E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(2): 264-271
© 2018 IJFAS
www.fisheriesjournal.com
Received: 08-01-2018
Accepted: 12-02-2018

Takele Shitaw
Department of Fisheries Wetland and Wild Life Management Bahir Dar University College of Agriculture and Environmental Sciences, Bahir Dar, Ethiopia

Shewit G Medehin
Department of Fisheries Wetland and Wild Life Management Bahir Dar University College of Agriculture and Environmental Sciences, Bahir Dar, Ethiopia

Wassie Anteneh
Department of Fisheries Wetland and Wild Life Management Bahir Dar University College of Agriculture and Environmental Sciences, Bahir Dar, Ethiopia

Correspondence
Takele Shitaw
Department of Fisheries Wetland and Wild Life Management Bahir Dar University College of Agriculture and Environmental Sciences, Bahir Dar, Ethiopia

Gillnet selecitvity of some *Labeobarbus species* in Lake Tana

Takele Shitaw, Shewit G Medehin and Wassie Anteneh

Abstract
This study was conducted from May to December2016 and the aim was to investigate the effect of gillnet selectivity on Labeobarbus species of Lake Tana. Fish were collected monthly at four sampling sites (Bahir Dar, Kunzla, Gumara and Gorgora) using a gillnets of 6, 8, 10, 12, and 14 cm stretched mesh size. The selectivity each species was analyzed by Sparre and Venema, 1992. A total of 2662 Labeobarbus specimens were collected within eight sampling months at all sampling sites. The highest catch composition of Labeobarbus fish species of Lake Tana was obtained at mesh size of 6 cm and 8 cm. 75% of the total catch in *L. brevicephalus* was collected by 6 cm mash size of gillnet. The recommended mesh sizes of each species except *Labeobarbus brevicephalus* were found to be between 9 cm and 10 cm.10 cm mash size of gillnet is recommended for all Labeobarbus fish species of Lake Tana. Effort control regulations, limiting the gillnet fishery in spawning seasons and/or areas, will be appropriate to prevent the Labeobarbus fish species of Lake Tana.

Keywords: Gillnet selectivity, Lake Tan

1. Introduction
Labeobarbus species of Lake Tana, belonging to the family of large *Cyprinidae* are the only species flock in the world [1, 2, 3]. It is the most abundant genus of the family and consists of 15 species (*L.acutrostris*, *L. brevicephalus*, *L. macrophtalmus*, *L. megastoma*, *L. platydorsus*, *L.truttiformis*, *L. dainellii L. tsanensis*, *L. surkis*, *L. gorgorensis*, *L. Crassibarbis*, *L. gorguari*, *L. nedgia*, *L. longissimus* and *L. intermedius* forming a unique species flock in Lake Tana [2]. Gillnets are widely used in artisanal fisheries in developing countries because they are efficient, relatively inexpensive and capable of catching higher amount of commercially valuable species than other fishermen gears [4]. The same is true for the Lake Tana fisheries. Gillnet selectivity studies are frequently used to estimate the abundance and size structure of fish populations, particularly where trawls cannot be used [5]. Due to the lack of nonselective gears, it is necessary to use several gillnets of differing mesh sizes simultaneously to estimate selectivity. Dramatic reduction of the adult *Labeobarbus* and the even lower proportion of recruits at the end of the 1990s, show the necessity for the development, implementation and control of fisheries legislation in Lake Tana [6]. Their aggregations at the river mouth during spawning migrations makes them vulnerable to recruitment overfishing, because their exploitation can, in extreme cases, lead to a dramatic decrease in the number of recruits. Moreover, at present there is no limitation on the number and type of gillnets used. Information about gillnet selectivity of the *Labeobarbus* species is required in order to advise on management measures to protect the reproductively active part of the population. Such measures could involve the introduction of a minimum mesh size and closed seasons and/or areas. Proper fishery management requires that fishing gear harvest large mature fish while allowing the small juveniles to escape [7]. Gillnet selectivity studies of Lake Tana *Labeobarbus* species previously have been done by [6, 8] at the Southern Gulf of Bahir Dar and the mouths of the four permanent contributing rivers. But no detail information is available for the whole lake system of some *Labeobarbus* fish species. So the objective of this study was to investigate the effect of the small mesh gillnets on the length at first capture of *Labeobarbus vis-à-vis* the effect on rejuvenation and the economic survival of the fishermen with a view to proffering appropriate management strategy for the fishery. Generate scientific information about gillnet selectivity of the some endemic *Labeobarbus* species of Lake Tana for sustainable utilization of the Lake Tana fishery was the mandate of this study.

