Status of Fisheries in Agusan Marsh: Lapaz and Talacogon, Agusan del Sur, Mindanao

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ABSTRACT

In support to policy formulation of fisheries in Agusan Marsh, a stock assessment was conducted for the period of May 2014 to December 2016 using the data collected from Lapaz and Talacogon, Agusan del Sur within the Agusan Marsh. Results showed that Lapaz contributed 54% of the catch over Talacogon. A total of eighteen species, belonging to 13 genera and 11 families with 7 native and 11 introduced species were found in the marsh. Majority of the total catch consisted of Channa striata, Oreochromis niloticus, and Cyprinus carpio (35%, 27%, and 26%, respectively). Osphronemus latilavus, Glossogobius celebicus and Mugil cephalus were listed as seasonal species. An invasive janitor fish (Pterygoplichthys disjunctivus) was observed as by-catch. A strong pattern of high catch rates occurred during the rainy months of January, February, June, and December. Ten types of commonly used fishing gears were found, majority of which include fish pots, set gillnets, electrofishing and set long lines. Multivariate analysis showed similarity in species composition both in Lapaz and Talacogon. Exploitation of dominant species showed unsustainable level for O. niloticus, C. batrachus, C. caprio, and C. gariepinus, mainly due to excessive capture of immature-sized fishes by major fishing gears. The estimated exploitation rate is beyond the optimum level for O. niloticus and C. carpio in both years and followed by C. striata and C. gariepinus in 2016. Only C. bartachus is estimated to be exploited below the optimum level. Generally, the key species in Agusan Marsh are at risk of overfishing, hence, immediate policy measures must be given high attention.

Keywords: fisheries, Agusan Marsh, dominant species, exploitation

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1. INTRODUCTION

Agusan Marsh is one of the most ecologically significant wetlands in the Philippines, found in the heart of Mindanao’s Agusan Basin, where rivers, creeks and tributaries, mainly in the provinces of Agusan del Norte, Agusan del Sur, and Compostela Valley converge and drain northward to Agusan River and in Butuan Bay. The main habitats of the Marsh are the freshwater swamp forest (with Terminalia, peat swamp and sago palm forest subtypes), secondary scrub, herbaceous swamp, open water (oxbow/floodplain lakes, pools), and flowing water (rivers, streams). Peat forests have been confirmed in Bunawan and Caimpugan. Over 200 bird species have been known to spend at least part of the year in the Marsh, making it an important site for migratory birds from northern Asia and Siberia. The marsh has been declared a protected site under NIPAS (1994), Presidential Proclamation 913 (1996), and RAMSAR (1999). The Agusan Marsh Wildlife Sanctuary covers less than 111,540 ha in 8 municipalities of Agusan del Sur. Recently the Agusan Marsh was placed high on the list of Philippine nominations to the World Heritage Natural Sites. (Primavera and Tumanda 2008).

The marshland acts like a sponge, soaking up excess water from the mountains during rainy season, creating a huge area for wetland wildlife and protecting the downstream towns of Butuan City from catastrophic floods. It contains nearly 15% of the nation’s freshwater resources in the form of swamp forests. The Agusan Marsh covers eight municipalities.
of San Francisco, Bunawan, Veruela, Loreto, Talacogon, Lapaz, and Sta. Josefa in the province of Agusan del Sur (Figure 1). In terms of biodiversity, the marsh consists of flora and fauna with 112 species of trees, 127 birds, 14 freshwater fish, 21 species of amphibians, 39 species of reptiles and others (DENR Caraga Region 2013).

Being a wetland, the Agusan Marsh is also thriving with native fish, including 18 freshwater fish species which is the focus of this study. One fish species, the janitor fish, is recognized as invasive. However, like any other freshwater system, it also faces threats and other related problems, including land conversion and watershed denudation, crocodile infestation, illegal fishing, poor water quality, logging, dynamics in governance, boundary conflicts, and low biodiversity awareness (Foundation for the Philippine Environment 2016).

Earlier studies of Herre (1953), Davies (1991), Oloroso et al. (2000), Talde et al. (2004), and Hubilla-Travis et al. (2008), have already documented the fish species in the Agusan Marsh. Jumawan and Seronay (2017) also did a study on the length-weight relationships of fishes in eight floodplain lakes in Agusan Marsh. However, at present, there are limited studies on the marsh, especially on fish stock assessment, which provides decision makers with the information necessary to make reasoned choices.

To generate reliable data as the basis in the formulation of policies for sustainability of the fishery resources, this study aimed to determine the landed catch and effort, fishing gears used and its catch composition, length sizes of the dominant species caught by major fishing gear, its impact to the long term sustainability, and the exploitation level of the dominant species in the area.

2. MATERIALS AND METHODS

2.1 SAMPLING SITES

The Bureau of Fisheries an Aquatic Resources-13, National Stock Assessment Program (NSAP) conducted fish stock assessment in coordination with the Provincial Fisheries Office (PFO)-Agusan del Sur and different Municipal Agriculture Offices (MAO) of Agusan del Sur. The number of boat landings, presence of direct fishers, and strategic location of local traders were the basis in selecting the sampling sites. These were then categorized into major and minor landing sites, depending on the volume of fish catch landed. Four monitoring stations have been selected in the study sites as shown in Figure 1 and Figure 2A-D. The following are the selected stations:

a). La Flora, Talacogon

Barangay La Flora is considered as a major landing center with direct fishers and where majority of catch is recorded. It is situated at 08°23'40.1"N, 125°49'01.8"E, 5 km away from the town proper and accessible by motorcycle. It is a small barangay with a population of 1,212 in 2015, representing 3.2% of the total population in the municipality (PhilAtlas 2020). Fishing and agriculture are primary livelihood activities in the area. Most of the fishers are indigenous people that live in and around the protected area. Many of them live in floating houses that rise with the changing water levels. The common fishing gears used are set long lines, fish pots, set gillnets, scoop net, fish trap, and electrofishing method. Fishers usually go out for fishing at 4:00 am and return between 7 am-10 am while some arrives between 3:30 pm-5 pm. The catch of the day are brought to buyers’ floating houses along the river where they are sorted and weighted. The farm gate price is dictated by the buyer in most cases in Agusan Marsh.

b). San Agustin, Talacogon

Barangay San Agustin is situated at 08°27'06"N, 125°46'55.8"E and considered as a minor landing with less than ten boats per landing. Fishing boats start to arrive early in the morning between 6:30 am -8 am. There are direct buyers in the area and the common gears are set gillnet and set longline with occasional catch from electrofishing. Oftentimes, the area becomes dry whenever there is no rainfall, hence this landing center has relatively few recorded data.

c). Purok Agpangon-Poblacion, Lapaz

The area is situated at 08°17'49.3"N, 125°49'80"E far from the town proper and this is considered as a major landing center. There is no formal structure for a landing center, instead some fishers bring their catch to the resident buyer and some are displayed on a nearby covered court. Other fishers stay along the riverbank while they dock their non-motorized boats or dug-out banca. It is the buyer or linen using motorcycle or “habal-habal” who meets the fisher at the riverbank and buy their catch. The usual time of landing takes place between 6 am-10 am. The common fishing gears and methods used are fishpot,
Figure 1. Map of Agusan Marsh showing the sampling sites (image source: DENR 2020).
set gillnet, set long line, and electrofishing.

