Ichthyofaunal integrity, hydrological and environmental features trade-off in the Sunderbans, India

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Received: 2 May 2020 / Accepted: 14 September 2020

Abstract. Herein, we studied the ichthyofaunal diversity of the Bidyadhari River in the Indian Sundarbans for three consecutive months (April 2018-June 2018). The fishes in this study were captured and collected from two collecting stations (points) using bag nets operated by local fishers. We determined Simpson’s index of diversity (1-D), Shannon-Wiener’s index (H) and the coefficient of community (CC) to find out the species richness, abundance, evenness and the levels of similarity between the two collection points. We converted the H values to true diversities (effective number of species [ENS]) for an adequate comparison. The indices and coefficient (H = 3.72-4.05, 1-D = 0.96-0.97 and CC = 0.87) indicate that the overall integrity of biodiversity of the two collecting points is moderately high. From the true diversity values, we conclude that the first collecting point is 1.39 times as diverse as the second one. It is attributed to a complex of abiotic and biotic factors that we talk about in the discussion part. We also recorded 19 species of fishes which are new reports for the Indian Sundarbans and discuss the possible reasons for their occurrence.

Keywords: ecology, effective number of species, mangroves, new-records, salinity.

1. Introduction

One of the end goals of conservation is to recommend zones for rebuilding or protection. Researchers are required to propose straightforward, engineered and—if possible—cheap means for the assessment of the natural status of streams and rivers (Darwall & Vie', 2005). Also, the organic components in the biological community should be recognized to comprehend the strength of a conservation or restoration framework (Marzluff & Ewing, 2008). Due to their life-history traits, versatility and their affectability to changes in their natural surroundings, fishes are great bio-markers and regularly utilized for the appraisal of the biological integrity of waterways (Karr, 1981; Welcomme et al., 2006). Fish diversity consists of species richness (number of species in a characterized territory), species abundance (relative number of species) and phylogenetic diversity (connections between various groups of species). These three are related to the dynamic changes in hydrological features and the change in assemblage seasonally (Brinda et al., 2010).
The Sundarbans mangrove forest in the eastern state of West Bengal, India comprises about half of the total mangrove area of India; 2114 km² (FSI, 2017). It is one of the most productive ecosystems of the world with a good percentage of its human population depending on it for subsistence (Andharia, 2020). Fishes provide a whole range of ecosystem services to the region.

In the present case study, we looked at the diversity of fish species, their dominance and similarity between two collecting stations (points). We tried to recognize the role of hydrological factors in the composition of the fishes of the region. Also, some species of fishes we encountered are new records for the Indian Sundarbans. These records give us insight into their distribution and, possible reason for their range extension. We have provided the taxonomic descriptions of the newly recorded fishes in the results section.

2 Material and Methods

2.1 Study Area

The location of the Sundarbans mangrove delta is between 20°31’ and 22°38’ North and 88°50’ and 90°28’ East. In India, it lies in the state of West Bengal covering three districts. It’s bounded by the Bangladesh Sundarban in the east, River Hooghly in the west, Nadia district in the north (the Dampier-Hodges line) and the Bay of Bengal in the South. The Indian Sundarbans is a UNESCO world heritage site with rich floral and faunal diversity (Sarkar & Bhattacharya, 2003). Species of the family, Rhizophoraceae dominates the mangroves of the Ganges Delta (Barik & Chowdhury, 2014). Recent research documented 27 species of true mangroves plants from the Sundarbans (Sreelekhsmi et al., 2020).

For this study, we carried out ichthyofaunal sampling at two collection stations (also referred hereafter as community A and community B): Point A: N 22°02.749’/ E 088°44.480’ and point B: N 21°59.682’/ E 088°42.759’ (Fig. 1). Both were located near the islands: Gosaba and Bali-I. These islands are the last inhabited area before the protected mangrove forests start.
2.2 Species Composition and Nomenclature

We followed standard literature to identify the fishes (e.g., SmithVaniz, 1984; Whitehead, 1985; Talwar & Jhingran, 1991). We used online databases to ascertain the valid nomenclature (e.g., Froese & Pauly, [eds] 2019; Van der Laan et al., 2020; Fricke et al., 2020). IUCN Red List (2020) was used to evaluate the conservation status of each species.

2.3 Field Sampling and Taxonomic Analysis

Between April 2018 to June 2018 (pre-monsoon season), we accompanied fishers to the two collecting stations on the Bidyadhari River for 10 consecutive days of every month. The fishers used 'Behundi/ Benthi jaal', a form of the bagnet. The net had a width of 40 m, length of 53 m and a height of 14 m with the tapering end having a 2.8 m diameter. The mesh size was 1mm made of nylon monofilament. The nets were deployed right before the onset of the high tide and the soak time was for three hours. The pH value and temperature of the water (HANNA™) were taken before the nets were deployed. The salinity of the water was
measured using a refractometer (ERMA™). Dissolved oxygen (Digital Instruments™) and the euphotic depth (using a Secchi disk) was also measured.

The fish were collected opportunistically from the catch. They were fixed (in 10% formalin) and later stored (in 70% ethanol). The specimens were deposited and catalogued at the National Zoological Collection, Zoological Survey of India. Counts of measurements were made on the left side of the specimens using digital vernier callipers (Mitutoyo™) and stereoscopic microscopes (Leica™).

2.4 Statistical Analysis

Diversity indices (Simpson’s, Shannon-Wiener) were computed using the PAST (PAleontological STatistics) software version 3.20 (Hammer et al., 2001). The Coefficient of community was calculated using the MS Excel statistics package to find the degree of similarity in biodiversity between the sampled points. The Shannon values were turned to true biodiversity values by calculating the exponent (in MS Excel) of the Shannon-Weiner index for the respective communities.

