphins (right top and bottom) encompassing 50% of all sightings made in coastal waters offshore of the Sundarbans mangrove forest between 2004 and 2013.

Finless porpoises

The finless porpoise occurs in tropical to warm temperate shallow waters of the Indo-Pacific. They are normally found in shallow bays and estuaries, although they can also occur far from shore over broad continental shelves. In Bangladesh finless porpoises generally prefer deeper and more saline waters compared to Irrawaddy dolphins.

Finless porpoises are extremely vulnerable to entanglement in gillnets. They are considered Vulnerable (VU) in the Global IUCN Red List due to at least a 30% reduction in their range-wide population. About 1,400 finless porpoises occur in the coastal waters of Bangladesh, which compares favorably to other areas where the species has been studied (Smith et al. 2008) (Figure 6).

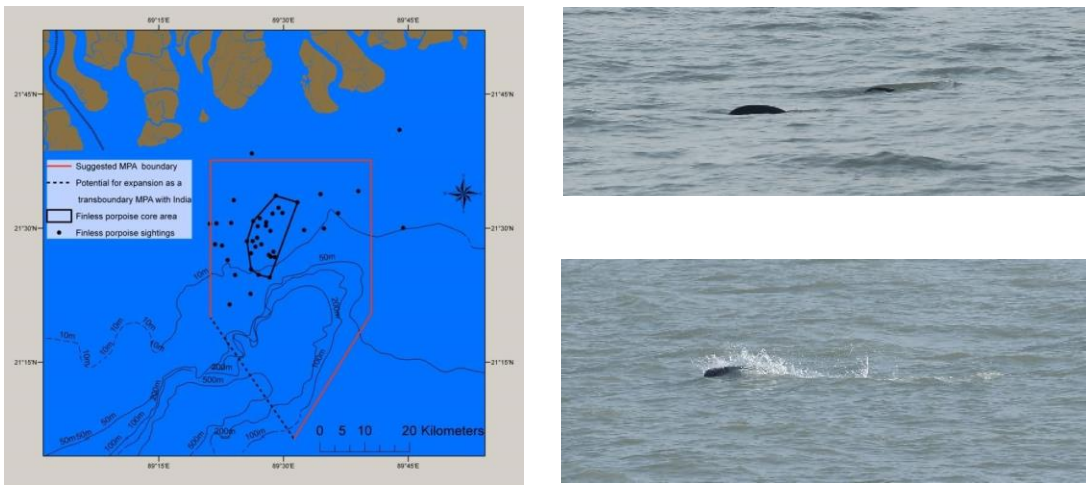

Figure 6. Map from the SoNG MPA proposal (WCS 2014) (left) showing that the SoNG MPA covers 117 km^2 of priority habitat for Vulnerable finless porpoises (right top and bottom) encompassing 56% of all sightings recorded in coastal waters offshore of the Sundarbans mangrove forest between 2004 and 2013.

Indo-Pacific humpback dolphins

Indo-Pacific humpback dolphins occur in shallow, coastal waters of the northern Indian and eastern Pacific oceans. They are generally associated with freshwater inputs and range offshore over broad continental shelves less than 100 m deep. The Indo-Pacific humpback dolphin is considered VU in the Global IUCN Red List. Genetic evidence from humpback dolphins in Bangladesh separates them from other populations in eastern Africa, Thailand, Australia and the Arabian Sea, indicating that they are potentially a subspecies or even a different species from humpback dolphins in neighboring countries (Amaral et. al 2020). A photo-identification study conducted by WCS identified a population of more than 600 individual humpback dolphins occurring in Bangladesh's coastal waters adjacent to the Sundarbans with about 23% exhibiting scars and mutilations from entanglements in fishing gears (Mansur et al. 2012) (Figure 7).

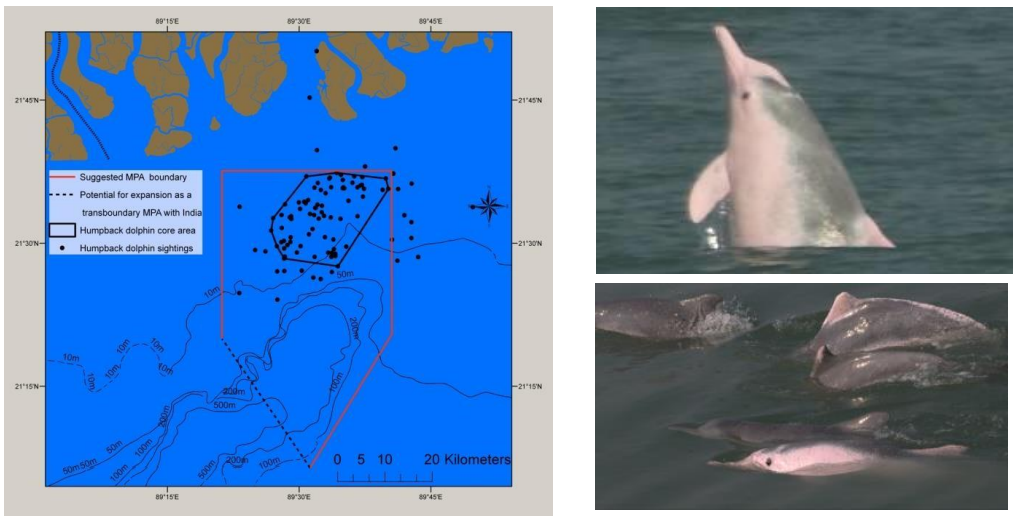

Figure 7. Map from the SoNG MPA proposal (WCS 2014) (left) showing that the SoNG MPA covers 327 km^2 of priority habitat for Vulnerable Indo-Pacific humpback dolphins (right top and bottom) encompassing 73% of all sightings recorded in coastal waters offshore of the Sundarbans mangrove forest between 2004 and 2013.

Indo-Pacific bottlenose dolphins

Indo-Pacific bottlenose dolphins have a clumped distribution in the warm temperate to tropical waters in the Indo-Pacific, from South Africa in the west to the southern half of Japan and southeast Australia in the east. In Bangladesh, the species occurs throughout the clear offshore waters but in large numbers at the head of the Swatch-of-No-Ground submarine canyon where cool, upwelled waters provide biologically productive habitat (Smith et al. 2008) (Figure 8). A photo-identification study of bottlenose dolphins in the SoNG conducted by WCS discovered 1,700–2,200 Indo-Pacific bottlenose dolphins in the Bangladesh portion of the submarine canyon, making it among the world's largest populations (Mansur et al. 2012). Genetic evidence collected during this study also revealed that this large population is genetically distinct from populations in other parts of the Indian Ocean and the western Pacific (Amaral et al. 2017).

Indo-Pacific bottlenose dolphins are currently considered Near Threatened (NT) in the Global IUCN Red List. However, about 28% of the photo-identified individuals in Bangladesh

exhibited injuries related to entanglements with fishing gear (Mansur et al. 2012). This implies a strong potential for fatal entanglements that could jeopardize the conservation status of this relatively large population.

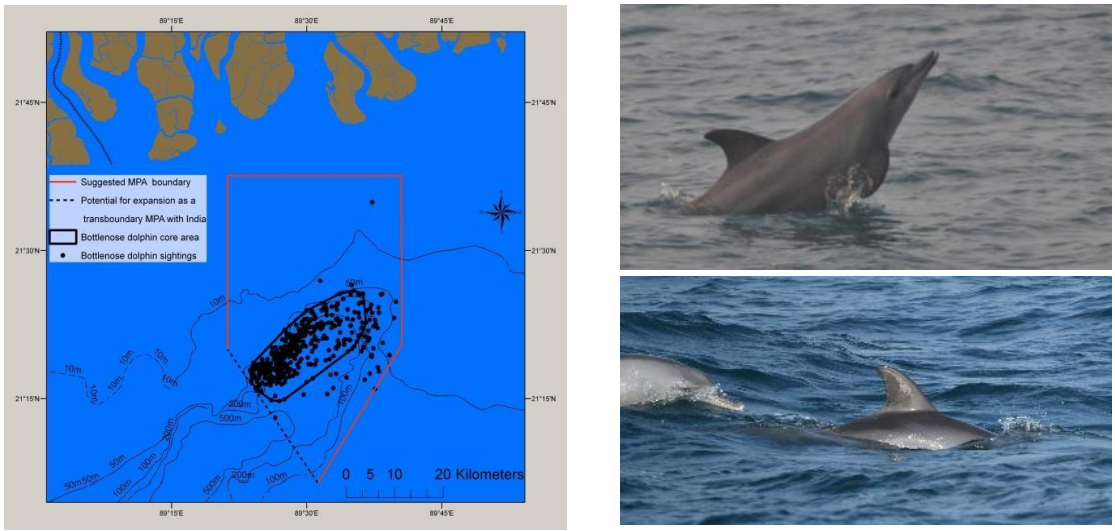

Figure 8. Map from the SoNG MPA proposal (WCS 2014) (left) showing that the SoNG MPA covers 282 km^2 of priority habitat for Near Threatened Indo-Pacific bottlenose dolphins (right top and bottom) encompassing 90% of all sightings recorded in the SoNG between 2004 and 2013.

Bryde's whales

Almost 150 sightings of Bryde's whales were made in the SoNG between 2004–2012 (Figure 9). Groups of up to 15 whales were recorded, while the average group size was 2.2 individuals. A genetic study revealed that this smaller, coastal form forms a discrete population unit. Results of this study also revealed extremely low genetic diversity within the smaller form of Bryde's whale, the lowest ever measured in baleen whale populations. Only a single maternal line (haplotype) was detected in the 30 individual whales sampled in Bangladesh (Kershaw et al. 2013).

Figure 9. Maps from the SoNG MPA proposal (WCS 2014) (left) showing that the SoNG MPA covers 290 km^2 of priority habitat for Bryde's whales (right) encompassing 90% of all sightings recorded in the SoNG between 2004 and 2013.

Pantropical spotted dolphins

Pantropical spotted dolphins are found in all parts of the world's ocean between latitudes of about 40° North and 40° South. They prefer waters characterized by a sharp thermocline less than 50 m deep, surface temperatures greater than 25° C, and salinities less than 34 ppt. Globally, together with spinner dolphins, pantropical spotted dolphins are among the most dominant species in tropical cetacean communities and considered to be Least Concern (LC) on the Global IUCN Red List.

Little is known about pantropical spotted dolphins in Bangladesh. During the photo-identification study of Indo-Pacific bottlenose dolphins in the SoNG, a total of 29 sightings of pantropical spotted dolphins were recorded in waters greater than 100 m deep with an average group size of 84 and ranging between 20 and 350 individuals (Figure 10). While pantropical spotted dolphins are not believed to be facing critical threats, entanglements are known from gillnet fisheries.

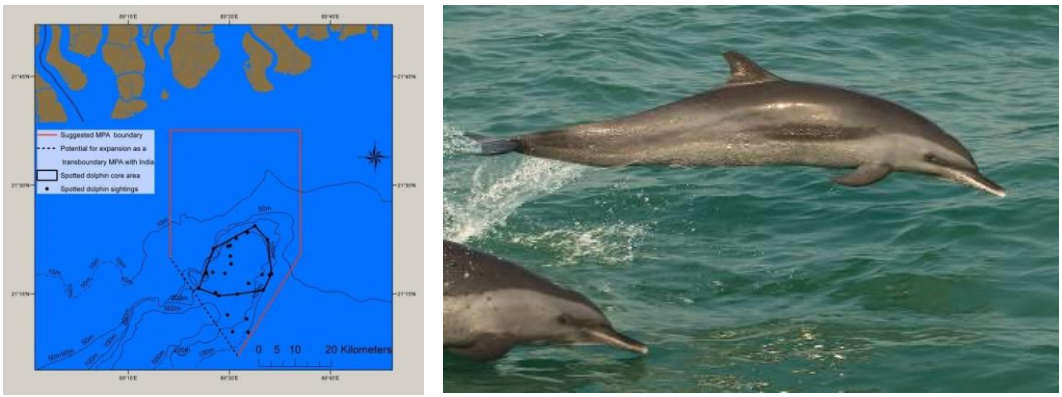

Figure 10. Map from the SoNG MPA proposal (WCS 2014) (left) showing that the SoNG MPA covers 263 km^2 of priority habitat for pantropical spotted dolphins (right) encompassing 86% of all sightings recorded in the SoNG between 2004 and 2013.

Spinner dolphins

Similar to pantropical spotted dolphins, spinner dolphins range in tropical and subtropical waters between 40° N and 40° S. Most records of spinner dolphins are associated with islands or steep bottom topography. However, in the Eastern Tropical Pacific spinner dolphins occur in large groups of several hundred to thousands in waters with a shallow mixed layer and sharp thermocline. They are often found in close association with spotted dolphins. Spinner dolphins die in large numbers in purse-seine, gillnet, and trawl fisheries. Annual mortalities of hundreds to thousands of spinner dolphins have been reported in the few fisheries that have been investigated in India and Sri Lanka. The species is considered Data Deficient (DD) in the IUCN Red List.

Little is known about the status of spinner dolphins in Bangladesh. During the photo-identification study of Indo-Pacific bottlenose dolphins in the SoNG, 37 sightings were made of spinner dolphins with an average group size of 97 and ranging from 4-550 individuals (Figure 11). Spinner dolphins are not believed to be facing critical threats in Bangladesh. However, two mortalities were recorded in gillnets by WCS citizen scientists.

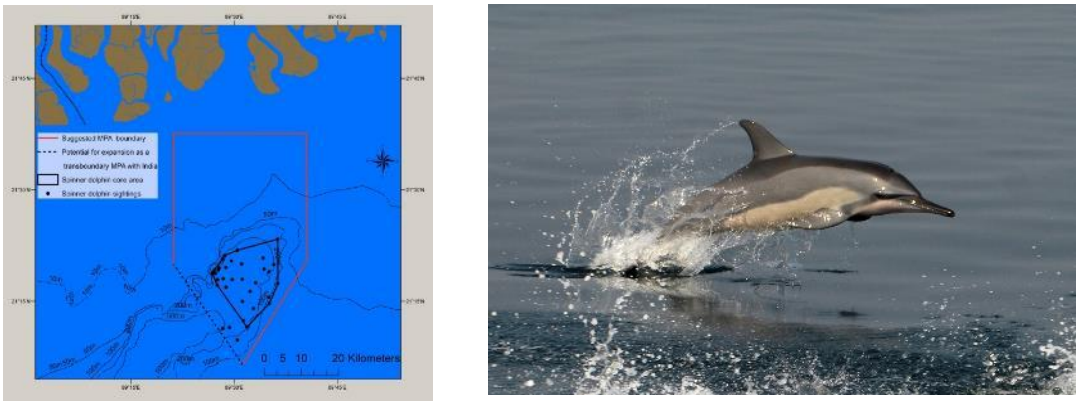

Figure 11. Map from the SoNG MPA proposal (WCS 2014) (left) showing that the SoNG MPA covers 263 km^2 of priority habitat for spinner dolphins (right) encompassing 91% of all sightings recorded in the SoNG between 2004 and 2013.

Other cetaceans

During dedicated cetacean surveys conducted by WCS in and around the SoNG MPA between 2005 and 2013, one sighting was made each of a group of false killer whales *Pseudorca crassidens* (Figure 12 - top left) and rough-toothed dolphins *Steno bredanensis* (Figure 12 - top right).

False killer whales are large dolphins that occur across the world's oceans in tropical and sub-tropical deep waters in groups of between 10 and 20 individuals, but occasionally gathering in groups of more than 500 individuals. They are considered NT in the IUCN Global Red List due to mortalities as fishery bycatch.

Although relatively uncommon, rough-toothed dolphins (Figure 12 - top right) also occur across the globe in deep tropical, subtropical, and warm temperate waters in groups of 5 to 10 individuals often associated with other species. The only reported sighting of this relatively large dolphin species in Bangladesh was from the continental shelf. Rough-toothed dolphins are considered LC in the Global IUCN Red List.

In 2018, a single orca *Orcinus orca* (Figure 12 - bottom) was photo-documented by a member of the WCS citizen science fishermen ten kms west of the SoNG MPA. Also known as killer whales, orcas are the largest dolphins. Except for humans, they are the world's most cosmopolitan mammal occurring in almost all marine habitats in groups of up to 40 individuals with both resident and transient populations. Orcas are considered DD in the Global IUCN Red List.

