Ichthyofaunal Assessment of Barima- Mora Passage Special Protected Area

Region 1, Guyana

Prepared by
Mark Ram, Guyana Marine Conservation Society

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Acknowledgment

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Introduction

Mangrove forests dominate the shorelines of tropical and subtropical regions, and they are among the most productive ecosystems in the world. Mangrove vegetation also called 'mangal' are salt-tolerant species found in coastal zones that influence marine food webs at every level (Flowers & Colmer, 2015). Mangrove forests play an important role in coastal ecosystems with a range of functions that support millions of people (Barbier et al. 2011, Friess et al. 2019a). These mangrove ecosystem services include coastal protection from storms, climate mitigation through carbon storage and sequestration (Alongi 2009), and supporting functions to fisheries (Aburto-Oropeza et al. 2008, Barbier et al. 2011).

Many species of fish use mangroves as nursery grounds because of both the nutritional and physical benefits they provide (Alongi, 2009). For example, they serve as a source of food for fish and as a safe place for juvenile fish located along Guyana's coastline (National Agricultural Research Institute, 2014). Mangrove forests are ideal as nursery grounds for fishes because of three factors; accessibility, survival, and growth (Alongi, 2009). Nursery grounds within mangroves are accessible because of the lateral trapping effect of the mangroves, which holds back and slow water flow, by absorbing wave energy and minimizing wave heights (Mazda et al., 2006). The complexity of the mangrove forest structure shelters juveniles from predators, ensuring higher survival rates (Rönnbäck, 1999).

Mangrove ecosystems are among the planet's most important tropical Social-Ecological Systems (SES) and for Guyana, wherein Region 1 alone, provides over US$ 3.4 billion in ecosystem services each year (Monsammy, 2019). Mangrove ecosystems of Region 1 are a mosaic of wetlands that extend from the brackish parts of the lower Kaituma River up to the Shell Beach Protected Area (SBPA) and across the Venezuelan border where they line the massive Orinoco River and its tributaries. These wetlands have benefitted hundreds of families belonging to the different indigenous groups living and freely migrating on both sides of the border who have lived and moved freely along the rivers and mangroves for centuries. From a functional perspective, these natural systems

provide low-cost barriers to minimize the impacts that threaten infrastructure and people's lives from flooding and sea-level rise. They are biodiversity hotspots where over half a dozen IUCN Red-listed animal species live, and many natural medicinal products are only now being discovered in these pristine social and ecological systems. The dynamic hydrological networks that weave through a mosaic of interconnected coastal lands linked to the Atlantic Ocean make them important nursery areas for fish, crabs, shrimp and other aquatic species, which local coastal communities depend upon for generating income and subsistence survival for their families.

Fish is a major food source and is an important source of protein for indigenous and non-indigenous communities of the Barima-Mora passage region. There is a growing demand for fish is growing within the region, as well as in booming markets in the regional capital of Mabaruma, across the coastal cities of Guyana, and in neighboring Venezuela. Increase demand can result in unsustainable fishing where fish populations decline and rural indigenous communities can suffer increased food insecurity.

In Guyana, knowledge of mangrove fishes is not well documented and limited to some information on commercial fishes. To date, in Guyana, all marine fisheries researches have focused solely on commercially important species from mangrove fringes and there has been no attempt to document riverine mangrove fishes. Therefore, there is much to be explored with regards to fish community structure in mangrove ecosystems such as species abundance, richness, diversity, and distribution in the riverine mangroves. These community structure indices are crucial to establish a baseline for the remaining healthy natural mangrove forest fish communities and to improve mangrove fish resource management and conservation.

This survey assessed the current state of fisheries of the BMPSPA, which included the community composition, commercial importance, and conservation status. This study provides a baseline for the monitoring of fishes over time, will contribute to the growing understanding of the status of fishes in the area. It also serves as a key input to the application of the Barima-Mora Passage to the UNESCO World Heritage Committee.

Methods

Study site

The BMPSPA, located in the northern part of Region 1 near the Venezuelan border, approximately 5 km north of the town of the regional capital of Mabaruma and adjacent to the Marahouana settlement at the intersection of the mouth of the Barima and Aruka rivers contains the largest remaining mangal ecosystems forests in Guyana.

