RESEARCH ARTICLE

The Fisheries of Liguasan Marsh, North Cotabato, Mindanao, Philippines

Emelyn A. Donia, Al-Azeez T. Pautong, Rosemarie R. Pechon, Maria Angelica F. Cecilio*, Kimber M. Andales, Therese Angeline B. Mallare, Usop D. Pendaliday Jr., Roel C. Marabulas

Bureau of Fisheries and Aquatic Resources (BFAR-12)-National Stock Assessment Program, 2nd Floor RD Building Dadiangas South, Santiago Boulevard General Santos City

ABSTRACT

Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office 12-National Stock Assessment Program (NSAP) covered six sampling stations around Liguasan Marsh to conduct a stock assessment on the freshwater fishes landed in Bagoinged, Datu Mantil, Malingao, Matilac, Ponol, and Tombras in North Cotabato, Philippines. The study was conducted from 2015 to 2017. Results of the study showed that *Channa striata*, *Cyprinus carpio*, *Labeo rohita,* and *Oreochromis niloticus* were the most common freshwater species caught by the fishing gears operating in Liguasan Marsh. A total of 13 species were found during the study; ten were introduced and three were native. Data analysis using length frequency data of the dominant freshwater species in Liguasan Marsh was found to be alarming. Froese and Lbar performance indicators were already breaching the limit reference points. In addition, exploitation rates were observed to be above the limit of 0.6, and the distribution of the length sizes of the dominant fishes caught showed excessive capture of immature sizes. Therefore, the study recommends continuing stock assessment activity and conducting further studies in Liguasan Marsh to investigate further the stock status of the fisheries in Liguasan Marsh, North Cotabato.

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1. INTRODUCTION

Freshwater is vital to life, and yet it is a finite source. Of all the waters on Earth, only 3% is freshwater; its biodiversity comprises a significant resource in economic, cultural, aesthetic, scientific, and educational terms (Dudgeon et al. 2006). Liguasan Marsh is rich in biodiversity and important for the livelihoods of the approximately 278,000 people living around the area. The marsh is a depository for water drained from the Cotabato River Basin, which help prevent flooding of low-lying downstream areas in central Mindanao, thus making farming viable in the lowlands. In addition, communities in the marsh rely on fish as a major source of their daily income (De La Paz and Colson 2008).

The marsh is home to 112,000 Maguindanaon families whose primary income source is agriculture or fishing, depending on the water level. The marsh offers great potential for environmental tourism because of its abundant biodiversity. However, the area is a stronghold of insurgents, and access is restricted. It is home to about 30 fish species (24 of which have commercial value), three species of reptiles, and water birds such as species of wild ducks, herons, and egrets. It is also the refuge of the rare Oriental order (*Anhinga melanogaster*), Purple swamp hen (*Porphyrio porphyrio*), and the threatened Philippine hawk eagle, Spotted imperial pigeon, and Rufous-lored kingfisher (De La Paz and Colson 2008).

The Department of Environment and Natural Resources (DENR) and Winrock International survey revealed that farming, livestock/poultry production, and fishing are the three significant sources of livelihood for the people in the marshland, where 80.4% of the households relied on farming for subsistence, while 46.2% and 44.5% were engaged in fishing and livestock/poultry raising, respectively. Illegal fishing activities threaten Liguasan Marsh by indiscriminately killing or eliminating aquatic fauna

regardless of size and species. Illegal fishing, therefore, affects the biodiversity of the aquatic habitat and endangers the existence of some fauna.

Owing to these threats and because of the natural resources it provides and the great variety of aquatic wildlife it supports, research on the fisheries in the Liguasan Marsh must be prioritized. However, there needs to be more information on the status of the fishery resources due to limited studies in the area. Therefore, it is crucial to conduct this study to establish a baseline and provide recent assessments on the fisheries of Liguasan Marsh, including species composition, fishing gear used, exploitation values, distribution of length sizes, seasonality, and the growth and mortality rate of the dominant species around Liguasan Marsh. The paper also aims to give additional information for future fishery management to improve and conserve the fishery resources in Liguasan Marsh.

1.1 Map of the fishing ground

Liguasan Marsh is located in south-central Mindanao, the island's largest swamp and marsh area. It is a large area that includes many river channels, freshwater lakes and ponds, marshes, and farmland subject to seasonal flooding in the basin of the Mindanao River. During heavy rainfall, most of the area in Liguasan Marsh is underwater, but some 140,000 ha dry out during dry periods and are cultivated. The marsh consists of two adjoining marsh basins, Liguasan and Libungan, with different water regimes. Liguasan lies at the confluence of Pulangi, Maganoy, Buluan, and Allah rivers, while Libungan lies at the Libungan and Mindanao rivers.

2. MATERIALS AND METHODS

2.1 Study area

The Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office 12-National Stock Assessment Program (NSAP) conducted an actual fish landing survey for the selection of a landing center in coordination with the Provincial Fisheries Office (PFO) and different Local Government Units (LGUs) of North Cotabato. The study sites were selected based on boat landed, the volume of catch unloading, and accessibility. For this study, six landing centers were selected as study sites: Pikit, Ponol, Tombras, Malingao, Datu Mantil, and Brgy. Matilac (Figure 1; Figure 2A–F).