3. Results

3.1 Ichthyofaunal composition

The ichthyofaunal composition of the two collecting points amounted to 446 specimens comprising 114 species belonging to 90 Genera, in 40 families and 16 orders, under two classes: Chondrichthyes and Actinopterygii. The complete list of fishes collected from both the points is in Table 1 following Van der Laan et al. (2020) along with their respective IUCN conservation statuses. The fish faunal composition of the two stations (points) showed that point A has a higher number of fish species composition percentage-wise. The different orders of fish and their representation in percentage (Fig. 2) are as follows: Perciformes (35.7%) with 42 species dominating the region, followed by Clupeiformes (15.2%) with 17 species and Gobiiformes (9.8%) with 11 species. The fourth-order is Pleuronectiformes (8%) with nine species, followed by Scombriformes (6.3%) with seven species. Cumulatively, these five orders comprise 75% of the species encountered. The rest 25% is comprised of 11 orders; Silluriformes (5.4%), Mugiliformes (5.4%), Cypriniformes (4.5%), Scorpaeniformes (1.8%), Anguilliformes (1.8%), Tetraodontiformes (1.8%), Beloniformes (1.8%), Myliobatiformes (0.9%), Aulopiformes (0.9%), Cichliformes (0.9%) and Gadiformes (0.9%).
Figure 2. Major dominating fish orders in percentage from the two points in the Sundarbans

The fish species contributing to the highest dominance among the collected samples are: *Amblypachyodon mola* - 27 examples, *Bregmaceros mcclellandi* - 22 examples, *Escualosa thoracata* - 21 examples, *Puntius sophore* - 13 examples, *Gonialosa manmina* - 12 examples, *Coilia ramcarati* - 11 examples, *Periopthalmus novemradiatus* - 10 examples, *Ilisha kampeni* - 10 examples, *Salmostoma bacaila* - 10 examples and *Planiliza tade* - 10 examples.

We recorded 19 fish species for the first time from Indian Sundarbans region during this study (Table 1). That effectively brings the total number of fish species recorded from the Indian Sundarbans to 374.

Table 1. The list of fishes collected from the two points in the Indian Sundarbans