2. Materials and Methods

2.1 Description of the Study Area

Lake Tana, is the largest lake in Ethiopia with an area of about 3200 km^2 and it is located in the northwestern highlands of Ethiopia at an altitude of about 1800 m with an average depth of 8 m and maximum depth of 14 m and it is the only source of the Blue Nile River and constitutes almost half of the freshwater bodies of the country [9, 10]. Lake Tana, the third largest Lake in Africa next to Victoria and Tanganyika, originated by the blocking the Blue Nile River with volcanic basalt two million years ago [11, 12]. It is characterized by low nutrient concentrations, relatively high silt concentrations with a loading rate of 8.96-14.84 million tons of soil per year [13] and the trophic status is oligotrophic to mesotrophic [2, 9, 14].

The Lake Tana area has a warm climate with four years mean annual rainfall of about 1564 mm, of which 59 percent falls in the months of July and August, when the mean rainfall can be 444-483 mm per month. The seasonal rains cause the lake level to fluctuate regularly with an average difference between the minimum, in May-June, and maximum in September-October of about 1.5 m. Lake Tana and its adjacent wetlands both directly and indirectly provide a livelihood for more than 500 000 people [15] and about three million people live in the catchment. This Ethiopia's largest lake is source of Blue Nile. The only out flowing river is Blue Nile. Ichthyo (fish) fauna is isolated from the lower Blue Nile by a 40m waterfall located 30 km from Lake Tana. Fogera and Dembia Floodplains are the largest wetlands of the country and border Lake Tana in the eastern and northern parts, respectively [16]. The population density ranges from 151-200 persons km^2 in the north and in some parts of Fogera plain to the east, and from 101-150 persons km^2 in the more fertile lowland areas to the east and southwest [16].