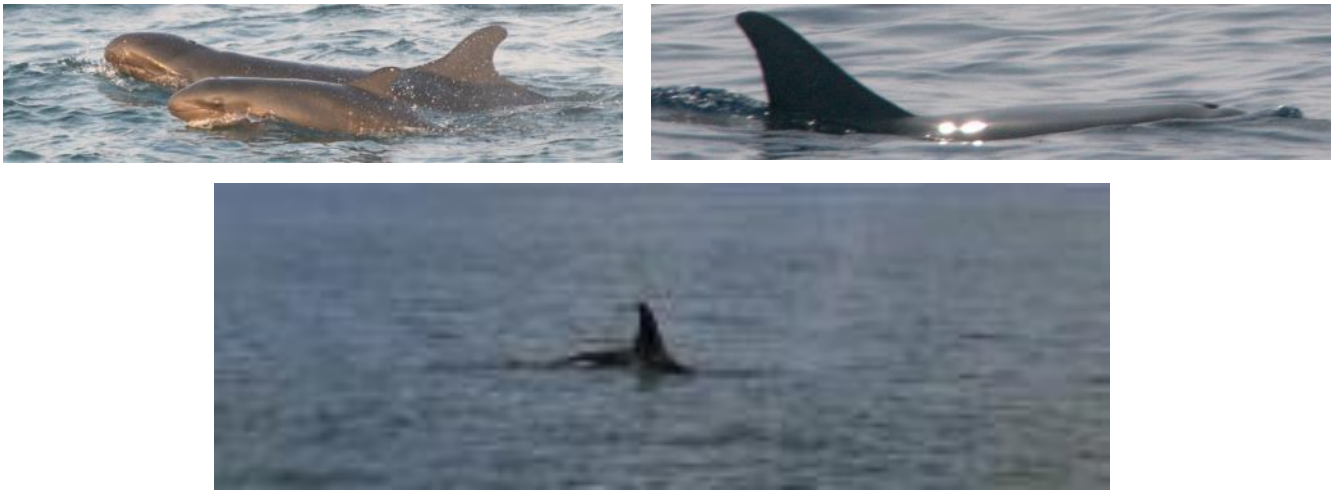

Figure 12. False killer whales (top left) and rough-toothed dolphins (top right) were recorded by WCS researchers, while a single orca or killer whale (bottom) was photographed at the edge of the SoNG by a fisherman trained as a citizen scientist by WCS.

Sharks

The diverse and productive habitat in the SoNG MPA is ideal for supporting many globally threatened sharks. The roots of mangroves in the Sundarbans provide attachment sites for egg laying or oviparous species (e.g., grey bamboo shark *Chiloscyllium griseum*) and nursery areas for viviparous sharks (e.g., hammerheads *Sphyrna spp.* and blacktip sharks *Carcharhinus limbatus*) which give live birth to pups that find shelter from predators among mangrove roots (Figure 13).

Figure 13. The Sundarbans mangroves provide ideal habitat for juvenile grey bamboo sharks *Chiloscyllium griseum* (top), scalloped hammerheads *Sphyrna lewini* (bottom left) and blacktip sharks *Carcharhinus limbatus* (bottom right).

At least 11 shark species were recorded by WCS in the SoNG MPA during at-sea investigations and by citizen science fishermen. These include Critically Endangered (CR) scalloped hammerhead and EN whale sharks (Figure 14). Considering the habitat types available within the SoNG MPA and records of their occurrence elsewhere in the Bay of Bengal, it is likely that the SoNG MPA supports another 28 shark species of which four are CR, six are EN, seven are VU, four are NT, six are LC and one is DD (Appendix 2).

Participants in community consultations conducted by WCS (see below) mentioned that sharks are frequently caught in gillnets, set-bag nets and industrial trawls. Fish traders mentioned that shark landings have declined substantially in the coastal water in the past ten years.

Figure 14. CR Scalloped hammerhead *Sphyrna lewini* (left) and EN whale shark *Rhincodon typus* (right) recorded by citizen science gillnet fishermen in the SoNG MPA.

Predicted distribution of sharks

Data collected by the WCS *Citizen Science Fishermen Safety Network* were used to predict habitat preference of sharks in the coastal water of Bangladesh. The predicted distribution of sharks was then modeled using a maximum entropy modelling approach (MaxEnt) that predicts species occurrence by finding the most widespread species 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. We used temperature, depth, primary productivity, salinity, pH, light at the bottom and dissolved oxygen as the environmental variables. These values were extracted from the Bio-oracle website[2]. and the NOAA ETOPO1 1 Arc-Minute global bathymetry dataset (Amante & Eakins 2009). Environmental variables were resampled into a unique cell size (0.083 x 0.083 degrees) and clipped to the geographic extent of Bangladesh's EEZ using ArcMap and R software packages.

Using data from 620 shark catches identified to species, maps were generated of the predictive distribution of six species including spadenose (N=309), blacktip (N=95), pigeye (N=71), scalloped hammerhead (N=60), tiger (N=47) and bull sharks (N=38) (Figure 15). Including an additional 57 shark catches identified only to genus, a predictive distribution model was also generated for all sharks combined (Figure 16). All six species models as well as the combined model confirm the importance of the SoNG MPA as highly suitable for sharks.

[2] https://www.bio-oracle.org

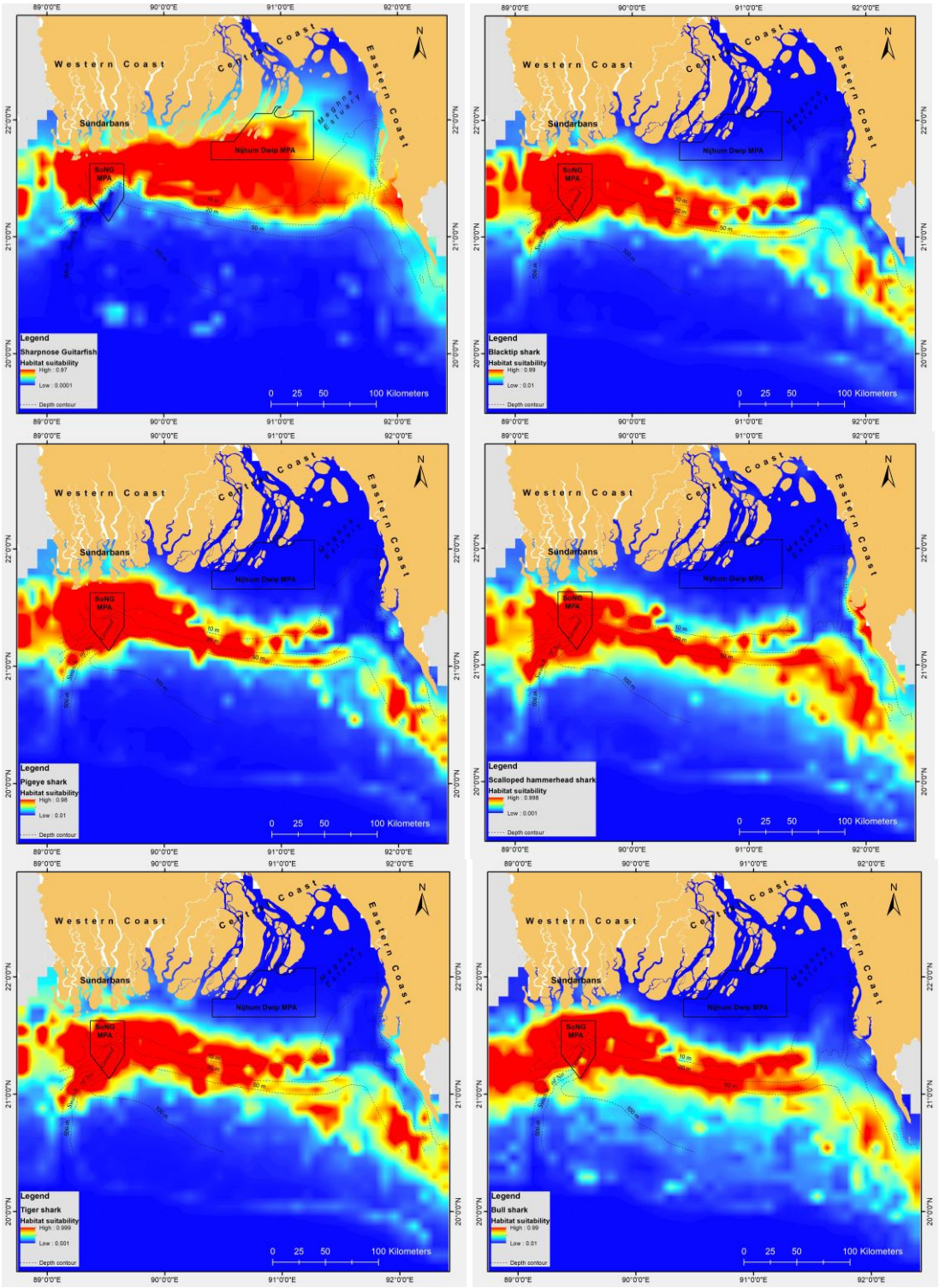

Figure 15. Predicted distribution of spadenose (top left), blacktip (top right), pigeye (middle left), scalloped hammerhead (middle right), tiger (bottom left), and bull sharks (bottom right), according to habitat suitability models.

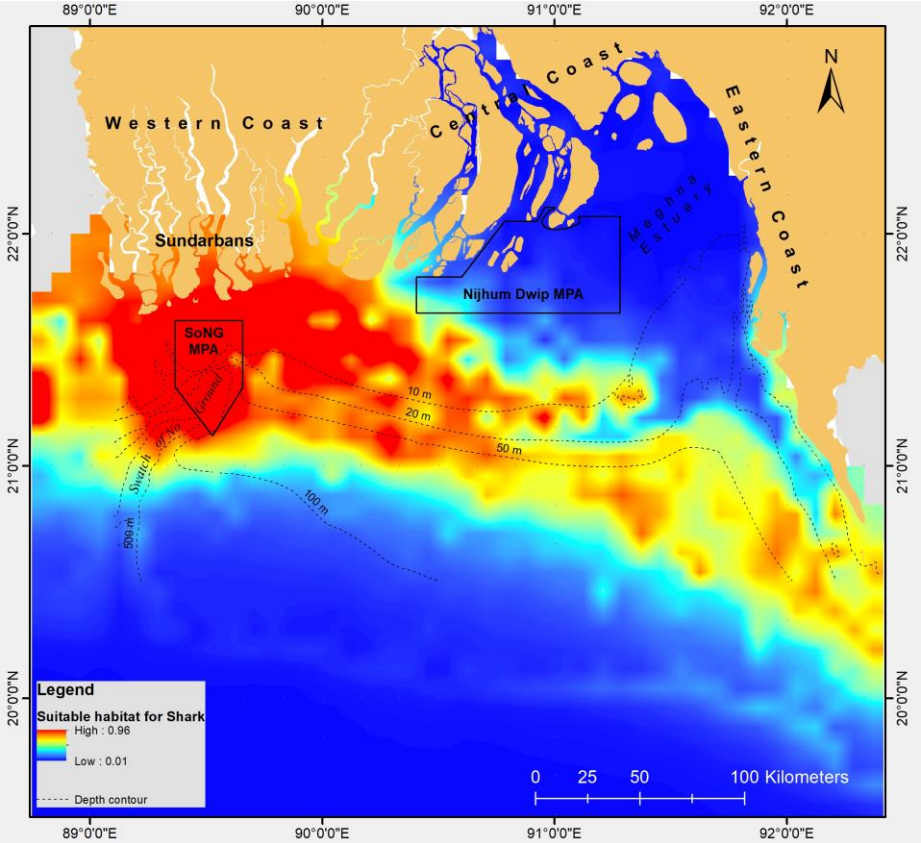

Figure 16. Predicted distribution for all sharks combined (N=677) based on catch data from gillnet fishermen.

Rays

Mangrove channels and shallow estuarine waters adjacent to the SoNG MPA are ideal habitat types for bottom dwelling rays, e.g., mangrove whipray *Urogymnus granulata* and giant freshwater whipray *Urogymnus polylepis*, while deep waters in the SoNG support pelagic rays, e.g., devil rays *Mobula spp.* and eagle rays *Aetobatus spp.* (Figure 17).

Figure 17. The Sundarbans mangroves provide ideal habitat for the mangrove whipray *Urogymnus granulatus* (top left), giant freshwater whipray *Urogymnus polylepis* (top right), Kuhl's or shortfin devil ray *Mobula kuhlii* (bottom left) and spotted eagle ray *Aetobatus ocellatus* (bottom right).

Seven ray species caught primarily in small-mesh gillnets, mid-water baited longlines, and unbaited bottom longlines, have been documented by WCS and others in the SoNG MPA (Appendix 3). Largetooth sawfish *Pristis pristis* and sharpnose guitarfish *Glaucostegus granulatus* are considered CR, giant freshwater whipray *Urogymnus polylepis* is EN, whitespotted whipray *Maculabatis gerrardi* is VU, longtail butterfly ray *Gymnura poecilura* is NT, Bengal guitarfish *Rhinobatos annandalei* and Bengal whipray *Brevitrygon imbricata* are DD (Figure 18). Other rays identified only to family level (Dasyatidae) or genus level (*Gymnura, Rhinoptera, Aetobatus,* and *Urogymnus spp.*) were also recorded.

Figure 18. Rays recorded in the SoNG MPA include CR Largetooth sawfish *Pristis pristis* (top left) and sharpnose guitarfish *Glaucostegus granulatus* (top right), EN giant freshwater whipray *Urogymnus polylepis*, VU whitespotted whipray *Maculabatis gerrardi* (middle left), NT longtail butterfly ray *Gymnura poecilura* (middle right), DD Bengal guitarfish *Rhinobatos annandalei* (bottom left), and DD Bengal whipray *Brevitrygon imbricata* (bottom right).

During formal and informal consultations, fishermen reported that the mangrove channels adjacent to the SoNG MPA are ideal habitat for sawfishes (Figure 19). Chowdhury et al. 2018 reported at least five largetooth sawfish caught per year in waters near the Sundarbans at the northern edge of the SoNG MPA.

Figure 19. One of the largest sawfish ever recorded in Bangladesh, show here after the rostrum was cut off, a CR largetooth sawfish *Pristis pristis,* was caught in an industrial trawl net in shallow estuarine waters south of the Sundarbans mangrove forest and brought to a fish market in Khulna on September 17th 2018.

Another 48 species of rays are suspected to occur in the SoNG MPA based on their occurrence in neighboring waters in Bangladesh or in similar habitat in other countries bordering the Bay of Bengal. Of these species, seven are listed as CR, 10 as EN, 14 as VU, five as NT, one as LC, nine as DD in the Global IUCN Red list with two not listed (Appendix 3).

According to the community consultations (see below), rays, especially sawfish, are targeted in the Sundarbans and adjacent shallow coastal waters using unbaited bottom longlines and set bag nets.

Predicted distribution of rays

Using the same data collected by the WCS citizen science fishermen we used the same maximum entropy (MaxEnt) modelling approach with the same environmental variables as used for sharks to predict the distribution of rays from catches in the coastal water of Bangladesh. From 213 catches identified to species we generated distribution maps for giant freshwater whipray (N=57), sharpnose guitarfish (N=53), Bleeker's whipray *Pateobatis bleekeri* (N=32), honeycomb whipray *Himantura undulata* (N=21), longtail butterfly ray (N=18), shorttail stingray *Dasyatis brevicaudata* (N=17), and narrow cowtail ray *Pastinachus sephen* (N=15) (Figure 20). Incorporating an additional 168 catches identified only to genus, a combined model was generated for all rays combined (Figure 21). These models predict the most suitable habitat for rays in the estuarine nearshore shallow waters extending from the Sundarbans across the central coast to the Meghna estuary, thus underscoring the importance of shallow northern waters of the SoNG MPA as priority ray habitat.

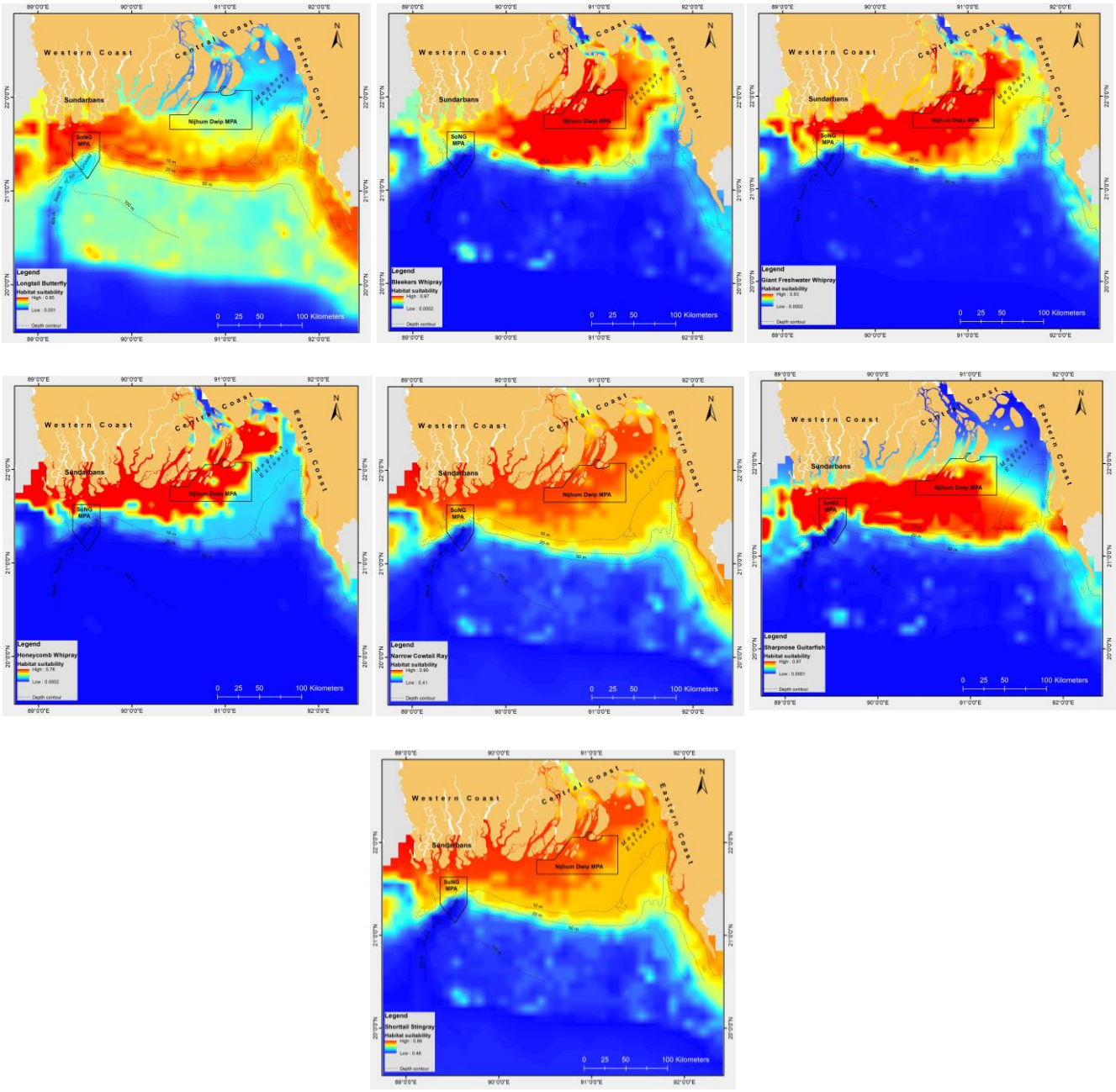

Figure 20. Predicted distribution of longtail butterfly rays (top left), Bleeker's whiprays (top middle), giant freshwater whiprays (top right), honeycomb whiprays (middle left), narrow cowtail rays (middle middle), sharpnose guitarfish (middle right), and shorttail stingrays (bottom middle).

