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FULL PAPER

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 laticlavius, Glossogobius celebius* 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.

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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 liner 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,

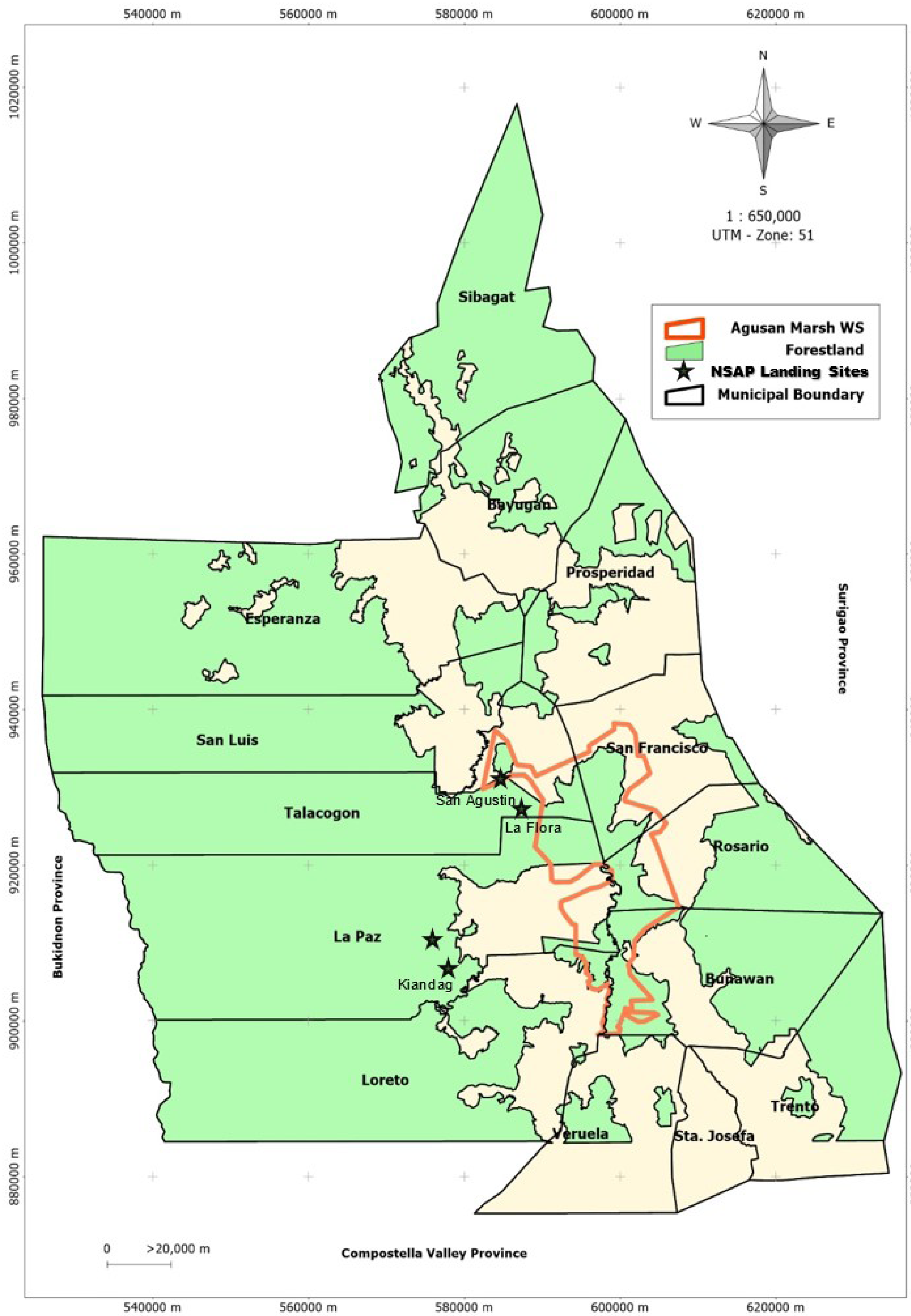


Figure 1. Map of Agusan Marsh showing the sampling sites (image source: DENR 2020).

Figure 2. Monitored NSAP landing centers: a) Brgy. La Flora, Talacogon (major landing center); b) Brgy. San Agustin, Talacogon (minor); c) Brgy. Agpangon, Lapaz (major); and d) Brgy. Kiandag, Lapaz (minor).

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 PRIMER 7, following the guide on analysis as stated by Clarke and Gorley (2006). The data set were 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 ($L\infty$), 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 morality (M) values were obtained from $L\infty$ 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

Table 1. Distribution of fisherfolk in eight municipalities along Agusan Marsh (DA-BFAR 2017).

Municipality	Capture fishing	Aquaculture	Fish Vending	Gleaning	Fish processing	Others	Total
Lapaz	**771**	**16**	**0**	**520**	**0**	**50**	**1357**
Talacogon	**221**	**5**	**15**	**0**	**7**	**32**	**280**
Loreto	152	6	62	7	15	12	254
Bunawan	161	2	58	29	10	8	268
San Francisco	28	3	11	4	1	309	356
Rosario	11	29	5	0	3	0	48
Santa Josefa	7	0	3	0	0	1	11
Veruela	3	6	1	0	0	0	10
Total	**1354**		**67**	**155**	**560**	**36**	**2584**

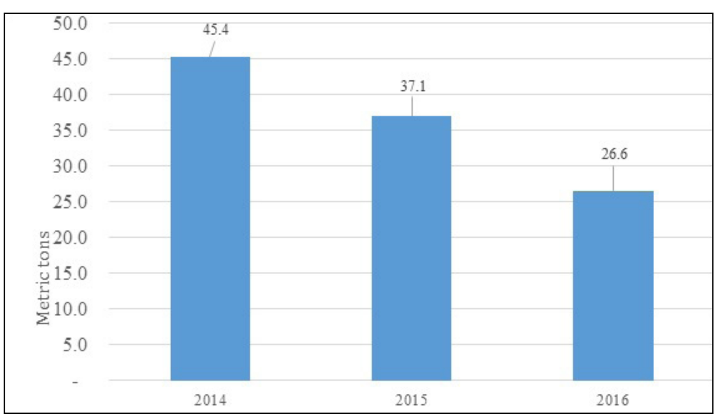


Figure 3. Annual landed catch in Lapaz and Talacogon, Agusan Marsh from May 2014 to December 2016.

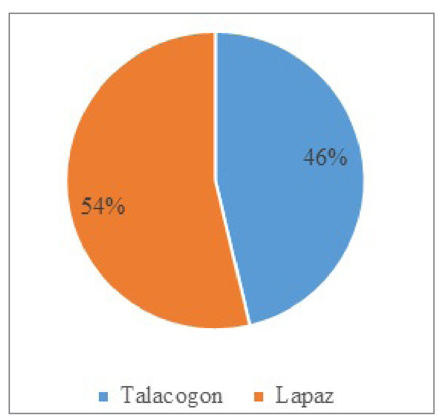


Figure 4. Annual catch in the municipality of Lapaz and Talacogon, Agusan Marsh from May 2014 to December 2016.

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	*Trichopodus 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 laticlavius*	-	-	0.01	0.01
17	*Glossogobius celebius*	-	-	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.