The BMPSPA is at the heart of the dynamic mangal ecosystems driven by tides, floods and rainfall. There are three mangrove species (*Avicennia germinans*, *Rhizophora spp*., *Laguncularia racemosa*), which are closely linked to the surrounding freshwater swamps and tidal wetlands found along the rivers, tidal creeks, and estuarine areas. The red mangroves (*Rhizophora spp*) were more dominant than the other species which occur in much smaller patches. *Nypa fruticans*, a non-native mangrove palm was also common along the river edges. This introduced species from South East Asia is abundant in tidally influenced and saltier parts of Mora Passage and the Waini Rivers. It tends to cover wet areas along the rivers and in wet areas behind the mangroves, and it can spread profusely, blocking out space for native species to establish themselves. A total of 24 sites were sampled of which 19 were sampled using gillnets and 5 using drag nets.

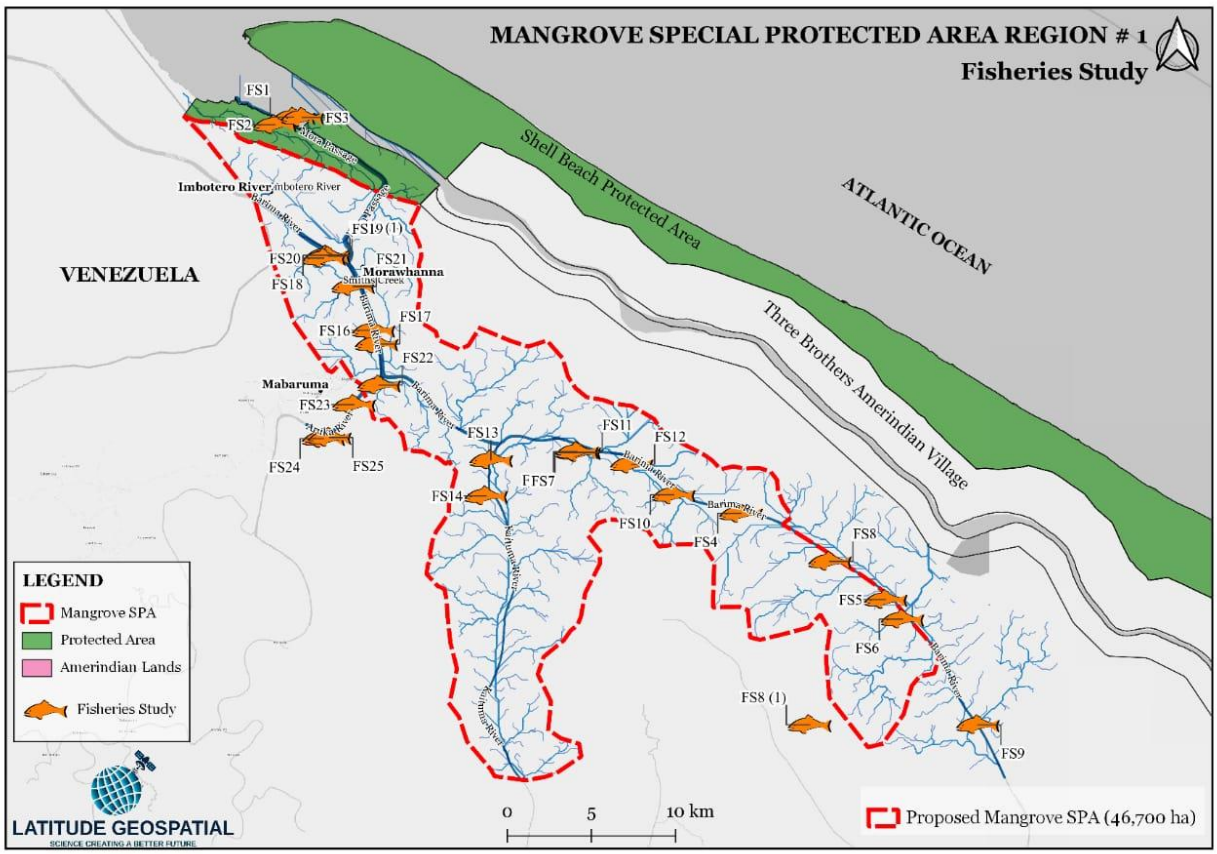

Figure 1: Sampling sites

Psychochemical parameters

The temperature was measured in °C with a handheld thermometer probe to the nearest one decimal place. Dissolved oxygen was measured with a multi-parameter water quality meter to the nearest mg/L. pH was measured to one decimal place with a waterproof pH meter and salinity was recorded in percent to the nearest one decimal place using a refractometer.