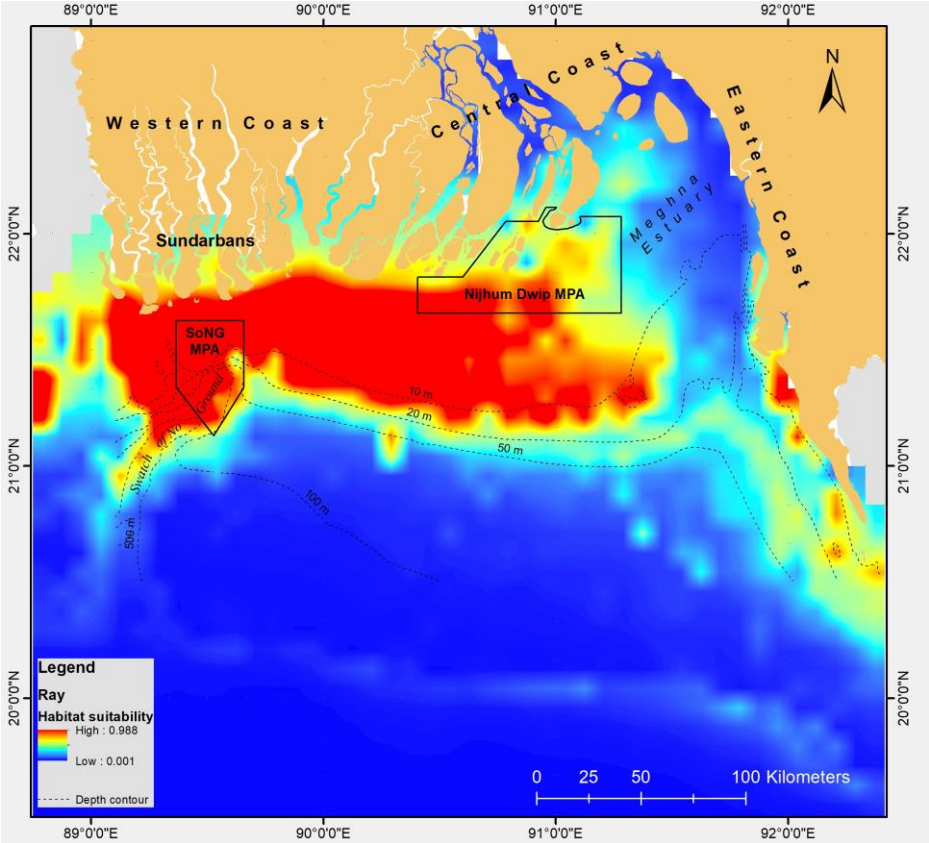

Figure 21. Predicted distribution of all rays combined based on catch data from gillnets and unbaited bottom longlines (N=381).

Marine turtles

WCS investigations have confirmed the occurrence of CR hawksbill turtles *Eretmochelys imbricate*, EN green turtles *Chelonia mydas* (Figure 22), and VU olive ridley turtles *Lepidochelys olivacea* in the SoNG MPA. During at-sea surveys conducted between 2004-2018 in the northeast monsoon season, WCS recorded multiple pairs of mating olive ridley turtles in waters deeper than 100 m in the SoNG MPA. This olive ridley turtle population, which originates from nesting beaches along the coast of the northern Bay of Bengal, is declining as evidenced by a sharp decline in the number of females returning to nesting beaches (Shankera et al. 2003).

Figure 22. An EN green turtle *Chelonia mydas* (left) and a CR hawksbill turtle *Eretmochelys imbricate* (right) found entangled in gillnets were safely released back into the water by fishermen trained as citizen scientists by WCS.

Sea birds

During at-sea surveys in December 2017 to January 2018 in waters in and around the SoNG MPA, WCS recorded 114 birds including brown-headed gull *Larus brunnicephalus* (43) (Figure 23 - right), greater crested tern *Thalasseus bergii* (32), black-headed gull *Larus ridibundus* (9), lesser crested tern *Thalasseus bengalensis* (7), Pallas's gull *Larus ichthyaetus* (6), gull *Larus sp.* (5), little tern *Sternula albifrons* (4), whiskered tern *Chlidonias hybrida* (3), and five were unidentified. During earlier surveys, common terns *Sterna hirundo* and a pomarine jaeger *Stercorarius pomarinus* were recorded by WCS in the MPA (Figure 23 - left) while the masked booby *Sula dactylatra*, great black-headed gull *Larus ridibundus*, western gull *Larus occidentalis,* and storm petrel (Hydrobatidae family) were recorded by the Isabela Foundation[3].

Figure 23. The first photo-verified record of a pomarine jaeger *Stercorarius pomarinus* (left) in Bangladesh by WCS in 2013, and a brown-headed gull *Larus brunnicephalus* which is the most common sea bird in the SoNG MPA (right).

FISH AND FISHERIES

Marine fisheries contribute about 15% of Bangladesh's total fish production of which about 82% comes from small-scale fisheries and the remainder from industrial trawls (DoF 2018). While there is a lack of detailed data on fish productivity in the SoNG MPA, WCS investigations

[3] https://www.thedailystar.net/backpage/swatch-no-ground-treasure-trove-marine-lives-1407508

indicate that the submarine canyon and adjacent waters are among the most productive marine environments in Bangladesh supporting diverse fisheries and fishery-dependent livelihoods.

Hilsa

Hilsa shad *Tenualosa ilisha* is the most productive and economically valuable fish species in Bangladesh (DoF 2016) with more than a half million tons landed per year and supporting the livelihoods of at least 2.5 million people (Islam et al. 2016). Declines in hilsa catches led the Government of Bangladesh to adopt the Hilsa Fishery Management Action Plan in 2005. This plan included initiatives to improve spawning, brood and juvenile protection as well as overall ecosystem resilience through spatial and temporal fishing bans leading to increases in hilsa production and size and fisher income (Rahman et al. 2020). The SoNG MPA and surrounding waters is favorable habitat for hilsa that migrate from the Bay of Bengal to estuaries and freshwater rivers for spawning (Figure 24).

Figure 24. Hilsa (*Tenualosa ilisa*) is an important target species of the medium-mesh gillnet fishery in the SoNG MPA.

Between October 2015 and March 2018, high quality data were collected by trained members of the WCS *Citizen Science Fishermen Safety Network* from 1,010 medium-mesh gillnet sets targeting hilsa concentrated mainly offshore the Sundarbans with the majority in the SoNG MPA (Figure 25). Altogether 90.7% of medium-mesh hilsa gillnet sets resulted in the catch of at least one hilsa with an average of 245 fish per net set (SD=656.8, range=1-10,000). Small size hilsa or jatka (<10 inches or 26 cm in length) comprised approximately 14.1% of the total hilsa catch by number and 5.4% by weight.

There were significant differences (Kruskal Wallis p<0.001, df=9, N=884) in mean fish weights according to month. The largest fish were caught in June-September (450-500 grams), the lowest (200-300 grams) in January, February and May, and middle-sized ones (300-450 grams) in October-December. Differences in the frequency of legal size hilsa catch versus small size or jatka catch according to month were also significant (Chi-square test p<0.001, df=9, N=884): The greatest proportion of small size fish catches occurred during October-December; 80.3% accounting for 82.2% of the total weight of jatka recorded. The proportion of jatka to legal size hilsa catch according to weight was 33.3% from October- December compared to only 4.0% from June-September (Figure 26). Management regulations in the SoNG MPA informed by robust fishery information, such as the spatial and temporal distribution of jatka catches, can help safeguard hilsa stocks and sustain productive hilsa fisheries.

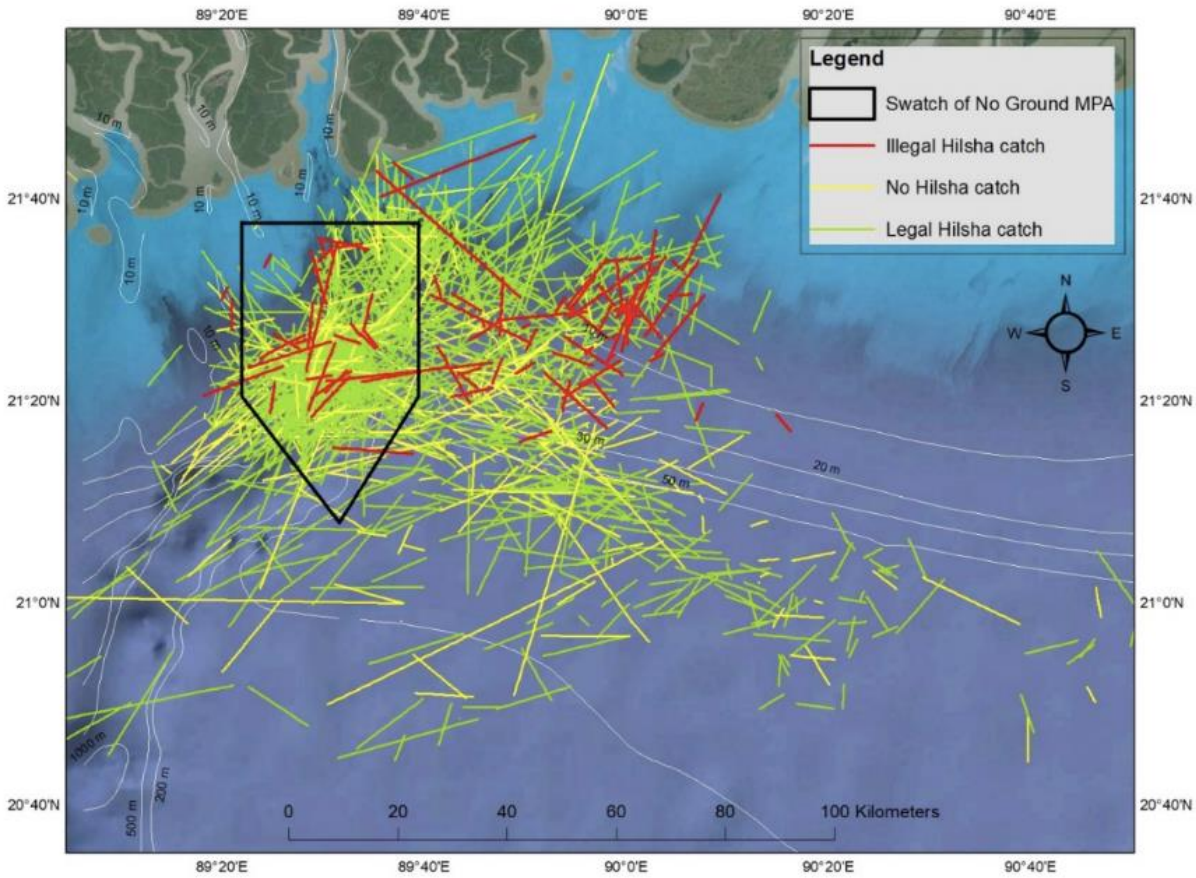

Figure 25. Map of medium-mesh gillnet sets targeting hilsa in and around the SoNG MPA showing sets catching legal size hilsa in green, illegal size hilsa in red and no hilsa in yellow. Interestingly no jatka catches occurred offshore of the 50 m contour line although a considerable portion of net sets with legal size hilsa occurred in waters deeper than 50 m.

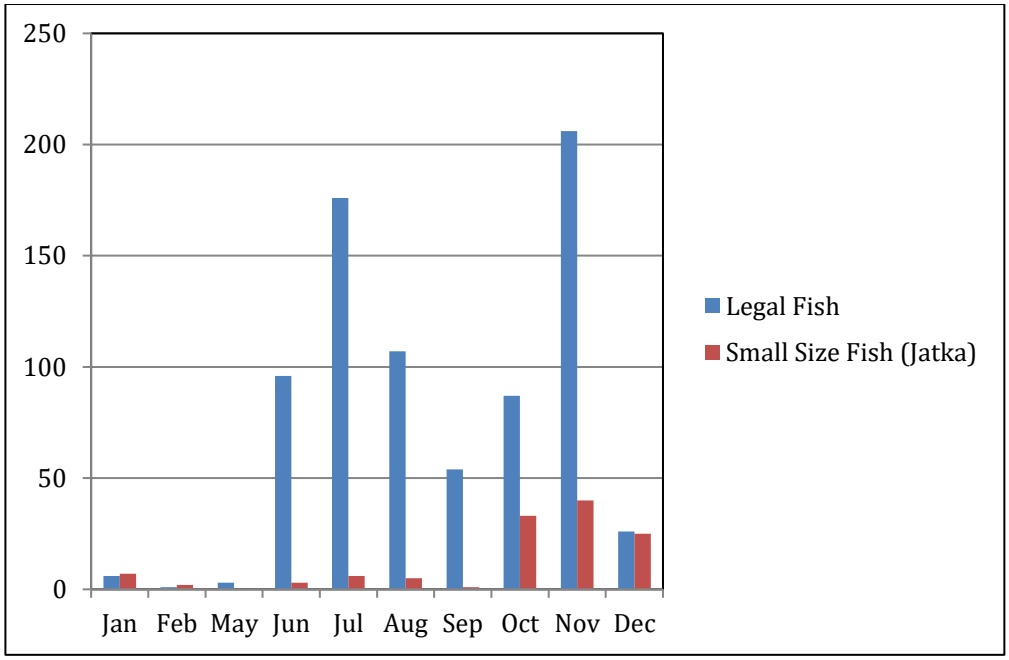

Figure 26. Bar chart showing the variation in mean numbers of legal size hilsa catches versus small size or jatka catches recorded by medium-mesh hilsa gillnet fishermen according to month.

Other finfishes

Citizen scientist fishermen recorded 20 bony finfish families in medium-mesh gillnet sets inside or nearby the SoNG MPA. The most common were shad (Clupeidae – including hilsa) and scad (Carangidae), both appearing in more than 50% of 1,010 net sets with a decline in catch frequency between 31% for Bombay duck (Harpadontidae) (Figure 27) and 33% for threadfin sea catfish (Ariidae), and less than 20% for the remaining 16 families with only five families, including ribbon fish (Trichiuridae), pomfret (Stromatidae), Gangetic whiting (Sillaginidae) and fourfinger threadfin (Polynemidae), caught in more than 10% but less than 20% of the net sets and the remaining 11 families in less than 10% of the medium-mesh gillnet sets (Table 1).

Figure 27. The globally NT Bombay duck *Harpadon nehereus* is a target species of medium-mesh gillnet fisheries in the SoNG MPA.

There were significant differences in the mean catch weight of non-target bony fishes in medium-mesh hilsa gillnets according to month (Kruskal Wallis $p<0.001$, df=9, N=1,002) with a clear increase in non-target catches in January and February but also proportions greater than or close to the same as hilsa catches in June and September-December (Figure 28).

Table 1. Family, common English name(s), local name(s) and % catch frequency of bony fishes recorded by citizen science fishermen in gillnets set in and around the SoNG MPA between October 2015 and March 2018.