**d). Purok Kiandag-Poblacion, Lapaz**

Purok Kiandag-Poblacion is situated 08°17'49.5"N, 125°49'49.7"E and is categorized as a minor landing center with less than 10 observed fishers and fishing boats. Like other areas, fishers usually arrive between 8 am-11 am to be in time for the arrival of buyers and to keep their catch fresh. During the monitoring, the operation of electrofishing was also active, similar to the previously described areas.

### 2.2 Data collection

Prior to the data collection, proper training for the enumerators was conducted by the National Fisheries Research and Development Institute (NFRDI) training team. The data collection started on May 2014 to present. However, the results of the study prepared for this report only covered the period May 2014 to December 2016.

Two enumerators were assigned in each municipality to conduct catch and effort monitoring which include fish identification, length and weight measurements, fishing gears and boat inventory (in the monitored sites only), and other relevant data. The data collection was done every two days with one day interval. Day one was dedicated for monitoring of a major landing site, whereas day two was for a minor landing site. Entry of data used the prescribed forms and report was submitted to the regional office for encoding into the NSAP database system (Santos et al. 2017).

### 2.3 Data Analysis

#### 2.3.1 Fisherfolk Profile

For the fisherfolk profile, the data were extracted from the BFAR-FishR database system, an
online fisherfolk registration that promotes simplified and standardized registration system for the fisheries sector. The registration was done at the municipal level through the MAO and assisted by BFAR-Fisheries Livelihood Development Technicians (FLDTs). This was carried out by conducting house to house registration using forms or by inviting fisherfolk in a specified area for the registration. The filled-out forms were encoded in a Tablet issued by BFAR and then uploaded to the database.

For the monthly catch, effort, seasonality, and other relevant information, data were processed by generating the monthly and annual catch and effort from the NSAP database system. These were then exported to MS Excel using pivot table for analysis. Furthermore, the data from the four monitored stations were consolidated per municipality to enable clearer local-level comparison.

2.3.2 Annual Catch

The annual catch was generated from the NSAP Database system embedded with a raising factor based on the sampling days divided by the total days in a month.

2.3.3 Catch Composition and Relative Abundance

The catch composition was determined by gear type. Relative abundance was ranked based on how common or rare a fish species is in relation to other fish species.

2.3.4 Catch Per Unit Effort (CPUE)

Monthly catch per unit effort per gear was computed and standardized into kilograms per boat per day (kg/boat/day). Annual mean CPUE was obtained by the summation of the monthly catch landed over the summation of the number of fishing days per month and per year. Total number of fishing days was obtained by averaging the number of fishing days operation per year.

2.3.5 Multivariate Analysis

The weight of the caught species were recorded from the four landing sites and analyzed through hierarchical clustering (cluster analysis), ordination by non-parametric multidimension (MDS), permutation-based hypothesis testing (ANOSIM), and similarity percentage (SIMPER) analyses.

2.3.6 Length Size Composition

To evaluate the length size status of the stock in comparison to sustainability reference points, the Froese indicator tool was adopted (Froese 2004). This was computed based on the percentage of juveniles, mature, and mega-spawners. In this study, the target reference were (a) juvenile catch should be <10% to allow maturation process to occur; (b) mature catch should be 70%-80% which is the length that reach the size at first maturity (Lm) and; (c) <10% mega-spawners with size larger than the optimum mature size.

2.3.7 Growth and Population Parameters

The length frequency of *Channa striata*, *Oreochromis niloticus*, *Clarias batrachus*, *C. gariepinus*, and *Cyprinus carpio* were raised to monthly basis by getting the ratio of total weight landed and sample then multiplied to the number of frequencies. To obtain the growth parameters, growth rate (K), asymptotic length (*L∞*), growth performance index (Ø’), and the Von Bertalanffy Growth Function (VBGF) was fitted in FISAT II (FAO-ICLARM Stock Assessment Tools), a computer package (Gayanilo et al. 2005). The total mortality (Z) and natural mortality (M) values were obtained from *L∞* and K estimates using the length converted catch curve. The instantaneous fishing mortality rate (F) was computed as F=Z-M and the exploitation rate (E) as E=F/Z. Gulland (1971) suggested that for an optimally-exploited stock, fishing mortality should be about equal to natural mortality, resulting in fixed $E_{opt} = 0.50$. This means that values above the optimum of 0.50 represent overexploitation.

3. RESULTS AND DISCUSSION

3.1 Fisherfolk Profile

The BFAR-FishR fisherfolk distribution record in November 2017 is presented in Table 1. A total of 2,584 fisherfolks were registered under the eight municipalities along Agusan Marsh. Of this, 1,354 or 52% were fishers, while the rest were involved in various activities like gleaning (21.7%), fish vending
(6%), aquaculture (2.6%), fish processing (1.4%), and other activities (15.9%). This only shows that many fisherfolk are highly dependent on the fisheries resources in Agusan Marsh for daily subsistence and for generating income. The highest aggregation of fishers was found in the municipality of Lapaz (771), whereas Veruela has the lowest (3).

### 3.2 Annual Landed Catch

From May 2014 to December 2016, Lapaz and Talacogon had an aggregated annual landed catch of 109 MT in the four landing centers monitored. The trend of annual catch is presented in Figure 3. The observed highest catch was in May 2014 to December 2014 with 45.4 MT. This decreased to 37.1 MT in 2015 and further decreased to 26.6 MT in 2016. Lapaz and Talacogon contributed 54% and 46% of the annual catch, respectively (Figure 4).

### 3.3 Catch Composition and Relative Abundance

Table 2 shows the catch composition and relative abundance (%) of Lapaz and Talacogon for the period of May 2014 to December 2016. In Lapaz, twelve (12) species were recorded and monitored. The bulk was dominated by *Oreochromis niloticus*, *Channa striata*, *Cyprinus caprio*, *Clarias batrachus*, and *Trichopodus pectoralis*, which accounted for more than 98% of the total catch. Talacogon on the other hand has 17 recorded species, dominated by the same top four species of Lapaz including *Clarias gariepinus*. The...
results imply that Lapaz had higher catch contribution due to the presence of more fishers than in Talacogon. Moreover, the latter had a more diverse species composition due to the use of more fishing gears in the area.