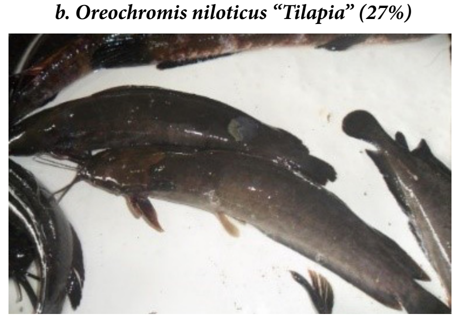
	Species	Family	Local Name	Status	Reference
1.	*Channa striata*	Channidae	Haluan	Introduced	Pauly et al. 1990
2.	*Oreochromis niloticus*	Cichlidae	Tilapia	Introduced	Juliano et al. 1989; Bleher 1994
3.	*Cyprinus carpio*	Cyprinidae	Karpa	Introduced	Juliano et al. 1989
4.	*Clarias batrachus*	Clariidae	Agok-ok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

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

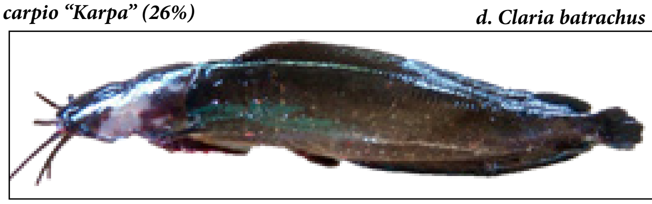
a) Channa striata "Haluan" (35%)

b. Oreochromis niloticus "Tilapia" (27%)

c. Cyprinus carpio "Karpa" (26%)



d. Claria batrachus "Agok-ok" (6%)



e. Clarias gariepinus "Pantat" (2%)

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 Guerero (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

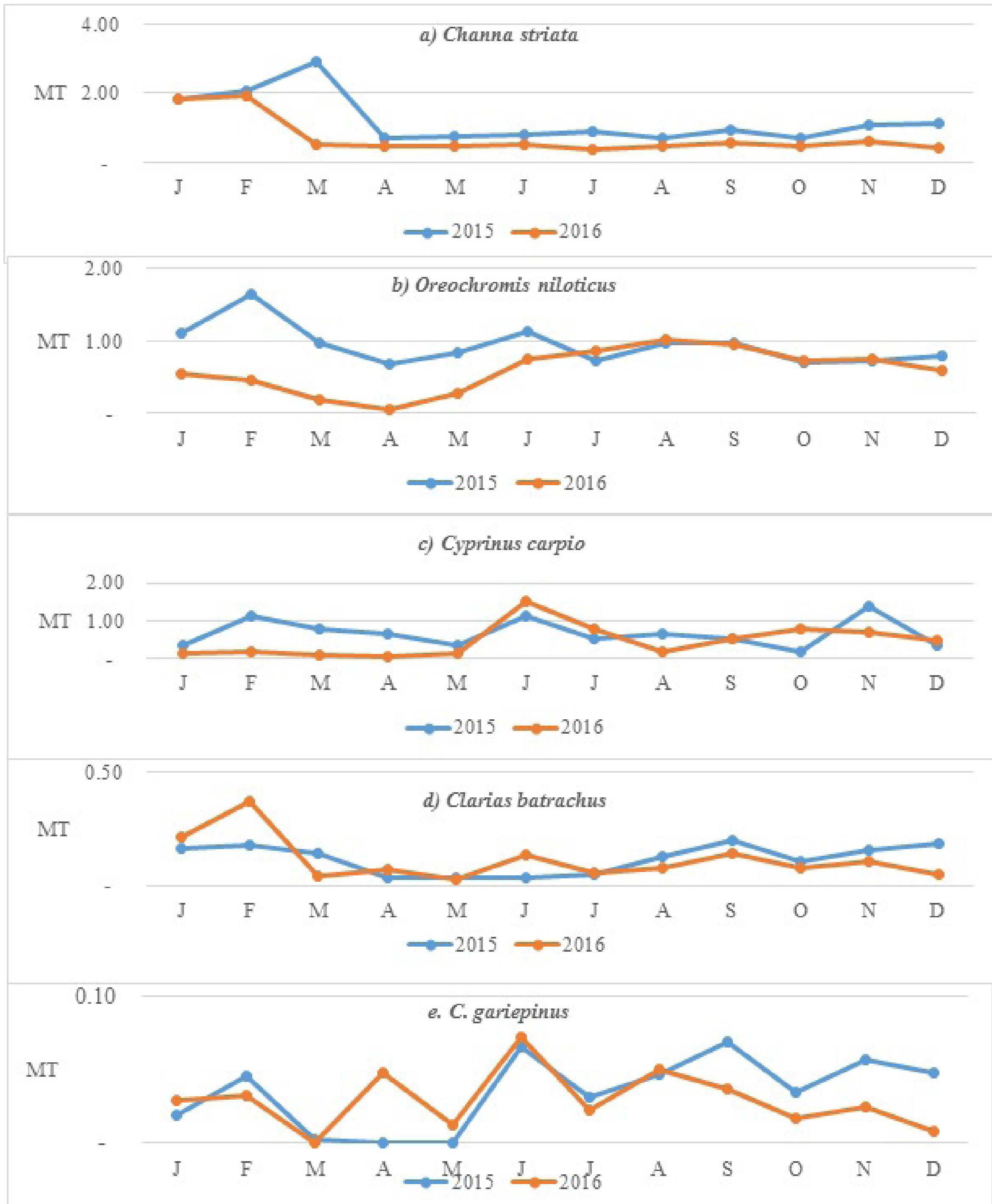


Figure 6. Seasonality pattern of a) *Channa striata*, b) *Oreochromis niloticus*. c) *Cyprinus carpio*, d) *Clarias batrachus*, and e) *C. gariepinus* caught in Agusan Marsh from January 2015 to December 2016.

Figure 7. Common fishing gears used in Agusan Marsh: a) fishpot or *bobo*; 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*

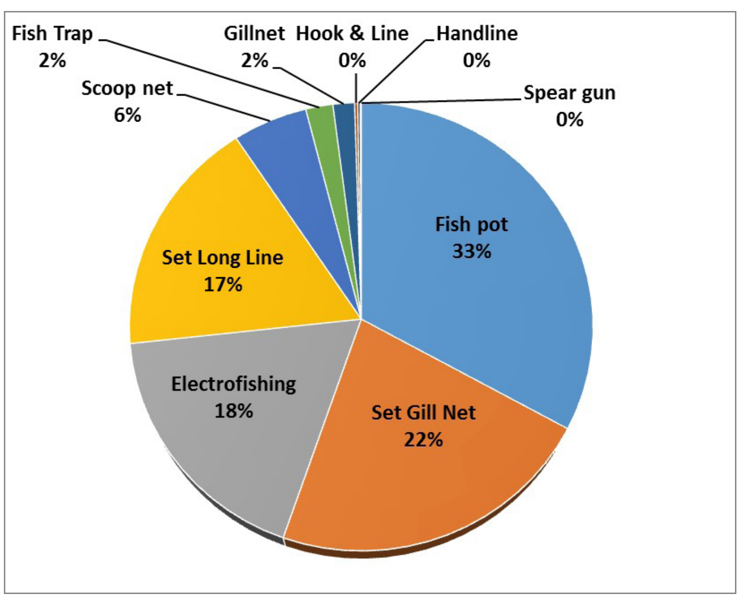


Figure 8. Percentage share of landings of most common fishing gears used in Lapaz and Talacogon, Agusan Marsh from May 2014 to December 2016.

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.

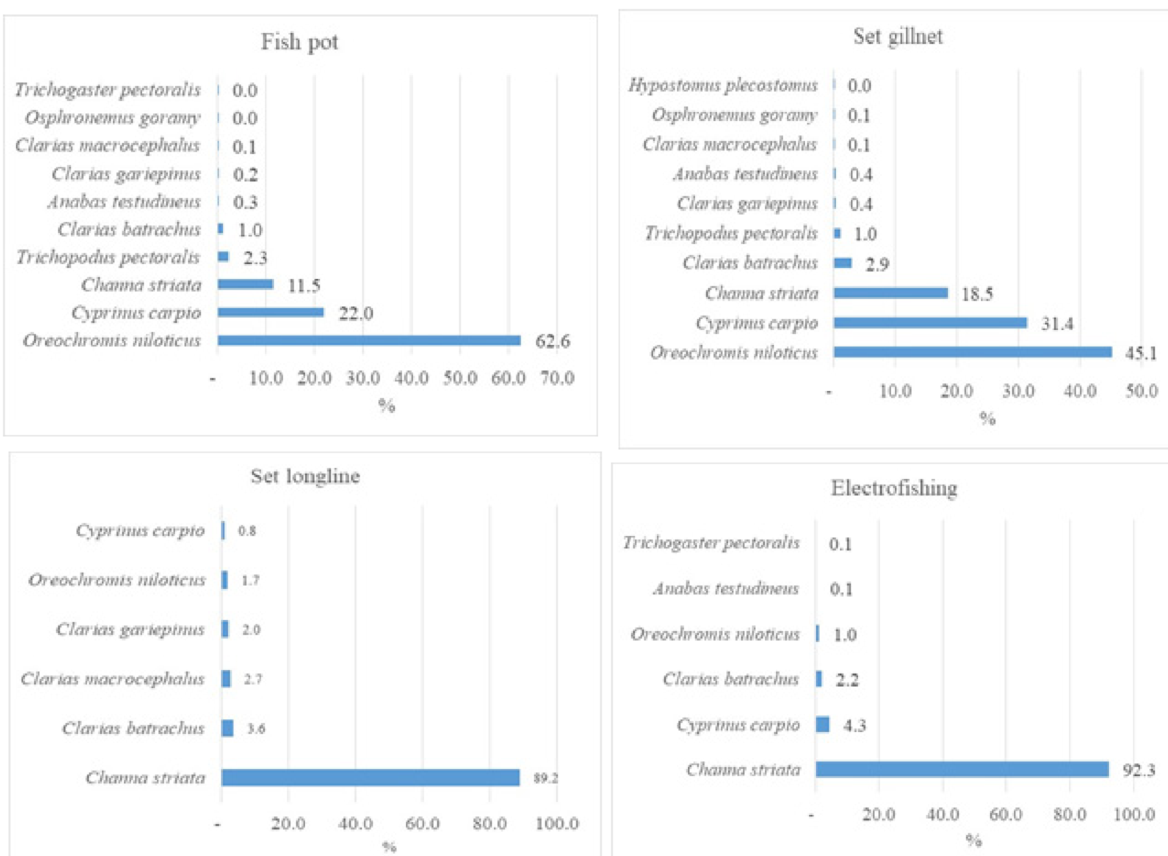


Figure 9. Species composition caught by common fishing gears in Lapaz municipality from May 2014 to December 2016