Family	Common English name(s)	Local name(s)	% catch frequency medium mesh (N=1,010)	% catch frequency large mesh (N=146)
Clupeidae	Sardine	Raish, Dhela	74.5	14.2
Carangidae	Torpedo scad, Blackfin scad, Trevally, Oxeye scad, Bigeye scad	Mouri, Kongkon, Morma, Boro choukka	54.2	62.5
Ariidae	Threadfin sea catfish, Yellow sea catfish, Large mouthed catfish	Kata mach, Mochon, Med	31.0	59.3
Harpadontidae	Bombay duck	Loitta	33.4	3.2
Trichiuridae	Ribbonfish	Churi, Baim, Eel	18.9	5.1
Stromateidae	Pomfret	Fighter, Foli chanda, Chanda,	18.4	24.5
Sillaginidae	Gangetic whiting	Tular dandi	18.1	1.9
Scombridae	Mackerel, Queenfish, Spotted queenfish	Maitta, Rupsha, Bom maitta, Chitol, Ram chitol	15.9	50.9
Polynemidae	Fourfinger threadfin	Tairel	12.0	27
Belonidae	Needle fish	Kakila, Chala	9.8	11.6
Exocoetidae	Flying fish	Thuris, Uromach	6.5	7.7
Serranidae	Grouper	Vol	3.0	3.2
Sciaenidae	Croaker	Poma	2.0	13.5
Lobotidae	Tripletail	Koi	1.5	0.0
Lutjanidae	Snapper	Lal fuli, Jaba, Lal chokh, Sakhina	1.1	17.4
Centropomidae	Sea perch	Vetki	0.3	0.0
Istiophoridae	Marlin	Golpata	0.2	2.5
Hemiramphidae	Halfbeak	Thute, Thot kata, Jot kata	0.2	0.0
Pomacentridae	Banded sergeant	Pathari, Pathor	0.1	0.0
Gerreidae	Biddy	Modhuchosa, Tak chanda	0.1	5.1

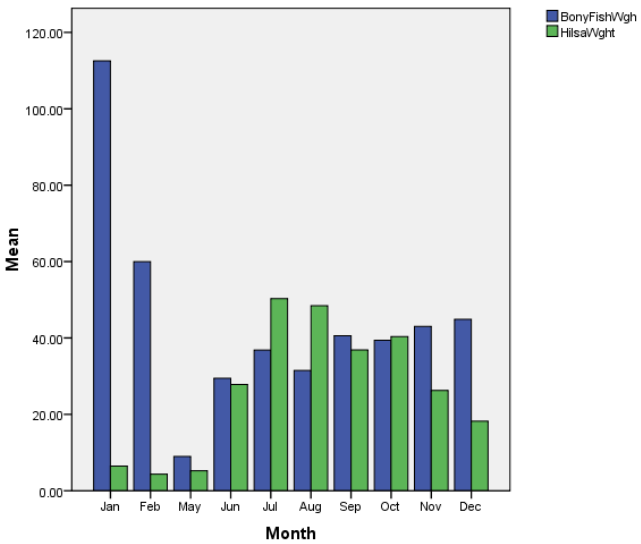

Figure 28. Mean catch weights (kg) of bony fishes other than hilsa (blue) compared to hilsa (green) catches according to month in 1,002 medium-mesh hilsa gillnet sets.

The WCS *Citizen Science Fishermen Safety Network* also collected high quality data during 146 large-mesh finfish gillnet sets from October 2015 to March 2018. A large portion of these large-mesh gillnet sets were concentrated in deeper offshore waters in the SoNG MPA and adjacent waters to the west and east, with substantial overlap with medium-mesh hilsa gillnet sets in the SoNG MPA (Figure 29).

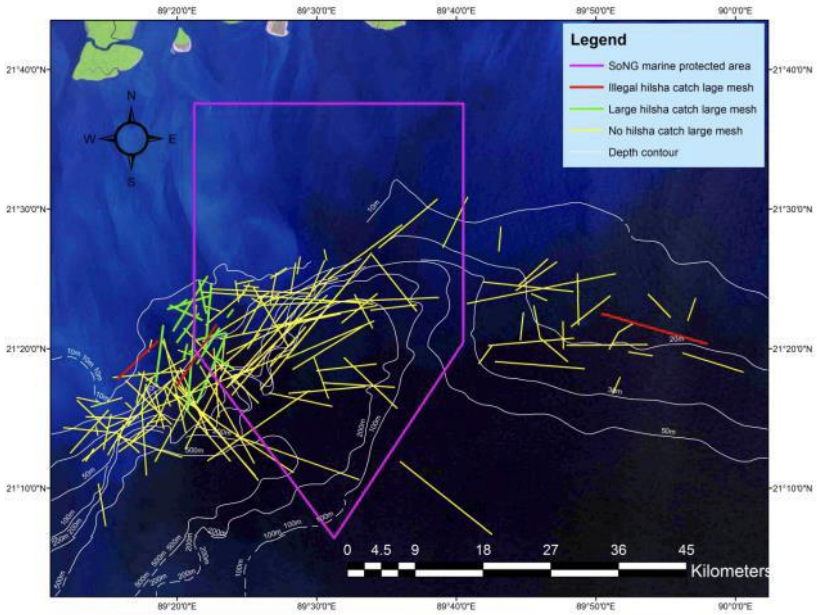

Figure 29. Large-mesh finfish gillnet sets with catches of legal size hilsa in green and catches of small size or jatka catches in red with the remaining net sets in yellow that caught no hilsa fish. The number of hilsa catches in large-mesh gillnets was too few to conduct further statistical analysis.

Sixteen families of bony finfishes were recorded in large-mesh finfish gillnets in the SoNG MPA and adjacent waters, with the most common being scad (Carangidae), sea catfish (Ariidae), and queen fish (Scombridae) recorded in more than 50% of 155 net sets with a major decline in the catch frequency to less than 40% for the remaining 13 families. Of the remaining families, only fourfinger threadfin (Polynemidae) and pomfret (Stromatedae) were caught in more than 20% of the net sets, and four families - snapper (Lutjanidae), Sardine (Clupediae), croaker (Sciaenidae) and needle fish (Belonidae) - were caught in more than 10% but less than 20% of the net sets with the seven remaining families caught in less than 10% of the net sets.

There were significant differences in the mean catch weight of bony fishes in large-mesh finfish gillnets according to month (Kruskal Wallis $p<0.001$, $df=3$, $N=146$) with a clear increase in non-target catches each month from January to April (Figure 30).

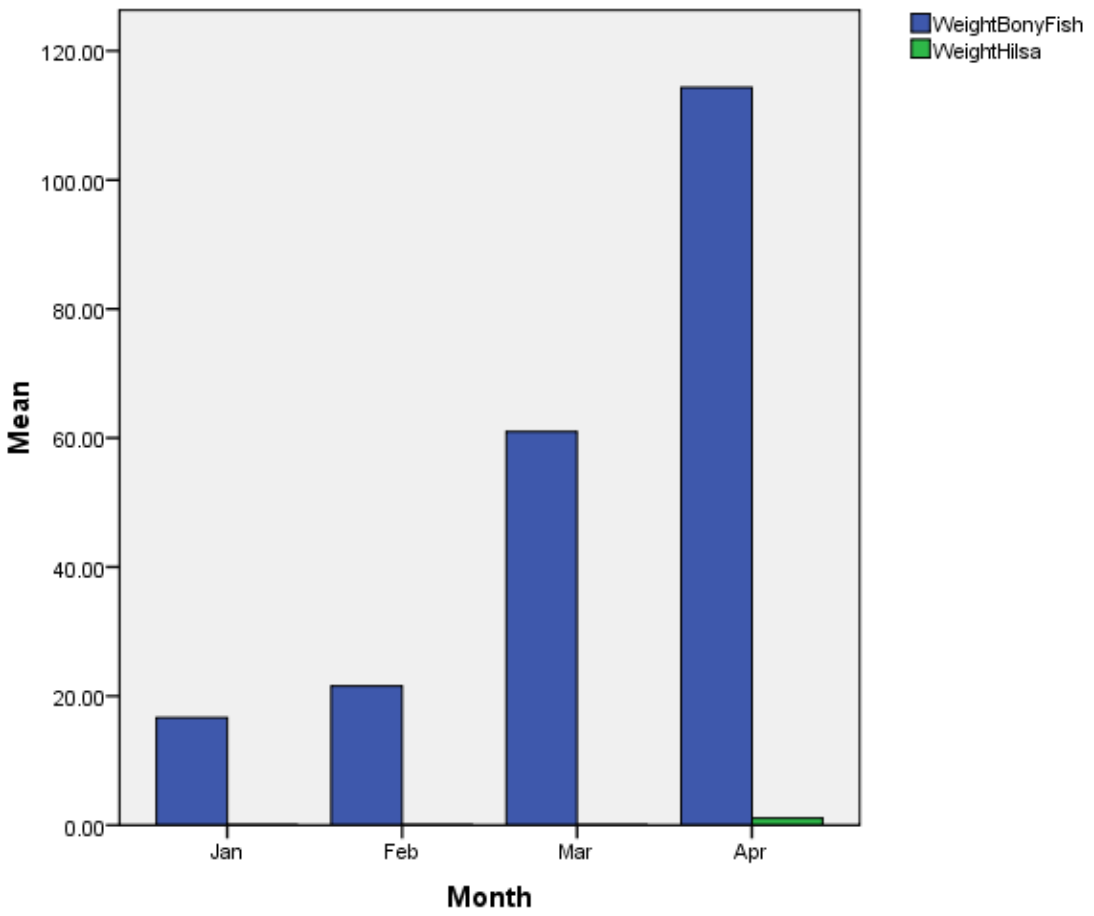

Figure 30. Mean catch weights (kg) of bony fishes other than hilsa (blue) compared to hilsa (green) catches according to month in 146 large-mesh finfish gillnet sets.

Fishing practices

During at-sea investigation conducted by WCS in December-January 2017-18, WCS sampled catches from six fishing vessels operating medium (N=1) and small-mesh (N=1) gillnets, estuarine set-bag nets (N=2), and midwater baited longlines (N=2), to identify finfish caught from the SoNG MPA. WCS recorded 19 species and four genera, with one of the 19 species - the Bombay duck *Harpadon nehereus* – considered NT in the Global IUCN Red List. WCS also conducted interviews with ten fishermen using medium (N=1) and small-mesh (N=3) gillnets, estuarine set-bag nets (N=3), midwater baited longlines (N=2), and one unbaited bottom longline during the same survey. During these interviews, fishermen reported catching two additional finfish species including the toli shad *Tenualosa toli*, which is considered VU in the Global IUCN Red List (Appendix 4).

Four types of fishing gear were recorded in the SoNG MPA during at-sea surveys conducted by WCS during the northeast monsoon season in 2017-18. These include set-bag nets, gillnets, longlines, and trawl nets.

Set-bag nets

Waters of the SoNG MPA less than 10 m deep are dominated by set-bag nets (SBN) which are responsible for nearly 28% of the total small-scale marine fishery landings in Bangladesh (Nabi and Ullah 2012). Set-bag nets or *'behundi'* or *'badha jaal'* include estuarine set-bag nets (ESBN) (Figure 31) and marine set-bag nets (MSBN), the latter being larger, deployed in deeper water. The minimum legal mesh-size at the cod end of both ESBNs and MSBNs is 45 mm. During at-sea investigations in 2017-18, WCS recorded similar mesh-sizes for ESBNs and MSBNs ranging between 5-100 mm with an average of 30 mm mesh-size at the cod end (N=13).

Figure 31. Estuarine set bag nets are the most common fishing gear operated at the northern edge of SoNG MPA.

Almost half of 59 gears recorded in or within 10 km from the SoNG MPA during a survey conducted by WCS in 2017-18 were ESBNs. These are among the most destructive fishing gear types because they are non-selective, catching large numbers of small juvenile fish and crustaceans that are mostly processed into low-value poultry or fish feed (Nabi et. al. 2012). Seasonal settlements for processing fish caught in set-bag nets are located on Dubla Island and on Narikelbaria Char and Shela Char located along the southern fringe of Sundarbans north of the SoNG MPA. In the winter of 2001-02, about 20,000 fishermen operated almost 3,000 SBNs offshore the Sundarbans near the northern boundary of the SoNG MPA (Hoq 2008). This number has almost certainly increased from this estimate made almost twenty years ago.

Gillnets

According to the DoF Fisheries Yearbook 2017-18, more than 20,000 mechanized and nearly 17,000 non-mechanized vessels operate gillnets along the coast of Bangladesh. At-sea surveys conducted by WCS in 2017-18 covering 145 linear km in the SoNG MPA revealed that 41% of the total active fishing gears were gillnets, making it the second most common fishing gear type operated in the SoNG MPA.

Gillnets can be divided into large-mesh (LDGN) (>13 cm) (Figure 32-top left), medium-mesh (MDGN) (8.0-12.5 cm) (Figure 32-top right), and small-mesh (SDGN) (2.5-7.5 cm) (Figure 32-bottom) gillnets. During visits to fishing ports used by fishermen that operate in the SoNG MPA, WCS recorded the specifications of five types of medium-mesh and two types of large-mesh gillnets that operate in the SoNG MPA (Table 2).

According to 39 gillnetters interviewed at-sea, the main types deployed in the SoNG MPA are *chandi* (7.6-11.4 cm) and *sada jaal* (7.6-10.2 cm) in shallow waters, and *lamba* (7.6-11.4 cm) and *lash jaal* (8.3-10.8 cm) in deeper water. All five MDGN types target hilsa, while the two LDGN types target larger finfish such as barramundi *Lates calcarifer*, grouper ***Epinephelus spp.***, sea catfish *Arius spp.*, and fourfinger threadfin *Eleutheronema tetradactylum.*

Figure 32. Drifting large-mesh (top left), medium-mesh (top right), and small-mesh (bottom) gillnets are common gear types operated in SoNG MPA.

Table 2. Seven types of gillnets deployed in the SoNG MPA including gear specifications and target species.

Local Name	**Gear type**	**Mesh size** (cm)	**Distance between Floats** (m)	**Total net length** (m)	**Width** (m)	**Deployment**	**Soak** (hrs)	**Target species**
Chandi jaal	MDGN	7.6-11.4	150-1,000	1,286-7,751	7.2-45.5	Surface	2-10	Hilsa
Sada jaal	MDGN	7.6-10.2	400-600	3,657-5,144	10.9-13.7	Surface/ bottom	4-6	Hilsa
Lamba jaal	MDGN	7.6-11.4	400-1,003	4,858-9,049	35.7-36.7	Surface	2-12	Hilsa
Lash jaal	MDGN	8.3-10.8	700-880	6,371-8,024	36.5-41	Surface	3-5	Hilsa
Lal jaal	MDGN	8.9-12.7	800-1,000	6,172-8,573	13.6-14.5	Surface	3-9	Hilsa
Koral jaal	LDGN	22.9-25.4	72+	494-494	6.8+	Bottom	10-12	Barramundi, Fourfinger threadfin, Sea catfish, Snapper
Nakura jaal	LDGN	17.8-27.9	400-550	3,472-4,243	10.9-13.7	Surface/ bottom	7-15	Fourfinger threadfin, Fea catfish

Based on data provided by the WCS *Citizen Science Fishermen Safety Network*, medium-mesh nets targeting hilsa (N=1,010) were deployed in waters generally less than 20 m deep but also as deep as 200 m, concentrated mainly offshore the Sundarbans with the majority in the SoNG MPA. Large-mesh gillnets operated by WCS citizen science fishermen (N=146) targeting larger finfish were set in waters generally deeper than 20 m with a few in waters deeper than 200 m inside the submarine canyon. During consultations facilitated by WCS in coastal fishing communities (see below), fishermen reported that foreign fishing vessels often deploy illegal monofilament gillnets in the SoNG MPA.

Longlines

According to the DoF Fisheries Yearbook 2017-18, about 3,000 longline vessels (Figure 33, left) operate in the Bangladesh EEZ. According to WCS investigations, longliners operating in the SoNG MPA target mainly pike congers (e.g., *Congresox* and *Muraenesox spp.*), croakers (e.g., *Johnius, Dendrophysa, Pama,* and *Protonibea spp.*), grouper (e.g., *Lutjanus spp.*) and sea catfish (e.g., *Arius spp.*). The dried air bladders or maw of these species, especially Indian pike conger and croaker, are sold for extraordinarily high prices to traders who export them to China.

A different type of longline, with thousands of unbaited hooks (Figure 33, right) targeting rays, including CR sawfishes, are reportedly used along the northern edge of the SoNG MPA. These sharp hooks are set just above the bottom and snag rays in water less than 10 m deep. The average length of these gears measured during WCS at-sea investigations was 4,000 m with a range of 3,710-4,800 m (N=6).

Figure 33. Baited midwater longlines hook sharks in and around the SoNG submarine canyon (left), while unbaited hooks dangling from longlines set just above the bottom snag rays in shallow parts of the SoNG MPA near the Sundarbans (right).

Industrial trawl nets

According to the DoF Fisheries Yearbook 2017-18, Bangladesh has 253 registered industrial fishing trawlers (Figure 34) operating 759 gears. Despite being banned since 2016, bottom trawl nets are the main gear type used by industrial trawling vessels in Bangladesh. This gear is a major threat to marine biodiversity because they are non-selective and destroy seabed habitat (Palanques et al. 2001). According to the DoF, all bottom trawlers should be converted into 'ecofriendly' mid-water trawlers for catching pelagic species (e.g., anchovies, sardines, tuna) in waters deeper than 40 m. [4,5] Fishermen interviewed during WCS at-sea investigations reported that industrial trawlers discard large amounts of undersized fish, and that industrial trawlers from India, Myanmar, and Thailand often fish illegally in the SoNG MPA.