Figure 1. Map of the study site.

Figure 2. Monitored landing centers covered by National Stock Assessment Program in North Cotabato: a) Datu Mantil, b) Matilac, c) Bagoinged, d) Malingao, e) Tombras, and f) Ponol.

2.2 Data collection

Trained enumerators collected the data. Data collection and sampling techniques used were NSAP standard methods (Santos et al. 2017). The data were collected every after two days, even on weekends and holidays. This is done throughout the month so that a total of ten sampling days are conducted for each landing center. The information gathered includes landing center, fishing ground, boat name, types of boats (motorized and non-motorized), fishing effort (number of fishing days/hours, number of hooks used per fishing operation), number of fishers on board, types of fishing gear, total catch and total sampled catch per fishing gear and length measurements. The length measurements of the sampled catch were done by taking subsamples randomly from the fish styrofoam, sorting by species, and weighing each species component to determine the total weight of each species from the catch. All these pieces of information were recorded to four NSAP forms and submitted to the regional NSAP data analysts to encode the data.

2.3 Data processing and analysis

2.3.1 Fisherfolk profile

For the fisherfolk profile, the data were extracted from the DA-BFAR Farmers Registration System, an online registry system for the agriculture sector. The registration was done at the municipal level through the Municipal Agriculture Office (MAO) and assisted by the BFAR-Fisheries Livelihood Development Technicians (FLDTs). This was conducted house-to-house using forms or by inviting fisherfolk in a specified area for registration. In addition, the actual count of fishing boats and gears for 2015, 2016, and 2017 was extracted from NSAP Database System.

2.3.2 Annual catch

The annual catch was estimated using the total landed catch recorded during sampling days. The total catch was raised from the total number of sampling days conducted divided by the total days in a month. Estimation was also done separately by fishing ground and the fishing gear used.

2.3.3 Species composition and relative abundance

The dominant fish species caught were determined based on the species contribution by weight to the total harvest from 2015 to 2017. All species were then arranged through percentage ranking by order of highest to lowest contribution to the total catch.

2.3.4 Length size composition

The length frequency data of the sampled fishes were measured using the total length of the fish. This was used to determine the percentage of matured individuals from the total catch based on the length at first maturity of the species. This was also employed in Froese and length-based analyses of some major species.

2.3.5 Growth performance indicators

The growth performance indicator was analyzed on the major freshwater species found in Liguasan Marsh. A total of 5,802 length frequencies were measured, of which 2,304 came from *Cyprinus carpio*; 2,307 individuals for *Channa striata*, and 1,191 length frequencies for *Labeo rohita*. Monthly length frequencies of the major freshwater species were processed using the computer program FISAT version 1.2.2 (Gayanilo et al. 2005).

The von Bertalanffy growth parameters L_∞ and K were estimated first using the Powell-Wetherall Method (Wetherall 1986) to approximate the asymptotic length (L_∞) and the ratio of the coefficients of mortality and growth (Z/K). Verification and final selection of growth parameters were carried out with the ELEFAN I (Electronic Length Frequency Analysis) routine. The final values of L_∞ and K were used to calculate the length converted catch curve (Pauly 1984) to derive estimates of the instantaneous total mortality (Z). Further, estimates of natural mortality (M) were derived with the empirical equation given by Pauly (1980):

$$Log10M = -0.006 - 0.279 \cdot \text{Log10}L_\infty + 0.6543 \cdot Log10K + 0.4634 \cdot Log10T$$

where L_∞ and K are the VBGF (Von Bertalanffy Growth Function) growth parameters, and T is the annual mean habitat temperature (°C) of the water in which the stock in question lives. For this study, the temperature value used was 28.3°C, the mean surface water temperature for the Philippines (Dalzell and Ganaden 1987). Furthermore, the fishing mortality ($F = Z–M$) and exploitation ($E=F/Z$) rates were obtained.

Lbar, length-based method, was used to evaluate the robustness of the average length of the species *Channa striata, Cyprinus carpio,* and *Labeo rohita* to estimate fishing mortality expressed as Fishing Mortality over Natural Mortality (F/M). Lbar is the average of fish above length at first capture (L_c), which is the fully exploited phase of the fishery. Decreasing length, especially when the majority of the catch is under length at maturity, will drive down the abundance and distribution of reproducing individuals, leading to growth and recruit overfishing of the stocks (Froese 2004; FISHE 2015). According to Soliman et al. (2009), overfishing happened due to excessive harvesting of juveniles and high exploitation of older individuals.

However, the limitation of this study is the absence of reproductive biological information on the species to determine exactly the onset of its maturity. Froese Indicator Tool (Froese 2004), which requires length-frequency data as the primary input for the analysis, was used to evaluate the condition of the stock based on simple biological indicators categorized as one percent of mature fish in the catch with 90–100% as a target. This follows the "let them spawn" principle wherein the immature sizes should be allowed to grow in the fishery. The second indicator is the percent share of catch with optimum length (L_{opt}) with 100% as a target or the "let them grow" principle, which is, giving the fish sufficient time to grow to reach the size at first maturity (L_m). This is based on the premise that the stock will sustain if the fish are given a chance to complete their spawning period, and every spawner must produce at least one replacement spawner before they are harvested.