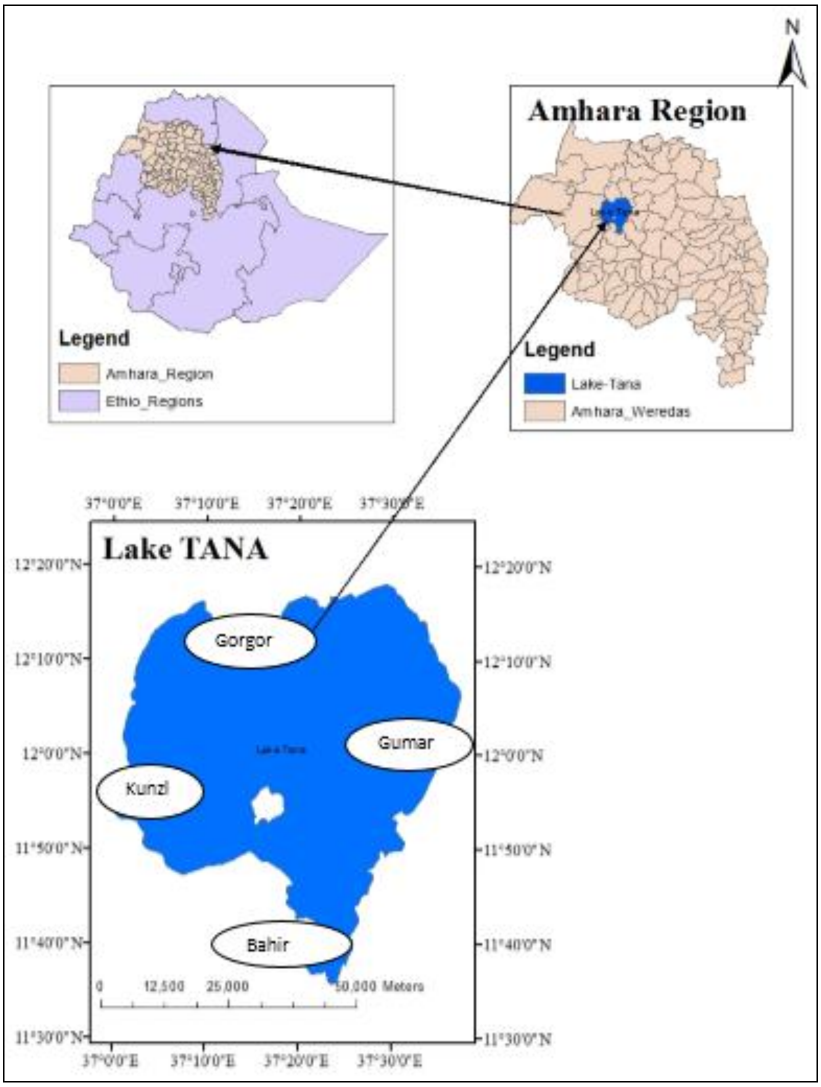

Fig 1: Map of Lake Tana and sampling sites

2.2 Sampling and Data Collection

The data was collected at four sampling sites (Gorgora from North, Bahir Dar Gulf from South, Nabega from East and Kunzla from West direction of the lake), which are a good representatives of the whole lake in its North-South and East-West direction, were selected (Fig 1). Fish samples were collected monthly at each site for eight months. Gillnets of 6, 8, 10, 12 and 14 cm stretched mesh were used and set overnight in the lake at a depth of about 3m. The five gillnets were connected end to end and the resulting 150 m long panel was set around sunset and retrieved at dawn. Thus, the average gillnet setting time was 12 hrs throughout the sampling period. After the retrieval of the sampling gear, fish caught in the five gillnets were collected separately in five labeled boxes and the variable such as total length, weight, sex and maturity stage were measured on each specimen for other studies at the field. *Labeobarbus* species were identified into species level using keys developed by [2, 17].

2.3 Data Analysis

The selectivity each species was analyzed by [18]
S (L) = exp $^{((L-Lm)2)/(2*S2)}$
Where, L is the length of the fish
Lm is the optimum length to be caught
S is the SD or a measure of the width of the selection curve.
Therefore, the selection curve is fully defined by the two parameters Lm and S.
Two gillnets of the same fishing power were used, the first one with a mesh size of 8 cm and the second 6 cm. This mesh size of the gillnet have the same selective curve and maximum number of the catch was recorded by 6 cm and 8 cm mesh size of gillnet in the study.
Two nets with different mesh sizes such that their selection curves overlap are needed.
First step. The first step consists of in calculating the logarithms of the ratios for each length-group.
Second step. The second step consists in a linear regression analysis with the logarithms of the ratios as the dependent variable and the corresponding length intervals midpoints as the independent variable.
The model tested has the following form.
LnC2/C1 = βo + β1.L
LnC2/C1 = βo + β1.L
Third step: it gives the results. The optimal length for the smaller mesh sizes is given by:
Lm1 =-2*(βo*m1)/β1*(m1+m2)
The optimal length for the bigger mesh size is given by:
Lm1 =-2*(β1*m2)/β1*(m1+m2)
The common standard deviation is given by:
Lm1 =Square root of [2*βo (m1- m2)/β1^2*(m1+m2)]
The selection curves of the two nets were evaluated by the following equations:
S (L) = exp (L-Lm) 2/(2*S2)
The relationship between the optimum length (Lm) and the mesh size (m) is given by the following equation.
Lm = Sf*m
The selection factor (Sf) is estimated from:
Sf = (-2*β0)/ (β1*(m1+m2))
Optimum length (Lm)
The recommended mesh size (m)
Lm = Sf*m ⇒m = Lm/Sf