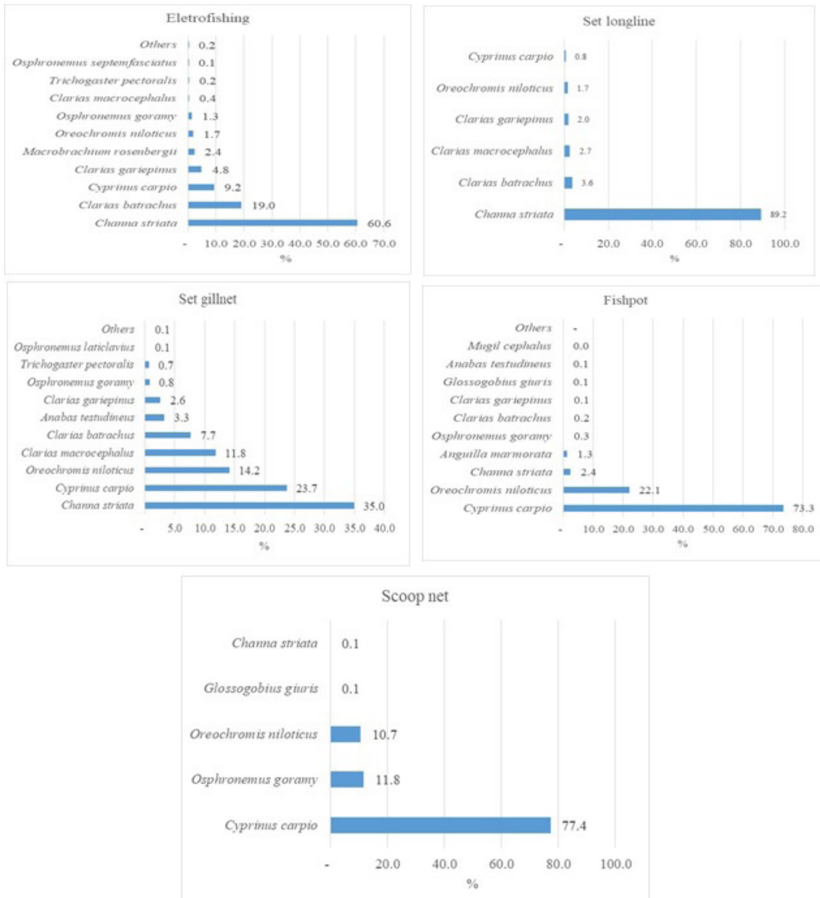


Figure 10. Species composition caught by common fishing gears in Talacogon municipality from May 2014-December 2016.

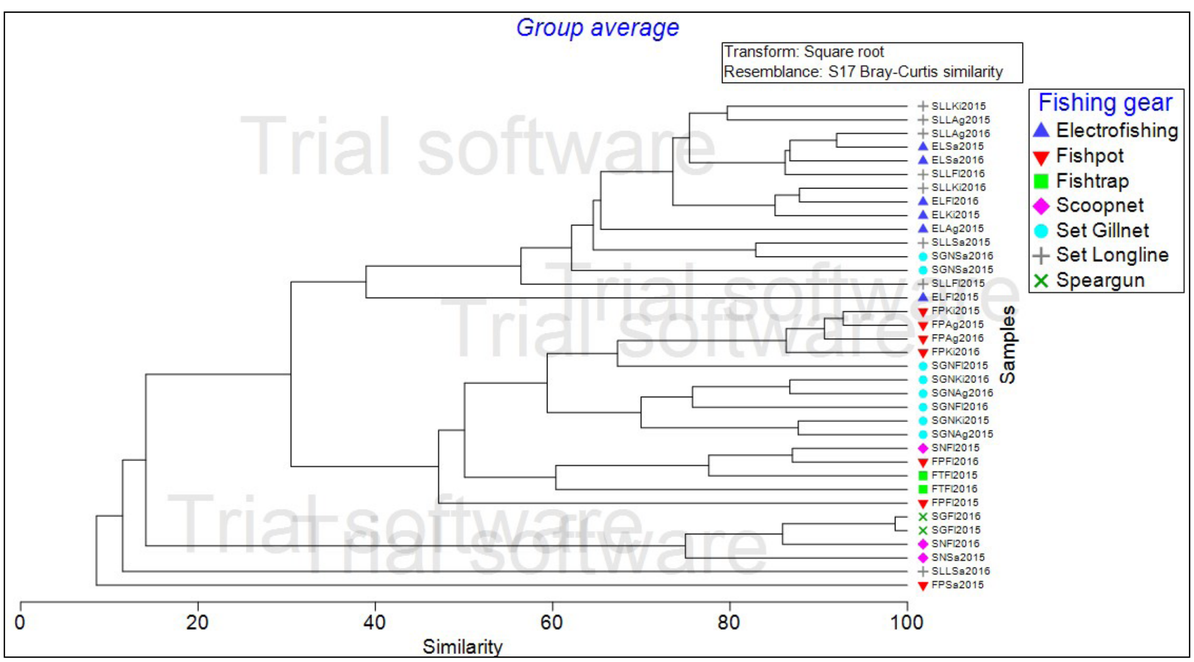


Figure 11. Dendogram on group average clustering

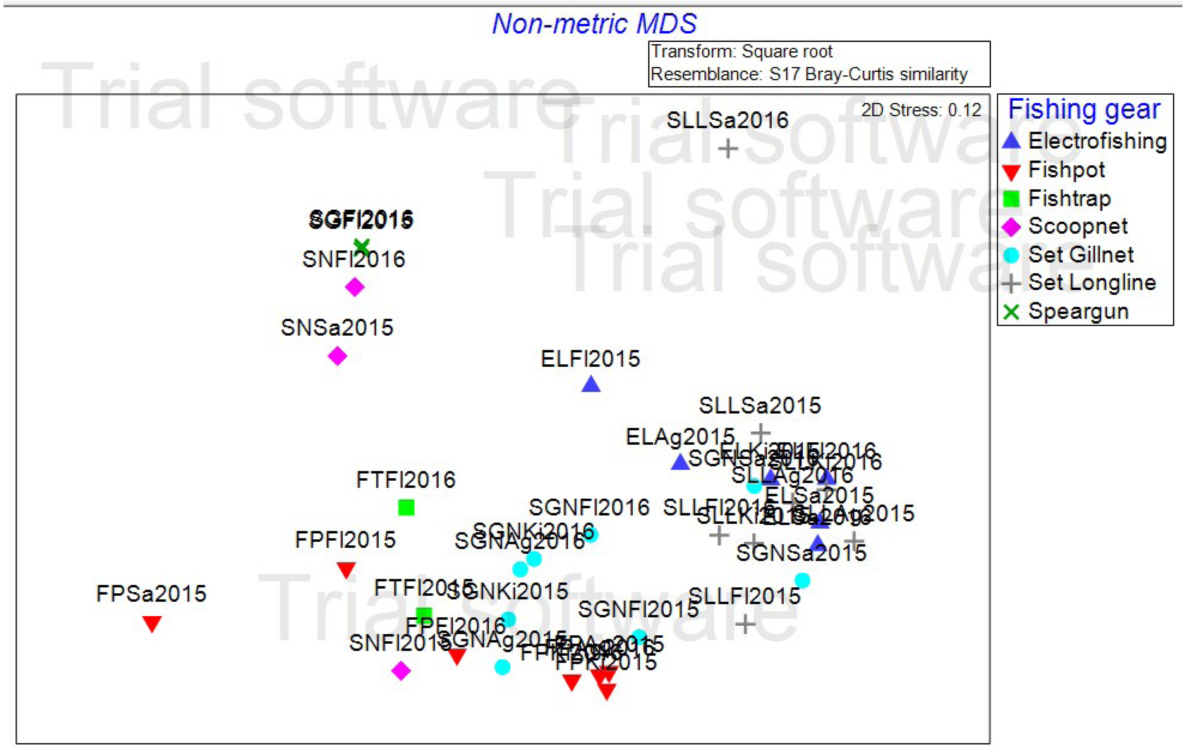


Figure 12. Multidimensional scaling ordination (stress = 0.12) based on Bray-Curtis similarities