The third and last indicator is the percent share of megaspawner in the catch, with 0%–10% as a target or the "let them live" principle. Megaspawner is an individual that has reached a size of at least 10% larger than the optimum length for a population. The large-sized spawner will contribute more productivity as a bigger female produces more and larger eggs and is more fecund than smaller ones (Froese 2004; FISHE 2015)

3. RESULTS AND DISCUSSION

3.1. Fisherfolk profile/fishing gears

The BFAR-FishR fisherfolk distribution is presented in Table 1. A total of 28,887 fisherfolk were registered under the 17 municipalities along Liguasan Marsh. Out of this number, 6,533 were engaged in capture fishing, which showed that many of the fisherfolk in North Cotabato were highly dependent on fishing for daily subsistence and for generating income, while the rest were involved in various activities like aquaculture (3,449), fish processing (895), fish vending (1224), gleaning (363), and other activities. Midsayap, Pigcawayan, and Pikit are the top three municipalities with the highest registered fisherfolk of 550, 207, and 187, respectively.

Table 1. Distribution of fisherfolk in municipalities of North Cotabato (BFAR-FishR 2015–2017).

Municipalities	Aquaculture	Capture Fishing	Fish Processing	Fish Vending	Gleaning	*others	Total
Alamada	134	3	-	-	4	118	259
Aleosan	112	459	16	14	22	128	751
Antipas	187	5	6	6	6	126	336
Arakan	11	-	-	-	-	86	97
Carmen	87	168	4	102	3	105	469
City of Kidapawan	258	5	6	32	1	277	579
Kabacan	299	168	1	31	28	190	717
Libungan	61	49	7	9	3	123	252
Magpet	595	2		6		114	717
Makilala	131	4		3		276	414
Matalam	641	3		2		149	795
Midsayap	107	1853	55	282	50	1148	3495
MLang	99	68		3		11088	11258
Pigkawayan	159	825	41	96	16	368	1505
Pikit	222	2824	759	611	225	1584	6225
President Roxas	173	1		9	4	148	335
Tulunan	33	94		11		259	397
Grand Total	**3449**	**6533**	**895**	**1224**	**363**	**16423**	**28887**

The catch information revealed that ten fishing gear types were used to catch freshwater species, and all were classified as municipal fishing gear (Table 2). The most common gears noted in Liguasan Marsh were gillnet, fish trap, fish corral, and harvesting net (Figure 3A-D).

The percentage contribution of fishing gear is shown in Figure 4. The highest percentage share of fish was caught by fish trap (61.97%), followed by gillnet (19.48%), harvesting net (11.18%), and fish corral (4.10%). Other gears that contributed less than 2% of the catch comprised cast net, hook and line, pole and line, fyke net, shrimp trap, encircling gillnet and electrofishing. In contrast, Baclayo et al. (2020) noted that electrofishing and fish traps were the most frequent gear for catching fish in Agusan Marsh.

Table 2. Annual number of municipal fishing gear monitored in study sites covered by the National Stock Assessment Program (NSAP) from 2015 to 2017.

Fishing Gear	2015	2016	2017	Grand Total
Gillnet	72	49	48	**160**
Fish Trap	51	48	46	**145**
Fish corral	37	29	20	**86**
Harvesting net	32	36	15	**83**
Cast net	15	13	9	**37**
Hook & Line	13	11	5	**29**
Fyke net	20	0	0	**20**
Pole & line	1	5	12	**18**
Electro Fishing	4	0	0	**4**
Shrimp trap	0	0	4	**4**
Grand Total	**245**	**191**	**159**	**586**

Figure 3. Common fishing gears used in Liguasan Marsh: a) fish trap, b) gillnet, c) harvesting net, d) fish corral.

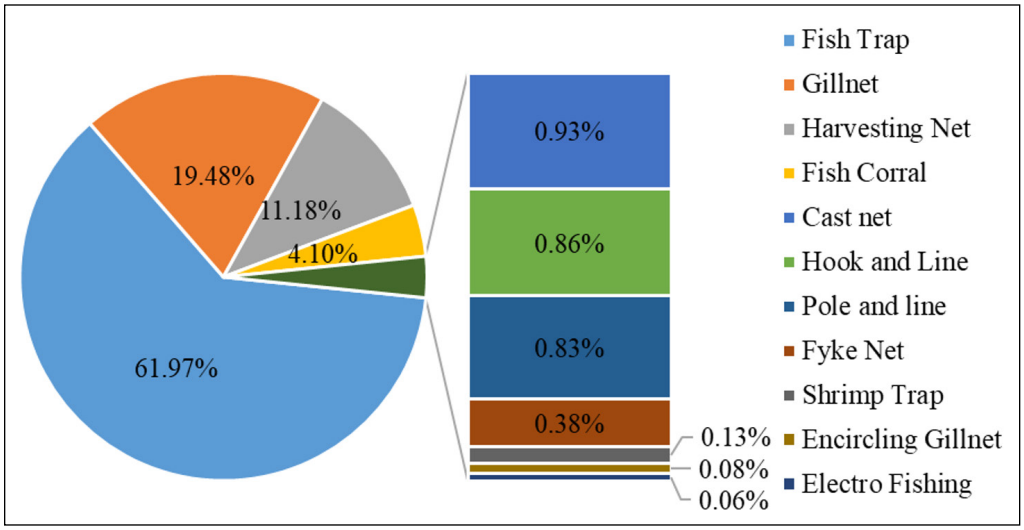

Figure 4. Percentage share of landings of most common fishing gears operated in Liguasan marsh, North Cotabato, from January 2015 to December 2017.