3. Results and Discussions

3.1 Selectivity *L.intermedius*

Table 1: Gillnet selectivity of *L.intermedius*

	Gillnet 6 cm	Gillnet 8 cm	Gillnet 10 cm	Gillnet 12 cm	Gillnet 14 cm
N	306	293	42	69	12
%N	42.4	40.6	5.8	9.6	1.7
Max length	35	42	52	56	66
SD Length	5.2	5.6	4.4	11.9	3.3
Max weight	615	1060	1625	2145	4305
SD weight	228.4	250	228.2	1123.8	69.4
Recommended mesh size	9.4 cm				

N: Number, SD: standard deviation

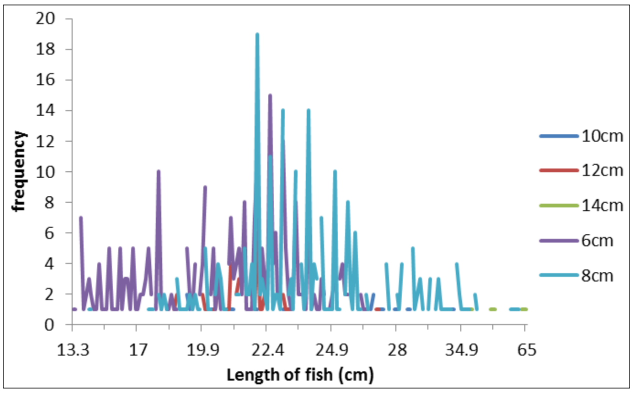

Fig 1: Selectivity of *L. intermedius*

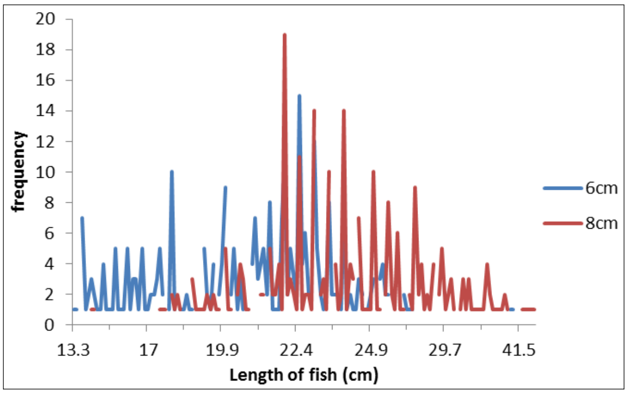

Fig 2: Selection curve of *L. intermedius*

As figure 2 shown above the selection curve of *L.intermedius* species there was an overlap within the two gillnet (6 cm and 8 cm mesh size) and the highest catch was collected at this region.

3.2 Gillnet selectivity of *L. megastoma*

Table 2: Gillnet selectivity of *L. megastoma*

	Gillnet 6 cm	Gillnet 8 cm	Gillnet 10 cm	Gillnet 12 cm	Gillnet 14 cm
N	42	52	42	13	7
%N	26.9	33.3	26.9	8.3	4.5
Max length	39	41	44	48	53
SD Length	7.4	5.2	4.2	5.6	2.7
Max weight	580	715	1070	1101	2175
SD weight	178.5	158.6	181.6	117.6	337
Recommended mesh size	9.1cm				