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	
	A	C%	A	C%	A	C%	A	C%	A	C%	A	C%	A	C%
Anguilla marmorata					4.52	11.23								
Channa striata	30.25	58.96	13.49	12,5					16.29	28.8	35.35	68.33		
Clarias batrachus	11.12	26.61							6.12	8.3	9.66	15.95		
Clarias gariepinus	3.62	11.35									6.06	10.18		
Cyprinus carpio			25.72	26.38	25.8	67.53	20.76	100	15.08	26.27			5.65	100
Oreochromis niloticus			38.67	48.2	8.09	15.75			18.6	29.1				
Trichopodus pectoralis			5.68	5.18										

Table 5. Percentage on species contribution on the average Bray-Curtis dissimilarity within each group (fishing gears). The first two columns represents average abundance of a particular fishing gear.

Groups	R Statistics	Sig.level %	Possible permutations	Actual permutations	Number observed
Electrofishing, Fishpot	0.636	0.1	1716	999	0
Electrofishing, Fishtrap	0.927	3.6	28	28	1
Electrofishing, Scoopnet	0.938	1.2	84	84	1
Electrofishing, Set gillnet	0.429	1.5	3003	999	4
Electrofishing, Set longline	-0.035	56.5	3003	999	564
Electrofishing, Speargun	1	3.6	28	28	1
Fishpot, Fishtrap	0.11	27.8	36	36	10
Fishpot, Scoopnet	0.317	6.7	120	120	8
Fishpot, Set gillnet	0.073	15.9	6435	999	158
Fishpot, Set longline	0.566	0.1	6435	999	0
Fishpot, Speargun	0.695	2.8	36	36	1
Fishtrap, Scoopnet	0	40	10	10	4
Fishtrap, Set gillnet	0.379	11.1	45	45	5
Fishtrap, Set longline	0.698	4.4	45	45	2
Fishtrap, Speargun	1	33.3	3	3	1
Scoop net, Set gillnet	0.694	1.2	165	165	2
Scoopnet, Set longline	0.879	0.6	165	165	1
Scoop net, Speargun	0.167	30	10	10	3
Set gillnet, Set longline	0.394	0.4	6435	999	3
Set gillnet, Speargun	1	2.2	45	45	1
Set longline, Speargun	0.957	2.2	45	45	1

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

Groups Electrofishing & Fishpot
Ave. dissimilarity = 78

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
Trichopodus pectoralis	0	5.68	2.84
Macrobrachium rosenbe	1.5	0	2.57

Groups Electrofishing & Fishtrap
Ave. dissimilarity = 77

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 rosenbe	1.5	0.68	7.03
Anguilla marmorata	0	4.52	6.68

Group Electrofishing & Set Longline
Ave. dissimilarity = 48

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

Group Electrofishing & Speargun
Ave. dissimilarity = 87

Species	Electrofishing	Speargun	Contribution %
Channa striata	30.25	0	46.52
Clarias batrachus	11.12	0	20.23
Macrobrachium rosenbe	1.5	0	11.58
Cyprinus carpio	4.59	5.65	11.35
Clarias macrocephalus	1.45	0	6.48

Group Electrofishing & Set Gillnet
Ave. dissimilarity = 50

Species	Electrofishing	Set Gillnet	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

Group Electrofishing & Scoopnet
Ave. dissimilarity = 87

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 rosenbe	1.5	0	5.35

Group Fishpot & Speargun
Ave. dissimilarity = 77

Species	Fishpot	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

Group Fishtrap & Scoopnet
Ave. dissimilarity = 53

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 striate	3.4	0.58	7.22

Group Fishtrap & Set Gillnet
Ave. dissimilarity = 49

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

Group Fishtrap & Set Lo
Ave. dissimilarity = 68

Species	Fishtrap	Set Longline	Contribution %
Channa striata	3.4	35.35	46.16
Clarias batrachus	1.09	9.66	17.65
Clarias gariepinus	0	6.06	10.37
Cyprinus carpio	25.8	5.17	9.75
Oreochromis niloticus	8.09	2.02	5.32
Clarias macrocephalus	0	3.07	4.77

Group Fishtrap & Speargun
Ave. dissimilarity = 77

Species	Fishtrap	Speargun	Contribution %
Cyprinus carpio	25.8	5.65	51.77
Oreochromis niloticus	8	0	71.99
Anguilla marmorata	4.52	0	83.62
Channa striata	3.4	0	91.97

Group Scoopnet & Set G
Ave. dissimilarity = 74

Species	Scoopnet	Set Gillnet	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

Group Scoopnet & Speargun
Ave. dissimilarity = 49

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

Group 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
Anabas testudineus	2.32	3.56	4.79

Group 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 & Set Longline
Ave. dissimilarity = 62

Species	Set Gillnet	Set Longline	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 macrocephalus	5	4.85	7.87
Clarias gariepinus	3.27	4.71	7.64

Group Set Longline & Speargun
Ave. dissimilarity = 89

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 macrocephalus	5	0	8.74
Anabas testudineus	3.56	0	5.34

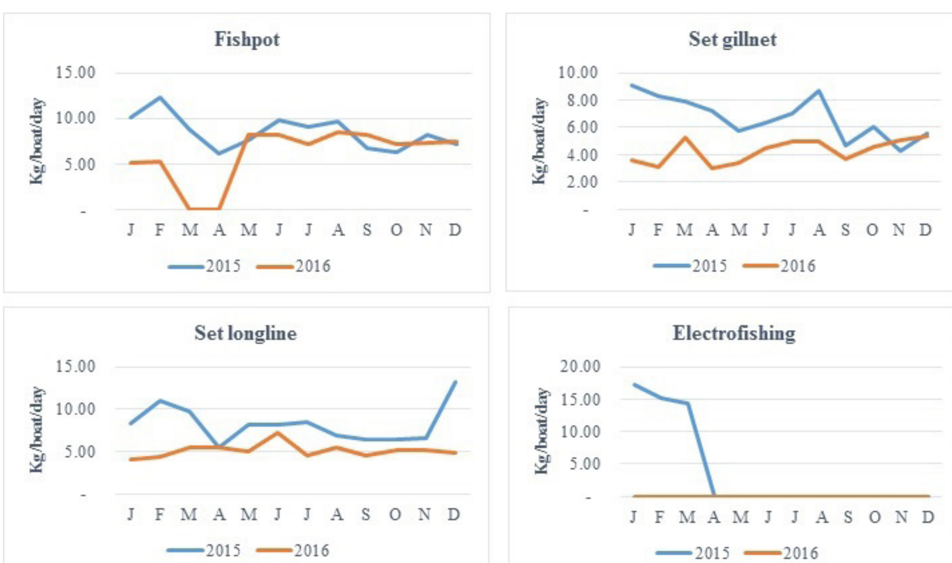


Figure 13. Mean Catch per Unit Effort (CPUE) of fishing gears employed in Lapaz: a) Fishpot, b) Set gillnet, c) Electrofishing, and d) Set longline from January 2015 to December 2016.