Lapaz and Talacogon catch composition recorded a total of 11 families belonging to 13 genera and 18 species (Table 3). The number of species found in this study is less than the reported >30 fish species by Hubilla-Travis et al. (2008), but slightly higher than the report of Talde et al. (2004) and Oloroso et al (2000) which was 14. The number of species corresponds closely to the one reported by Davies (1991) as cited by Hubilla-Travis et al. (2008) with 16 species. This observed variance may be due to the difference in the number of monitored landing sites and the duration of observed period.

In terms of relative species abundance, the top three dominant species were found to be *Channa striata* under family Channidae, *Oreochromis niloticus* of family Cichlidae, and *Cyprinus carpio* of family Cyprinidae, representing 35%, 27%, and 26% of the monitored catch, respectively. Three catfish or “Pantat” species namely *Clarias batrachus*, *C. gariepinus*, and *C. macrocephalus* share 6%, 1.7%, and 1.2%, respectively (Figure 5). As to catch abundance, introduced species accounted for 98% of the total catch and the remaining 2% came from native species. Native and introduced species comprised of 7 and 11 species, respectively. It should be mentioned that since the earliest report (Herre 1953), the number of native species had significantly decreased and had been replaced and dominated by introduced species (Jumawan and Seronay 2017).

Table 2. Species composition and % relative abundance of Lapaz and Talacogon from May 2014- December 2016.

| Scientific Name                  | Catch (mt) Lapaz | % Relative Abundance | Catch (mt) Talacogon | % Relative Abundance |
|----------------------------------|------------------|----------------------|----------------------|----------------------|
| 1 *Channa striata*               | 17.18            | 29.31                | 21.06                | 41.76                |
| 2 *Oreochromis niloticus*        | 25.86            | 44.13                | 3.53                 | 7.00                 |
| 3 *Cyprinus carpio*              | 12.77            | 21.79                | 15.40                | 30.53                |
| 4 *Clarias batrachus*            | 1.21             | 2.07                 | 5.30                 | 10.50                |
| 5 *Clarias gariepinus*           | 0.28             | 0.48                 | 1.52                 | 3.02                 |
| 6 *Osphronemus goramy*           | 0.02             | 0.03                 | 1.45                 | 2.88                 |
| 7 *Clarias macrocephalus*        | 0.26             | 0.44                 | 0.99                 | 1.97                 |
| 8 *Trichopsis pectoralis*        | 0.87             | 1.49                 | 0.00                 | 0.01                 |
| 9 *Anabas testudineus*           | 0.14             | 0.24                 | 0.35                 | 0.70                 |
| 10 *Macrobrachium spp.*          | -                | -                    | 0.45                 | 0.89                 |
| 11 *Anguilla marmorata*          | -                | -                    | 0.19                 | 0.38                 |
| 12 *Trichogaster pectoralis*     | 0.01             | 0.02                 | 0.11                 | 0.22                 |
| 13 *Osphronemus septemfasciatus* | -                | -                    | 0.03                 | 0.06                 |
| 14 *Glossogobius giuris*         | -                | -                    | 0.03                 | 0.05                 |
| 15 *Pterygoplichthys disjunctivus* | 0.00          | 0.01                 | 0.01                 | 0.02                 |
| 16 *Osphronemus latilaevis*      | -                | -                    | 0.01                 | 0.01                 |
| 17 *Glossogobius celebicus*      | -                | -                    | 0.00                 | 0.00                 |
| 18 *Mugil cephalus*              | 0.00             | 0.00                 | -                    | -                    |

**Grand Total** | **58.60** | **100.00** | **50.44** | **100.00** |
Table 3. List of fish species, family, local name, and category status recorded during the period of May 2014 to December 2016 in Lapaz and Talacogon, Agusan Marsh.

| Species               | Family           | Local Name | Status  | Reference           |
|-----------------------|------------------|------------|---------|---------------------|
| 1. Channa striata     | Channidae        | Haluan     | Introduced | Pauly et al. 1990   |
| 2. Oreochromis niloticus | Cichlidae     | Tilapia    | Introduced | Juliano et al. 1989; Bleher 1994 |
| 3. Cyprinus carpio    | Cyprinidae       | Karpa      | Introduced | Juliano et al. 1989 |
| 4. Clarias batrachus  | Clariidae        | Agok-øk    | Introduced | Juliano et al. 1989 |
| 5. Clarias gariepinus | Clariidae        | Taiwan     | Introduced | Juliano et al. 1989 |
| 6. Osphronemus goramy | Osphronemidae    | Gurami     | Introduced | FishBase 2019       |
| 7. Trichogaster pectoralis | Osphronemidae | Gurami    | Introduced | FishBase 2019       |
| 8. Osphronemus septemfasciatus | Osphronemidae | Gurami | Introduced | FishBase 2019       |
| 9. Osphronemus lactitilapis | Osphronemidae | Gurami  | Introduced | FishBase 2019       |
| 10. Pterygoplichthys disjunctivus | Loricariidae | Janitor   | Introduced | FishBase 2019       |
| 11. Clarias macrocephalus | Clariidae     | Hito, Pantat | Native | FishBase 2019       |
| 12. Anabas testudineus | Anabantidae     | Puyo      | Native  | FishBase 2019       |
| 13. Macrobrachium spp. | Palaemonidae    | Uwang     | Native  | FishBase 2019       |
| 14. Anguilla marmorata | Anguillidae     | Kasili    | Native  | FishBase 2019       |
| 15. Glossogobius giuris | Gobiidae       | Pijanga   | Native  | FishBase 2019       |
| 16. Glossogobius celebius | Gobiidae     | Pijanga   | Native  | FishBase 2019       |
| 17. Mugil cephalus    | Mugillidae      | Banak     | Native  | FishBase 2019       |

Family (11) Genus (13) Species (18) Native (7) Introduced (11)

Figure 5. Top five species monitored in Agusan Marsh from May 2014 to December 2016: a) *Channa striata* “Haluan”; b) *Oreochromis niloticus* “Tilapia”; c) *Cyprinus carpio* “Karpa”; d) *Clarias batrachus* “Pantat”; and e) *Clarias gariepinus* “Taiwan”
Moreover, the other observed species with least occurrence were highly seasonal and migratory (e.g. Osphronemus laticlavius, Glossogobius celebius, and Mugil cephalus). This could be also attributed to anthropogenic activities such as siltation, pollution, and overfishing, which Guerrero (2014) noted to severely degrade most freshwater bodies and reduce biodiversity. Agusan Marsh was also heavily impacted with these anthropogenic factors, mainly from siltation through improper upland farming practices and illegal logging, pollution effluents from mining activities, and overfishing from unregulated and illegal fishing activities, e.g. electrofishing and fine mesh nets. Other reasons why some species are the least abundant may be attributed by invasion of janitor fish (Pterygoplichthys disjunctivus), which is believed to proliferate in the marsh although this study only record it as by-catch from set gillnet since it is not a target species. Invasive species can destroy biodiversity, permanently alter habitats (directly or indirectly), and even cause species extinction (NOAA 2020).