N: Number, SD: standard deviation

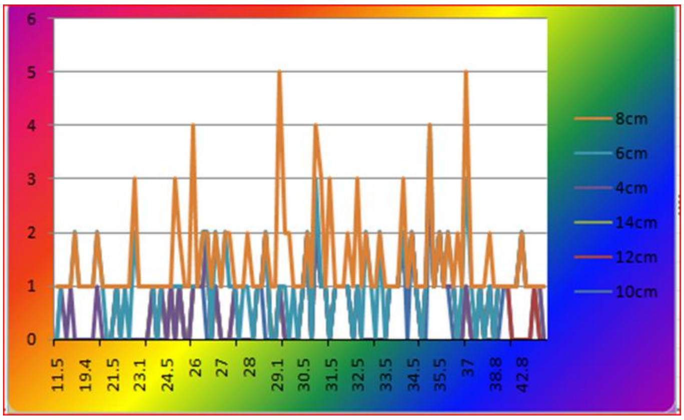

Fig 3: selectivity of *L. megastoma*

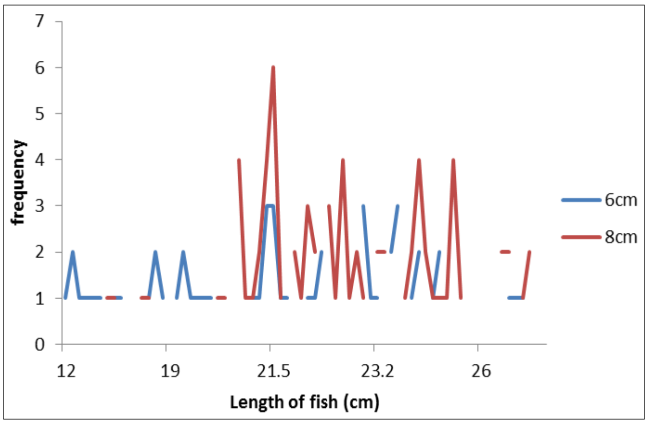

Fig 4: Selection curve of *L. megastoma*

3.3 Selectivity of L. *tsanensis*

Table 3: Gillnet selectivity of *L. tsanensis*

	Gillnet 6 cm	Gillnet 8 cm	Gillnet 10 cm	Gillnet 12 cm	Gillnet 14 cm
N	130	121	32	6	7
%N	43.9	40.9	10.8	2.2	2.4
Max length	44	60	36	40	54
SD Length	4.2	3.8	4.5	5.4	13.5
Max weight	1330	2545	730	1150	2870
SD weight	135.5	299.5	147	276.6	1061.7
Recommended mesh size	9.3 cm				