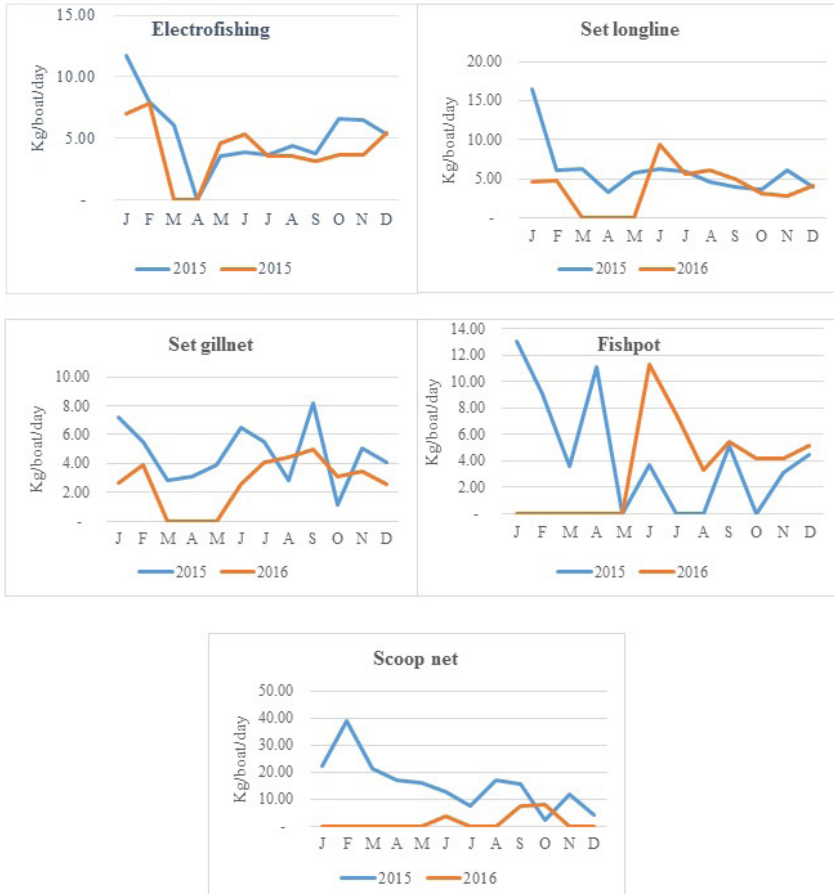


Figure 14. Mean Catch per Unit Effort (CPUE) of fishing gears employed in Talacogon : a) Electrofishing, b) Set longline, c) Set gillnet, d) Fishpot, and e) Scoop net from January 2015 to December 2016.

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 56.5cm. 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

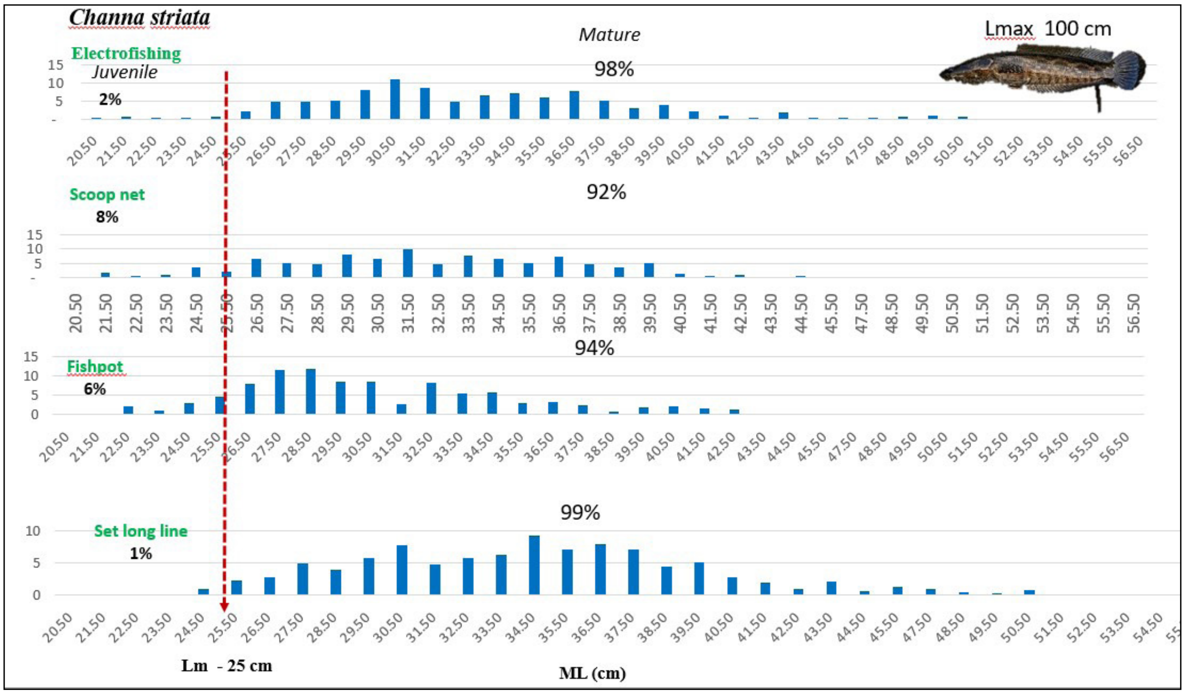


Figure 15a. Length composition of *Channa striata* caught by electrofishing, scoop net, fishpot, and set longline in Lapaz and Talacogon, Agusan Marsh in 2016.

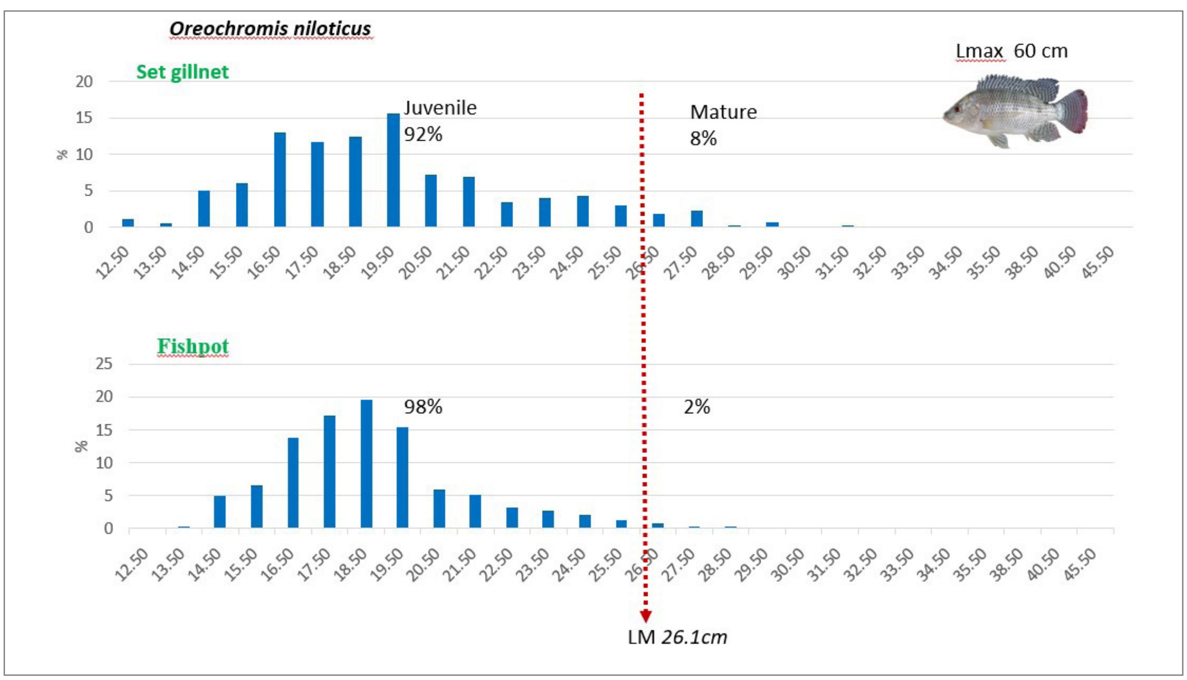


Figure 15b. Length composition of *Oreochromis niloticus* caught by set gillnet and fishpot in Lapaz and Talacogon, Agusan Marsh in 2016.