| Order             | Family           | Species                             | Common name         | IUCN Status |
|-------------------|------------------|-------------------------------------|---------------------|-------------|
| Myliobatiformes   | Dasyatidae       | *Brevitrygon imbricata* (Bloch & Schneider, 1801) | Scaly whipray      | DD          |
| Anguilliformes    | Muraenidae       | *Gymnothorax tile* (Hamilton, 1822)  | Mud moray eel       | LC          |
| Clupeiformes | Congridae | **Uroconger lepturus** (Richardson, 1845) | Slender conger eel | LC |
| Clupeiformes | Clupeidae | **Escualosa thoracata** (Valenciennes, 1847) | White sardine | LC |
| Clupeiformes | Clupeidae | **Gonialosa manmina** (Hamilton, 1822) | Ganges river gizzard shad | LC |
| Clupeiformes | Clupeidae | **Sardinella longiceps** Valenciennes, 1847 | Indian oil sardine* | LC |
| Clupeiformes | Clupeidae | **Sardinella fimbriata** (Valenciennes, 1847) | Fringe-scaled sardinella* | LC |
| Clupeiformes | Clupeidae | **Tenualosa toli** (Valenciennes, 1847) | Toli shad | VU |
| Clupeiformes | Engraulidae | **Setipinna taty** (Valenciennes, 1848) | Scaly hairfin anchovy | LC |
| Clupeiformes | Engraulidae | **Setipinna tenuifilis** (Valenciennes, 1848) | Common hairfin anchovy | DD |
| Clupeiformes | Engraulidae | **Coilia ramcarati** (Hamilton, 1822) | Ramcarat grenadier anchovy | DD |
| Clupeiformes | Engraulidae | **Thryssa gautamiensis** Babu Rao, 1971 | Gautama thryssa | DD |
| Clupeiformes | Engraulidae | **Thryssa kammalenosoides** Wongratana 1983 | Godavari thryssa* | NE |
| Clupeiformes | Engraulidae | **Thryssa spinidens** (Jordan and Seale, 1925) | Bengal thryssa* | DD |
| Clupeiformes | Engraulidae | **Stolephorus commersonii** Lacepede, 1803 | Commerson’s anchovy | LC |
| Clupeiformes | Pristigasteridae | **Raconda russeliana** Gray, 1831 | Raconda | LC |
| Clupeiformes | Pristigasteridae | **Pellona ditchela** Valenciennes, 1847 | Indian pellona | LC |
| Taxon      | Family       | Species                     | Common Name                        | Status |
|------------|--------------|-----------------------------|------------------------------------|--------|
| Clupeiformes | Pristigasteridae | *Ilisha megaloptera* (Swainson, 1839) | Bigeye ilisha                      | LC     |
| Clupeiformes | Pristigasteridae | *Ilisha kampeni* (Weber & De Beaufort, 1913) | Kampen’s ilisha                   | LC     |
| Cypriniformes | Cyprinidae | *Salmostoma bacaila* (Hamilton, 1822) | Large razorbelly minnow            | LC     |
| Cypriniformes | Cyprinidae | *Puntius sophore* (Hamilton, 1822) | Pool barb                          | LC     |
| Cypriniformes | Cyprinidae | *Cirrhinus mrigala* (Hamilton, 1822) | Mrigala                            | LC     |
| Cypriniformes | Cyprinidae | *Pethia ticto* (Hamilton, 1822) | Tic-tac toe barb                   | LC     |
| Silluriformes | Plotosidae | *Plotosus canius* (Hamilton, 1822) | Eel catfish                        | NE     |
| Silluriformes | Bagridae | *Mystus gulio* (Hamilton, 1822) | Long whiskers catfish              | LC     |
| Silluriformes | Bagridae | *Sperata seenghala* (Sykes, 1839) | Giant river catfish                | LC     |
| Silluriformes | Ariidae | *Netuma thalassina* (Ruppell, 1837) | Giant sea catfish                  | LC     |
| Silluriformes | Ariidae | *Nemapteryx nenga* (Hamilton, 1822) | Engraved catfish                   | NE     |
| Silluriformes | Ariidae | *Arius arius* Hamilton, 1822 | Threadfin sea catfish              | LC     |
| Aulopiformes | Synodontidae | *Harpadon nehereus* (Hamilton, 1822) | Bombay duck                        | NT     |
| Class           | Family        | Species Name                                    | Common Name                  | Status  | Region |
|-----------------|---------------|-------------------------------------------------|------------------------------|---------|--------|
| Gadiformes      | Bregmacerotidae | *Bregmaceros mcclellandi* Thompson, 1840       | Unicorn cod                  | NE      |        |
| Scombriformes   | Trichiuridae  | *Lepturacanthus savala* (Cuvier, 1829)          | Savalai hairtail             | NE      |        |
| Scombriformes   | Trichiuridae  | *Lepturacanthus pantulii* (Gupta, 1966)         | Coromandel hairtail          | DD      |        |
| Scombriformes   | Trichiuridae  | *Eupleurogrammus glossodon* (Bleeker, 1860)    | Longtooth hairtail*          | LC      |        |
| Scombriformes   | Scombridae    | *Scomberomorus lineolatus* (Cuvier, 1829)       | Streaked seerfish*           | LC      |        |
| Scombriformes   | Scombridae    | *Scomberomorus guttatus* (Bloch & Schneider, 1801) | Indo-Pacific king mackerel   | DD      |        |
| Scombriformes   | Stromateidae  | *Pampus chinensis* (Euphrasen, 1788)            | Chinese silver pomfret       | NE      |        |
| Scombriformes   | Stromateidae  | *Pampus argenteus* (Euphrasen, 1788)           | Silver pomfret               | NE      |        |
| Gobiiformes     | Eleotridae    | *Butis butis* (Hamilton, 1822)                  | Crazy fish                   | LC      |        |
| Gobiiformes     | Gobiidae      | *Boleophthalmus boddarti* Pallas 1770           | Boddart’s goggle-eyed goby   | LC      |        |
| Gobiiformes     | Gobiidae      | *Odontamblyopus rubicundus* (Hamilton, 1822)   | Rubicundus eel goby          | LC      |        |
| Gobiiformes     | Gobiidae      | *Pseudapocryptes elongatus* (Cuvier, 1816)     | Elongate mudskipper          | LC      |        |
| Gobiiformes     | Gobiidae      | *Periophthalmus novemradiatus* (Hamilton, 1822) | Pearse’s mudskipper          | NE      |        |
| Gobiiformes     | Gobiidae      | *Acentrogobius cyanos* (Bleeker, 1849)          | Threadfin blue goby*         | LC      |        |
| Gobiiformes     | Gobiidae      | *Glossogobius giuris*                           | Tank goby                    | LC      |        |
| Class         | Subclass | Family     | Genus                          | Species                        | Common Name       | Status |
|--------------|----------|------------|--------------------------------|--------------------------------|-------------------|--------|
| Gobiiformes | Gobiidae |            | *Glossogobius*                  | *celebius*                     | Celebes goby*     | LC     |
|              |          |            | (Valenciennes, 1837)            |                                |                   |        |
| Gobiiformes | Gobiidae |            | *Scartelaos*                    | *histophorus*                  | Walking goby      | LC     |
|              |          |            | (Valenciennes 1837)             |                                |                   |        |
| Gobiiformes | Gobiidae |            | *Trypauchen*                    | *vagina*                       | Pink worm goby    | LC     |
|              |          |            | (Bloch & Schneider, 1801)       |                                |                   |        |
| Gobiiformes | Gobiidae |            | *Oxyurichthys*                  | *microlepis*                   | Maned goby*       | LC     |
|              |          |            | (Bleeker, 1849)                |                                |                   |        |
| Gobiiformes | Gobiidae |            | *Gobiopsis*                     | *macrostoma*                   | Long jaw goby     | LC     |
|              |          |            | Steindachner, 1861             |                                |                   |        |
| Pleuronectiformes | Paralichthyidae |            | *Pseudorhombus*     | *arsiuis*                       | Large tooth flounder | LC |
|              |          |            | (Hamilton, 1822)               |                                |                   |        |
| Pleuronectiformes | Soleidae |            | *Solea*                        | *ovata*                        | Ovate sole*       | LC     |
|              |          |            | Richardson, 1846               |                                |                   |        |
| Pleuronectiformes | Cynoglossidae |            | *Cynoglossus*                  | *lingua*                       | Long tongue sole  | LC     |
|              |          |            | Hamilton, 1822                 |                                |                   |        |
| Pleuronectiformes | Cynoglossidae |            | *Cynoglossus*                  | *quadrilineatus*               | Four lined tongue sole     | LC |
|              |          |            | (Bleeker, 1851)                |                                |                   |        |
| Pleuronectiformes | Cynoglossidae |            | *Cynoglossus*                  | *cynoglossus*                  | Bengal tongue sole| LC     |
|              |          |            | (Hamilton, 1822)               |                                |                   |        |
| Pleuronectiformes | Cynoglossidae |            | *Cynoglossus*                  | *arel*                         | Largerscale tongue sole | DD |