Fish sampling

Fishes were sampled during the dry season (6-11 September 2021) using a combination of dragnet and gill nets with different dimensions that included (1) 200 m × 1.30 m - 50 mm mesh, (2) 200 × 1.30 m - 40 mm mesh, and (3) 200 m × 1.30 m - 25 mm mesh. Gillnets were set close to the mangrove forest edge to capture larger fishes. Gillnets will

also be placed in open areas along rivers and streams to capture larger fish. The gill nets were deployed before the onset of the high tide and will be checked hourly for two hours at all sites. Drag nets were used to capture smaller fishes present between the mangrove roots and small pools, where possible. Fishes caught were photographed and identified to species level using taxonomic keys and guides before releasing them back into their natural habitats.

Community surveys

Random villagers from the communities were interviewed to understand fisheries trends in the area. Information on population dynamics, species composition, consumer preference, fishing techniques, etc. were collected.

Results

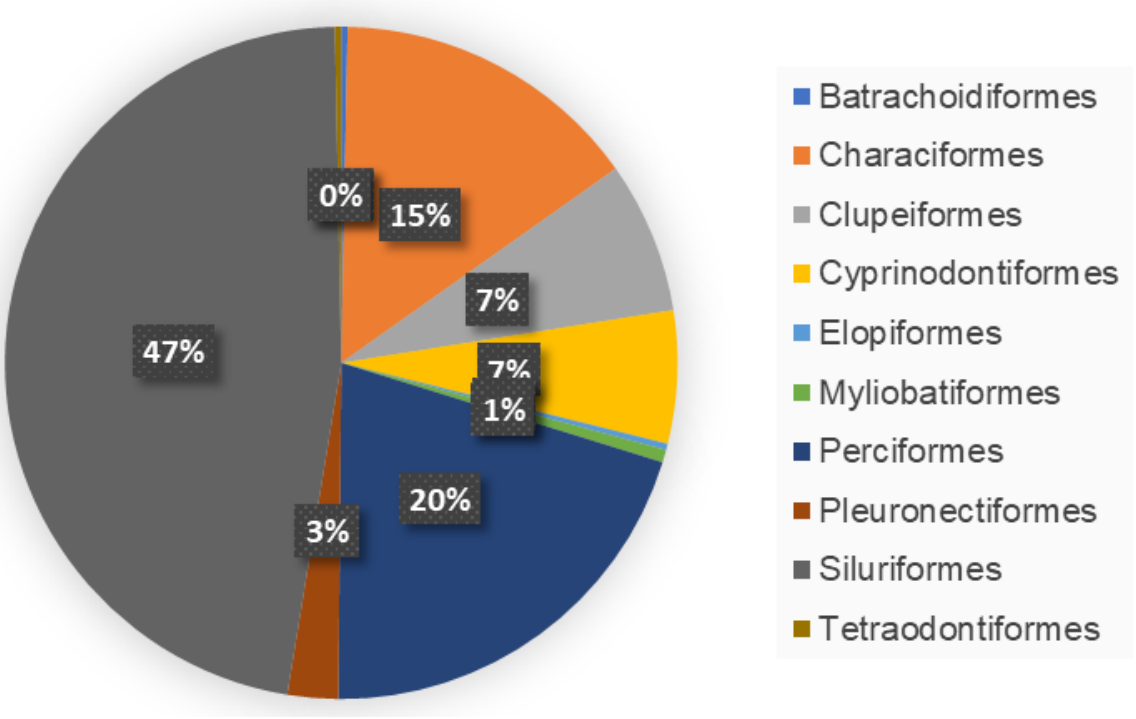

Figure 2: Family composition of fishes from the BMPSPA

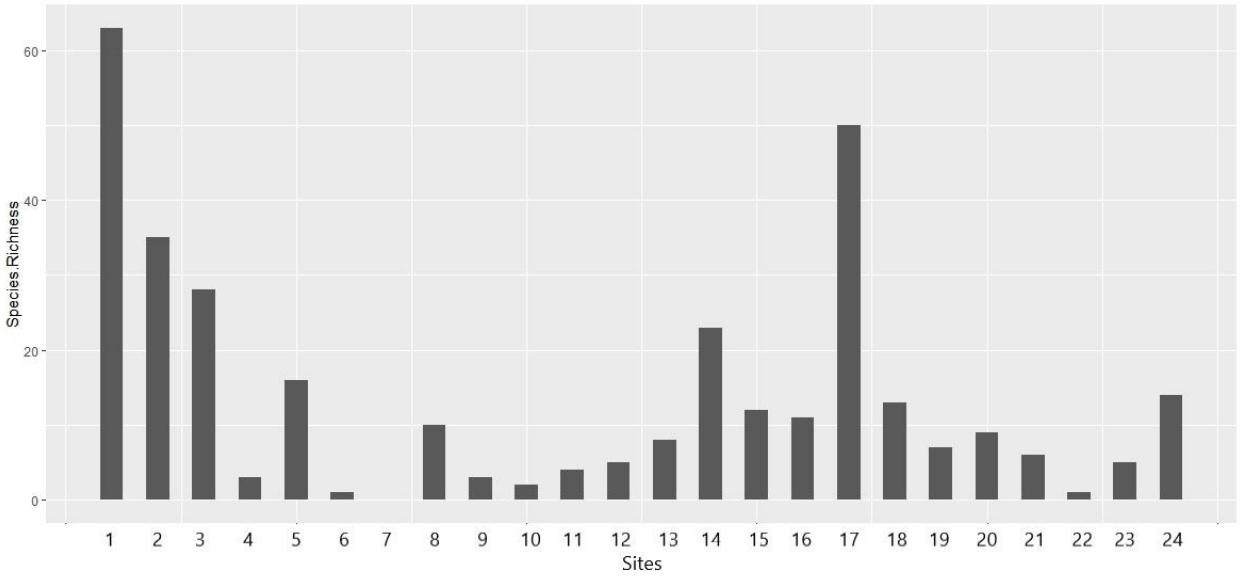

Figure 3: Species richness of different sampling sites at the BMPSPA.