N: Number, SD: standard deviation

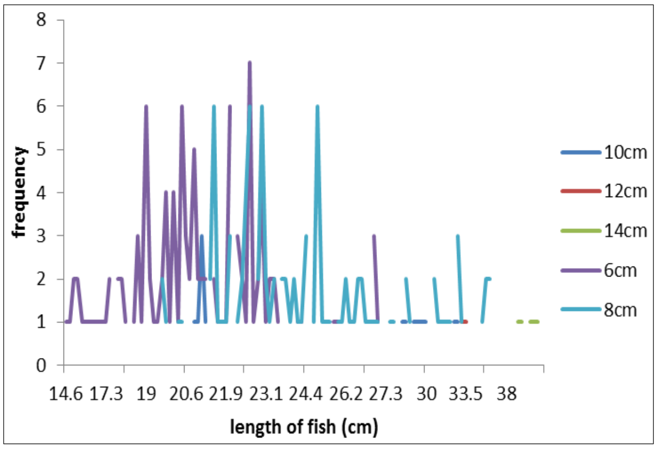

Fig 5: Selectivity of *L. tsanensis*

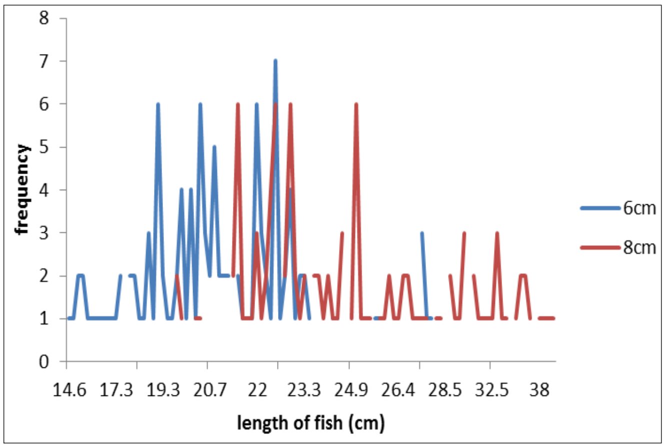

Fig 6: Selection curves of *L. tsanensis*

3.4 Selectivity of *L. platydorsus*

Table 4: Selectivity of *L. platydorsus*

	Gillnet 6 cm	Gillnet 8 cm	Gillnet 10 cm	Gillnet 12 cm	Gillnet 14 cm
N	98	111	26	10	8
%N	38.7	43.9	10.8	4	3.2
Max length	66	63	59	52	60
SD Length	6.7	7.1	9.2	10.2	12.1
Max weight	1445	3852	2685	2125	9960
SD weight	179.9	480.2	591.7	675	2893.5
Recommended mesh size	9.24 cm				

N: Number, SD: standard deviation

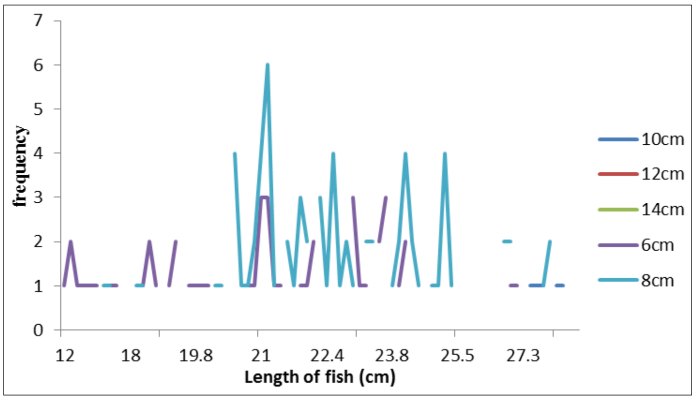

Fig 7: Selectivity of *L. platydorsus*

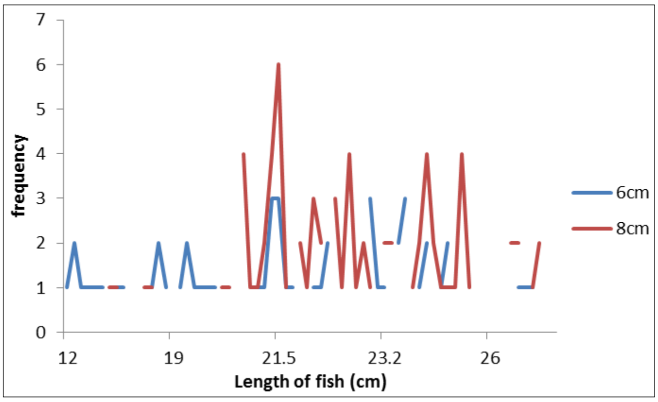

Fig 8: Selection curves of *L. platydorsus*

As figure 8 shown above there was an overlap between at 8 cm mesh size and 6 cm mesh size of gillnet and the maximum catch was obtained at this region of a gillnet.

3.5 Selectivity of *L.brevicephalus*

Table 6: Selectivity of *L.brevicephalus*

	Gillnet 6cm	Gillnet 8cm	Gillnet 10 cm	Gillnet 12 cm	Gillnet 14 cm
N	85	28	4	2	1
%N	70.8	23.3	3.3	1.7	0.8
Max length	24	26	28	20	20
SD Length	2.9	8.3	2.6	0	-
Max weight	1026	250	140	90	105
SD weight	110.5	56.5	38.5	1.4	-
Recommended mesh size	8.01cm				