|              |          |            | (Bloch & Schneider, 1801)       |                                |                   |        |
| Pleuronectiformes | Cynoglossidae |            | *Cynoglossus*                  | *macrolepidotus*               | Indian tongue sole*| NE |
|              |          |            | (Bleeker, 1851)                |                                |                   |        |
| Pleuronectiformes | Cynoglossidae |            | *Cynoglossus*                  | *semifasciatus*                | Bengal tongue sole*| DD |
|              |          |            | Day, 1877                       |                                |                   |        |
| Pleuronectiformes | Cynoglossidae |            | *Paraplagusia*                 | *bilineata*                    | Double lined tongue sole | NE |
|              |          |            | (Bloch, 1787)                  |                                |                   |        |
| Cichliformes | Cichlidae |            | *Oreochromis*                  | *mossambicus*                  | Mozambique tilapia | VU |
|              |          |            |                                |                                |                   |        |
| Class         | Family       | Species Name                        | Common Name               | Status |
|--------------|-------------|-------------------------------------|---------------------------|--------|
| Beloniformes | Belonidae   | *Strongylura strongylura*           | Spottail needlefish       | NE     |
|              |             | (van Hasselt, 1823)                 |                           |        |
| Beloniformes | Hemiramphidae | *Hyporhamphus limbatis*             | Congaturi halfbeak        | NE     |
|              |             | (Valenciennes, 1847)               |                           |        |
| Mugiliformes | Mugilidae   | *Planiliza macrolepis*              | Largescal e mullet        | LC     |
|              |             | (Smith, 1846)                       |                           |        |
| Mugiliformes | Mugilidae   | *Planiliza melinoptera*             | Otomebora mullet          | NE     |
|              |             | (Valenciennes, 1836)               |                           |        |
| Mugiliformes | Mugilidae   | *Planiliza tade*                    | Tade mullet               | DD     |
|              |             | (Forsskal, 1775)                    |                           |        |
| Mugiliformes | Mugilidae   | *Mugil cephalus*                    | Flathead grey mullet      | LC     |
|              |             | Linnaeus, 1758                      |                           |        |
| Mugiliformes | Mugilidae   | *Rhinomugil corsula*                | Corsula mullet            | LC     |
|              |             | (Hamilton, 1822)                    |                           |        |
| Tetraodontiformes | Tetraodontidae | *Lagocephalus spadiceus*       | Half-smooth golden puffer | LC    |
|              |             | (Richardson, 1845)                 |                           |        |
| Tetraodontiformes | Tetraodontidae | *Lagocephalus guentheri*  | Diamondback puffer*       | LC     |
|              |             | Miranda Ribeiro, 1915              |                           |        |
| Scorpaeniformes | Platycephalidae | *Grammoplites scaber*   | Spot flathead             | NE     |
|              |             | (Linnaeus, 1758)                   |                           |        |
| Scorpaeniformes | Platycephalidae | *Platycephalus indicus*       | Bartail flathead           | DD     |
|              |             | (Linnaeus, 1758)                   |                           |        |
| Perciformes  | Ambassidae  | *Parambassis lala*                  | Hifin glassy perchlet*    | NT     |
|              |             | (Hamilton, 1822)                   |                           |        |
| Perciformes  | Ambassidae  | *Parambassis ranga*                | Indian glassy fish        | LC     |
|              |             | (Hamilton, 1822)                   |                           |        |
| Perciformes  | Latidae     | *Lates calcarifer*                 | Barramundi                | LC     |
|              |             | (Bloch, 1790)                      |                           |        |
| Perciformes  | Terapontidae | *Terapon theraps*                  | Largescal e target fish   | LC     |
|              |             | Cuvier, 1829                       |                           |        |
| Order          | Family          | Species                             | Common Name                    | Status   |
|---------------|----------------|-------------------------------------|--------------------------------|----------|
| Perciformes   | Terapontidae   | *Terapon jarbua*                    | Target fish                    | LC       |
| Perciformes   | Sillaginidae   | *Sillaginopsis domina*              | Flathead Sillago               | NE       |
| Perciformes   | Sillaginidae   | *Sillago sihama*                    | Silver sillago                 | LC       |
| Perciformes   | Carangidae     | *Caranx sexfasciatus*               | Bigeye trevally                | LC       |
| Perciformes   | Carangidae     | *Scomberoides commersonnianus*      | Tulang queenfish               | LC       |
| Perciformes   | Carangidae     | *Scomberoides tala*                 | Barred queenfish               | LC       |
| Perciformes   | Carangidae     | *Megalaspis cordyla*                | Torpedo scad                   | LC       |
| Perciformes   | Leiognathidae  | *Photopectoralis bindus*            | Orange-fin ponyfish            | NE       |
| Perciformes   | Leiognathidae  | *Nuchequula blochii*                | Two-blotch ponyfish            | NE       |
| Perciformes   | Leiognathidae  | *Nuchequula gerreoides*             | Decorated ponyfish             | NE/DD    |
| Perciformes   | Datnioididae   | *Datnioides polota*                 | Silver tiger perch             | LC       |
| Perciformes   | Gerreidae      | *Gerres macracanthus*               | **Longspined silver- biddy**   | NE       |
| Perciformes   | Gerreidae      | *Gerres setifer*                    | Small Bengal silver-biddy      | NE       |
| Perciformes | Haemulidae | Pomadasys maculatus (Bloch, 1793) | Saddle grunt | LC |
|-------------|------------|-----------------------------------|--------------|----|
| Perciformes | Sparidae   | Acanthopagrus berda (Forsskal, 1775) | Goldsilk seabream | LC |
| Perciformes | Sparidae   | Acanthopagrus longispinnis (Valenciennes, 1830) | Bengal yellowfin seabream | DD |
| Perciformes | Sparidae   | Rhabdosargus sarba (Forsskal, 1775) | Goldlined seabream | LC |
| Perciformes | Sciaenidae | Otolithes ruber (Bloch & Schneider, 1801) | Tigertooth croaker* | LC |
| Perciformes | Sciaenidae | Chrysochir aureus (Richardson, 1846) | Reeves croaker | LC |
| Perciformes | Sciaenidae | Pennahia anea (Bloch, 1793) | Donkey croaker | LC |
| Perciformes | Sciaenidae | Johnieops dussumieri (Bleeker, 1855) | Bearded croaker | NE |
| Perciformes | Sciaenidae | Johnieops borneensis (Bleeker, 1851) | Sharpnose hammer Croaker | NE |
| Perciformes | Sciaenidae | Johnius belangerii (Cuvier, 1830) | Belanger’s croaker | LC |
| Perciformes | Sciaenidae | Pama pama (Hamilton, 1822) | Pama croaker | DD |
| Perciformes | Sciaenidae | Panna microdon (Bleeker, 1849) | Panna croaker | LC |
| Perciformes | Sciaenidae | Johnius glaucus (Day, 1876) | Pale spot-fin croaker* | NE |
| Perciformes | Sciaenidae | Johnius coitor (Hamilton, 1822) | Coitor croaker | LC |
| Class      | Family     | Scientific Name                      | Common Name                      | Status   |
|------------|------------|--------------------------------------|----------------------------------|----------|
| Perciformes| Sciaenidae | *Macrospinosa cuja* (Hamilton, 1822) | Cuja croaker                     | DD       |
| Perciformes| Sciaenidae | *Daysciaena albida* (Cuvier, 1830)   | Bengal corvina                   | LC       |
| Perciformes| Sciaenidae | *Pterotolithus maculatus* (Cuvier, 1830) | Blotch tiger-toothed croaker | LC       |
| Perciformes| Polynemidae| *Eleutheronema tetractylum* (Shaw, 1804) | Fourfinger threadfin             | NE       |
| Perciformes| Polynemidae| *Leptomelanosoma indicum* (Shaw, 1804) | Indian threadfin                 | NE       |
| Perciformes| Polynemidae| *Polynemus paradiseus* Linnaeus, 1758 | Paradise threadfin               | LC       |
| Perciformes| Mullidae   | *Upeneus sulphureus* Cuvier, 1829     | Sulphur goatfish*                | LC       |
| Perciformes| Toxotidae  | *Toxotes chatareus* (Hamilton, 1822)  | Spotted archerfish               | LC       |
| Perciformes| Scatophagida| *Scatophagus argus* Linnaeus, 1766   | Spotted scat                     | LC       |
| Perciformes| Sphyraenidae| *Sphyraena jello* Cuvier, 1829       | Pickhandle barracuda*            | NE       |