Presence of introduced species in the area poses risk to the endemic and native species (Visto et al. 2015). The presence of janitor fish Pterygoplichthys disjunctivus in Agusan Marsh was studied by Hubilla et al. (2007). She mentioned this species is an adverse competitor of indigenous fishes, destroy nets and pen cages, and has negative impact on local fisheries. P. disjunctivus are voracious feeders and can tolerate adverse climatic condition. With no natural predators, they can multiply fast and out-compete the native fish and other freshwater organisms for food and habitat (Hubilla et al. 2006). As a result, many fishers raised their concern on the removal of the invasive janitor fish in Agusan Marsh during a local consultation.

3.4 Seasonality

Figure 6 shows the seasonality pattern of the five dominant species in Agusan Marsh for the period of January 2015 to December 2016. Channa striata catch was high during the first quarter of the year both in 2015 and 2016, declining in the succeeding months. O. niloticus, on the other hand, illustrate a consistent pattern of catch from August to November with highest in February 2015. Moreover, C. batrachus had a consistent pattern in February and September, and, lastly, C. gariepinus was most abundantly caught in the month of June for both years.

Seasonal patterns of dominant species were heavily influenced by the rainy season. These periods result in high water level where these types of species are most likely to appear in high abundance. Talde et al. (2004) stated that periodic feeding pattern to a general increase in food volume intake starts at the onset of the rainy season (November) and flood months (February to late April), suggesting that the water level has an effect on the feeding activity of the Agusan Marsh fish community. It has been observed that the dry months of March, April, and May show clear patterns of minimal catch since fishes were dependent on the rise of the water. This can be explained by the reported effects of flood inundation to the aquatic wildlife in the Amazon River. During flood periods, the fishes enter the water-laden areas and feed on abundant vegetative and animal food resource. At the same time, this serves as breeding season for many fish populations within the inundated areas (Bodmer 2011), producing an increase in abundance of aquatic animals (Kingsford et al. 1999). Likewise, rain-fed and flood-prone rice fields serve as important feeding and nursery areas for fishes (Coche 1967; Heckman 1974). Fish species migrate into rice fields at the beginning of the wet season to feed and spawn, and subsequently return to permanent water bodies as water level subsides (Coche 1967; Fernando 1993; Meusch 1996).

3.5 Fishing Gears and Species Composition

During the monitoring, a total of ten types of fishing gears were recorded, and the most common were fishpots, set gillnets, electrofishing, set long line, and scoop net while the least were fish trap, gillnet, hook and line, handline, and speargun (Figure 8). Jumawan and Seronay (2017) also mentioned gillnets, electrofishing, fish trap, and multiple hook and line as the most common gears and methods of catching fishes in Agusan Marsh.

Figure 7 and 8 illustrate the common fishing gears operating in Lapaz and Talacogon and the percentage shares of each gear, respectively. Figure 8 shows that fishpot contributed the most percentage share of fish landing (33%).

Figure 9 and 10 show the species composition and relative abundance of the fishes caught by specific
Figure 6. Seasonality pattern of a) *Channa striata*, b) *Oreochromis niloticus*, c) *Cyprinus carpio*, d) *Clarias batrachus*, and e) *C. gariepinus* caught in Agusan Marsh from January 2015 to December 2016.
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Figure 7. Common fishing gears used in Agusan Marsh: a) fishpot or bobe; b) surface gillnet or pukot; c) electrofishing or pangkuryente; d) set longline or palangre; e) scoop net or sikpaw; and f) fish trap or bantak

Figure 8. Percentage share of landings of most common fishing gears used in Lapaz and Talacogon, Agusan Marsh from May 2014 to December 2016.
fishing gears. Common catch composition in Lapaz (Figure 9) are *C. striata*, *O. niloticus*, *C. carpio*, and *C. batrachus* which were primarily caught by fishpot, set gillnet, set long line, and electrofishing. Few catches were recorded for *Trichopodus pectoralis* and *Anabas testudineus*. In Talacogon (Figure 10) *C. striata* was consistently caught in higher abundance by electrofishing, set long line, and set gillnet. Likewise, *C. carpio* and *O. niloticus* were highly caught by fishpot. The other species only constituted a small portion of the catch of the most commonly used gears. Overall, the most abundant fishing method is the fishpot since this is an easy and efficient method. Fisher place several units (20-60 units) of fishpots into the marsh areas daily, and harvest it the next day with considerable catch and income.

### 3.6 Multivariate Analysis

Cluster analysis of fishing gears revealed three main groups (Figure 11). Group 1 composed of set longline, electrofishing, and set gillnet; Group 2 included fishpot, set gillnet, scoopnet, and fishtrap; and Group 3 with speargun, scoopnet, and fishpot. Similarity level at 50% which the different groups were indicated by Cluster analysis shows similarities among Group 1, 2, and 3. The two-multidimensional plot showed a stress value of 0.12 (Figure 12) based on Bray-Curtis similarities, it also showed three different groups relative to the result of the cluster analysis.

Table 4 shows the species that cumulatively contributed 90% to the average Bray-Curtis similarity within the different fishing gear groups. Speargun has 99% similarity to other fishing gears followed by fishpot (72%), fishtrap (70%), set gillnet (68%), set longline (66%), electrofishing (63%), and scoopnet (21%). Species caught with fishpot were dominated by *Oreochromis niloticus* with 39% average abundance and 48% average contribution to the total catch. The result of the similarity percentage analysis coincides with results shown in Figure 9 and 10 for fishpot where *Oreochromis niloticus* contributed 63% catch contribution in Lapaz and 22% in Talacogon for the species composition.
Figure 10. Species composition caught by common fishing gears in Talacogon municipality from May 2014-December 2016.