Figure 34. Commercial trawl fishing poses a major threat to the rich biodiversity in the SoNG MPA.

[4] https://www.daily-sun.com/post/148058/How-to-stop-bulldozing-the-Bay-of-Bengal
[5] Marine Fisheries Rules, 1983

Industrial longlines

Pelagic longlines targeting tuna and billfish incidentally catch high numbers of marine turtles, sharks and rays, and often entangle or hook marine mammals and seabirds.[6,7] The Government of Bangladesh has earmarked 61.7 crore Taka (USD 7.6 million) for purchasing three industrial deep-sea longline vessels for harvesting pelagic fish beyond currently utilized fishing grounds. This pilot project aims to encourage private investments in industrial fisheries.[8]

CONSERVATION THREATS

Bycatch of cetaceans and marine turtles

Cetaceans and marine turtles are not targeted by fishers and have no economic value in Bangladesh. Both marine wildlife groups still occur in the northern Bay of Bengal in relatively large numbers but are threatened by accidental entanglement in fishing gear.

Cetaceans are mammals that die if they cannot surface to breathe. Small cetaceans, including finless porpoises and Irrawaddy, Indo-Pacific bottlenose, pantropical spotted, and spinner dolphins, have been recorded as entangled and killed in gillnets deployed inside or in nearby waters of the SoNG MPA. Fishermen report that they are willing to release entangled cetaceans, but entanglements are difficult to detect before they pull up their gear when the cetaceans are found already dead.

Between February 2007 and July 2020, a cetacean mortality database compiled by WCS recorded the deaths of 13 Irrawaddy dolphins, six finless porpoises, one Bryde's whale, one sperm whale, and one unidentified cetacean near the northern edge of the SoNG MPA. Fishing gear entanglement accounted for 100% of the total seven mortalities that included information on the cause of death. From June 2015 through February 2019, WCS citizen scientists documented 42 cetacean mortalities in 4,247 gillnet sets among which five were recorded from the SoNG MPA (three in medium and two in large-mesh gillnets) (Table3).

More than 28% of 1,144 Indo-Pacific bottlenose dolphin and 15% of 407 Indo-Pacific humpback dolphin individuals that were photo-identified during WCS studies conducted between 2005 and 2009 had marks that were almost certainly caused by entanglements in fishing gears (Mansur et al. 2012, WCS 2013). This implies a strong potential for fatal interactions that could jeopardize the conservation status of both populations which otherwise appear favorable.

[6] https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-pelagic-longlines
[7] https://www.bmis-bycatch.org/bycatch-species-groups
[8] https://www.newagebd.net/article/116647/govt-embarks-on-tuna-mission-in-bay-of-bengal

Table 3. Cetacean mortalities recorded between June 2015 and February 2019 by citizen science fishermen from entanglements in large and medium mesh-size gillnets.

Species	Total	Large mesh	Medium mesh	Inside SoNG MPA
Irrawaddy dolphin	15	7	8	1
Indo-Pacific humpback dolphin	6	1	5	0
Finless porpoise	8	3	5	1
Indo-Pacific bottlenose dolphin	9	2	7	2
Pan-tropical spotted dolphin	2	1	1	0
Spinner dolphin	2	1	1	1
TOTAL	42	15	27	5

Marine turtles are also accidentally caught in fishing gears. Like cetaceans, these reptiles also need to come to the surface to breath. However, they can remain submerged for 4-7 hours, which is much longer than cetaceans, who drown after about 15 minutes. This means there is a strong potential for reducing turtle mortalities through rescue and release.

Between June 2015 to February 2019 the WCS *Citizen Science Fishermen Safety Network* reported catches of 80 olive ridley turtles, three hawksbill turtle, and one green turtle in 4,247 gillnet sets, with 64% released alive. Safe release procedures for threatened marine wildlife, including marine turtles, is a part of the training given to network members.

The number of turtle entanglement varies seasonally with the largest number of catches in the southwest monsoon in June and October (Figure 35). WCS studies indicate that longer net soak times resulted in more frequent turtle catches (Kruskal Wallis p=0.001, df=2, N=1,010) with 357 minutes for the mean net soak time of gillnet sets without turtle catches and 517 minutes for the mean net soak time of gillnet sets with turtle catches. Despite frequent entanglements in gillnets, according to community consultations, the largest number of marine turtles are entangled in set-bag nets.

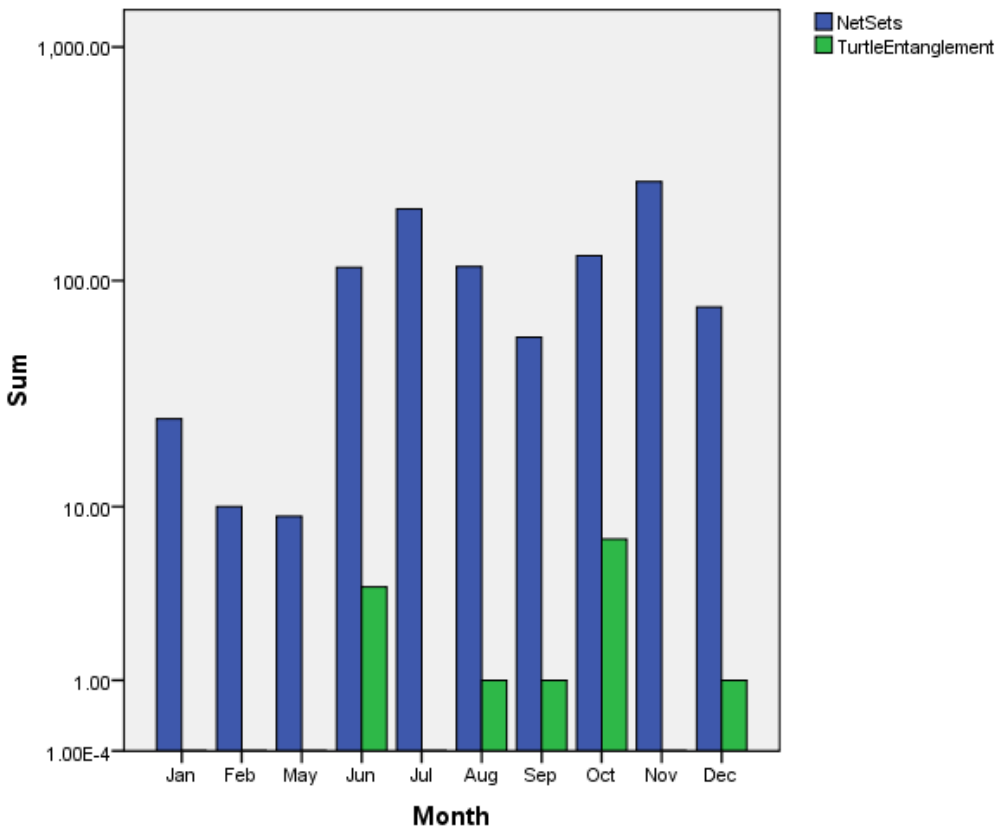

Figure 35. Number of net sets (blue) and number of turtle entanglements (green) in medium-mesh hilsa gillnets reported by fishermen trained as citizen scientists by WCS. Note that the y-axis is on a logarithmic scale.

A tuna longline survey in the north-western Bay of Bengal near the SoNG MPA recorded 59 bycatches of marine turtles, almost all olive ridleys, with 0.30 catches per 1,000 hooks set, which is more than four times greater than the hooking rate of marine turtles in the Arabian Sea (Varghese et al. 2010). During five years in the late 1990s more than 30,000 olive ridley turtles were reported to have died in industrial trawl nets along the nearby Orissa coast with 14,000 turtles found dead in 1998 alone (Padev et al. 1998).

Targeted and non-targeted catches of sharks and rays

Between June 2015 and February 2019, almost 9,000 shark individuals from eight species and 130 ray individuals from six species were recorded caught by the *WCS Citizen Science Fishermen Safety Network* in 2,397 medium and large-mesh gillnet sets in the SoNG MPA. Among these, scalloped hammerhead and sharpnose guitarfish are particularly of concern because of their CR status in the Global IUCN Red List.

The majority (84% of 32 entanglements) of scalloped hammerhead sharks were caught in large-mesh gillnets and one sharpnose guitarfish was caught in a medium-mesh gillnet. Other globally threatened species recorded by the network in the SoNG MPA were the EN giant freshwater whipray, VU spinner shark and whitespotted whipray, NT spadenose, spottail, tiger, blacktip, and bull sharks and longtail butterfly ray, and DD pigeye shark and Bengal guitarfish.

Fishermen interviewed by WCS during the 2017-18 at-sea investigations reported that sharks and rays are not their target species, but that due to the increased demand in international markets for shark fins, mobula gill plates, and ray skins especially from larger species, they are retained.

Overexploitation of fisheries

Almost all major commercial finfish groups, including shad, pomfret, croaker, catfish, Indian salmon, sardine, and shrimp are overexploited. Without urgent management measures, many will become depleted beyond their capacity to recovery. Conversely, small pelagic, non-targeted fish, such as sardines, are increasing (Fanning et al. 2019). Such shifts in fish catch composition indicate ecosystem changes that may be impossible to reverse with unknown impacts on threatened marine wildlife.

Catch per unit effort (CPUE) is declining in both small-scale and industrial fisheries in Bangladesh. The CPUE of gillnetters targeting hilsa, skipjack, tuna and mackerel decreased from about 650 kg/day/boat in 2001-02 to less than 100 kg/day/boat in 2005-06 (Khan 2010). Catch composition is also changing from large, slow-growing fish such as fourfinger threadfin, which is one of the target species of large-mesh gillnets operating in the SoNG MPA, to smaller, fast-growing species, such as sardines (Fanning et al. 2019).

Although bottom trawling has been illegal in Bangladesh since 2016, a large portion of the catch reported from industrial trawls in 2019 was bottom dwelling shrimp. This implies that industrial trawlers continue to trawl on the bottom despite fishery laws prohibiting this destructive fishing practice (Fanning et al. 2019).

While the number of both estuarine and marine set-bag nets has increased, catch rates of ESBNs have decreased from 18 kg/haul in 1987 to less than 10 kg/haul in 2007 (Huntington et al. 2007), while the catch rate of MSBNs also decreased from 85 kg/haul in 1985 to 24 kg/haul in 2002-2003 (Khan 2010). Non-selective ESBNs and MSBNs are one of the direst threats to estuarine and marine biodiversity that supports economically valuable finfish and globally threatened marine wildlife.

Oil and gas exploration and development

Seismic surveys are used to determine the location and size of oil and gas reservoirs. Intense broadband pulses produced by seismic air guns can cause hearing impairment and physiological and behavioral changes in cetaceans (Gordon et al. 2004). Oil exploration and recovery may exclude cetaceans from valuable habitat and disturb feeding, resting and breeding behavior. Pollutants released during offshore drilling are also a health risk to cetaceans and surface oil can impair their respiratory system through toxic petroleum vapors (Helm et al. 2015).

During an at-sea survey in the Meghna river mouth in February 2017 near Nijhum Dwip, WCS recorded only two cetaceans while a seismic survey was occurring. However, during two subsequent surveys in the same area when seismic surveys were not occurring, WCS documented the highest densities of Irrawaddy dolphin and finless porpoises ever recorded in Bangladesh.

Offshore oil and gas are growth sectors in Bangladesh (MoFA 2014). To date, Bangladesh has approved 26 blocks for oil and gas exploration of which 11 are shallow sea blocks and 15 are deep sea blocks (Figure 36) in the EEZ of Bangladesh.

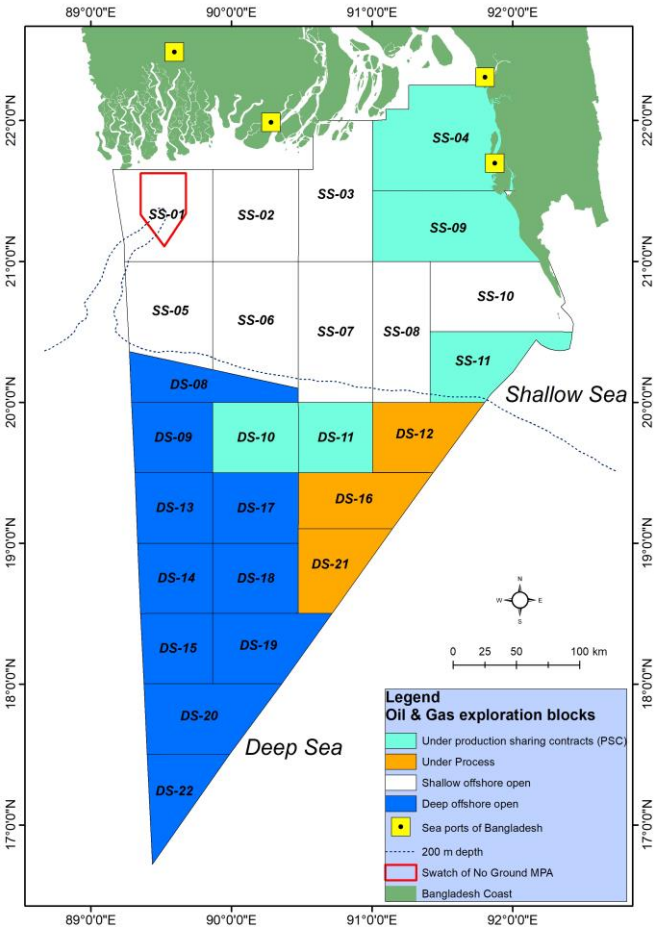

Figure 36. Oil and gas exploration blocks in the Bangladesh EEZ in relation to the SoNG MPA, with shallow blocks (SS, white/green) <200 m deep and deep-sea blocks (DS, blue/green/orange) >200 m deep. Map reproduced from Hossain et al. 2014.

Oil and gas exploration block SS-01 covers the entire SoNG MPA area, with blocks SS-02 and SS-06 covering nearby waters and SS-05 in the newly settled maritime boundary adjacent to the SoNG MPA. To date no oil and gas exploration is known inside SoNG MPA, but international bidding for exploring deep-sea blocks is being considered.[9,10]

Vessel traffic

Large transport vessels discharge hazardous oil and increase the risk of bio-invasions through ballast water discharges (Seebens et al. 2013). Ship strikes can kill highly mobile, surface-active marine megafauna (Van Waerebeek et al. 2007), especially large whales (Wilcock et al. 2014). Shipping also produces low-frequency sounds that can change the movements and disrupt communication of cetaceans (Tennessen & Parks 2016).

[9] http://www.petrobangla.org.bd/site/page/18628f28-4849-435f-aaf4dcc3c1e8bea4/%E0%A6%B8%E0%A6%AE%E0%A7%81%E0%A6%A6%E0%A7%8D%E0%A6%B0-%E0%A6%AC%E0%A7%8D%E0%A6%B2%E0%A6%95

[10] https://www.theindependentbd.com/post/194380

Bangladesh has two major international ports, Mongla and Chittagong, with plans to develop two additional major ports in Payra (inaugurated in 2016 and scheduled to be completed by the end of 2021) and Matabari (inaugurated in 2020 and scheduled to be completed by 2026). Commercial shipping vessels transit the SoNG MPA one the way to Mongla and Payra ports (Figure 37).

During 2016-2017, Mongla Port handled over 7.5 million metric tons of goods and serviced more than 1,700 vessels with a threefold increase over the last 15 years. Major development has been undertaken in recent years to improve the capacity of Mongla Port.[11,12,13] Once the Padma bridge and the Khulna-Mongla rail line become fully operational, connecting Mongla to Dhaka, [14] commercial vessel through the SoNG MPA will likely increase.

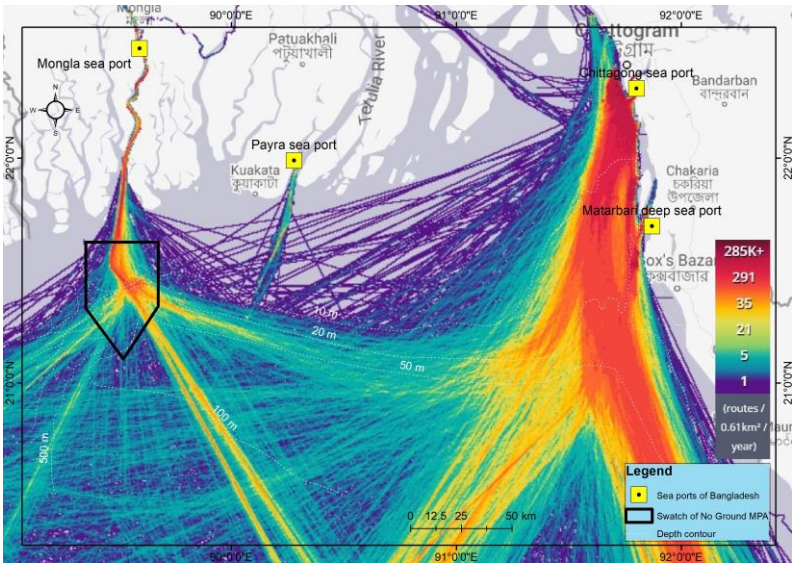

Figure 37. Commercial vessel traffic to and from the Mongla and Payra ports will likely increase and could impact the SoNG MPA. High (dark red), medium (yellow to lighter blue) and minimum (purple) density of commercial vessel traffic in 2019 was derived from https://www.marinetraffic.com/en.