Explanations: NE-Not Evaluated, DD-Data Deficient, LC-Least Concern, VU- Vulnerable, NT-Near Threatened.

*New records*

### 3.2 Taxonomic account of new records

We used the following abbreviations in this section: BD- body depth, ex-examples/individuals, HL- head length, and SL- standard length.

1. *Sardinella longiceps* (Valenciennes, 1847), Indian oil sardine (Plate I, 1).
Material examined: 2 ex, 19.06.18, Point 1, ZSI/ F 12905/2.

Description: Body moderately compressed. Belly with a sharp keel of scutes 27–29; pre-pelvic-15–17, post-pelvic-12. Pelvic fin with one unbranched and eight branched rays. Dorsal fin rays 13, anal fin rays 14–15. Dense frontoparietal striae. A distinct black spot on the posterior edge of gill cover.

Distribution: Indian Ocean. From the Gulf of Aden up to the Andaman Islands (Whitehead, 1985; Rajan et al., 2013).

IUCN Status: Least Concern (LC).

Remarks: The fish has good fishery value. Size- 180–185 mm (SL).

2. Sardinella fimbriata (Valenciennes, 1847), Fringe scaled sardine (Plate I, 2).

Material examined: 3 ex, 18.6.18, Point 1, ZSI/F 12887/2.

Description: Belly with a sharp keel of 31–32 scutes; pre-pelvic- 17–18, post-pelvic- 14. Pelvic fin with one unbranched and seven branched rays, dorsal fin with 14 rays, anal fin rays 15. Scales with well-developed posterior median extensions and discontinued striae. Many frontoparietal striae. A black spot at the dorsal fin origin.

Distribution: Indo-West Pacific. From Kuwait to the eastern portion of Papua New Guinea (Kailola, 1987; Abou-Seedo, 1992).

IUCN Status: Least Concern (LC).

Remarks: This fish has good fishery value. Size- 123–137 mm (SL).

3. Thryssa kammalensoides Wongratana, 1983, Godavari thryssa (Plate I, 3).

Material examined: 2 ex, 19.6.18, Point 1, ZSI/F 12901/2.

Description: Belly with 27 scutes; pre-pelvic- 18, post-pelvic- 9. Gill rakers on the lower limb of the first gill arch 24–25. Serrae, not clumped together. Maxilla reaching the edge of the gill cover, not reaching pectoral fin base. Branched anal fin rays 32. A dark blotch on the nape region extending to the upper part of the gill opening.

Distribution: Only known from Indian estuarine and coastal waters (Whitehead et al., 1988; Mishra & Krishnan, 1999), it’s the first record of the species from West Bengal, India.

IUCN Status: Not Evaluated (NE).

Remarks: This fish is of fishery value. Size- 108–114 mm (SL).

4. Thryssa spinidens (Jordan and Seale, 1925), Bengal thryssa (Plate I, 4).

Material examined: 2 ex, 19.6.18, Point 1, ZSI/F/12705/2.

Description: Maxilla not reaching pectoral fin base, it goes beyond gill cover. Belly scutes 27; pre-pelvic- 16, post-pelvic- 11. Gill rakers on the lower arm of the first gill arch 13. Teeth enlarged. Anal fin with three branched rays and 41 unbranched rays. The tip of snout at the
level of the upper rim of the eye. No black blotch (usually absent) on the upper part of the gill opening.

Distribution: Bay of Bengal large marine ecosystem. India to Thailand (Whitehead et al., 1988; Monkolprasit et al., 1997).

IUCN Status: Data Deficient (DD).

Remarks: This fish is of fishery value. Size 135–140 mm (SL).

5. *Eupleurogrammus glossodon* (Bleeker, 1860), Longtooth hairtail (Plate I, 5).

Material examined: 1ex, 19.6.18, Point 1, ZSI/F/12873/2.

Description: Body tapering, ribbon-like. The subopercle lower margin, convex. The eyes close to dorsal profile. One pair of fangs at the tip. Pectoral fin extending beyond the lateral line. A black dermal process at the tip of each jaw.

Distribution: Indo-West Pacific. From the Persian Gulf to Thailand (Nakamura & Parin, 1993).

IUCN Status: Least Concern (LC).

Remarks: The fish has good fishery value. Size 110 mm (SL).

6. *Scomberomorus lineolatus* (Cuvier, 1829), Streaked seerfish (Plate I, 6).

Material examined: 1 ex, 19.6.18, Point 1, ZSI/F/12875/2.

Description: A considerably compressed body. Eight dorsal and eight anal finlets. Gill rakers on the lower limb of the first gill arch 7–9. Second dorsal fin closer to caudal fin than snout. Lateral line gradually bending downwards towards caudal keels. Horizontally narrow black bars laterally.

Distribution: Indo-West Pacific. India to Java (Allen & Smith-Vaniz, 1994; Kapoor et al., 2002).

IUCN Status: Least Concern (LC).

Remarks: The fish has good fishery value. Size 190 mm (SL).

7. *Acentrogobius cyanomos* (Bleeker, 1849), Blue-spotted goby (Plate I, 7).

Material examined: 1 ex, 19.6.18, Point 1, ZSI/F/12735/2.

Description: Pelvic fin medially joined. Cheek and opercle naked. Scales ctenoid except for the ones on pectoral fin base and breast which are cycloid. First dorsal fin with six spines, second dorsal fin with one spine and 10 soft rays, pectoral fin with 18 rays, and anal fin with one spine and nine soft rays. Longitudinal scale series 23. Pre-dorsal scales 10. Presence of numerous bright pale blue spots on the body and dorsal and anal fin.

Distribution: Indo-West Pacific. India to Indonesia (Rema Devi, 1993; Kottelat et al., 1993).

IUCN Status: Least Concern (LC).
Remarks: The fish has no significant fishery value. Collected for the ornamental fish trade for its colourful appearance. Size- 80 mm (SL).

8. *Oxyurichthys microlepis* (Bleeker, 1849), Maned Goby (Plate I, 8).

Material examined: 1 ex, 18.6.18, Point 2, ZSI/F/12799/2.

Description: Pelvic fin medially joined by a simple frenum. Nape with a narrow dermal crest. First dorsal fin with six spines, second dorsal fin with one spine and 12 soft rays, pectoral fin with 20 rays, and anal fin with one spine and 13 soft rays. Longitudinal scale series 42. Predorsal scales 14. A distinctive round black spot on the upper portion of the eye. Many scales on the nape and back have a dense black-brown spot on them.

Distribution: Indo-West Pacific. Pakistan to North-eastern Australia (Talwar & Jhingran, 1991; Pezold & Larson, 2015).

IUCN Status: Least Concern (LC).

Remarks: The fish has no significant fishery value. Collected in the aquarium fish trade for its colourful appearance and also collected to be used as baitfish. Size- 80 mm (SL).

9. *Glossogobius celebius* (Valenciennes, 1837), Celebes goby (Plate I, 9).