Figure 11. Dendogram on group average clustering
Table 4. Species contribution to the average Bray-Curtis similarity within the different fishing gear groups.

| Species                  | Electrofishing S=63 | Fishpot S=72 | Fishtrap S=70 | Scoop net S=21 | Set gillnet S=72 | Set longline S=66 | Speargun S=98.62 |
|--------------------------|---------------------|--------------|---------------|----------------|------------------|-------------------|------------------|
| Anguilla marmorata       | 4.52                | 11.23        |               |                |                  |                   |                  |
| Channa striata           | 30.25               | 58.96        | 13.49         | 12.5           | 16.29            | 28.8              | 35.35            |
| Clarias batrachus        | 11.12               | 26.61        |               |                |                  | 6.12              | 9.66             |
| Clarias gariepinus       | 3.62                | 11.35        |               |                | 6.06             |                   | 10.18            |
| Cyprinus carpio          | 25.72               | 26.38        | 25.8          | 67.53          | 20.76            |                   | 5.65             |
| Oreochromis niloticus    | 38.67               | 48.2         | 8.09          | 15.75          | 18.6             |                   | 29.1             |
| Trichopodus pectoralis   | 5.68                | 5.18         |               |                |                  |                   |                  |
Likewise, *Channa striata, Clarias batrachus,* and *Clarias gariepus* were mainly caught by electrofishing, fishpot, set gillnet, and set longline. This corresponds with the result in Figure 9 and 10 with the species composition caught by common fishing gears in Lapaz and Talacogon. Other species listed in Table 4 likewise corresponds with the findings in Figure 9 and 10. In contrast, Table 5 shows the species contributing to the dissimilarities between fishing gear groups.

Table 6 shows the result of the analysis on similarities between fishing gears across the fishing area. The findings revealed that electrofishing and fishpot as well as fishpot and set longline, were significantly different. The differences between fishing gears are mainly due to the variety of the catch contribution and particularly the species composition caught with each type of gear.

Nevertheless, the analysis on similarities between fishing area were not significantly different. This signify that fishing practices and fishing pressure of each fishing gear generally affect the similarities between fishing gears.

### 3.7 Average Catch per Unit Effort (CPUE)

The mean CPUE of fishing gears used in Lapaz and Talacogon are shown in Figure 13 and 14. Fishpot obtained mean CPUE values ranging from 6.2-12.3 kg/boat/day with highest value in February and 5.3-8.4 kg/boat/day with highest value in August 2015 and August 2016. On the other hand, set gillnet yielded mean CPUE values ranging from 4.28-9.1 kg/boat/day with highest value in January and 3.08-5.3 kg/day with highest value in March 2015 and March 2016. Moreover, set longline obtained mean CPUE values ranging from 5.4-13.1 kg/boat/day in 2015 and 4.0-7.2/kg/boat/day in 2016 with peaks recorded in December 2015 (Figure 13). Lastly, for electrofishing, this study only obtained records for January to March 2015 in which CPUE values were found to range from 14.31-17.3 kg/boat/day. This indicate that electrofishing has the highest CPUE among the fishing gears in Lapaz.

In Talacogon, similar types of fishing gears as in Lapaz were used, except for the scoop net. The CPUE of electrofishing yielded a catch rate ranging
Table 6. Analysis on similarities for pairwise test on differences between fishing gear groups

| Gear Groups | Electrofishing & Fishpot | Ave. dissimilarity | Species | Electrofishing | Fishpot | Contribution % |
|-------------|--------------------------|--------------------|---------|----------------|---------|----------------|
| Oreochromis niloticus | 0.78 | 38.67 | 27.65 |
| Channa striata | 30.25 | 13.49 | 24.3 |
| Cyprinus carpio | 4.59 | 25.72 | 19.3 |
| Clarias batrachus | 11.12 | 4.43 | 11.07 |
| Clarias gariepinus | 3.62 | 2.05 | 4.78 |
| Trichiurus lepturus | 0 | 5.68 | 2.84 |
| Macrobrachium rosenbergi | 1.5 | 0 | 2.57 |

| Gear Groups | Electrofishing & Fishtrap | Ave. dissimilarity | Species | Electrofishing | Fishtrap | Contribution % |
|-------------|---------------------------|--------------------|---------|----------------|----------|----------------|
| Cyprinus carpio | 4.59 | 25.8 | 30.78 |
| Channa striata | 30.25 | 3.4 | 24.9 |
| Oreochromis niloticus | 0.78 | 8.09 | 11.76 |
| Clarias batrachus | 11.12 | 1.09 | 11.12 |
| Macrobrachium rosenbergi | 1.5 | 0.68 | 7.03 |
| Anguilla marmorata | 0 | 4.52 | 6.68 |

| Gear Groups | Electrofishing & Set Longline | Ave. dissimilarity | Species | Electrofishing | Set Longline | Contribution % |
|-------------|-------------------------------|--------------------|---------|----------------|---------------|----------------|
| Channa striata | 30.25 | 35.35 | 44.35 |
| Clarias batrachus | 11.12 | 9.66 | 17.69 |
| Clarias gariepinus | 3.62 | 6.06 | 13.87 |
| Cyprinus carpio | 4.59 | 5.17 | 11.01 |
| Clarias macrocephalus | 1.45 | 3.07 | 5.39 |

| Gear Groups | Electrofishing & Speargun | Ave. dissimilarity | Species | Electrofishing | Speargun | Contribution % |
|-------------|----------------------------|--------------------|---------|----------------|----------|----------------|
| Channa striata | 30.25 | 16.29 | 26 |
| Oreochromis niloticus | 0.78 | 18.6 | 24.19 |
| Cyprinus carpio | 4.59 | 15.08 | 17.66 |
| Clarias batrachus | 11.12 | 6.12 | 8.28 |
| Clarias macrocephalus | 1.45 | 5 | 7.97 |
| Anabas testudineus | 0 | 3.56 | 5.01 |
| Clarias gariepinus | 3.62 | 3.27 | 2.66 |

| Gear Groups | Electrofishing & Scoopnet | Ave. dissimilarity | Species | Electrofishing | Scoopnet | Contribution % |
|-------------|---------------------------|--------------------|---------|----------------|----------|----------------|
| Channa striata | 30.25 | 0.58 | 39.06 |
| Cyprinus carpio | 4.59 | 20.76 | 20.24 |
| Clarias batrachus | 11.12 | 0 | 17.83 |
| Oreochromis niloticus | 0.78 | 6.23 | 6.83 |
| Clarias gariepinus | 3.62 | 0 | 5.8 |
| Macrobrachium rosenbergi | 1.5 | 0 | 5.35 |

| Gear Groups | Fishtrap & Speargun | Ave. dissimilarity | Species | Fishtrap | Speargun | Contribution % |
|-------------|---------------------|--------------------|---------|----------|----------|----------------|
| Oreochromis niloticus | 38.67 | 0 | 44.92 |
| Cyprinus carpio | 25.72 | 5.65 | 36.57 |
| Channa striata | 13.49 | 0 | 6.2 |
| Anguilla marmorata | 0.95 | 0 | 5.06 |