3.2. Annual landed catch

From January 2015 to December 2017, annual catch estimates for six landing centers covered by NSAP had an aggregated annual production of 1,059.27 metric tons (Figure 5). An increasing catch trend was observed during the study. The observed highest catch was in the last year of the study. Figure 6 shows the percent contribution of the monitored landing centers in Liguasan Marsh, CY 2015–2017. The study revealed that Bagoinged owned a 61.21% share of the total landings, followed by Datu Mantil with 13.51%, and Tombras with the least contribution of about 2.79% throughout the study period. Among the eight families presented in Figure 7, two of the families exhibited the highest percentage share, the family Channidae and Cyprinidae, which obtained 42.56% and 36.59%, respectively. Other families were observed in low percentage shares throughout the study period.

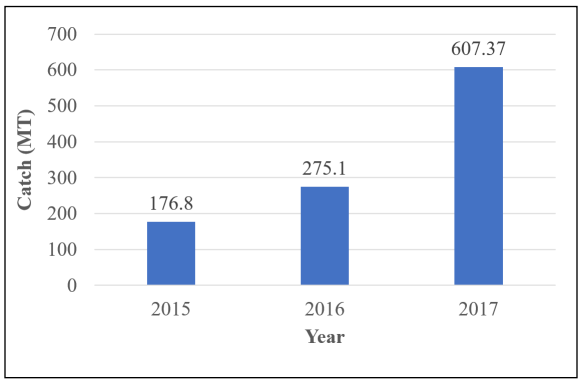

Figure 5. Annual catch estimates (metric tons) of freshwater species landed in Liguasan Marsh (NSAP Data 2015–2017).

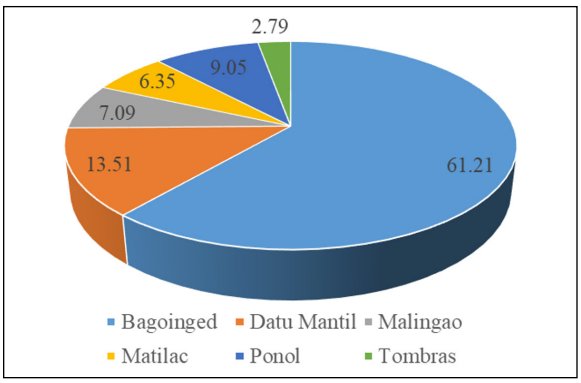

Figure 6. Percent contribution of the monitored landing centers in Liguasan Marsh from 2015 to 2017.

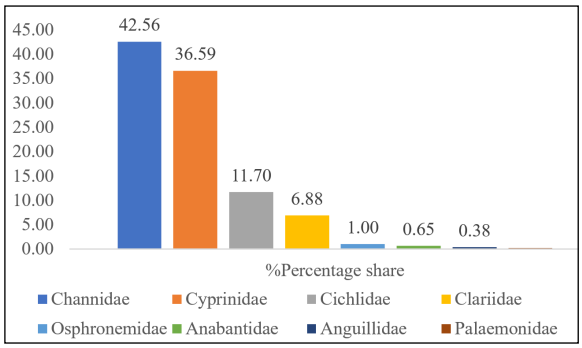

Figure 7. Percentage share of landings in Liguasan Marsh by family from 2015 to 2017.

3.3. Species composition and relative abundance

Stock assessment of freshwater species conducted in Liguasan Marsh from 2015 to 2017 recorded eight families (Table 3). There were thirteen species in 11 genera, which include Anabas, Anguilla, Channa, Clarias, Cyprinus, Labeo, Macrobrachium, Oreochromis, Osphronemus, Puntius, and Trichogaster (Table 4).

Table 3. List of fish species monitored with corresponding family, local name, and category status from January 2015 to December 2017 in Liguasan Marsh, North Cotabato.

Species	Family	Local Name	Status
Anabas testudineus	Anabantidae	Puyo	Native
Anguilla anguilla	Anguillidae	Salan	Introduced
Anguilla marmorata	Anguillidae	Kasili	Native
Channa striata	Channidae	Haluan	Introduced
Clarias batrachus	Clariidae	Hito/Katipa	Introduced
Clarias macrocephalus	Clariidae	Hito	Native
Cyprinus carpio	Cyprinidae	Karpa	Introduced
Labeo rohita	Cyprinidae	Rohu	Introduced
Macrobrachium rosenbergii	Palaemonidae	Udang	Native
Oreochromis niloticus	Cichlidae	Tilapia	Introduced
Osphronemus goramy	Osphronemidae	Manabing	Introduced
Trichogaster pectoralis	Osphronemidae	Gurami	Introduced
Puntius sirang	Cyprinidae	Sirang	Native

Family (9) Genus (11) Native (5) Introduced (9)

Table 4. Species composition and % relative abundance of freshwater species landed in Liguasan Marsh from 2015 to 2017.