Material examined: 1 ex, 18.6.18, Point 2, ZSI/F/12904/2

Description: Head flattened. Lower jaw projecting. Branchiostegal membranes attached to the side of the isthmus. First dorsal fin with six spines, second dorsal fin with one spine and eight soft rays, anal fin with one spine and seven soft rays. And the pectoral fin with 19 rays. Predorsal scales 15. Longitudinal series scales 32. Presence of two additional pores a1 and a2 on the head (Akihito & Meguro, 1975: Fig. 3). Five lateral blotches, caudal fin mottled in appearance.

Distribution: Asia and Oceania (Bright & June, 1981).

IUCN Status: Least Concern (LC).

Remarks: The fish has considerable significance in fisheries in combination with *Glossogobius giuris*. Size- 118 mm (SL).

10. *Cynoglossus semifasciatus* Day, 1877, Bengal tongue sole (Plate I, 10).

Material examined: 1 ex, 26.5.18, Point 2, ZSI/F/12861/2.

Description: Body considerably elongated. Snout rounded, the angle of mouth extending a little beyond vertical from the eye. Rostral hook short. Two lateral lines on the eyed side and none on the blind side. Mid-lateral line with 73 scales with 12 scales between two lateral lines. Dorsal fin with 102 rays, anal fin rays 77 and caudal fin with 10 rays. The eyed side reddish brown with a few faint, uneven bands.
Distribution: India, Sri Lanka and possibly Thailand (Mishra & Krishnan, 2003; De Bruin et al., 1995; Monkolprasit et al., 1997).

IUCN Status: Data Deficient (DD).

Remarks: Of significant fishery interest. Size - 160 mm (SL).

11. Cynoglossus macrolepidotus (Bleeker, 1851), Largescale tongue sole (Plate I, 11).

Material examined: 1ex, 19.6.18, Dobanki Sundarbans, ZSI/F/12850/2.

Description: Body greatly elongated. Snout pointed, the angle of mouth reaching beyond the lower eye, about midway between gill opening and the snout tip. Rostral hook short. Two lateral lines on the eyed side and none on the blind side. Scales ctenoid on the eyed side, cycloid on the smooth side. Mid-lateral line having 59 scales and eight scales between the two lateral lines. Dorsal fin rays 122, anal fin rays 73 and caudal fin with 10 rays. The eyed side uniform brown.

Distribution: From India up to Indonesia (Mishra et al., 1999; Fricke et al., 2017).

IUCN Status: Not Evaluated (NE).

Remarks: Of significant fishery interest. Size - 132 mm (SL).

12. Solea ovata Richardson, 1846, Ovate sole (Plate I, 12).

Material examined: 3 ex, 29.5.2018, Point 2, ZSI/F/12833/2.

Description: Body ovate. Body depth two times of total length. Snout obtusely pointed with the maxilla reaching to the midpoint of the lower eye, rostral hook short. Only one lateral line on the eyed side and none on the blind side. Eyes separated by a concave space which is scaled. The pectoral fin on the ocular side about 1.8 times as long as the one on the blind side. Scales ctenoid on both sides. Caudal fin separated from the dorsal and anal fin. Dorsal fin rays 66, anal fin rays 48. The eyed side, brown with black blotches on the body and fins.

Distribution: Indo-west Pacific. India to Indonesia (Munroe, 2001; Kapoor et al., 2002).

IUCN Status: Least Concern (LC).

Remarks: Of significant fishery interest. Size - 58-63 mm (SL).

13. Lagocephalus guentheri Miranda Ribeiro, 1915, Diamondback puffer (Plate II, 13).

Material examined: 3 ex, 29.5.2018, Point 2, ZSI/F/12787/2.

Description: Spinule patch on the back halfway through the interorbital origin to the dorsal fin base. Dorsal fin rays 12, 12 anal fin rays. Caudal fin in fresh specimens with slight posterior extensions (looks like doubly emarginated). Dorsal half of body with broad dusky bands, caudal fin tips white.

Distribution: Indo-west Pacific. Saudi Arabia to Japan (Matsuura et al., 2011; Bogorodsky & Randall, 2018).
IUCN Status: Least Concern (LC).
Remarks: Consumed locally in the Sundarbans (Mishra et al., 2018). Size- 53-65 mm (SL).
14. *Parambassis lala* (Hamilton, 1822), Hi-fin glassy perchlet (Plate I, 14).
Material examined: 1 ex, 29.5.2018, Point 2, ZSI/F/12918/2.
Description: Body compressed deeply. Lower jaw longer than the upper jaw. The first dorsal fin has six spines and second dorsal fin with one spine and 12 soft rays, anal fin with three spines and 15 soft rays. Caudal fin forked. Body brightly coloured with red and yellow.
Distribution: Occurs in India, Bangladesh and Myanmar (Talwar & Jhingran, 1991; Vidthayanon et al., 2005).
IUCN Status: Near Threatened (NT).
Remarks: Of little interest to the fishery. Size- 25 mm (SL).
15. *Gerres macracanthus* Bleeker, 1854, Longspined silverbiddy (Plate I, 15).
Material examined: 1 ex, 29.5.2018, Point 2, ZSI/F/12888/2.
Description: Elongated body, BD- 36.8 % of SL. Dorsal fin with nine spines and 10 soft rays, 2nd dorsal spine filamentous, anal fin with three spines and seven soft rays. Lateral line with 42 scales. Eight indistinct vertical bands on the flanks.
Distribution: Indo-West Pacific. Red Sea to New Guinea (Weber & De Beaufort, 1931; Iwatsuki et al., 2013).
IUCN Status: Not Evaluated (NE).
Remarks: Significant interest to the fishery. Size- 67 mm (SL).
16. *Otolithes ruber* (Bloch & Schneider, 1801), Tigertooth croaker (Plate I, 16).
Material examined: 2 ex, 29.5.2018, Point 2, ZSI/F/12728/2.
Description: Body slender. Mouth oblique. First dorsal fin with 10 spines, second dorsal fin with one spine and 28 soft rays, anal fin with two spines and seven soft rays. The caudal fin is rhomboidal. Gill rakers on the lower limb of 1st gill arch 10. Big canine teeth on both jaws. Swim bladder carrot-shaped with 30-32 branching appendages on each side.
Distribution: Indo-West Pacific. East Africa to Australia (van der Elst, 1993; Hoese et al., 2006).
IUCN Status: Least Concern (LC).
Remarks: Of significant interest to the fishery. Size- 112 mm (SL).
17. *Johnius glaucus* (Day, 1876), Pale spotfin croaker (Plate I, 17).
Material examined: 3 ex, 29.5.2018, Point 2, ZSI/F/12900/2.
Description: Mouth is small, inferior. First dorsal fin with 10 spines, second dorsal fin with one spine and 30 soft rays, anal fin with two spines and seven soft rays. Gill rakers on the
lower limb of the 1st gill arch. The caudal fin, rhomboidal. Swim bladder hammer-shaped with 14-15 branching appendages on each side.