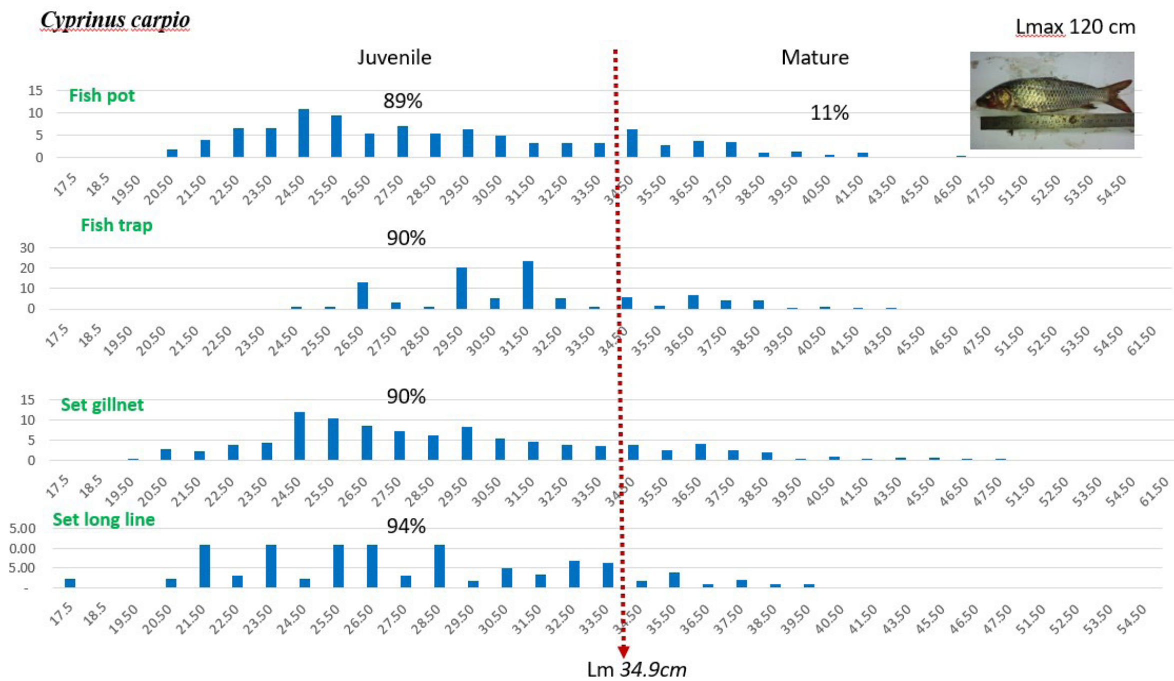


Figure 15c. Length composition of *Cyprinus carpio* caught by fishpot, fish trap, set gillnet, and set long line in Lapaz and Talacogon, Agusan Marsh in 2016.

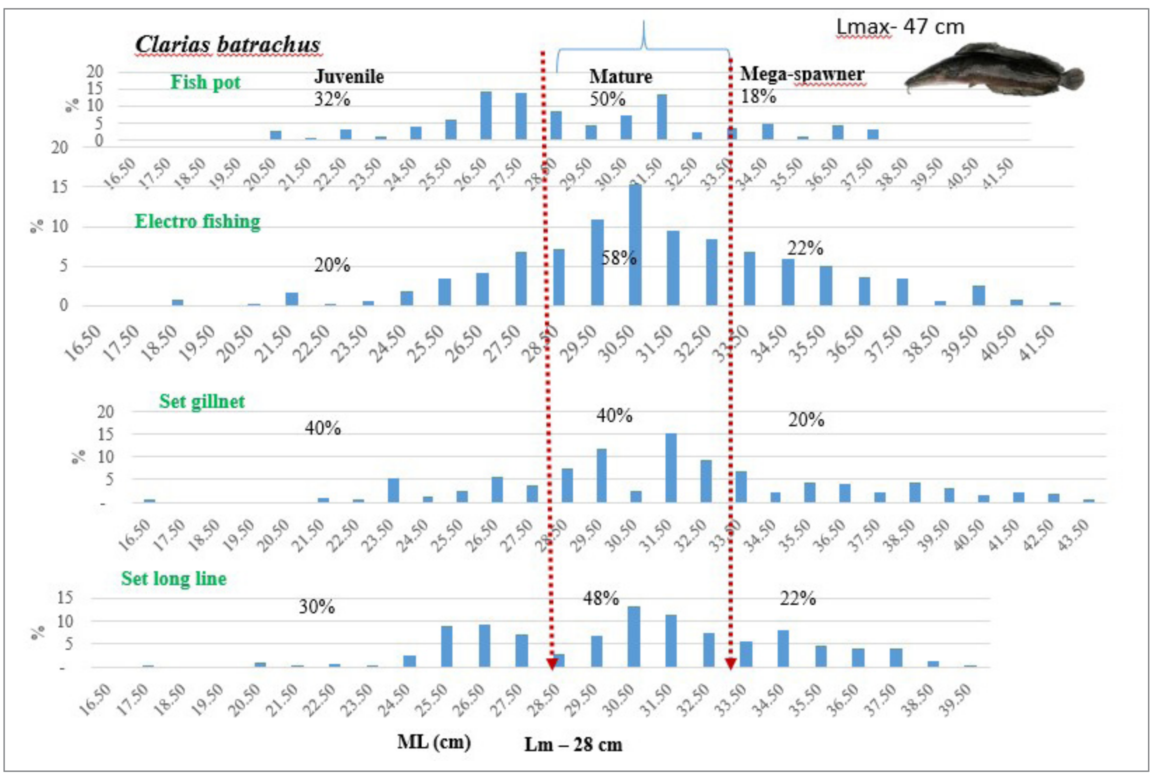


Figure 15d. Length composition of *Clarias batrachus* caught by fishpot, electrofishing, set gillnet, and set longline in Lapaz and Talacogon, Agusan Marsh 2016.

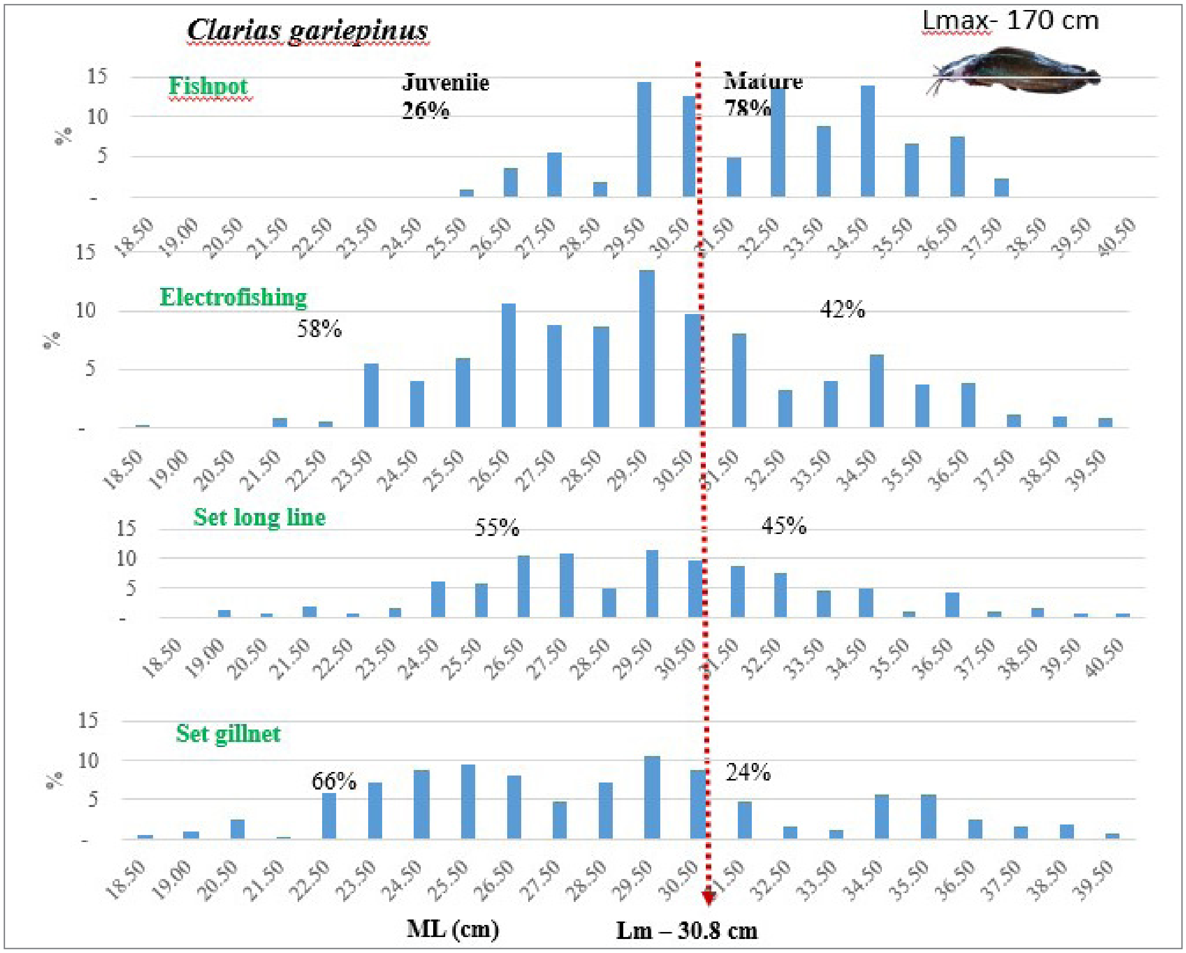


Figure 15e. Length composition of *Clarias gariepinus* caught by fishpot, electrofishing, set gillnet, and set longline in Lapaz and Talacogon, Agusan Marsh 2016