| Gear Groups | Fishtrap & Scoopnet | Ave. dissimilarity | Species | Fishtrap | Scoopnet | Contribution % |
|-------------|---------------------|--------------------|---------|----------|----------|----------------|
| Cyprinus carpio | 25.8 | 20.76 | 51.11 |
| Oreochromis niloticus | 8.09 | 6.23 | 21.7 |
| Anguilla marmorata | 4.52 | 0 | 11.98 |
| Channa striata | 3.4 | 0.58 | 7.22 |

| Gear Groups | Fishtrap & Set Gillnet | Ave. dissimilarity | Species | Fishtrap | Set Gillnet | Contribution % |
|-------------|------------------------|--------------------|---------|-----------|------------|----------------|
| Channa striata | 3.4 | 16.29 | 24.77 |
| Oreochromis niloticus | 8.09 | 18.6 | 13.03 |
| Cyprinus carpio | 25.8 | 15.08 | 12.45 |
| Clarias macrocephalus | 0 | 5 | 11.48 |
| Clarias batrachus | 1.09 | 6.12 | 10.92 |
| Anabas testudineus | 0 | 3.56 | 7.46 |
| Anguilla marmorata | 4.52 | 0 | 7.26 |
| Clarias gariepinus | 0 | 3.27 | 5.86 |

| Gear Groups | Fishtrap & Set Lc | Ave. dissimilarity | Species | Fishtrap | Set Lc | Contribution % |
|-------------|------------------|-------------------|---------|----------|--------|----------------|
| Channa striata | 3.4 | 35.35 | 46.16 |
| Oreochromis niloticus | 8.09 | 18.6 | 17.65 |
| Clarias batrachus | 1.09 | 6.06 | 10.37 |
| Clarias gariepinus | 0 | 5.17 | 9.75 |
| Cyprinus carpio | 25.8 | 2.02 | 5.32 |
| Oreochromis niloticus | 8.09 | 0 | 8.32 |
| Clarias macrocephalus | 0 | 3.07 | 7.77 |

| Gear Groups | Fishtrap & Speargun | Ave. dissimilarity | Species | Fishtrap | Speargun | Contribution % |
|-------------|---------------------|--------------------|---------|----------|----------|----------------|
| Cyprinus carpio | 25.8 | 0.58 | 71.99 |
| Oreochromis niloticus | 4.52 | 0 | 83.62 |
| Channa striata | 3.4 | 0 | 91.97 |

| Gear Groups | Scoopnet & Set G | Ave. dissimilarity | Species | Scoopnet | Set G | Contribution % |
|-------------|-----------------|------------------|---------|---------|------|----------------|
| Channa striata | 0.58 | 16.29 | 30.22 |
| Cyprinus carpio | 20.76 | 15.08 | 18.99 |
| Clarias batrachus | 0 | 6.12 | 13.51 |
| Clarias macrocephalus | 0 | 5 | 10.84 |
| Oreochromis niloticus | 6.23 | 18.6 | 10.07 |
| Clarias gariepinus | 0 | 3.27 | 7.68 |

| Gear Groups | Scoopnet & Speargun | Ave. dissimilarity | Species | Scoopnet | Speargun | Contribution % |
|-------------|---------------------|--------------------|---------|----------|----------|----------------|
| Cyprinus carpio | 20.76 | 5.65 | 73.56 |
| Oreochromis niloticus | 6.23 | 0 | 23.93 |
Table 6. continuation. Analysis on similarities for pairwise test on differences between fishing gear groups

| Groups Fishpot & Fishtrap | Ave. dissimilarity = 43 |
|----------------------------|-------------------------|
| Species                    | Fishpot     | Fishtrap    | Contribution % |
| Cyprinus carpio            | 25.72       | 25.8        | 45.51          |
| Oreochromis niloticus      | 38.67       | 8.09        | 26.6           |
| Channa striata             | 13.49       | 3.4         | 9.4            |
| Anguilla marmorata         | 0.95        | 4.52        | 8.62           |

| Groups Fishpot & Scoopnet | Ave. dissimilarity = 56 |
|----------------------------|-------------------------|
| Species                    | Fishpot     | Scoopnet    | Contribution % |
| Cyprinus carpio            | 25.72       | 20.76       | 50.56          |
| Oreochromis niloticus      | 38.67       | 6.23        | 33.65          |
| Channa striata             | 13.49       | 0.58        | 5.65           |
| Anguilla marmorata         | 0.95        | 0           | 4.46           |

| Groups Fishpot & Set Gillnet | Ave. dissimilarity = 50 |
|-------------------------------|-------------------------|
| Species                       | Fishpot     | Set Gillnet | Contribution % |
| Channa striata                | 13.49       | 16.2        | 23.53          |
| Oreochromis niloticus         | 38.67       | 18.6        | 21.89          |
| Cyprinus carpio               | 25.72       | 15.08       | 16.49          |
| Clarias batrachus             | 4.43        | 6.12        | 10.81          |
| Clarias macrocephalus         | 1.07        | 5           | 7.6            |
| Clarias gariepinus            | 2.05        | 3.27        | 6.26           |
| Arhabas testudineus           | 2.32        | 3.56        | 4.79           |

| Groups Fishpot & Set Longline | Ave. dissimilarity = 72 |
|-------------------------------|-------------------------|
| Species                       | Fishpot     | Set Longline | Contribution % |
| Oreochromis niloticus         | 38.67       | 2.02        | 32.19          |
| Channa striata                | 13.49       | 35.35       | 27.17          |
| Cyprinus carpio               | 25.72       | 5.17        | 16.75          |
| Clarias batrachus             | 4.43        | 9.66        | 8.84           |
| Clarias gariepinus            | 2.05        | 6.06        | 4.7            |
| Trichopodus pectoralis        | 5.68        | 0           | 4.01           |

| Group Scoopnet & Set Longline | Ave. dissimilarity = 85 |
|-------------------------------|-------------------------|
| Species                      | Scoopnet | Set Longline | Contribution % |
| Channa striata               | 0.58     | 35.35       | 41.27          |
| Cyprinus carpio              | 20.76    | 5.17        | 24.11          |
| Clarias batrachus            | 0        | 9.66        | 16.62          |
| Clarias gariepinus           | 0        | 6.06        | 7.93           |
| Oreochromis niloticus        | 6.23     | 2.02        | 7.28           |