Distribution: Western Indian Ocean (Mishra & Srinivasan, 1999).

IUCN Status: Not Evaluated (NE).

Remarks: Of significant interest to the fishery. Size- 105-126 mm (SL).

18. *Upeneus sulphureus* Cuvier, 1829, Sulphur goatfish (Plate I, 18).

Material examined: 5 ex, 18.6.2018, Point 1, ZSI/F/12819/2.

Description: BD 3.2 times SL. First dorsal fin with eight spines, second dorsal fin with one spine and eight soft rays, anal fin with one spine and six soft rays. Scales on second dorsal and anal fins. Barbels reach the posterior margin of preopercle. Two narrow yellow stripes in live and freshly dead specimens. No bars on caudal fin lobes.

Distribution: Indo-West Pacific. East Africa to Australia (Uiblein & Heemstra, 2010).

IUCN Status: Least Concern (LC).

Remarks: Of significant interest to the fishery. Size- 59-79 mm (SL).

19. *Sphyraena jello* Cuvier, 1829, Pickhandle barracuda (Plate I, 19).

Material examined: 1 ex, 18.6.2018, Point 1, ZSI/F/12878/2.

Description: Maxilla reaches to just below the anterior margin of the eye. No gill rakers on the first-gill arch. First dorsal fin with five spines, second dorsal fin with one spine and nine soft rays, the anal fin with two spines and eight soft rays. Caudal fin forked. Pored lateral line scales 138.

Distribution: Indo-West Pacific (Allen & Erdman, 2012).

IUCN Status: Not Evaluated (NE).

Remarks: Of significant interest to the fishery. Size- 216.5 mm (SL).

### 3.3 Environmental Parameters

Water quality parameters displayed a strong tidal incursion along with considerable freshwater influence due to monsoonal discharge in the Sundarban delta. Moderately high salinity (mean 1.011-1.017) and high dissolved oxygen (mean 9.6-10.1) were observed (Table 2). The average water pH was slightly alkaline and was relatively constant among sites ranging between pH 7.4 and 8.2. We observed higher salinity in the first location compared to the second one.

Table 2. Mean values of selected environmental parameters of the two collection points in the Indian Sundarbans (Apr 2018-June 2018)
### 3.4 Diversity status

The values of Shannon Wiener index (H) and Simpson’s diversity index (1-D) for both communities are shown in (Fig. 3-4).

| Collection Point | Salinity | Dissolved oxygen (mg L⁻¹) | pH | Water temperature (°C) | Secchi Depth (inches) |
|------------------|----------|---------------------------|----|------------------------|-----------------------|
| Point 1          | 1.017    | 9.6                       | 8.2| 24                     | 36                    |
| Point 2          | 1.011    | 10.1                      | 7.4| 25                     | 38                    |

Figure 3. The Shannon-Wiener Index (H) of Community A= 4.05 and Community B= 3.72

Figure 4. The Simpsons Diversity Index (1-D) of Community A=0.97 and Community B= 0.96
Community A has a Shannon-Wiener Index value of 4.05, while community B has a value of 3.72. The true diversity, the effective number of species (ENS) calculated from the Shannon indices for community A, is 57 whereas, for community B, it is 41. This means community A is 1.39 times more diverse than community B. Community A has a Simpson’s diversity index of 0.97 while community B has 0.96. The coefficient of community value is 0.87.

4. Discussion

The Shannon-Wiener diversity measure comes from information theory (Rissanen, 1997). It measures the number of individuals observed for each species in a sample plot. In this case study, community A has a Shannon index of 4.05, suggesting that the richness and evenness of the community are more than that of community B, which has a value of 3.72. But these two values are just indices. To effectively compare the two communities, we obtained the true species diversity values (effective number of species) for both of them. We found that community A has a diversity of 57 species which is 1.39 times more than the ENS of community B- 41. A modified scale of pollution in terms of species diversity exists that shows a negative correlation between the Shannon index and pollution (Staub et al., 1970). According to its range, both the communities are only slightly polluted.

Simpson’s Index of Diversity (1-D) for community A is 0.97. It has a greater diversity when compared to Community B, whose value is 0.96. But the indices of both communities suggest a stable species-diversity along the stretch of the river from point A to point B with only little fluctuation. The coefficient of community value of 0.87 represents a good deal of similarity between the two communities (a value of 1 suggesting a complete overlap of the communities) yet not being the duplicates.

A significant correlation between mangrove forest characteristics and estuarine fish species exists (Manson et al., 2005; Sandoval et al., 2020). Therefore, the absence of the complementary role of the mangroves (Cronna & Ronnback, 2005) along with anthropogenic pressures can be the reason why community B has relatively less number of species. Its location near the village of Amlamethi suggests that it has fewer mangrove cover and faces human-related pressures. In the present study, the coefficient of community shows that though not identical, the two communities share similarities.

We have provided the IUCN statuses of all the fishes listed in this study. From our collection, we found only two fish species belonging to the conservation category near threatened (NT) and two fish species in the vulnerable (VU) category. Others fell mostly into the least concern (LC) or not evaluated (NE) followed by the data deficient (DD) categories.
We have provided only those assessments that are based globally. The basis of some categorizations in the IUCN Red List (2020) are regional assessments from other parts of the world (e.g. *Eleutheronema tetradactylum* is assessed to be endangered [Motomura et al., 2015] based on studies only from the Persian Gulf). So, the applicability of such assessments for the Indian Sundarbans remains to be ground-truthed. There is an urgent need to assess the status of these fishes in the Indian Sundarbans region as they are collected regularly for human consumption and sale.

One of the vulnerable (VU) fish, *Oreochromis mossambicus* (Peters, 1852) is an invasive species in India. It seems that they are capable of tolerating high salinity levels. It faces extirpation in its native range.