N: Number, SD: standard deviation

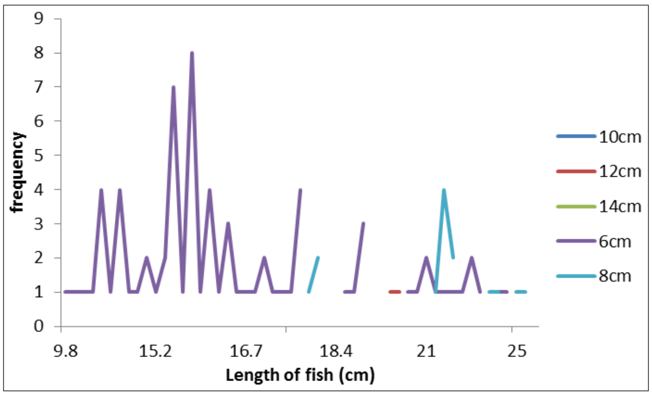

Fig 9: Selectivity of *L.brevicephalus*

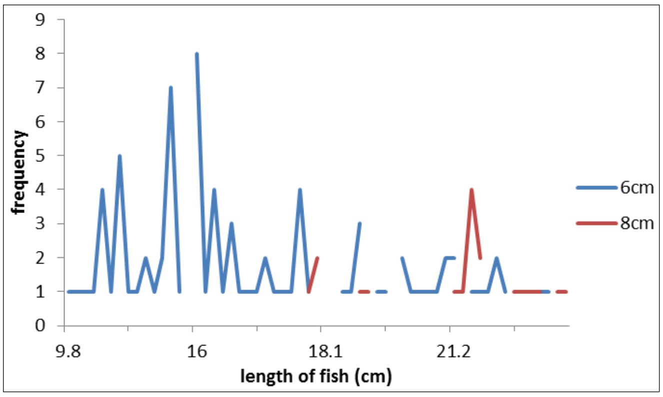

Fig 10: Selection curve of *L.brevicephalus*

Even if there was some overlap between 6 cm mesh size gillnet and 8 cm mesh size gillnet, large number of catch was collected by 6 cm mash size of gillnet As figure 10 shown above. This is because of *L.brevicephalus* is the smallest *Labeobarbus* fish species of Lake Tana. So small mash size of gillnet have high efficiency than large mash size of gillnet to catch this species.

4. Discussions

A total number of 722 *L. intermedius*, ranging from 13.3–66 cm (total length: TL) were collected in the present study. The standard deviation for optimum catch length ranged between 3.3 and 11.9 cm. The highest number of catch was collected in the smallest mesh size of gillnet and the number of individuals caught during the fishing period decreased with the increase of mesh size. The mean length of captured fish was 20.98 cm for 6 cm mesh size, 24.71 cm for 8 cm mesh size 25.3 cm for 10 cm mesh size, 25.87 cm for 120 cm mesh size, and 40.58 cm for 14 cm mesh size of gillnet. Even if there is some overlap or the mean length of fish captured by 6 cm mesh size and 80 mm mesh size of gillnet, the mean length of fish captured by 12 cm was greater than 6 cm and 8 cm mesh size of gillnet. The mean length of fish was almost linearly proportional to mesh size as seen from the observed and fitted catch curves (figure 1 and 2). All gillnets are selective in a certain range. The range of selectivity of gillnets increased with increasing mesh size. A total number of 156, *L. megastoma* ranging from 20–53 cm (total length: TL) were collected in this study. The standard deviation for optimum catch length ranged between 2.6 cm and 7.4 cm. Even if the external anatomy of *L. megastoma* was different from the *L.intermedius* the selectivity of all mesh size of gillnets was proportional to *L. intermedius.* The highest number of catch (32.9%) was collected in the smaller mesh size of gillnet and the number of individuals caught during the fishing period decreased with the increase of mesh size. The mean length of captured fish was 27.4 cm for 6 cm mesh size, 29.8 cm for 8 cm mesh size, 32.7 cm for 10 cm mesh size, 30.1 cm for 12 cm mesh size, and 43 cm for 14 cm mesh size of gillnet. The range of selectivity of gillnets increased with increasing mesh size. A total number of 296, *L. tsanensis* ranging from 19–60 cm (total length: TL) were collected. The standard deviation for optimum catch length ranged between 3.2 cm and 13.3 cm. This species have been similar physical structure with the *L. intermedius.* There was similar catch in a gillnet mesh size of 6 cm, 12cm and 14 cm the same as L. *intermedius* species. The highest number of catch was collected in the smaller mesh size of gillnet and the number of individuals caught during the fishing period decreased with the increase of mesh size. But the main thing that is surprising in this species was the highest catch in body weight was collected in a mesh size of 14 cm (2870g) from 1 specimen only. This indicates a few fish which was caught in larger mesh size of gillnet can substitute many fish which was caught in smaller mesh size of gillnet. The mean length of captured fish was 21.6 cm for 6 cm mesh size, 25.7 cm for 8 cm mesh size, 25.9 cm for 10 cm mesh size, 26.3 cm for 12 cm mesh size, and 42.9 cm for 14 cm mesh size of gillnet.