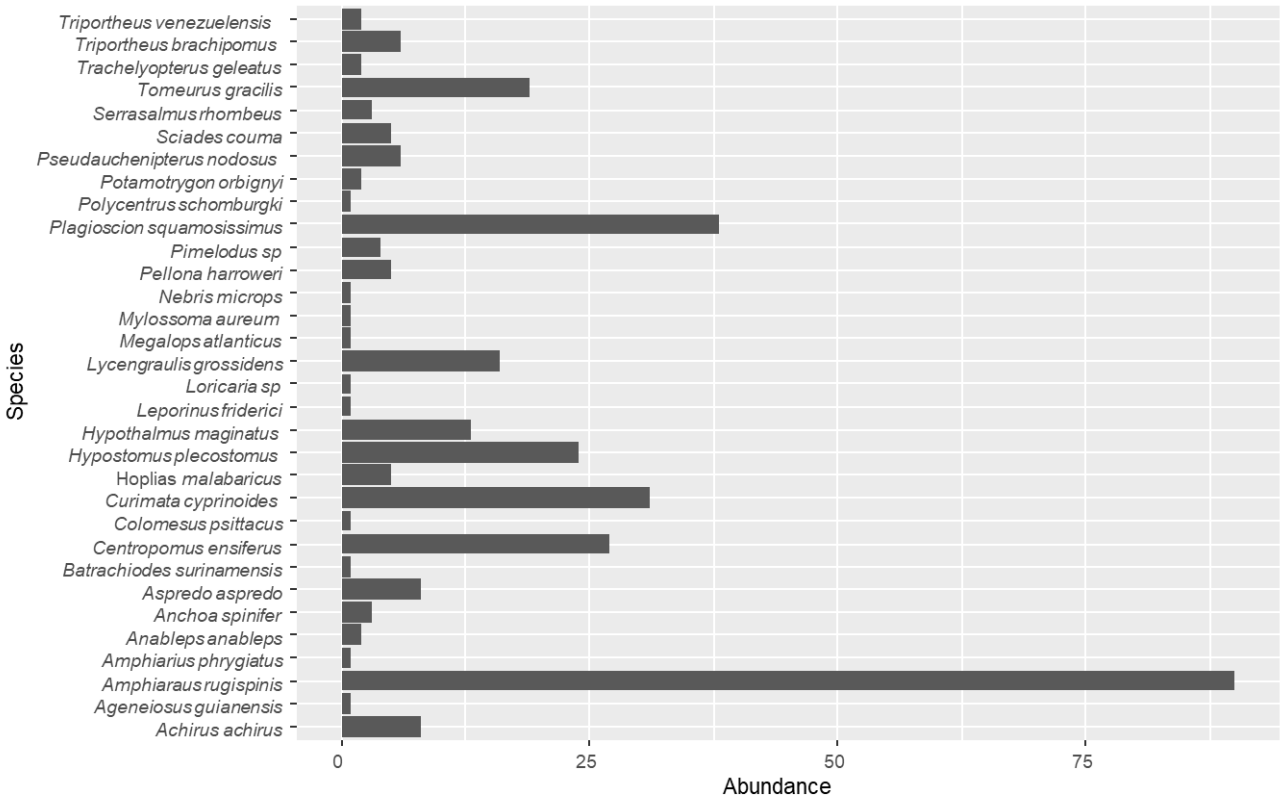

Figure 4: Fish species abundance of the BMPSPA

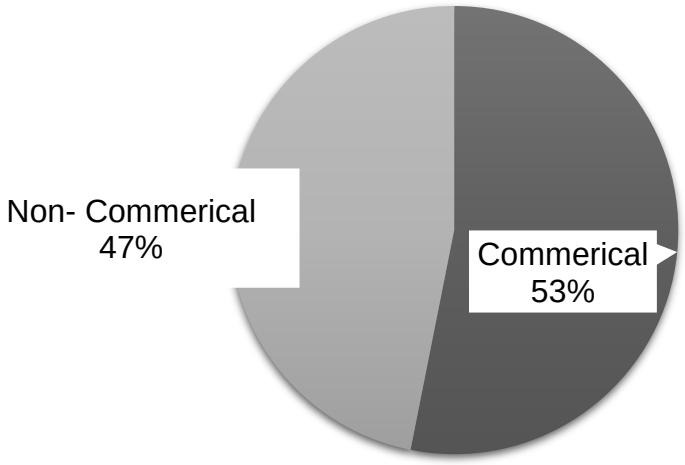

Figure 5: Commercial status of fishes from the BMPSPA

Table 1: Psychochemical parameters

Parameter	**Range**	**Mean**
Dissolved Oxygen (mg/L)	0.52-10.16	1.782083
Temperature (o^C)	28.1-37.5	32.36957
Electrical conductivity (us/cm)	50-14710	1654.458
Salinity (%)	0	0