Climate change

The world's climate is changing due to greenhouse gas emissions that are warming the world's ocean. Sea surface temperature in the Bay of Bengal is predicted to increase by 2.0–3.5° C by the end of the century (Vivekanandan et al. 2009). Ocean warming affects the exchange of gases between the ocean surface and the atmosphere, and it can lead to reduced mixing between nutrient-rich deep waters and relatively nutrient-poor surface waters. Major changes to ocean circulation will impact the dispersal of larval fish, particularly pelagic species.

[11] https://www.thefinancialexpress.com.bd/trade/mongla-port-sees-record-ship-anchoring-in-december-1609584112

[12] https://www.dhakatribune.com/bangladesh/2020/12/31/new-mongla-port-channel-commissioned-ahead-of-schedule

[13] https://www.dhakatribune.com/bangladesh/government-affairs/2020/02/18/ecnec-okays-mongla-port-capacity-expansion

[14] https://www.thedailystar.net/frontpage/padma-bridge-rail-link-promises-kolkata-four-hours-1572583

The biological features of the SoNG reflect the spatial complexity and temporal dynamism of freshwater discharge, a basin-scale current gyre, and upwelling at the head of the SoNG submarine canyon. These features occur in an ecological "dead end" at the head of the Bay of Bengal. This feature of the bay has important implications for the ecological value of the SoNG submarine canyon as a thermal refuge for mobile marine wildlife, such as cetaceans, sharks and rays, from warming temperatures in the northern Indian Ocean. The consequences of habitat loss in this ecological "dead end", which prevents pole-ward range shifts of mobile species that are possible in most other ocean basins (e.g., Atlantic and Pacific Oceans), could be catastrophic for species populations that cannot adapt to changing ocean conditions.

CONSULTATIONS WITH FISHING COMMUNITIES

Location, participants and procedures

WCS conducted five community consultations on conservation management in the SoNG MPA in Parerhat (Pirojpur District), Pathorghata (Barguna District), Bagerhat Sadar (Bagerhat District), and Alipur and Mohipur in the Kuakata District (Figure 38). Altogether, 142 villagers participated in the consultations including 96 fishermen and 46 fish traders, day-wage fish landing site workers, boat owners and boat crew (Table 4). Due to cultural sensitivity and a considerable distance between their homes and the meeting locations, no women participated in the consultations. WCS therefore arranged one consultation in Parerhat with six women to gain preliminary input from a female perspective.

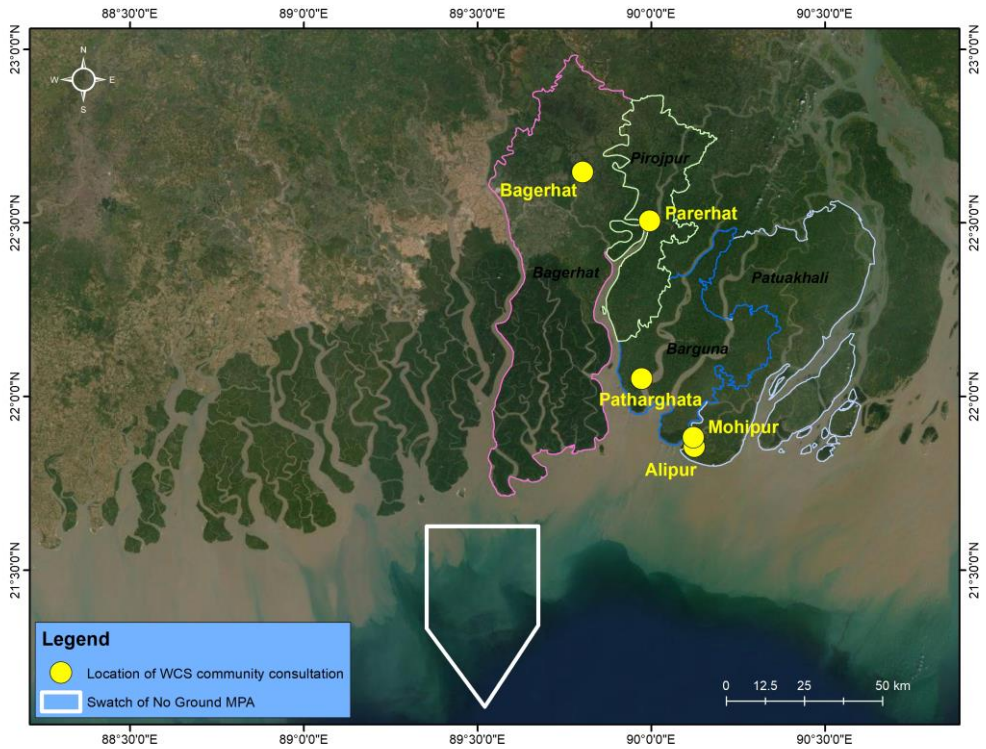

Figure 38. Locations of four fish landing sites and ports where fishermen who fish in the SoNG MPA operate from and community consultations were held.

Questions focused on five broad categories including (i) problems and challenges, (ii) fishing practices, gears, seasons, and catches, (iii) marine wildlife, (iv) knowledge and opinions about MPAs, and (v) enforcement and monitoring. All statements and recommendations made by participants were recorded in Bengali on a flip chart in clear view of participants to ensure transparency and accuracy.

Table 4. Number of participants in five community consultations, with information on the total population and number of registered fishermen in the Upazila according to the 2017-18 Bangladesh Statistical Yearbook (GoB 2018).

Location	Population of Upazila	No. of fishermen in Upazila	Male participants	Occupation	Female participants
KB Ghat, Bagerhat Sadar Upazila, Bagerhat District	217,278	220	32	16 fishers & 16 fishery workers	None
Parerhat, Zianagar Upazila, Pirojpur District	75,894	1,541	23	All fishermen	6 (all homemakers)
Pathorghata, Pathorghata Upazila, Barguna District	164,000	21,900	25	18 fishers & 7 fishery workers	None
Alipur, Kalapara Upazila, Kuakata District	237,831	2,755	31	15 fishers & 16 fish workers	None
Mohipur, Kalapara Upazila, Kuakata District	237,831	2,755	31	24 fishers & 7 fish traders	None

Problems and Challenges

Participants stated that weather forecasts received over a transistor radio were insufficient due to the lack of accurate and timely updates and location-specific predictions. The lack of basic navigation aids such as a Global Positioning System (GPS), signal buoys or lighthouses, and no means to communicate via cell phone or VHF radio further added to the risks they face from increasing extreme storms at-sea. Fishers mentioned being harassed by FD and Coast Guard officers when seeking refuge from storms in the Sundarbans mangrove forest. They also thought that rescue procedures were not satisfactory.

Fishermen emphasized industrial fishing vessels as a growing problem, reporting that domestic industrial bottom trawlers fish illegally in water less than 40 m deep and damage their gears. Participants mentioned that foreign vessels from India, Myanmar and Thailand overexploit fish by using monofilament gillnets or bottom trawls, and that they often fish during the hilsa ban season. The lack of monitoring and enforcement to stop illegal fishing was identified as a considerable challenge, along with mismanagement in the registration of fishermen and the distribution of the Vulnerable Group Feeding (VGF) rice subsidy provided to fishers as an incentive for their compliance with the seasonal fishing ban imposed by the Government.

Marine wildlife entanglement

According to the participants, there is no targeted shark fishery in the SoNG MPA, but rays are targeted using un-baited long lines with thousands of hooks. They mentioned that the *Kamot jaal* or shark net, a large-mesh (30-50 cm) gillnet made from very thick twine or cord

targeting sharks, was no longer in use since being reportedly banned in 2007 [15]. Participants considered industrial trawling and set-bag nets as the main threat to the marine wildlife. They mentioned that sharks and rays are entangled as non-target catches in medium-mesh gillnets, particularly in *Nakura jaals* during winter months and in *Chandi* and *Lash jaals* in the rainy season. The *Laukkha jaal*, a large-mesh gillnet similar to the *Kamot jaal* but smaller in mesh size (18-35 cm), twine thickness and net width, is deployed in deep waters of the SoNG MPA targeting barramundi, fourfinger threadfin, sea catfish, and snapper. This net was mentioned as being particularly dangerous for entangling marine wildlife, especially sharks and rays. Marine turtles are accidently caught in all gears but with the largest numbers in set bag nets, as reported by participants.

Fishermen explained that it is difficult to avoid marine wildlife mortalities because by the time they notice the animals entangled in their gear, especially dolphins, they are generally already dead. Some participants suggested that more dolphins could be saved from drowning in their nets if they had a devise to alert them about the entanglement. Most participants expressed their willingness to release entangled live turtles, dolphins, and legally protected sharks and rays if that was the Government rule.

Participating traders reported that shark and ray landings have declined while the prices paid for these animals has increased over the last ten years, and that they now rarely encounter full-grown hammerhead sharks, large freshwater whiprays, or sawfish.

Perception of SoNG MPA

Only 10.6% of the participants were aware of the existence of the SoNG MPA. However, after explaining the location and concept almost all fishermen agreed that, if regulations were equitably enforced, it could benefit fisheries and marine wildlife. To sustain productive small-scale fisheries, community members urged stricter enforcement of fishery rules, including the ban on set-bag nets with less than 45 mm mesh size at the cod end and monofilament gillnets, foreign vessels fishing in Bangladesh's territorial waters and industrial trawl vessel operating in waters less than 40 m deep. Fishermen also emphasized the importance of regulating the trade in illegal fishing gear as well as in vulnerable marine wildlife or their parts.

Monitoring, enforcement and sustainable fisheries

Almost all participants (94 of 96) agreed that existing fisheries regulations are ineffective because they are not properly monitored and enforced. Everybody agreed that only the Navy has the capacity to monitor and enforce compliance with fisheries regulations in the SoNG MPA. Many also expressed their willingness to assist the government in monitoring marine wildlife and fishing activity in the MPA as citizen scientists, especially if provided with a GPS and VHF radio.

Consultations with women

The long distance between the homes and the meeting venue hampered the participation of female members of fishing communities in consultations. WCS therefore met separately with six women in Parerhat, all homemakers who also make and repair fishing nets. The biggest challenge mentioned by these women was the financial insecurity and stress during the absence of the male family members, especially during storms. Like the male participants,

[15] https://www.thedailystar.net/news-detail-23614

these women also had no prior knowledge about MPAs. But after a WCS facilitator explained the concept, the women related MPA management regulations to their experience with the seasonal hilsa fishing ban. Based on their positive experience with increased hilsa catches after the ban periods, they agreed that MPAs could benefit them. The women indicated that they needed help to develop alternative or supplementary income generating activities such poultry rearing, farming, sewing, and making fishing nets.

GOVERNMENT AGENCY JURISDICTIONS AND MANDATES

The SoNG MPA was proposed by the FD for the conservation of threatened dolphins, porpoises, whales and sharks, and declared by the Ministry of Environment, Forest and Climate Change (MoEFCC) under the Wildlife (Conservation and Security) Act, 2012, Chapter IV, Section 13 (1, 2 and 3) as Bangladesh's first MPA. The FD is also the national authority for issuing export permits for threatened marine wildlife for which international trade is regulated under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and mandated to enforce wildlife and protected area rules.

Inland and marine capture fisheries, except in the Sundarbans Reserved Forest, are managed by the Ministry of Fisheries and Livestock (MoFL) through the Department of Fisheries (DoF). With the passage of the Marine Fisheries Bill 2020, the MoFL was empowered to declare multi-use MPAs in addition to no-take Marine Reserves. The MoFL is also the lead ministry for achieving the SDG 14 'Life below water' to conserve and sustainably use the oceans and marine resources, including effectively protecting 10% of the country's EEZ.

In addition to implementing fishery laws and rules, including the inspection of harvests, landings, and export shipments, the DoF conducts catch assessments, research and training aimed at maximizing production and use of living aquatic resources, issues permit for fishing vessels and registers fishermen. The Bangladesh Fisheries Development Corporation (BFDC) operates fish landing sites, cold storage, auction and processing centers as well as transportation.

The mandate of the Bangladesh Navy is to protect the country and its maritime resources from external maritime threats such as smuggling and trafficking with a fleet including 17 offshore patrol vessels.

In addition to providing security assistance at seaports and conducting relief and rescue operations after natural calamities, the Bangladesh Coast Guard supports the Navy in securing maritime borders, controlling piracy and illegal trafficking, protecting resources, and preventing environmental pollution. It also assists the DoF with the enforcement of fishery laws and regulations.

The Blue Economy Cell of the Ministry of Foreign Affairs (MoFA) coordinates the development and implementation of sustainable blue economy initiatives in collaboration with the MoEFCC, MoFL and other relevant ministries.

NATIONAL LEGAL FRAMEWORK FOR MPA MANAGEMENT

Biodiversity

The Constitution of the People's Republic of Bangladesh directs the state to safeguard natural resources, biodiversity, and wildlife for present and future citizens. Bangladesh was the first South Asian country to adopt 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, or destruction. The maritime area of Bangladesh has increased through successful boundary negotiations with Myanmar in 2012 and India in 2014, resulting in an EEZ of 118,813 km^2.

The Wildlife (Conservation and Security) Act, 2012 provides the legal basis for the conservation and management of wildlife, biodiversity and habitat. According to the act, the Chief Conservator of Forest has the power to determine vulnerable, endangered, and critically endangered species and assign them to Schedule I, II and III based on scientific data. Without special conditions, no one can remove these animals from their natural environment.

Chapter IV, 15(4), 16(4) and 20(4) of the Wildlife (Conservation and Security) Act 2012 provides guidelines for developing a management plan with specific areas for tourism development, and proper demarcation for protected areas. The act also provides regulations for improving habitat, protecting breeding grounds, preventing disturbance during breeding for the protection of dolphins, whales and porpoises through the control or prohibition of fishing activities or movement of watercrafts. After identifying detrimental activities, the act also empowers the FD to prohibit activities within two km from the border of an MPA. Finally, the act empowers the Government, after receiving inputs from the local community, to declare any public or private area outside the boundaries of an official protected area as a landscape zone, buffer area, or corridor for the movement and safe breeding of wild animals.

The National Fisheries Policy 1998 aims to develop and increase production of fish resources and create self-employment to improve the socio-economic condition of the fishers. The policy emphasizes the nutritional value of fish and the importance of maintaining an ecological balance and biodiversity. The Marine Fisheries Act 2020 regulates permits for fishing and fishing vessel, research and reporting requirements of catches. Section 29 of the bill also enables the Government to declare areas in which biodiversity is declining, or aquatic flora and fauna are threatened, as Marine Protected Areas.

The Biological Diversity Act 2017 defines activities negatively affecting threatened animals or biological resources as punishable offences. 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 with biodiversity conservation, wildlife protection and sustainable resource use. According to Article 33 of the act, the Government can declare any species as Vulnerable or Endangered and take measures to protect them.

Environment

The Environmental Conservation Act 1995 and the Environmental Conservation Rules 1997 mandate that industries must carry out an Environmental Impact Assessment (EIA) and put in place effluent treatment, report accidents or discharges of pollutants, and take remedial measures.

Fishing gears

The MoFL through the DoF is primarily responsible for enforcing fishery laws and rules, except in the Sundarbans. The jurisdiction in the SoNG MPA, where no effective measures have been implemented to date, is yet unclear but will be finalized during inter-ministry consultation between MoEFCC and MoFL. Despite having the legal authority to monitor fishing activities and enforce fishery regulations in protected areas, the FD lacks the infrastructure and capacity for overseeing fisheries in the SoNG MPA.

The Marine Fisheries Ordinance 1983 confers power to the DoF to enforce fishery rules. However, the Marine Fisheries Act 2020, which supersedes the Marine Fisheries Ordinance 1983, does not specify any gear regulations. The Marine Fisheries Rules 1983 (Sections 14 and 16) specify that the minimum mesh-size shall be (a) 45 mm at the cod end of shrimp trawling nets, (b) 60 mm for fish trawling nets, (c) 200 mm for large-mesh drifting gillnets, (d) 100 mm for small-mesh drifting gillnets, and (e) 45 mm at the cod end of set-bag nets.

Section 3a(iii) and (iv), 3(d), and 3(e) of the Protection and Conservation of Fish Act 1950 prohibit the manufacture, import, marketing, carrying, transporting, or processing of destructive fishing nets, traps, and gears. The act also allows the DoF to order seasonal prohibitions for any prescribed species as well as a minimum size below which no fish of any prescribed species shall be killed or sold. The DoF sometimes publishes separate rules to specify species and gear prohibitions under this act. For example, based on this act, the Government of Bangladesh imposed a 22-day ban on catching hilsa during their breeding season, and more recently a 65-day fishing ban (March to May) to protect fish stocks in the Bay of Bengal.