Scientific Name	CATCH (MT)			Total	% Relative Abundance
	2015	2016	2017		
Anabas testudineus	2.20	2.93	1.77	6.90	0.65
Anguilla anguilla	0.01	0.83	0.47	1.31	0.12
Anguilla marmorata	0.51	1.48	0.26	2.24	0.21
Channa striata	28.93	65.00	360.94	454.86	42.94
Clarias batrachus	16.36	34.55	16.65	67.55	6.38
Clarias macrocephalus	2.10	2.37	1.51	5.98	0.56
Cyprinus carpio	46.88	57.02	103.56	207.45	19.58
Labeo rohita	36.86	56.95	74.98	168.79	15.93
Macrobrachium rosenbergii	0.07	0.11	2.46	2.65	0.25
Oreochromis niloticus	39.14	45.84	40.01	124.99	11.80
Osphronemus goramy	0.24	0.36	0.02	0.61	0.06
Puntius sirang	1.26	3.83	0.80	5.89	0.56
Trichogaster pectoralis	2.25	3.85	3.95	10.05	0.95
Total	**176.80**	**275.10**	**607.37**	**1059.27**	**100.00**

Among the 13 species caught in six landing centers, eight were introduced and five were native. *Anabas testudineus, Anguilla marmorata, Clarias macrocephalus, Macrobrachium rosenbergii* and *Puntius sirang* were categorized as native, contributing only 2.23% to the catch monitored. The biggest contribution was attributed to *Channa striata* which obtained almost 50% of the harvested catch, followed by *Cyprinus carpio, Labeo rohita,* and *Oreochromis niloticus*, which dominated below 20% of the catch. Other species contributed less than 10% of the total harvested catch. A study in Agusan Marsh by Baclayo et al. (2020) monitored 18 eighteen species belonging to 12 families, of which nine recorded species were identified as introduced and six species as native with a relative abundance dominated by *Channa striata* (35%), *Oreochromis niloticus* (27%), and *Cyprinus carpio* (26%).

Another study conducted by Fabay et al. (2020) recorded eight species belonging to seven families, wherein most of the species were also monitored in this study. These families are Gobiidae, Cyprinidae, Anabantidae, Osphronemidae, Clariidae, Channidae, and Cichlidae.

The fishing gears documented in this study showed that gillnet, fish corral, fish trap, and harvesting net were the primary gears widely used in Liguasan Marsh. It was observed that the four major fishing gears had the same major species caught. *Cyprinus carpio* was observed as the most dominant species in gillnet and fish corral and ranked second in fish trap and harvesting net (Figure 8).

3.4. Seasonality

Figure 9 shows the seasonal pattern of dominant freshwater fish species monitored in Liguasan Marsh from 2015 to 2017. *Cyprinus carpio*, *Labeo rohita,* and *Oreochromis niloticus* were the most abundant species monitored during this period. The three species were generally caught throughout the year, but the data showed two distinct periods where the species were most abundant. The first was in May and June, which was very noticeable between 2015 and 2016. The second peak was in November and December, which was more visible in 2017.

3.5 Length sizes distribution

The size distribution of four major species caught in Liguasan Marsh was analyzed and shown in Figure 10. The study used 6,963 individuals for *C. carpio*, 5,215 for *C. striata*, 9,960 for *O. niloticus*, and 6,575 for *L. rohita* for length frequency measurement from the six sites. For *C. carpio*, based on its life history, this species attained a 28 cm length at first maturity, growing to a maximum length of 120 cm in