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 caught 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 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		2016	
	Actual LF	Raised LF	Actual LF	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

Table 9. Growth parameters of studied species from other country

Species	L∞ (cm)	K 1(year)	Ø'	Country	Source	Locality
Channa striata	36.8	0.44	2.78	China	FishBase 2019	
	52.8	0.21	2.75	Sri lanka	FishBase 2019	
	56.5	0.42	3.13	India	FishBase 2019	
	48.37	0.79	3.267		This study 2015	Agusan Marsh
	60.10	0.74	3.427		This study 2016	
Oreochromis niloticus	46.24	0.69	3.14	Lake Victoria	FishBase 2019	
	41.5	0.33		Lake Toho	FishBase 2019	
	58.59	0.39		Kaptai Reservoir	FishBase 2019	Benin, West Africa
	26.29	0.81		Lake Borollus	(El-Azab et al. 2013) This study 2015 This study 2016	Egypt
	46.68 41.06	0.67 0.81	3.30 3.135			
Cyprinus carpio	74.55	0.20				
	53.7	0.36	3.01	Shadegon Wetland	FishBase 2019	
	26.29					
	67	0.67	3.10		This study 2015	
	63.4	0.42	3.158		This study 2016	
Clarias batrachus	55.3	0.71	3.34	Germany	FishBase 2019	
	44.79	0.79	2.871		This study 2015	
	45.06	0.69	3.093		This study 2016	
	67.2	0.57	3.37	South Africa	FishBase 2019	Lake Sibaya
C. gariepinus	67.5	0.51	3.37	Zambia	FishBase 2019	Bangweulu Swamps
	76	.349	3.31	South Africa	FishBase 2019	Lake Sibaya
	102	0.45	3.67	South Africa	FishBase 2019	Lake Le Roux
	42.05	0.42	3.20		This study 2015	
	45	0.69	3.145		This study 2016	

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 RECOMENDATIONS

The annual monitored catch in Lapaz and Talacogon were in decreasing trend from 45.4-26.6 MT. *Channa straita* 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

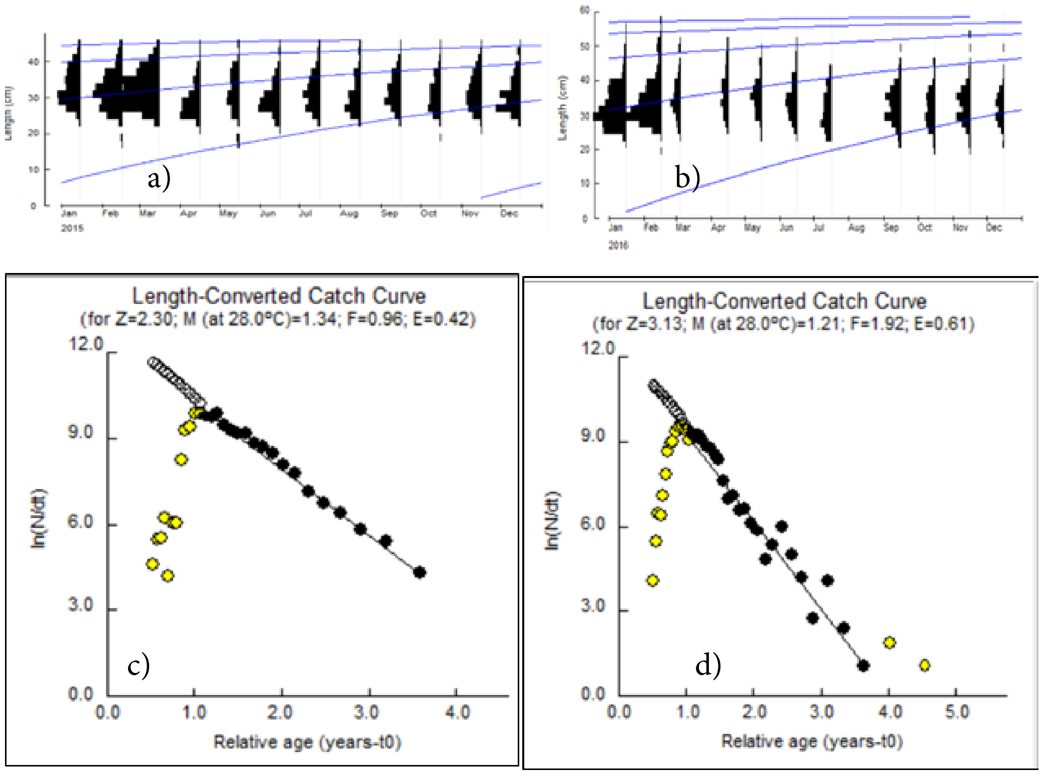

Figure 16. Von Bertalanffy Growth Function (VBGF) of *Channa striata* in 2015 (a) and 2016 (b); Length Converted Catch curve in 2015 (c) and 2016 (d)

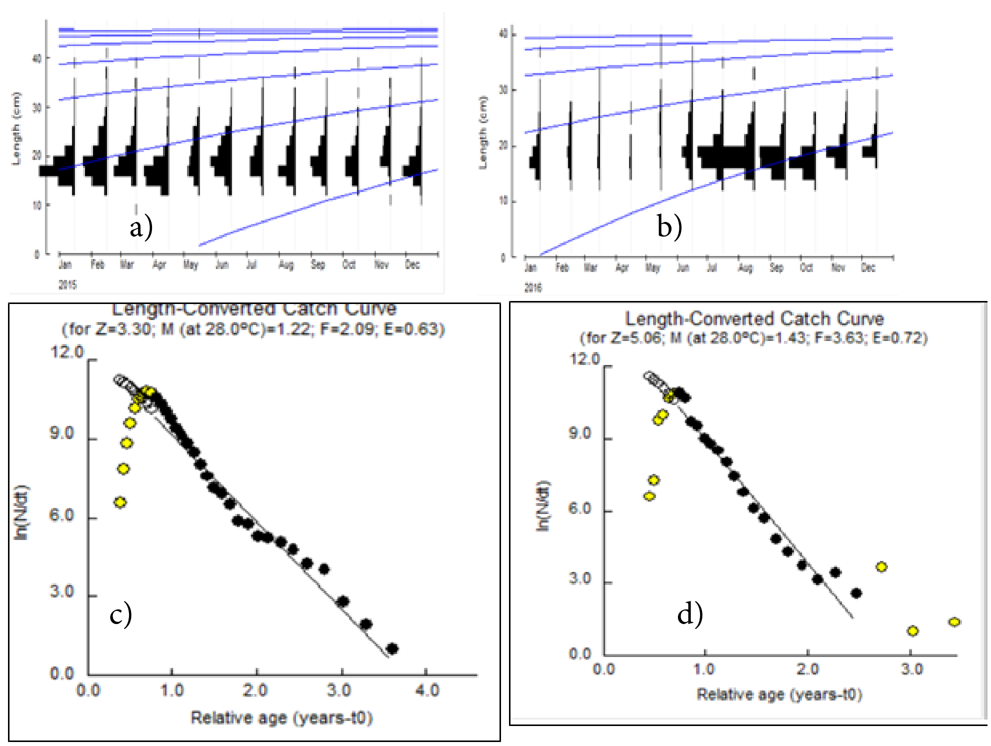

Figure 17. Von Bertalanffy Growth Function (VBGF) of *Oreochromis niloticus* 2015 (a), 2016 (b); Length Converted Catch curve 2015 (c) and 2016 (d)