| Group Set Gillnet & Speargun | Ave. dissimilarity = 89 |
|-------------------------------|-------------------------|
| Species                       | Set Gillnet | Speargun | Contribution % |
| Channa striata                | 16.29      | 21.04     | 34.12          |
| Oreochromis niloticus         | 18.6       | 12.36     | 20.04          |
| Cyprinus carpio               | 15.08      | 8.11      | 13.15          |
| Clarias batrachus             | 6.12       | 5.7       | 9.25           |
| Clarias gariepinus            | 5          | 4.85      | 7.87           |
| Clarias macrocephalus         | 3.27       | 4.71      | 7.64           |

| Group Set Longline & Speargun | Ave. dissimilarity = 86 |
|-------------------------------|-------------------------|
| Species                       | Set Longline | Speargun | Contribution % |
| Channa striata                | 35.35       | 0        | 50.83          |
| Clarias batrachus             | 9.66        | 0        | 19.43          |
| Cyprinus carpio               | 5.17        | 5.65     | 11.51          |
| Clarias gariepinus            | 6.06        | 0        | 10.78          |

| Group Set Gillnet & Speargun | Ave. dissimilarity = 86 |
|-------------------------------|-------------------------|
| Species                       | Set Gillnet | Speargun | Contribution % |
| Channa striata                | 16.29       | 0        | 24.94          |
| Cyprinus carpio               | 15.08       | 5.65     | 22.54          |
| Oreochromis niloticus         | 18.6        | 0        | 19.27          |
| Clarias batrachus             | 6.12        | 0        | 10.52          |
| Clarias gariepinus            | 5           | 0        | 8.74           |
| Arhabas testudineus           | 3.56        | 0        | 5.34           |

Figure 13. Mean Catch per Unit Effort (CPUE) of fishing gears employed in Lapaz: a) Fishpot, b) Set gillnet, c) Electrofishing, and d) Set longline from January 2015 to December 2016.
between 3.5-11.7 kg/boat/day and 3.2-7.8 kg/boat/day in 2015 and 2016, respectively. Set long line had 2.2-16.5 kg/boat/day and 2.7-9.4 kg/day, set gillnet had 1.17-8.2 kg/boat/day, fishpot had 3.7-13 kg/boat/day, and scoop net had 2.10-39 kg and 3.5-8.0 kg/boat/day in 2015 and 2016, respectively (Figure 14). The results found are in parallel with the trends of seasonal pattern of catch in Figure 6. The decrease of catch rate may be attributed to many factors such as overfishing, no regulations of size of fish, electrofishing, which may cause mortalities to the young ones, and a combination of environmental and anthropogenic factors.

### 3.8 Length Size Distribution

To compare the length sizes of species caught by the common fishing gears used in Agusan Marsh, five dominant species were subjected to Froese (2004) indicator tool in terms of sustainability by computing the percentage of immature, mature, and mega-spawner (Figure 15a-e).

For *C. striata*, based on its life history, this species normally attains its length at first maturity (Lm) at 25 cm and grows up to a maximum length (Lmax) of 100 cm in the Philippines (FishBase 2019). The result of our study reveals that this species is being caught by four primary fishing gears, namely electrofishing, set gillnet, fish pot, and set long line from the size of 20.5 cm to 56.5 cm. The observed longest fish was longer than the study of Dumalagan et al. (2017) which reported maximum length of 40.7 cm in a study in Agusan Marsh. Juveniles of *Channa striata* were found to be caught at smaller portion (1 to 8%), whereas mature and bigger sizes were high at 92-99%. This suggests *C. striata* has strong recruitment because mature individuals is able to reproduce and the target reference point was attained.

For *O. niloticus*, Lmax was found to be 60 cm while Lm was 26.1 cm in Lake Kivu in East Africa (FishBase 2019). The authors of this report found
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Figure 15a. Length composition of *Channa striata* caught by electrofishing, scoop net, fishpot, and set longline in Lapaz and Talacogon, Agusan Marsh in 2016.

Figure 15b. Length composition of *Oreochromis niloticus* caught by set gillnet and fishpot in Lapaz and Talacogon, Agusan Marsh in 2016.
Figure 15c. Length composition of *Cyprinus carpio* caught by fishpot, fish trap, set gillnet, and set long line in Lapaz and Talacogon, Agusan Marsh in 2016.

Figure 15d. Length composition of *Clarias batrachus* caught by fishpot, electrofishing, set gillnet, and set longline in Lapaz and Talacogon, Agusan Marsh 2016.
existing record of these parameters for this species in
the marshlands of the Philippines. The result shows
that with gillnet and fishpot, juveniles were heavily
catched which ranged from 92-98% while 2-8% of the
remaining catch composed of mature individuals.

For *C. carpio*, recorded Lmax is 120 cm and
34.9 cm in occurrence in Lake Naivasha in Kenya
(FishBase 2019). The result of this study revealed that
89-94% of the catch were juveniles, and only 6%-11%
were caught at mature adult stage using fishpot, fish
trap, set gillnet, and set long lines.

Moreover, 20-40% of *C. batrachus* caught
were juveniles, 40-58% were mature adults, and 18-
22% were mega spawners. Lastly, *C. gariepinus* catch
comprised of more juveniles (26-66%) than mature
(24-78%).

Among all the evaluated dominant species,
only *Channa striata* was found to be harvested at
sustainable level. In contrast, *Oreochromis niloticus,*
*Clarias batrachus, Cyrinus caprio,* and *G. gariepinus*
were all subjected to growth overfishing, where an
unsustainable number of juveniles or immature
individuals are being harvested.

According to Froese (2004), there are three
simple indicators of fisheries sustainability to observe.
First, let the fish spawn in order to maintain and
rebuild a healthy stock by allowing the fish to spawn
at least once in their life cycle. Second is to let them
grow to optimum length, a bit larger than the length
at first maturity. Lastly, let the mega-spawner live. It

**Figure 15e.** Length composition of *Clarias gariepinus* caught by fishpot, electrofishing, set gillnet, and set longline in Lapaz and Talacogon, Agusan Marsh 2016
means large females are to be protected as they are more fecund and eggs are large, thus, giving a greater chance of survival rate.

3.9 Growth and Population parameters

The actual and raised length frequency data of the five dominant species monitored from January to December 2015 and 2016 is presented in Table 7. For the analysis of the population parameters, raised length frequency data were used in the FiSAT II software (Gayanilo et al. 2005). The growth and population parameters are given in Table 8. The estimated L∞, K, and phi prime (Ø') of *Channa striata*, *O. niloticus*, *C. carpio*, *C. batrachus*, and *C. gariepinus* show variance both in 2015 and 2016. In terms of L∞, the largest was *C. carpio* with 67 cm in 2016 and *C. batrachus* as smallest with 42.1 cm in 2015. The estimated K ranged from 0.42-0.81 specifically for *C. carpio* and *C. gariepinus*, respectively. The Ø' ranged from 2.871-3.427 values and are within the range from other studies (Table 9). Values that does not fall within the range recorded in existing studies, are attributed to area-specific and environmental factors which may affect the growth rate of the fish (King 1995).