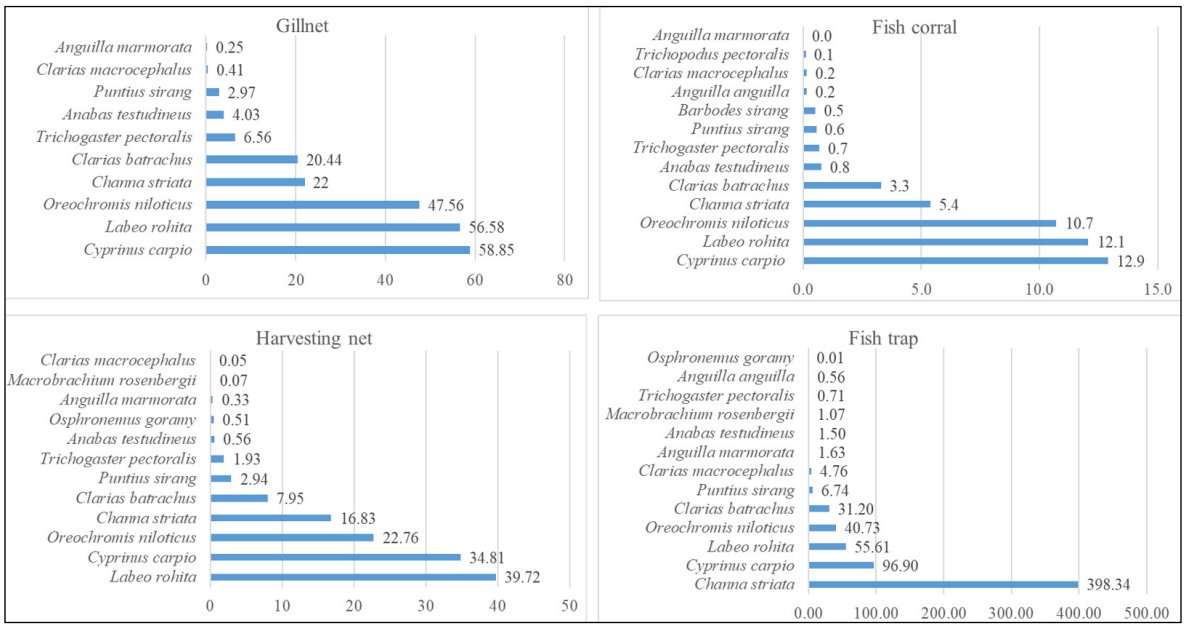

Figure 8. Ranking of species composition caught by common fishing gears in Liguasan Marsh from 2015 to 2017.

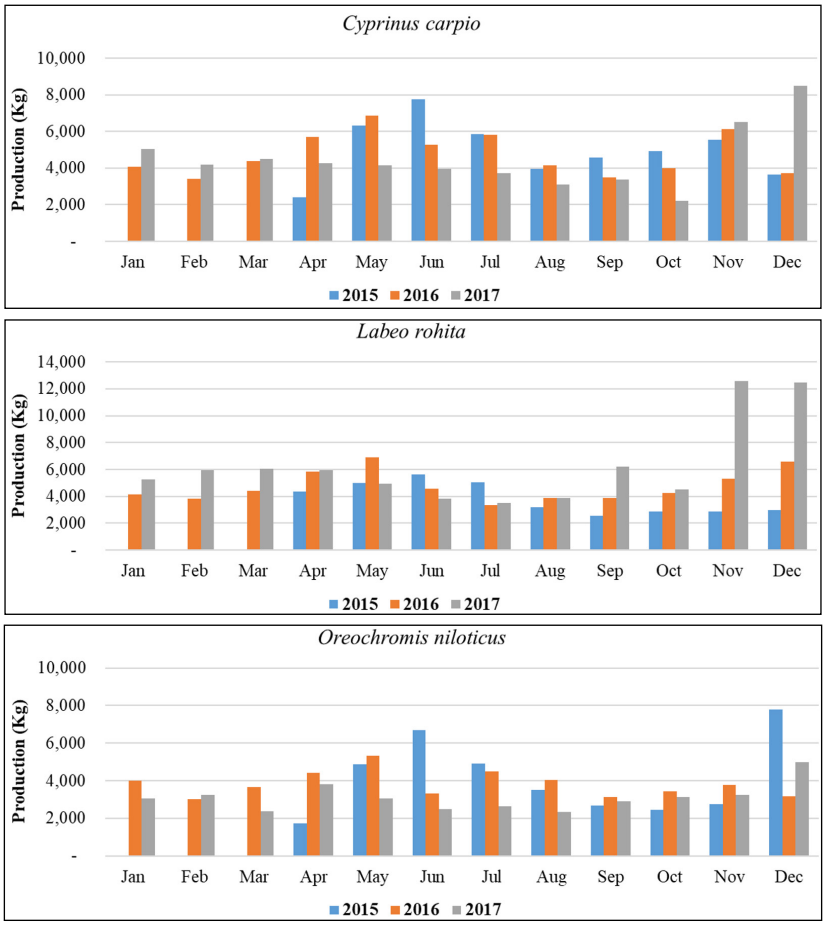

Figure 9. Trend of seasonality of dominant freshwater fish species caught in Liguasan Marsh from 2015 to 2017: a) *Cyprinus carpio*, b.) *Labeo rohita*, c.) *Oreochromis niloticus.*