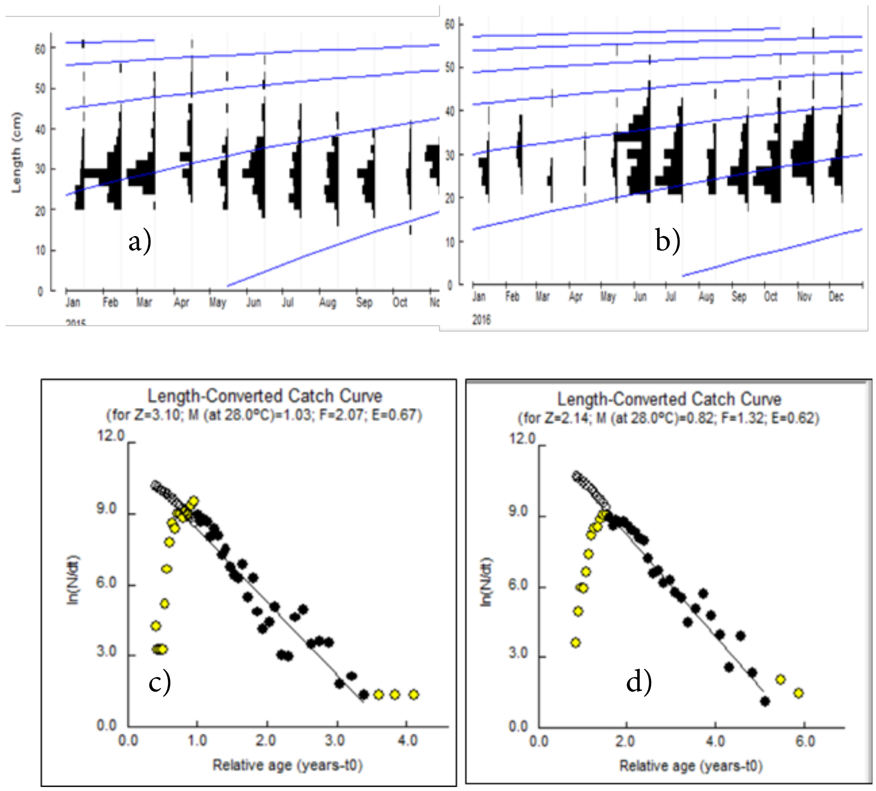

Figure 18. Von Bertalanffy Growth Function (VBGF) of *Cyprinus carpio* 2015 (a), 2016 (b); Length Converted Catch curve 2015 (c) and 2016 (d)

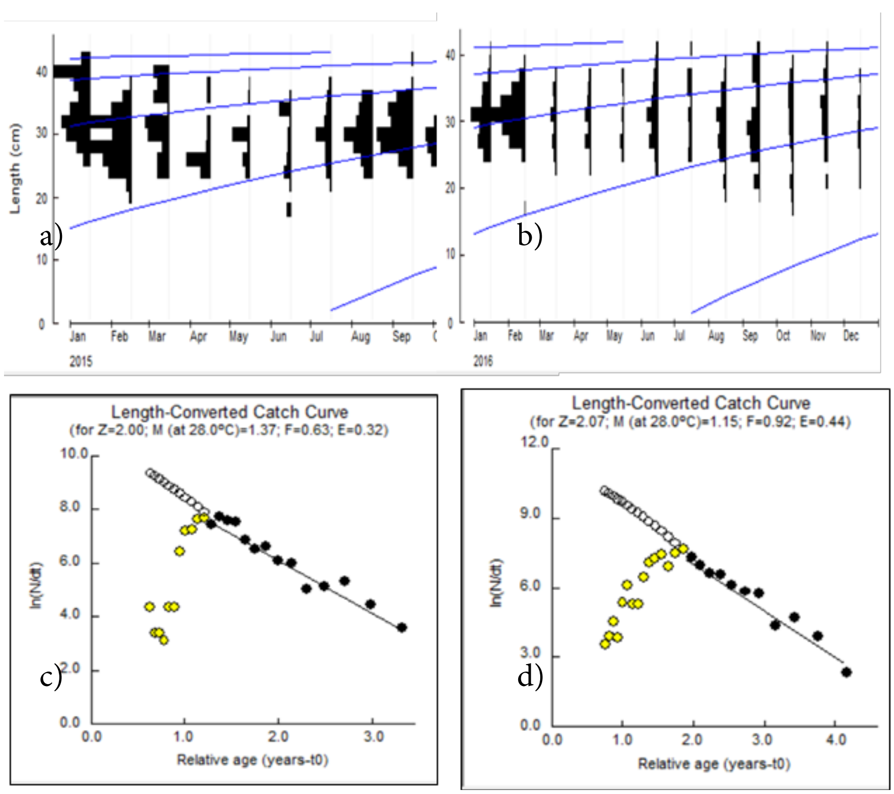

Figure 19. Von Bertalanffy Growth Function (VBGF) of *Clarias batrachus* 2015 (a), 2016 (b); Length Converted Catch curve 2015 (c) and 2016 (d)

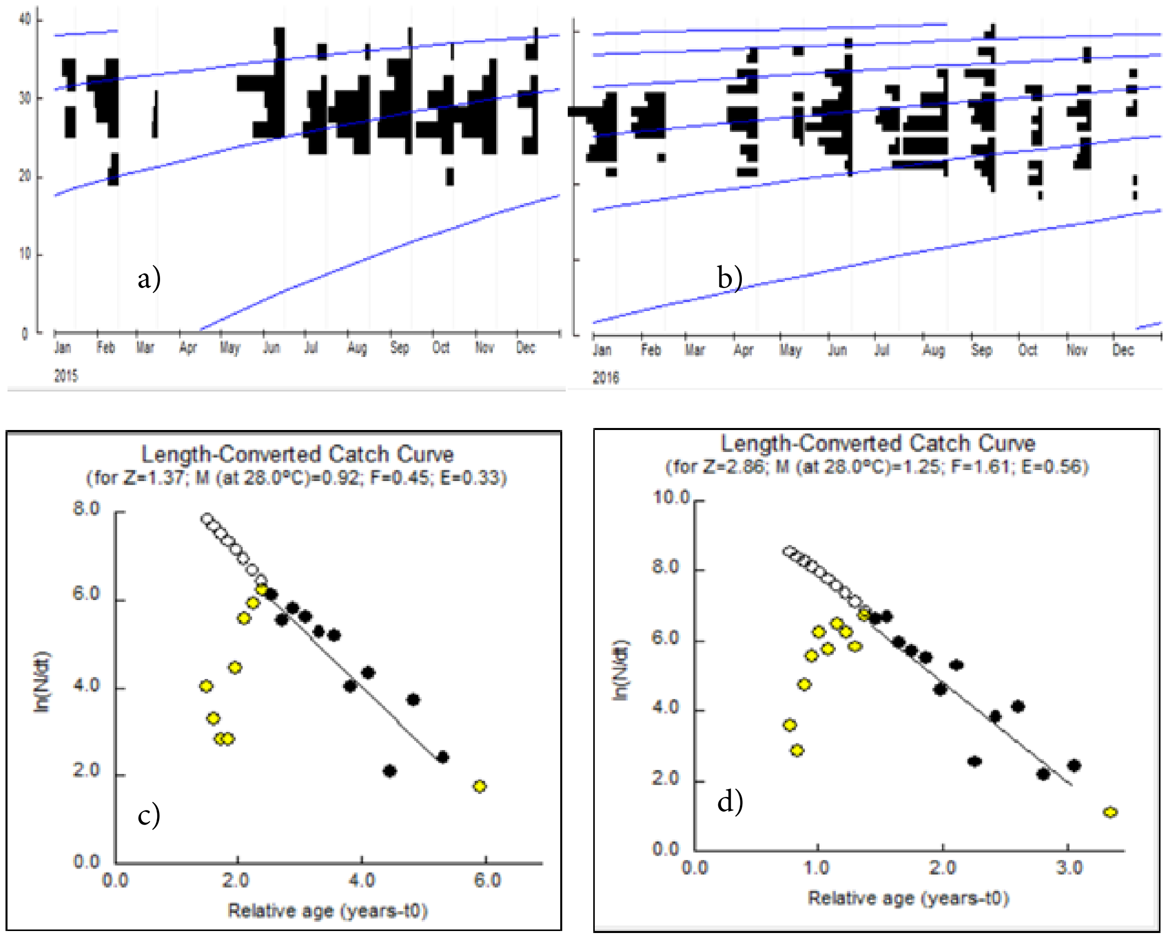

Figure 20. Von Bertalanffy Growth Function (VBGF) of *Clarias gariepinus* 2015 (a), 2016 (b); Length Converted Catch curve 2015 (c) and 2016 (d)