We suggest being mindful about the terms: Data Deficient (DD) and Not Evaluated (NE). One must never synonymize the former two with Least Concern (LC). There is an equal looming threat of extinction for every species that currently falls in the categories of DD or NE. We have graphically represented the number of fishes and the respective conservation categories (Fig. 5) into which they fall. All species reported in this study are economically significant and locally consumed, including Tetraodontiformes (Mishra et al., 2018).

![IUCN statuses of the fishes collected during the study](image)

**Figure 5.** IUCN conservation status of the fishes collected during the study

Pneumatophores and prop roots of the mangrove trees along with their fallen branches and leaves make a complex habitat for a host of prey organisms. These form an important
food source for many fish species (Verweij et al., 2006). Therefore mangroves form one of the core fish habitats of tropical estuaries and lagoons (Blaber, 2007).

A total of 19 fish species were recorded for the first time from the Indian Sundarban region during this study. It effectively brings the total number of fish species recorded from the Indian Sundarbans to 374.

Salinity plays a significant role in the distribution of marine and brackish water fishes. Long term variations in salinity can affect the distribution of such fish species (Cyrus & Blaber, 1992). In many studies, catch rates of abundant species correlated strongly with salinity patterns (Barletta et al., 2005; Lugendo et al., 2007). The salinity though recorded, was only during the time of sampling and not during other times of the day or the other days of the month. Such discrepancy disallows from correctly correlating salinity with fish distribution within the scope of this study. The need to collect data consistently over a period is necessary. We hypothesize that tidal incursion may have a role to play in their distribution.

Other abiotic factors like turbidity may also play a role in the presence of fish species that were absent before. Since turbidity is usually high in the mangrove region, it reduces the visual capacity of large predators. And the shallow waters exclude large fishes entering them. This helps smaller fish to take shelter and thrive in the creeks in and around mangroves (Cyrus & Blaber, 1987). The mean visible depth of both the collecting points was almost similar (point A- 36”, point B- 38”).

Another explanation of why we found these previously unreported fishes, may have been because they simply escaped the attention of science due to inadequate sampling and incorrect taxonomy. E.g., One newly described species of Moray eel; Gymnothorax pseudotile (Mohapatra, Smith, Ray, Mishra & Mohanty, 2017). It's considered to be a marine fish was very recently after its description, reported from the Indian Sundarbans (Chakraborty et al., 2018), showing how the species got overlooked as a distinct species in previous surveys.

The presence of Thryssa kammalensoides Wongratana, 1983 in the Sundarbans is intriguing as this species was previously recorded from the Odisha coast, with a northern limit up to Chandipur in the Balasore district of Odisha, India (Mishra & Krishnan, 1999). The feeding habit of Clupeids and Engraulids are described by James (1988) through the analysis of stomach content. He found that they are microphagists- they feed on zooplankton. Foraging could be a reason behind the occurrence of T.kammalensoides in the region. Both the quantity and type of food found in mangrove areas are different from the adjacent marine areas. Many of the microflora and fauna found in the sheltered mangroves are not present in
the offshore waters. This results in an increase in the diversity and quantity of food available to fishes (Robertson & Duke, 1990). It is a possibility that these Engraulids are found in the mangroves seasonally (June-July), and they may even conglomerate to breed.

We recorded more freshwater fish species from community B. The mean value of salinity of community B is considerably less than that of community A. Plus the collection point was very close to an island with several freshwater outlets and the added freshwater influx of the monsoons. We believe that those reasons allowed for the survival of freshwater fishes in the collection point.

Seasonal variations in nutrients are known to affect the coexistence of many species (Huh & Kitting, 1985). The first author noted an unusually large number of small shrimps getting caught in each haul. There could be a relation between the high incidence of these crustaceans with the observed fish species. We found some of the marine fish when the salinity of a point was considerably high. For example, in community B, the Pickhandle barracuda was caught on the day when the salinity of the place was considerably high- 1.019. The environmental parameters provide some important ecological insights.

5. Conclusion

In this study, we found that both the communities are moderately distinct from each other based on the values of their respective indices. But there also exists a good deal of similarity (in species) between them as evident from the similarity coefficient value.

The Shannon indices for both the communities are high. They indicate that both are high in species richness and evenness and that no particular species dominate the communities. The true diversity values (community A- 57, community B- 41) reveal that community A is 1.39 times as diverse (in fish species) as community B.

A high Simpson’s index indicates that the communities are very diverse. All the values are indicative of the overall good health of the mangrove ecosystem.

We recorded a total of 19 fish species from the mangroves for the first time bringing the total number of species recorded from the region to 374. The Indian Sundarbans is a highly variable region, and its variability affects the ever-changing ichthyofauna residing in its brackish waters. The present study is a baseline study for three months. We suggest long term monitoring to adequately assess the distribution and abundance of the ichthyofaunal diversity of the Sundarbans along with studying the problems (if any) of human-induced pressures on the unique environment.
Acknowledgement

The authors would like to thank Dr Kailash Chandra, director of the Zoological Survey of India (Z.S.I.), Kolkata, and Dr L. Kosygin Singh, Scientist-D, Fish Division, Z.S.I., Kolkata for providing permission and working facilities. The first and fifth author would like to thank Dr Erach Bharucha, director of BVIEER, Pune and Dr Shamita Kumar, BVIEER.

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PLATE I

1. CLUPEIDAE *Sardinella longiceps*

2. CLUPEIDAE *Sardinella fimbriata*

3. CLUPEIDAE *Thryssa kammalensoides*

4. CLUPEIDAE *Thryssa spinidens*

5. TRICHIURIDAE *Eupleurogrammus glossodon*

6. SCOMBRIDAE *Scomberomorus lineolatus*

7. GOBIIDAE *Acentrogobius cyanomos*

8. GOBIIDAE *Oxyurichthys microlepis*

9. GOBIIDAE *Glossogobius celebes*

10. CYNOGLOSSIDAE *Cynoglossus semifasciatus*

11. CYNOGLOSSIDAE *Cynoglossus macrolepidotus*
|   |   |   |
|---|---|---|
| **12. SOLEIDAE** | **Solea ovata** |   |
| **13. TETRAODONTIDAE** | *Lagocephalus guentheri* |   |
| **14. AMBASSIDAE** | *Parambassis lala* |   |
| **15. GERREIDAE** | *Gerres macracanthus* |   |
| **16. SCIAENIDAE** | *Otolithes ruber* |   |
| **17. SCIAENIDAE** | *Johnius glaucus* |   |
| **18. MULLIDAE** | *Upeneus sulphureus* |   |
| **19. SPHYRAENIDAE** | *Sphyraena jello* |   |