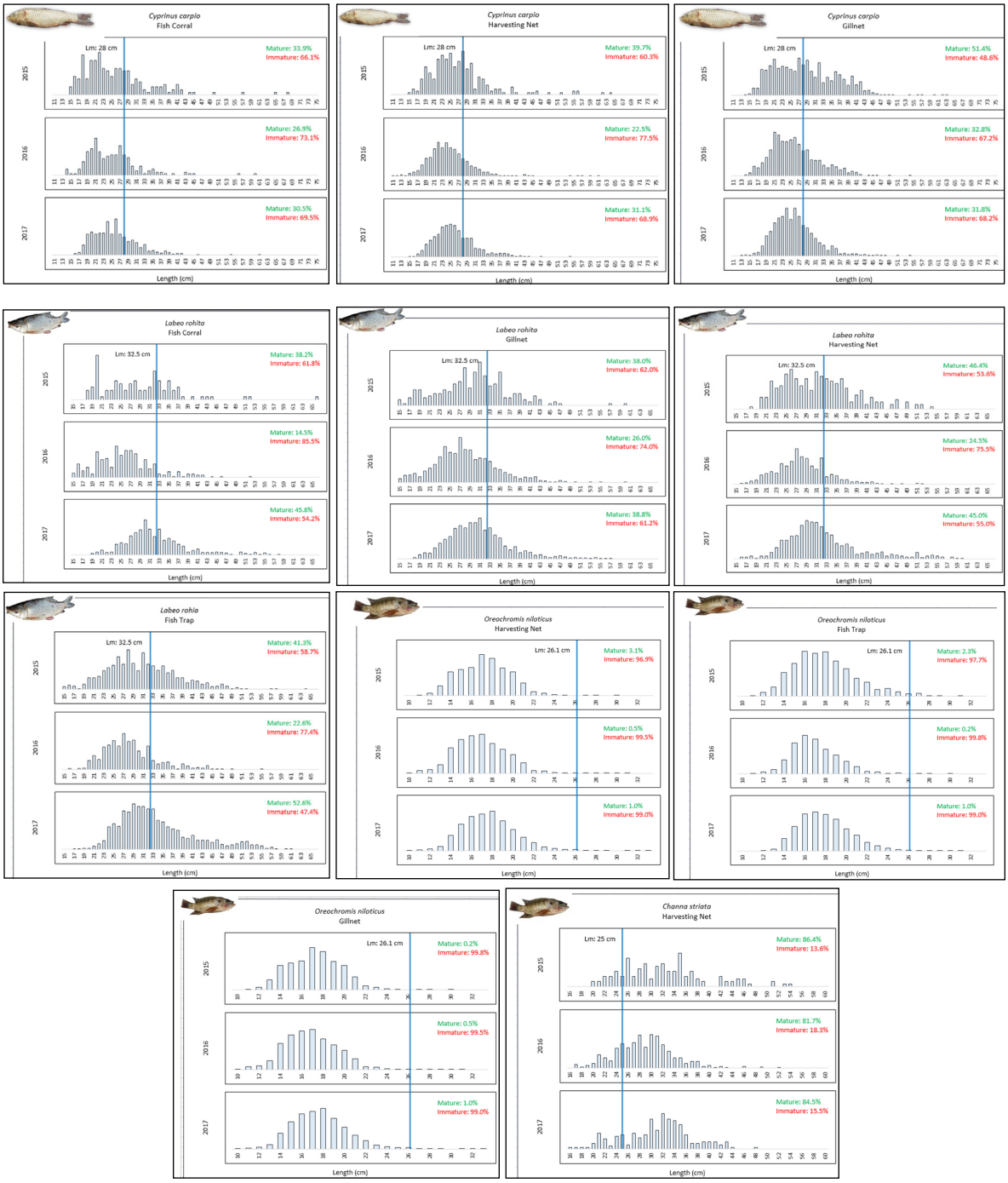

Figure 10. Length frequency distribution showing the length at first maturity of *Channa striata, Clarias batrachus, Cyprinus carpio, Labeo rohita,* and *Oreochromis niloticus* in Liguasan Marsh from 2015 to 2017.

the Philippines (FishBase 2019). This study revealed that up to 70% of the catch were juveniles, but 30% were caught at the mature stage.

On the other hand, *L. rohita* is a fast-growing species and attained about 35–45 cm total length (FAO 2023), while L_m was 28 cm. The result showed that juveniles were heavily caught compared to matured individuals in gillnets, harvesting nets, fish traps, and fish corrals.

For *O. niloticus*, the recorded L_{max} was 60 cm, while L_m was 26.1 cm in Lake Kivu, East Africa (FishBase 2019). The study revealed that almost 100% of the catch were immature. Lastly, for *C. striata*, the species attained its length at first maturity at 25 cm. Juveniles for this species were found to be caught in a smaller portion, whereas mature and bigger sizes were high.

Among all the dominant species monitored in Liguasan Marsh, only *Chana striata* were found to be harvested at a sustainable level. In contrast, *Oreochromis niloticus, Labeo rohita,* and *Cyprinus carpio* were all subjected to growth overfishing, wherein the harvested individuals were smaller than the size of their length at first maturity. According to Froese (2004), there were three simple indicators of fisheries sustainability to observe. First, let the fish spawn to maintain and rebuild a healthy stock by allowing them to spawn at least once in their life cycle. Second, let them grow to optimum length, a bit larger than the length at first maturity, and third, let the megaspawner live. It means that large females need to be protected, as they are more fecund and eggs are large, thus, giving a greater chance of survival rate (Baclayo et al. 2020).