Table 2: BMPSPA fish composition, conservation status and commercial importance

Order	Family	Species	No. of Individuals	Local Name	IUCN Status
Batrachoidiformes	Batrachoididae	*Batrachiodes surinamensis*	1	Pacu	Not Assessed
Characiformes	Serrasalmidae	*Serrasalmus rhombeus*	3	Piranha	Not Assessed
Characiformes	Curimatidae	*Curimata cyprinoides*	31		Not Assessed
Characiformes	Triportheidae	*Triportheus brachipomus*	6		Not Assessed
Characiformes	Triportheidae	*Triportheus venezuelensis*	2		Not Assessed
Characiformes	Anostomidae	*Leporinus friderici*	1		Not Assessed
Characiformes	Erythrinidae	*Hoplias malabaricus*	5	Huri	Least Concern
Characiformes	Serrasalmidae	*Mylossoma aureum*	1	Moracut	Not Assessed
Clupeiformes	Pristigasteridae	*Pellona harroweri*	5	Shad	Least Concern
Clupeiformes	Engraulidae	*Lycengraulis grossidens*	16	Herring	Least Concern
Clupeiformes	Engraulidae	*Anchoa spinifer*	3	Brown Herring	Least Concern
Cyprinodontiformes	Poeciliidae	*Tomeurus gracilis*	19		Not Assessed
Cyprinodontiformes	Anablepidae	*Anableps anableps*	2	Foureye	Not Assessed
Elopiformes	Megalopidae	*Megalops atlanticus*	1	Cuffum	Vulnerable
Myliobatiformes	Potamotrygonidae	*Potamotrygon orbignyi*	2	Singaray	Least Concern
Perciformes	Polycentridae	*Polycentrus schomburgki*	1	Granny Patwa	Not Assessed
Perciformes	Sciaenidae	*Plagioscion squamosissimus*	38	Basha	Least Concern
Perciformes	Sciaenidae	*Nebris microps*	1	Butterfish	Least Concern
Perciformes	Centropomidae	*Centropomus ensiferus*	27	Snook	Least Concern
Pleuronectiformes	Achiridae	*Achirus achirus*	8	Flounder	Least Concern
Siluriformes	Auchenipteridae	*Trachelyopterus geleatus*	2	Imiri	Not Assessed
Siluriformes	Auchenipteridae	*Ageneiosus guianensis*	1	Dawalla	Not Assessed
Siluriformes	Loricariidae	*Hypostomus plecostomus*	24		Not Assessed
Siluriformes	Ariidae	*Sciades couma*	5	Cuirass	Least Concern
Siluriformes	Aspredinidae	*Aspredo aspredo*	8	Banjoman	Least Concern
Siluriformes	Ariidae	*Amphiaraus rugispinis*	90	Twi Twi	Least Concern
Siluriformes	Pimelodidae	*Hypothalmus maginatus*	13	Highwater	Not Assessed
Siluriformes	Auchenipteridae	*Pseudauchenipterus nodosus*	6	Sweetman	Not Assessed

Siluriformes	Pimelodidae	*Pimelodus sp*	4	Lariman	Not Assessed
Siluriformes	Ariidae	*Amphiarius phrygiatus*	1	Kukwari	Least Concern
Siluriformes	Loricariidae	*Loricaria sp*	1		Not Assessed
Tetraodontiformes	Tetraodontidae	*Colomesus psittacus*	1	Puffer fish	Least Concern

Discussion

Fish composition

A total of 329 fishes from 32 species representing 10 families were recorded during this survey. The dominant species was *Amphiaraus rugispinis* (Twi Twi) who inhabits coastal, turbid waters of estuaries and river mouths. The Clupeiformes (herring, sardines, shad, anchovies, and allies) family was the most abundant family and this is expected since these filter-feeding fishes form large schools and occupy a diverse array of trophic guilds and habitats (Bloom & Egan, 2018). Site one had a higher species richness than the other sites due to a high abundance of *Amphiaraus rugispinis* from the Atlantic Ocean. All of the fish species recorded in this study are native to Guyana except for *Triportheus venezuelensis* which is native to Venezuela.

Most of the fishes capture by the gillnets were adults, while those capture by the dragnet were juveniles and this trend is well supported in literature due to their unique function of nursery support (Adite et al., 2013; Hutchison & Spalding, 2014; Laegdsgaard & Johnson, 1995). Mangroves usually support fisheries via two main mechanisms. The first is the high level of primary productivity from the mangrove trees and other producers in the mangrove environment (Hutchison & Spalding, 2014). This forms the basis of food chains that support a range of commercially important species. The second is the physical structure that they provide, which provides attachment points for species that need a hard substrate to grow on, as well as shelter from predation and a benign physical environment (Hutchison & Spalding, 2014). These two mechanisms combine to make mangroves particularly effective as nursery grounds for juveniles of species that later move offshore or to adjacent habitats such as coral reefs (Hutchison & Spalding, 2014).

Conservation status

The conservation status of each species was assessed using the IUCN Red List. While most of the species were not assessed, some were classified as least concerned indicating there are no immediate threats to these species. However, one species, *Megalops atlanticus* (Cuffum), was classified as vulnerable indicating that the species is

near threatened (*IUCN Red List of Threatened Species*, n.d.). While there has been no formal stock assessment of this species, multiple lines of evidence suggest that populations of *Megalops atlanticus* are declining from their historic levels throughout their range. This decline is largely due to regional commercial harvest, especially in Brazil. To conserve this and other species with their habitats, many countries are using marine protected areas in conjunction with existing fisheries regulations to build sustainable fisheries and protect marine biodiversity. Catch-and-release is commonly practiced by recreational anglers with strong conservation in regions where *Megalops atlanticus* is distributed. Considering the vulnerability of this species, the Barima Mora Passage can be the ideal habitat for this species if given a legally protected status.