Fishing areas

The Marine Fisheries Act 2020 empowers the Government to regulate or prohibit fishing or fishing gear in specific fishing areas/grounds and to impose bans on all or any fish species. Until new rules under this act are enacted, the Marine Fisheries Rules 1983 apply. Section 15 of these rules specifies that waters less than 40 m deep during high tide are reserved for small-scale fisheries using set-bag nets, hook and line and drifting gillnets, and that industrial trawlers can only operate in waters more than 40 m deep.

To protect fish breeding grounds and migration routes, the Marine Fisheries Sub-Strategy 2006 prohibits all fishing in waters less than five meters deep and within five km from the shore, and allocates waters less than 40 m deep and within 10 km from the shore to small-scale mechanized boats operating drifting gillnets, marine set-bag nets, and longlines.

Alternative income

The National Fisheries Policy 1998 provides guidelines for poverty alleviation through creating self-employment and improving socio-economic conditions of the fishers. The National Fisheries Strategy 2006 identifies and provides alternative income guidelines to give poor fishers the opportunity to diversify their livelihoods thus reducing the pressure on fishing resources.

INTERNATIONAL AND REGIONAL MECHANISMS FOR MPA MANAGEMENT

The *United Nations Convention on the Law of the Sea (UNCLOS)* defines the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. UNCLOS supports MPA creation and signatory parties for conserving marine resources and cooperating with other neighboring states. As a signatory nation, Bangladesh is required to cooperate with other states through Regional Fisheries Management Organizations (RFMOs) and other international cooperation mechanisms.

The Convention on Biological Diversity (CBD) is a global tool established in 1992 to conserve biological diversity, ensure actions that lead to the sustainable use of biological diversity, and the equitable sharing of genetic resources. Marine conservation is a priority theme for the CBD: Under "Aichi Target-11" all parties, including Bangladesh, committed to protect 10% of coastal and marine areas by 2020, especially areas of particular importance for biodiversity and ecosystem, as MPAs. The post-2020 CBD goal is for member countries to protect at least 30% of their land and sea areas with at least 10% under strict protection by 2030. CBD emphasizes implementation of conservation management in MPAs rather than creating "paper parks". Parties are required to prepare and update inventories of biological resources for planning, decision-making, and to ensure sustainability.

The *United Nations Sustainable Development Goals (SDGs)* identify a wide range of issues that need to be addressed to ensure the health, stability, and sustainability of ecosystems and species. According to SDG Goal 14 "Life Below Water", countries should protect 10% of their coastal and marine waters as MPAs by 2030.

The *International Maritime Organization (IMO)* is a specialized agency of the United Nations founded in 1948 to regulate shipping. Its responsibilities include safety, environmental concerns, legal matters, technical cooperation, maritime security, and the efficiency of shipping. IMO designates specific areas as dumpsites for ballast water to ensure environmental protection. These are useful if integrated into national and international MPA creation processes. For example, if an area is listed as "particularly sensitive sea area" (PSSA), all vessels undertake a list of protective measures whenever they are in that area.

The *Convention on Migratory Species (CMS)*, to which Bangladesh became a party in 2005, requires parties to take measures to protect, manage, and conserve the habitats of threatened species that cross national borders, including the integration of fisheries into coastal area management.

The *FAO Code of Conduct for Responsible Fisheries (CCRF)* was adopted in 2000 to ensure responsible and sustained fisheries. It outlines international standards of behavior for responsible practices to ensure the 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 *United Nations Environment Programme (UNEP)* Regional Seas Programme aims to sustainably manage coastal and marine degradation through a "shared seas" approach by engaging neighboring countries in protecting their common marine environment.

STRATEGIES TO REDUCE THREATS

Marine Spatial Planning

Marine Spatial Planning (MSP) is a science-based, stakeholder-informed ocean management tool that aims to balance biological, ecological, and economic objectives. MSP collects information on where, when, and how activities occur in marine environments, and it provides guidance on minimizing conflict and optimizing benefits (Ehler & Douvere 2009). MSP plays a crucial role in ensuring sustainable ocean resource use and ocean-based or blue economic growth. The global standard for MSP uses the free Marxan software (www.marxansolutions.org), which allows stakeholder inputs to be integrated with scientific data in a participatory planning process. The SoNG MPA was declared as a multi-use MPA where science-based, community informed MSP can be incorporated to define different zones for protecting threatened marine wildlife and managing human use (Figure 39).

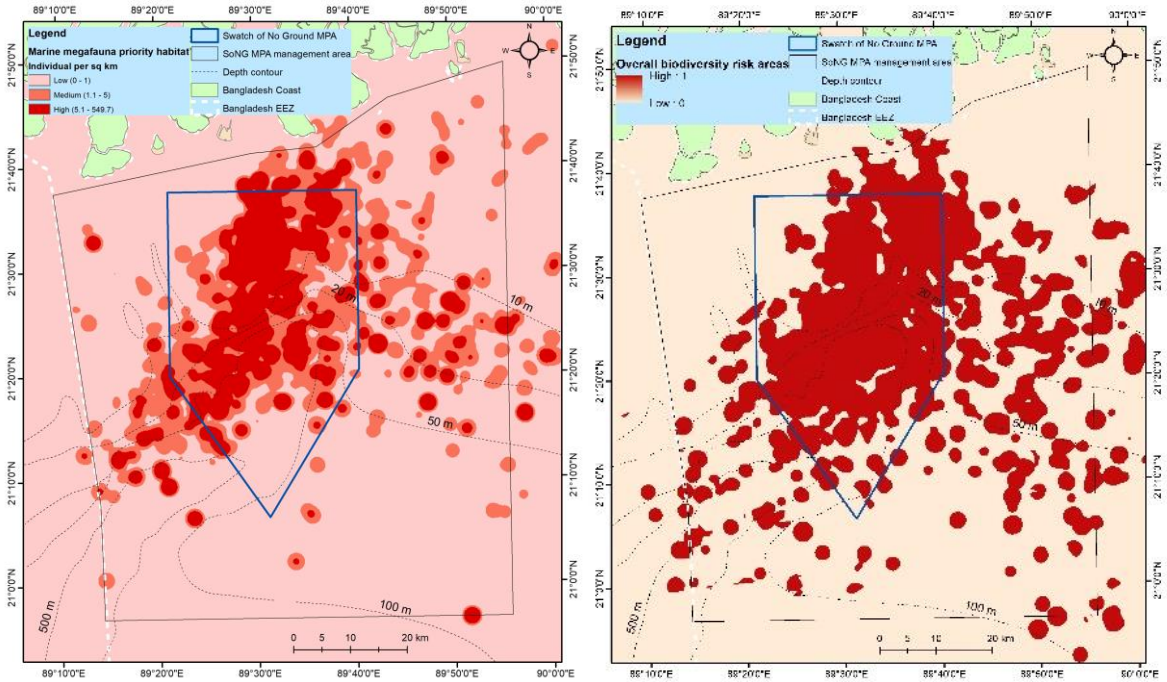

Figure 39. Spatially explicit data provided by WCS citizen science fishermen from June 2015 to February 2019 and from at-sea surveys and fisheries investigations conducted in winter seasons 2017/18 and 2018/19 were used to identify priority habitat for marine megafauna and seabirds (left) and areas of greatest risk according to the overlap of priority habitat and threats from non-target catches in fisheries and vessel traffic (right).

Community engagement and benefits

A key goal of MPAs is to benefit local communities that directly or indirectly depend on marine resources. In other words, a healthy ocean supports healthy people. When managed in the context of ecological and human systems, MPAs can lead to community empowerment, improved governance, productive and sustainable fisheries, and economic, social, educational, and cultural benefits (Bennett & Dearden 2014, Kittinger et al. 2014). Inadequate understanding of social and cultural values, attitudes, and practices can negatively impact conservation goals (Pomeroy et al. 2004).

Sharing information is the first step towards engaging communities, because their willingness to participate in MPA management is heavily influenced by their understanding (Rivera & Newkirk 1997). Acceptance of, and compliance with, MPA regulations requires communicating outcomes including social benefits and ecological improvements (Clarke 2016). Case studies from the Philippines, Indonesia and India have shown that MPA success is hindered by limiting participation, inequitable benefit sharing, and lack of mechanisms for conflict resolution (Christie 2004, Bavinck & Vivekanandan 2011).

During WCS at-sea interviews and community consultations, participants exhibited a strong interest in taking an active role in managing and monitoring human activities in the SoNG MPA. Their willingness provides a positive starting point for engaging local stakeholders. It also indicates the importance of ensuring transparent communication and community benefits.

The WCS *Citizen Science Fishermen Safety Network* provides small-scale fishers with training and equipment to safely navigate during storms in exchange for recording data on their fishing practices and catches. After a cyclone in September 2015, using a GPS provided by WCS and navigation skills learned from WCS training programs, one member of the network was able to save four fishermen floating in their life jackets at sea and another 18 fishermen stranded on remote coastal islands.[16] Because at-sea patrols have limited capacity for monitoring large ocean spaces, especially during the southwest monsoon season when weather conditions make patrols particularly difficult, citizen science networks are a promising option for evaluating the effectiveness of the SoNG MPA in protecting threatened marine wildlife and promoting sustainable fisheries, as well as guiding adaptive management strategies.

Raising awareness and increasing knowledge

Awareness about the SoNG MPA, including the location, management objectives, regulations, as well as anticipated benefits, for improving the understanding and support of marine resource dependent communities can be achieved by (i) installing informative signboards depicting location, objectives, benefits, and regulations at homeports and fish landing sites frequented by fishers active in the SoNG MPA; (ii) conducting educational community events and providing practical tools depicting applicable regulations; (iii) and community radio programs, documentary films, and media reports. Efforts to increase knowledge about the SoNG MPA should be closely coordinated with local constituencies, and organizers held accountable for the reliability of information shared.

[16]https://www.usaid.gov/sites/default/files/documents/1861/Saving%20lives%20welcome%20byproduct%20of%20GPS%20training%2003-09-2016.p df

WCS educational outreach initiatives, including interactive community events and practical tools (e.g., fish ruler indicating minimum legal measurements of regulated fish and mesh-size, laminated map and calendar indicating time-area closures and seasonal bans, and a traditional snake-and-ladder board game to teach ecological concepts and fishery rules) are examples of how increased knowledge can lead to improved compliance with fishery rules and regulations.

Incentives for compliance

In addition to communicating anticipated socio-economic and ecological improvements to fishing communities, reciprocal benefits for communities and MPA objectives should be established to strengthen compliance with SoNG MPA regulations and safely releasing threatened marine wildlife found entangled in fishing gears. Timely weather updates, navigation aids and improved means of communication for fishers at sea were identified as priorities during community consultations.

Monitoring and enforcement

Biological, threat, socio-economic and governance indicators are needed for assessing the effectiveness of the SoNG MPA. These could include such things as mortalities of marine wildlife and trends in fish catches recorded by citizen science fishermen, spatial and temporal distribution of illegal fisheries documented during SMART patrols (see below), standardized interviews in coastal communities with fishers that operate in the SoNG about their income, food security and working conditions at sea, and standardized interviews with field-level and senior officials from agencies engaged in management of the SoNG MPA (e.g., FD, DoF, Coast Guard and Navy) about governance issues. Data collected on biological, threat, socio-economic and governance indicators can be compiled and shared in a user-friendly database to enable a transparent process for monitoring progress in achieving MPA goals and informing adaptive management.

Spatial Monitoring and Reporting Tool (SMART)

One of the most successful strategies for enforcement and monitoring in MPAs uses a Spatial Monitoring and Reporting Tool (SMART). This free and user-friendly software (www.smartconservationtools.org) enables the collection, storage, communication, and evaluation of data on patrolling effort (e.g., time spent on patrols, areas visited, distances covered) and results (e.g., illegal fishing and marine wildlife observed, arrests made and warnings given).

A SMART approach combines this cutting edge, site-based management tool with capacity building and a set of protection standards. The power of SMART has been demonstrated in multiple sites around the world, where strengthened patrols guided by information from SMART have improved the performance of MPA staff and resulted in increases of marine wildlife and more sustainable and productive fisheries. SMART is currently being used by the FD in the Sundarbans to guide and evaluate wildlife and fishery protection efforts and adapt enforcement responses to conservation threats, with plans for expanding SMART patrols to other protected areas progressing.

Citizen science networks

The WCS *Citizen Science Fishermen Safety Network* engages small-scale fishermen as citizen scientists to record spatially explicit, as part of a long-term monitoring program in the SoNG MPA and provide an incentive for small-scale fishers to comply with MPA regulations. photo-verified data on their fishing practices, catches and bycatches in exchange for equipping and training them to increase their navigational safety. This successful model could be used to engage coastal communities

Sustainable financing

Sustainable financing for MPAs is a major challenge. Currently, a substantial portion of technical support for MPAs comes from donor agencies and NGOs, which is not sustainable in the long-term. A scoping study was conducted by WCS to evaluate sustainable finance options for conservation management in three wildlife sanctuaries for freshwater dolphins and the SoNG MPA (Iyer et al. 2019). Financing options were considered, including (i) private sector offset finance, (ii) government earmarking of tourism revenue, (iii) conservation trust funds, (iv) community eco-tourism, and (v) payment for ecosystem services.

The most promising long-term solution for supporting conservation management in the SoNG MPA is a probably establishing a conservation trust fund. While initially requiring substantial expertise and donor support, provisions from a trust fund can leverage financial support for infrastructure and operations from multi-lateral donors engaged in supporting a Blue Economy. Developing a new trust fund is a major undertaking. So, one option might be to expand and strengthen existing trust funds such as the Bangladesh Climate Change Trust Fund (BCCTF), Hilsa Conservation and Development Trust Fund, and the Arannayk Foundation Fund to ensure long-term and sustained funding for SoNG MPA management. Sustainability can be further enhanced by elevating MPAs to a national priority through a participatory planning process and raising awareness on the importance of protecting marine biodiversity for food security and sustainable fishing livelihoods.

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Appendix 1. Gazette Notification of the SoNG MPA.

রেজিস্টার্ড নং ডি এ-১

বাংলাদেশ গেজেট

অতিরিক্ত সংখ্যা
কর্তৃপক্ষ কর্তৃক প্রকাশিত

সোমবার, নভেম্বর ৩, ২০১৪

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার

পরিবেশ ও বন মন্ত্রণালয়

বন শাখা-২

প্রজ্ঞাপন

তারিখ ঃ ১২ কার্তিক ১৪২১/২৭ অক্টোবর ২০১৪

নং পবম/বঃ শাঃ-২/০২/বন্যপ্রাণী অভয়ারণ্য/১২/২০১০/১৫৫—বন্যপ্রাণী (সংরক্ষণ ও নিরাপত্তা) আইন, ২০১২ এর ধারা ১৩(১) এবং ১৩(২) এর ক্ষমতাবলে দক্ষিণ বঙ্গোপসাগরে অবস্থিত সোয়াচ অব নো-গ্রাউন্ড এর নিম্নতফসিল বর্ণিত ১৭৩৮ বর্গ কি. মি. অংশকে পাঁচ প্রজাতির বিপন্ন সামুদ্রিক ডলফিন (ইরাবতী ডলফিন, গোলাপি ডলফিন, বোতলনাক ডলফিন, চিত্রা ডলফিন, ঘুনি ডলফিন); পাখনাহীন পরপয়েস/শুশুক, কয়েক প্রজাতির তিমি (ব্রাইড্স তিমি, ফিন তিমি, কুঁজো তিমি, কমন স্পার্ম তিমি, খাটো স্পার্ম তিমি, ঘাতক তিমি, চদ্মঘাতক তিমি ইত্যাদি); এবং হাঙ্গর (হাতুরী হাঙ্গর, বাঘা হাঙ্গর, বিলাই হাঙ্গর, মুইচিয়া হাঙ্গর, কানি হাঙ্গর, চোখা হাঙ্গর, কালা হাঙ্গর, নীল হাঙ্গর, থুট্টি হাঙ্গর, ফৌরি হাঙ্গর, করাতি হাঙ্গর) সংরক্ষণ ও বংশবৃদ্ধির লক্ষ্যে বাংলাদেশ গেজেটে প্রকাশের তারিখ হতে "সোয়াচ অব নো-গ্রাউন্ড মেরিন প্রোটেক্টেড এরিয়া" হিসেবে ঘোষণা করা হলো ঃ

তফসিল

স্থানের নাম	প্রস্তাবিত সংরক্ষিত এলাকার নাম	সংরক্ষিত এলাকার পরিমাণ	সংরক্ষিত এলাকার গভীরতা	মন্তব্য
দক্ষিণ বঙ্গোপসাগর	"সোয়াচ অব নো-গ্রাউন্ড মেরিন প্রোটেক্টেড এরিয়া"	১৭৩৮ বর্গ কি. মি.	৯০০ + মি.	