3.6 Growth performance indicators

Results of performance indicators from L_{bar} and Froese for major species caught in Liguasan Marsh were presented in Table 5. The estimated optimum length (L_{opt}) of *Channa striata* was 38.5 cm, *Cyprinus carpio* (51.5 cm), and *Labeo rohita* (41.5 cm). The estimated optimum length refers to the length at which the fewest individuals of a population have to be harvested to reach the maximum biomass. However, the range where the optimum harvest was achieved falls at optimum length L_{opt} ± 10%, calculated as 10% lower than L_{opt} to 10%, higher than L_{opt} t. Data showed that from 2015 to 2017, all values presented in L_{opt} ± 10% for the analyzed species were far from the 100% target for optimum length and way below the 80% to 99% limit. As observed, *Cyprinus carpio* obtained below 2%, *Labeo rohita* less than 15%, and *Channa striata* got 31% L_{opt} to 10%. The percentage of the megaspawner of *Channa striata* was higher at the 10% target in 2015 and 2017, while *Cyprinus carpio* and *Labeo rohita* were within the range of the targeted reference points (0–10%).

The results from L_{bar} (F/M) analysis to determine the ratio of fishing mortality against natural mortality showed that fishing pressure for *Cyprinus carpio* was high, as reflected in the high F/M ratio calculated at 3.5 in 2015, 6.5 in 2016, and 6.4 in 2017. These values were already breaching the 2.0 limit reference points of the values to be avoided to attain sustainability. This study observed the exploitation ratio (E) of *Channa striata, Cyprinus carpio,* and *Labeo rohita* beyond the 0.5 target reference point.

4. CONCLUSION AND RECOMMENDATION

Results from a three-year (2015–2017) stock assessment from the six sampling areas revealed that *Channa striata*, *Cyprinus carpio, Labeo rohita,* and *Oreochromis niloticus* dominated the catch composition in Liguasan Marsh, accounting for 42.94%, 19.58%, 15.93%, and 11.80% respectively, of the overall catch. Other species of freshwater were also caught in minimal production. The four major gears commonly used by most fishers were fish corral, fish trap, gillnet, and harvesting net. Regarding seasonality, the major species were generally caught throughout the year, though the data shows two distinct periods where the species abundance is between May and June and November and December. This observation can be linked to the information published in the literature, which reported that some commonly caught species in Liguasan Marsh happened in June, August, and November.

With the present status, it is recommended to continue the freshwater stock assessment to monitor catch trends, conduct a reproductive biological study by technically trained and well-experienced personnel, conduct boat and gear inventory in the coastal areas around Liguasan Marsh to estimate the Maximum Sustainable Yield (MSY) for the top species recorded in Liguasan Marsh, and to use this current study as baseline information on the future fisheries management of freshwater fishes.

Table 5. Summary of biological performance indicator of major species caught in Liguasan Marsh from 2015 to 2017: a) *Channa striata*, b) *Cyprinus carpio*, c) *Labeo rohita*.

a) Channa striata

Performance Indicator	**Target Reference Point**	**Limit Reference Point**	**Results**			**Assessment Method**
			2015	**2016**	**2017**	
Fishing Mortality/LBAR F/M	F=M or F/M = < 1 or 2	F=M or F/M = > 1 or 2	1.1	1.8	1.3	Length Frequency Data/Data Mean Length
FROESE % mature % within ±10% of L_{opt} % mega-spawners	90-100% 100% 0-10%	50% and less 80%-99% 20%	24.3 24.1 13.4	17.2 23.7 6.8	27.0 31.0 11.2	FROESE Indicator
Exploitation Ratio	0.5	0.6	0.53	0.65	0.56	Length Frequency Data

b) Cyrinus carpio

Performance Indicator	**Target Reference Point**	**Limit Reference Point**	**Results**			**Assessment Method**
			2015	**2016**	**2017**	
Fishing Mortality/LBAR F/M	F=M or F/M = < 1 or 2	F=M or F/M = > 1 or 2	3.5	6.5	6.4	Length Frequency Data/Data Mean length
FROESE % mature % within ±10% of L_{opt} % mega-spawners	90-100% 100% 0-10%	50% and less 80%-99% 20%	2.6 1.9 1.1	0.6 0.4 0.2	0.4 0.4 0.1	FROESE Indicator
Exploitation Ratio	0.5	0.6	0.77	0.86	0.86	Length Frequency Data

c) Labeo rohita

Performance Indicator	**Target Reference Point**	**Limit Reference Point**	**Results**			**Assessment Method**
			2015	**2016**	**2017**	
Fishing Mortality/LBAR F/M	F=M or F/M = < 1 or 2	F=M or F/M = > 1 or 2	1.9	3.11	1.7	Length Frequency Data/Data Mean length
FROESE % mature % within ±10% of L_{opt} % mega-spawners	90-100% 100% 0-10%	50% and less 80%-99% 20%	8.0 14.6 3.9	2.6 6.7 0.8	10.1 14.1 6.3	FROESE Indicator
Exploitation Ratio	0.5	0.6	0.65	0.76	0.62	Length Frequency Data

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AUTHOR CONTRIBUTIONS

Donia EA: Conceptualization, Writing - Original Draft, Writing - Review & Editing, Formal Analysis. **Pautong AT:** Visualization, Formal Analysis, Review and Editing. **Pechon RP:** Visualization, Editing. **Mallare TAB:** Visualization, Editing. **Andales KM:** Visualization. **Marabulas RC**: Editing and Visualization. **Pendaliday UD Jr**.: Supervision. **Cecilio MAF**: Editing and Supervision.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICS STATEMENT

No animal or human studies were carried out by the authors.

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