### Table 7. Actual and raised length frequency data of five dominant species in Lapaz and Talacogon, Agusan Marsh for the period of January 2015 to December 2016.

| Species          | 2015 Actual LF | 2015 Raised LF | 2016 Actual LF | 2016 Raised LF |
|------------------|---------------|--------------|---------------|--------------|
| *Channa striata* | 5,326         | 14,518       | 4,436         | 7,881        |
| *Oreochromis niloticus* | 4,949     | 20,564       | 5,308         | 16,248       |
| *Cyprinus carpio* | 1,492         | 5,474        | 1,113         | 4,015        |
| *Clarias batrachus* | 867           | 1,782        | 750           | 1,887        |
| *Clarias gariepinus* | 230           | 594          | 270           | 580          |

### Table 8. Growth and population parameters of five dominant species caught in Lapaz and Talacogon, Agusan Marsh in 2015-2016.

| Species          | Year | L∞  | K   | Ø'  | Z   | M   | F   | E   |
|------------------|------|-----|-----|-----|-----|-----|-----|-----|
| *Channa striata* | 2015 | 48.37 | 0.79 | 3.267 | 2.3 | 1.34 | 0.96 | 0.42 |
|                  | 2016 | 60.10 | 0.74 | 3.427 | 3.13 | 1.21 | 1.92 | 0.61 |
| *Oreochromis niloticus* | 2015 | 46.48 | 0.67 | 3.164 | 3.3 | 1.22 | 2.09 | 0.63 |
|                  | 2016 | 41.06 | 0.81 | 3.135 | 5.06 | 1.43 | 3.63 | 0.72 |
| *Cyprinus carpio* | 2015 | 67   | 0.67 | 3.437 | 3.10 | 1.03 | 2.07 | 0.67 |
|                  | 2016 | 63.4 | 0.42 | 3.158 | 2.14 | 0.82 | 1.32 | 0.62 |
| *Clarias batrachus* | 2015 | 44.79 | 0.79 | 2.871 | 2.0 | 1.37 | 0.63 | 0.32 |
|                  | 2016 | 45.06 | 0.69 | 3.093 | 2.07 | 1.5 | 0.92 | 0.44 |
| *Clarias gariepinus* | 2015 | 42.05 | 0.42 | 3.20  | 1.37 | 0.92 | 0.45 | 0.33 |
|                  | 2016 | 45   | 0.69 | 3.145 | 2.86 | 1.25 | 1.61 | 0.56 |
In terms of fishing mortalities and exploitation, the species that exhibited high fishing mortalities consistent with high exploitation rates were *O. niloticus*, *C. carpio*, *C. striata* (0.61) and *C. garipienus* (0.56) in 2016. The high fishing mortalities were due to high fishing pressure brought by harvesting of immature sizes, which consequently resulted to exploitation rates beyond the threshold 0.50, indicating that these species were overexploited. On the other hand, of the five species investigated, only *C. batrachus* shows under-exploitation where the values ranged below the optimum between 0.32-0.44.

4. CONCLUSION AND RECOMMENDATIONS

The annual monitored catch in Lapaz and Talacogon were in decreasing trend from 45.4-26.6 MT. *Channa striata* was the most dominant species comprising 35% of the total catch. A consistent high catch was seen during February and June, while the CPUE yield peak during the flood seasons or rainy months particularly in January, February, June, and
December. Electrofishing is still existing in the area and poses harmful effects to the fish larvae, which may lead to mortalities due to electro effect. The species beyond threshold includes *O. niloticus* and *C. carpio* ranging from 92-95% and 89-94%, respectively. These species followed moderately beyond the threshold; *C. gariepinus* and *C. batrachus* ranging from 26-66% and 20-40%, respectively. In contrast, only *C. striata* fall within the threshold or target of 1-8% indicating that *C. striata* was caught at mature sizes. In terms of exploitation, *O. niloticus* and *C. carpio* exhibited very high exploitation for both years followed by *C. striata* and *C. gariepinus* in 2016. This was attributed to the heavy fishing pressure caused by catching more immature sizes using set gillnets, fishpots, fish trap, and set long lines. The species below exploitation was only *C. batrachus* (0.32 and 0.44). Generally, the key species in Agusan Marsh are at risk of overfishing.

With the present status, it is recommended to reduce the high fishing pressure in Agusan Marsh brought by the use of smaller mesh size and electrofishing. To attain this, there should be an immediate action from the Local Government Units (LGUs) to check and evaluate existing fishing methods and practices by the fishers. LGUs should also formulate ordinances in the use legal mesh size and bigger hook size. It is also suggested to conduct future reproductive biology study for key species to confirm the length at first maturity as it is critical to know what size should be the catch limit. In addition, it will determine what particular months need to be regulated to protect spawners. Also, the removal of janitor fish, which is a threat to the freshwater species in the Agusan Marsh, is recommended. There should be a strong support from the LGUs bordering Agusan Marsh in the implementation of fishery laws to stop electrofishing and other illegal fishing practices. The Protected Area Management Board (PAMB) should be strengthened through regular meetings for updates and formulation of resolutions in support to fisheries management for key species in Agusan Marsh. Intervention on other possible sources of livelihood aside from fishing is also strongly recommended.

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Appendices

Figure 16. Von Bertalanffy Growth Function (VBGF) of *Channa striata* in 2015 (a) and 2016 (b); Length Converted Catch curve in 2015 (c) and 2016 (d)

Figure 17. Von Bertalanffy Growth Function (VBGF) of *Oreochromis niloticus* in 2015 (a) and 2016 (b); Length Converted Catch curve in 2015 (c) and 2016 (d)
Figure 18. Von Bertalanffy Growth Function (VBGF) of *Cyprinus carpio* in 2015 (a) and 2016 (b); Length Converted Catch curve in 2015 (c) and 2016 (d).

Figure 19. Von Bertalanffy Growth Function (VBGF) of *Clarias batrachus* in 2015 (a) and 2016 (b); Length Converted Catch curve in 2015 (c) and 2016 (d).
Figure 20. Von Bertalanffy Growth Function (VBGF) of *Clarias gariepinus* in 2015 (a) and 2016 (b); Length Converted Catch curve in 2015 (c) and 2016 (d)