(১৯৩৭১)
মূল্য ঃ টাকা ৪.০০

চৌহদ্দি

উত্তর	ঃ	বঙ্গোপসাগর সুন্দরবন পর্যন্ত বিস্তৃত
দক্ষিণ পূর্ব	ঃ	বঙ্গোপসাগর
দক্ষিণ পশ্চিম	ঃ	বঙ্গোপসাগরের ভারতীয় জলসীমা
পূর্ব	ঃ	বঙ্গোপসাগর
পশ্চিম	ঃ	বঙ্গোপসাগরের ভারতীয় জলসীমা পর্যন্ত বিস্তৃত
অবস্থান	ঃ	জিপিএস অনুসারে "সোয়াচ অব নো-গ্রাউন্ড মেরিন প্রোটেক্টেড এরিয়া"র অক্ষাংশ ও দ্রাঘিমাংশ নিম্নরূপ ঃ

অবস্থান	অক্ষাংশ	দ্রাঘিমাংশ
উত্তর	২১°৩৭′৩৫″	৮৯°৩০′২২″
উত্তর পশ্চিম	২১°৩৭′৩৫″	৮৯°২১′১৩″
উত্তর পূর্ব	২১°৩৭′৩৫″	৮৯°৪০′৩০″
দক্ষিণ পশ্চিম	২১°১৯′৫৭″	৮৯°২১′১৩″
দক্ষিণ পূর্ব	২১°২০′২৮″	৮৯°৪০′৩০″
দক্ষিণ	২১°০৬′২৫″	৮৯°৩১′১৪″

রাষ্ট্রপতির আদেশক্রমে

মোঃ নজিবুর রহমান
সচিব।

মোঃ নজরুল ইসলাম (উপসচিব), উপপরিচালক, বাংলাদেশ সরকারি মুদ্রণালয়, তেজগাঁও, ঢাকা কর্তৃক মুদ্রিত।
আবদুর রশিদ (উপসচিব), উপপরিচালক, বাংলাদেশ ফরম ও প্রকাশনা অফিস,
তেজগাঁও, ঢাকা কর্তৃক প্রকাশিত। website : www.bgpress.gov.bd

Appendix 2. List of shark species confirmed and suspected in the SoNG MPA with their Global IUCN Red List status. CR=Critically Endangered, EN=Endangered, VU=Vulnerable, NT=Near Threatened, LC=Least Concerned, DD=Data Deficient and NL= Not listed.

Common Name	Local Name/ Bengali name	Scientific Name	Global Red List Status
Recorded			
Scalloped hammerhead	তাম্রমাথা হাতুড়ি হাঙ্গর/জুলিয়া মাগর/কাইন্যা/কাউন্যা	*Sphyrna lewini*	CR
Whale shark	তিমি হাঙ্গর	*Rhincodon typus*	EN
Spadenose shark	ছুরি/কোদালনাক/থুট্টি হাঙ্গর/কামোট	*Scoliodon laticaudus*	NT
Spinner shark	ঘূর্ণি হাঙ্গর/ কালা লতা বলি হাঙ্গর	*Carcharhinus brevipinna*	NT
Tiger shark	বাঘা হাঙ্গর	*Galeocerdo cuvier*	NT
Blacktip shark	ইলিশা বলি/কালা হাঙ্গর/লতা বলি হাঙ্গর	*Carcharhinus limbatus*	NT
Bull shark	ঘ-বলি হাঙ্গর	*Carcharhinus leucas*	NT
Spottail shark	ফোঁটালেজী/কালা লতা বলি হাঙ্গর	*Carcharhinus sorrah*	NT
Bigeye hound shark	গুলে হাঙ্গর	*Iago omanensis*	LC
Pigeye shark	ভোঁতা বলি হাঙ্গর	*Carcharhinus amboinensis*	DD
Sharpnose shark	বলি হাঙ্গর	*Rhizoprionodon sp*	NA
Suspected			
Oceanic whitetip shark	সাদাটুপি হাঙ্গর	*Carcharhinus longimanus*	CR
Great hammerhead	বড় হাতুড়ি হাঙ্গর/বড় জুলিয়া মাগর/কাইন্যা/কাউন্যা	*Sphyrna mokarran*	CR
Pondicherry shark	পন্ডিচেরী হাঙ্গর	*Carcharhinus hemiodon*	CR
Pelagic thresher	পেলাজিক কাস্তে হাঙ্গর	*Alopias pelagicus*	EN
Winghead shark	পাখমাথা হাতুড়ি হাঙ্গর/জুলিয়া মাগর/কাইন্যা/কাউন্যা	*Eusphyra blochii*	EN
Longfin mako	বড়পাখ মাকো হাঙ্গর	*Isurus paucus*	EN
Broadfin shark	বড়পাখ চেনারি হাঙ্গর/সেনারি হাঙ্গর	*Lamiopsis temminckii*	EN
Shortfin mako	ছোটপাখ মাকো হাঙ্গর	*Isurus oxyrinchus*	EN
Whitecheek shark	সাদাগাল হাঙ্গর/কামোট	*Carcharhinus dussumieri*	EN
Silky shark	রেশমি/সিল্কি হাঙ্গর	*Carcharhinus falciformis*	VU
Snaggletooth shark	শাঁখাদাঁতী/শিয়াল-বলি হাঙ্গর	*Hemipristis elongata*	VU
Smooth hammerhead	জোয়াল হাতুড়ি হাঙ্গর/মাঝারি জুলিয়া মাগর	*Sphyrna zygaena*	VU
(Great) White shark	সাদা হাঙ্গর	*Carcharodon carcharias*	VU
Bigeye thresher	বড়চোখা কাস্তে হাঙ্গর	*Alopias superciliosus*	VU
Hooktooth shark	বড়শিদাঁতী হাঙ্গর	*Chaenogaleus macrostoma*	VU
Common thresher	পাতি কাস্তে হাঙ্গর	*Alopias vulpinus*	VU
Blackspot shark	কালাফোঁটা হাঙ্গর	*Carcharhinus sealei*	NT
Slender bamboo shark	সরু টট্যাং/গুইলা	*Chiloscyllium indicum*	NT
Brownbanded bamboo shark	বাদামিডোরা/কালাপাখ টট্যাং/গুইলা/বিলাই হাঙ্গর	*Chiloscyllium punctatum*	NT
Blue shark	নীল হাঙ্গর	*Prionace glauca*	NT
Pygmy ribbontail catshark	ফিতালেজী বামন হাঙ্গর	*Eridacnis radcliffei*	LC
Crocodile shark	কুমির টট্যাং/গুইলা	*Pseudocarcharias kamoharai*	LC

Milk shark	দুধরাজ/চোখা/সাদা বলি হাঙ্গর/কামোট	*Rhizoprionodon acutus*	LC
Grey sharpnose shark	আটাইল্যা/সোনা বলি হাঙ্গর	*Rhizoprionodon oligolinx*	LC
Pygmy shark	বামন হাঙ্গর	*Euprotomicrus bispinatus*	LC
Megamouth shark	মেগামাউথ হাঙ্গর	*Megachasma pelagios*	LC
Ornate dogfish	কমলা হাঙ্গর	*Centroscyllium ornatum*	DD

Appendix 3. List of ray species recorded and suspected in the SoNG MPA with their Global IUCN Red List status. CR=Critically Endangered, EN=Endangered, VU=Vulnerable, NT=Near Threatened, LC=Least Concerned, DD=Data Deficient, NL=Not listed.

Common Name	Local Name	Scientific Name	IUCN status
Recorded			
Sharpnose guitarfish	সরুনাক পিতাম্বরি/নাঙলা	*Glaucostegus granulatus*	CR
Largetooth sawfish	বড়দাঁত করাত মাছ/খান্দা মাগর/খটক/করাতি হাঙ্গর/আইশা	*Pristis pristis*	CR
Giant freshwater whipray	মিঠাপানির শাপলাপাতা/পাইন্যা/বাইল্যা	*Urogymnus polylepis*	EN
Whitespotted whipray	ফুল শাপলাপাতা/জাতি শাপলাপাতা	*Maculabatis gerrardi*	VU
Longtail butterfly ray	চাবুকলেজী প্রজাপতি/বাদুড়/ পদুনি/পদ্মমামনি	*Gymnura poecilura*	NT
Bengal guitarfish	বাংলা পিতাম্বরি/নাঙলা	*Rhinobatos annandalei*	DD
Bengal whipray	বাংলা ফাইস্যা/পাইসি	*Brevitrygon imbricata*	DD
Suspected			
Giant guitarfish	বড় কুদালনাক পিতাম্বরি/নাঙলা	*Glaucostegus typus*	CR
Widenose guitarfish	চ্যাপ্টানাক পিতাম্বরি/নাঙলা	*Glaucostegus obtusus*	CR
Clubnose guitarfish	গদানাক পিতাম্বরি/নাঙলা	*Glaucostegus thouin*	CR
Bowmouth guitarfish	ধনুকমুখী পিতাম্বরি/ব্যাঙ হাঙর	*Rhina ancylostoma*	CR
Smoothnose wedgefish	মসৃণনাক নাঙলা/পিতাম্বরি	*Rhynchobatus laevis*	CR
Bottlenose wedgefish	বোতলনাক নাঙলা/পিতাম্বরি	*Rhynchobatus australiae*	CR
Green sawfish	সবুজ করাত মাছ/খান্দা মাগর/খটক//করাতি হাঙ্গর/আইশা	*Pristis zijsron*	CR
Pointed/Narrow sawfish	ছুরি করাত মাছ/খান্দা মাগর/খটক/করাতি হাঙ্গর/আইশা	*Anoxypristis cuspidata*	EN
Spinetail/Giant devil ray	বড় শিংচোয়াইন/লেজকাঁটা বাদুর/দেউমাছ	*Mobula mobular*	EN
Longhorned pygmy devil ray	লম্বাকাইন্যা বামন শিংচোয়াইন/দেউমাছ	*Mobula eregoodootenkee*	EN
Shortfin pygmy devil ray	কুহলির শিংচোয়াইন/দেউমাছ	*Mobula kuhlii*	EN
Sicklefin devil ray	চিলি শিংচোয়াইন/দেউমাছ	*Mobula tarapacana*	EN
Bentfin devil ray	বাঁকাপাখ শিংচোয়াইন/দেউমাছ	*Mobula thurstoni*	EN
Longhead eagle ray	বড়মাথা ঠোট্ট্যা/টুইটা ঘাপরি	*Aetobatus flagellum*	EN
Mottled eagle ray	নকশি ঠোট্ট্যা/ফুল টুইটা ঘাপরি	*Aetomylaeus maculatus*	EN
Ocellate eagle ray	ফুল ঠোট্ট্যা/টুইটা ঘাপরি	*Aetomylaeus milvus*	EN
Roughnose cowtail ray	থ্যাবড়ানাক থাইন/হাঙরাইল	*Pastinachus solocirostris*	EN
Honeycomb whipray	বাঘা/হরিণা শাপলাপাতা	*Himantura undulata*	VU
Leopard whipray	বাঘা/চিতা শাপলাপাতা	*Himantura leoparda*	VU
Round whipray	গোল শাপলাপাতা/ফাইস্যা/পাইসি	*Maculabatis pastinacoides*	VU
Banded eagle ray	ডোরাকাটা ঠোট্ট্যা/টুইটা ঘাপরি/শঙ্খচিল	*Aetomylaeus nichofii*	VU
Coach (Reticulated) whipray	জালি/বাঘা/চিতা শাপলাপাতা	*Himantura uarnak*	VU
Javan cownose ray	জাভান ভোঁতা ঘাপরি	*Rhinoptera javanica*	VU
Spotted eagle ray	চিত্রা ঠোট্ট্যা/ফুল টুইটা ঘাপরি	*Aetobatus ocellatus*	VU
Mangrove whipray	বাদা শাপলাপাতা	*Urogymnus granulatus*	VU
Giant manta ray	দেউ শিংচোয়াইন/দেউমাছ/লুইমনি	*Mobula birostris*	VU
Jenkin's whipray	জাকিনের ঘণ্টি/ঘুড়ি শাপলা	*Pateobatis jenkinsii*	VU

Shortlip numbfish	ভোঁতামুখ কারেন্ট মাছ	*Narcine brevilabiata*	VU
Tubemouth whipray	চোঙামুখ শাপলাপাতা	*Urogymnus lobistomus*	VU
Whitenose whipray	সাদানাক শাপলাপাতা/হাউশ	*Pateobatis uarnacoides*	VU
Zonetail butterfly ray	জোনটেইল প্রজাপতি/বাদুড়/পদুনি/পদ্মমামনি	*Gymnura zonura*	VU
Whitespotted eagle ray	সাদাফোঁটা ঠোট্যা/ফুল টুইটা ঘাপরি/শঙ্খচিল	*Aetobatus narinari*	NT
Cowtail ray	পাতি থাইন/হাঙরাইল	*Pastinachus sephen*	NT
Ganges stingray	গাঙ্গেয় শাপলাপাতা	*Himantura fluviatilis*	NT
Scaly whipray	চিত্রা ফাইস্যা/পাইসি	*Brevitrygon walga*	NT
Sharpnose stingray	সরুনাক শাপলাপাতা	*Telatrygon zugei*	NT
Pelagic stingray	বেগুনী/কালা শাপলাপাতা	*Pteroplatytrygon violacea*	LC
Smalleye stingray	ক্ষুদেচোখা শাপলাপাতা	*Megatrygon microps*	DD
Smallspot numbfish	ফুটকি/ছোটফোঁটা কারেন্ট মাছ	*Narcine maculata*	DD
Spot-tail sleeper ray	চিত্রালেজী কারেন্ট মাছ	*Narke dipterygia*	DD
Smoothback guitarfish	তেলাপিঠ পিতাম্বরি/নাঙলা	*Rhinobatos lionotus*	DD
Chinese numbfish	চীনা কারেন্ট মাছ	*Narcine lingula*	DD
Tentacle butterfly ray	টেন্টাকল প্রজাপতি/বাদুড়/ পদুনি/পদ্মমামনি	*Gymnura tentaculata*	DD
Tonkin numbfish	টঙ্কিন কারেন্ট মাছ	*Narcine prodorsalis*	DD
Bluespotted maskray	নীলফোঁটা/ফুল শাপলাপাতা/ নপরা	*Neotrygon caeruleopunctata*	DD
Brown numbfish	বাদামি কারেন্ট মাছ	*Narcine timlei*	DD
Fine-spotted leopard whipray	বাঘা শাপলাপাতা	*Himantura tutul*	NL
Bleeker's whipray	রাম্মি/চুনি শাপলাপাতা	*Pateobatis bleekeri*	NL

Appendix 4: List of finfish and shrimp recorded and suspected from the SoNG MPA and adjacent areas with their Global IUCN Red List status. Genus listings are for those genera from which we were unable to identify any specimens to the species level from that genus. VU= Vulnerable, NT= Near Threatened, LC= Least Concerned, NL=Not listed, CS=Catch sampling, FI=Fishermen interview.

Common name	Bengali name	Scientific name	IUCN RL Status	Source
Recorded				
Grunt fish	দাতিনা	*Pomadasys sp*	NA	CS
Goby	বাইল্যা	*Taenioides sp.*	NA	CS
Grouper	ভোল মাছ	*Epinephelus sp.*	NA	CS
Hairfin anchovies	ফাইস্যা মাছ	*Setipinna sp.*	NA	CS
Bombay duck	লইট্টা	*Harpadon nehereus*	NT	CS
Chacunda gizzard shad	চাকুন্দা মাছ	*Anodontostoma chacunda*	LC	CS
Goatee croaker	পোয়া মাছ	*Dendrophysa russelii*	LC	CS
Hilsa shad	ইলিশ	*Tenualosa ilisha*	LC	CS
Kawakawa	কাউয়া মাছ	*Euthynnus affinis*	LC	CS
Largescaled terapon	বারগুনি মাছ	*Terapon theraps*	LC	CS
Paradise threadfin	তপশে মাছ	*Polynemus paradiseus*	LC	CS
Scaly hairfin anchovy	তেলি ফাইস্যা	*Setipinna taty*	LC	CS
Spined anchovy	চান্দা মাছ	*Stolephorus tri*	LC	CS
Threadfin sea catfish	টেংরা মাছ	*Arius arius*	LC	CS
Torpedo scad	কাউয়া মাছ	*Megalaspis cordyla*	LC	CS
Ramcarat grenadier anchovy	অলুয়া, বৈরাগী মাছ	*Coilia ramcarati*	DD	CS
Chinese silver pomfret	রূপচাঁদা	*Pampus chinensis*	NE	CS
Eel worm goby	চেওয়া	*Taenioides anguillaris*	NE	CS
Flathead sillago	তুলার ডান্ডি/উন্দুরা মাছ	*Sillaginopsis panijus*	NE	CS
Indian pike conger	সোনা বাইম	*Congresox talabonoides*	NE	CS
Karut croaker	পোয়া	*Johnius carutta*	NE	CS
Pama croaker	পোয়া	*Otolithoides pama*	NE	CS
Savalai hairtail	ছুরি মাছ	*Lepturacanthus savala*	NE	CS
Coromandel shrimp	গোদ্দা চিংড়ি	*Parapenaeopsis coromandelica*	NE	CS
Roshna prawn	গুড়া চিংড়ি	Exopalaemon styliferus	NE	CS
Reported				
Toli shad	চন্দনা ইলিশ	*Tenualosa toli*	VU	FI
Engraved catfish	কাঁটা	*Nemapteryx nenga*	NE	FI