Commercial importance

Most of the species caught were commercially important (52%) to the people in this region. There are sold at local markets or traded for other goods and services in the region. This finding highlights the importance of mangroves to fisheries in the area, supporting both commercial and non-commercial fish species. It also emphasizes the need for intact mangrove habitats such as the proposed BMPSPA to support fisheries and livelihoods.

Water quality

The dissolved oxygen levels recorded in this study were lower than the recommended concentration of 5 mg/L for optimum fish health. However, sensitivity to low levels of dissolved oxygen is species-specific and some fish species are distressed when DO falls to 2-4 mg/L. Temperature strongly regulates the distribution and fitness of fishes. The temperature range of this study was slightly above the preferred range for most tropical fishes. Even though Guyana is in its dry season, the salinity was extremely low along the river and due to the presence of freshwater from Guyana's extended wet season. Lower salinity is preferred by more freshwater fish species as reflected by this study. The preferred conductivity for freshwater fish ranges between 200 to 1000 µS/cm and most of the sites were within this range. However, a few sites closer to the Atlantic Ocean were characterized by higher electrical conductivity indicating more saline conditions.

Fisheries trends

At the Kumaka fish market, both freshwater (basha, moracut, snook, etc) and marine fish (banga, curirass, butterfish, etc.) species are sold. Based on informal interviews, there is no decline with any of the species in the region, but greater effort is expended to capture some of these species, especially the moracut, which is endemic to the Region 1 area. Greater fishing efforts indicate shifting habitats due to increased anthropogenic activities in the river and the open sea. Non-destructible gill nets and hook and lines are the common fishing gears used along the rivers. Even though the gear types and techniques are sustainable, the local market demand for the moracut threatens the sustainability of this species.

Immigration from Venezuela

The harsh economic climate and political instability in neighboring Venezuela have led to the forced migration of Venezuelan families to Guyana and other neighboring countries. Region 1 is one of two regions in Guyana that share borders with Venezuela. As a result, there has been an influx of Venezuelan families into the villages with the region. The exact numbers of persons that have migrated to the villages are difficult to determine. However, it is estimated that there are over 23,0000 Venezuelan migrants in Guyana. Many of the migrants in Region 1 are indigenous peoples of the Warrau and other groups.

In terms of natural resource utilization and mangal resources, the new migrants have been observed in some communities, for example, Morawhanna, Smith's Creek and Imbotero using mangroves for construction purposes. Migrants have also cleared large areas of forest to construct new homes contributing to habitat and biodiversity loss. This habitat loss can adversely affect fish through the destruction of the nesting and spawning grounds. The higher population density in the region will also place greater pressure on the fish since it is the main source of protein for the local people.

Conclusion

The BMPSPA is a unique habitat for multiple species of freshwater and estuarine fishes. The area supports many commercial species and vulnerable species making it important for the livelihood of the local communities. Therefore, there is an urgent need for legal protection of this area to preserves the existing mangroves, biodiversity, and ecosystem services while maintaining the livelihood of locals.

Recommendations

- Continuous monitoring of the fish population should be undertaken to assess any changes in community structure over time.

- Water quality monitoring is important to track any changes in water as a result of saltwater intrusion from the Atlantic Ocean and anthropogenic activities.

- Aquatic invertebrates, especially crabs should also be surveyed since they are ecosystem indicators, and they can be used to determine the health of aquatic ecosystems.

- The dumping of solid waste in the river should be urgently addressed to avoid plastic contamination of aquatic organisms.

- A study should be undertaken to determine if microbial contamination is present in fishes specifically in areas where the communities are. This study is needed due to the lack of proper toilet facilities in many of the indigenous communities.

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Appendix

Achirus achirus

Centropomus ensiferus

Hypothalmus maginatus

Curimata cyprinoides

Triportheus brachipomus

Polycentrus schomburgki

Aspredo aspredo

Trachelyopterus geleatus

Hypostomus plecostomus

Serrasalmus rhombeus

Potamotrygon orbignyi

Centropomus ensiferus

Plagioscion squamosissimus