Like other *Labeobarbus* fish species of Lake Tana the range of selectivity of gillnets in *L. tsanensis* increased with increasing mesh size. Almost all of the highest catch composition some *Labeobarbus* fish species of Lake Tana was collected at meshes size of 6 cm and 8 cm. *Labeobarbus Platydorsus* species was greatly different from other *Labeobarbus* fish species of Lake Tana by its external anatomical structure. Due to this reason the selectivity of gillnet at different mesh size was different from other in optimum length and optimum weight. Since, 63 cm length and 3852g weight was collected at a mesh size of 8 cm > 10 cm and 12 cm (59 cm length, 2685g weight and 52 cm length, 2125 g weight). But the fish may be caught by entangled in gillnet mesh size of 8 cm and 6 cm, since a surprising weight (9960g) of *L. platydorsus* species was caught by a gillnet mesh size of 14 cm. A total number of 259, *L. platydorsus* ranging from 20-66 cm (total length: TL) were collected. The standard deviation for optimum catch length ranged between 2.4 cm and 12.1 cm. Although the optimum length and the optimum weight of *L. platydorsus* was cached in a smaller mesh size of gillnet, the catch composition of gillnet in terms of number was almost similar with other species. The mean length of captured fish was 22 cm for 6 cm mesh size, 24.8 cm for 8 cm mesh size, 29.6 cm for 10 cm mesh size, 36.3 cm for 12 cm mesh size, and 48.6 cm for 14 cm mesh size of gillnet. *Labeobarbus brevicephalus* was the smallest *Labeobarbus* fish species in Lake Tana. Its maximum total length cannot exceed more than 30 cm. The smaller mesh size of a gillnet could have an efficiency to catch a maximum length and weight of this species, since the optimum length of this species was 28 cm in this study. When the fishermen use 6 cm or 4 cm mesh size of gillnet this species has a grater probably to exploit than the other *Labeobarbus* fish species of Lake Tana. 70.8 % of the total catch was caught by a gillnet of 6 cm. The mean length of each mesh size of gillnet were 16.8 cm for 4 cm, 17.2 cm for 6 cm, 20.3 cm for 8 cm, 19.75 cm for 10 cm, 20 cm for 12 cm and 20 cm for 14 cm mesh size respectively.

Generally the highest number of catch for all the five *Labeobarbus* fish species of Lake Tana were collected at a gillnet mesh size of 6 cm and 8 cm this indicates when the fishermen use 6 and 8 cm mesh size of a gillnet all 15 *Labeobarbus* fish species of Lake Tana will exploited. Most of the time the fishermen uses this small mesh size of gillnet when the amount of catch is low. As the length frequency of each *Labeobarbus* species shown above most of the small size of fish was caught by a gillnet mesh size of 6 and 8 cm. The optimum length and optimum weight of each of the five species were increase with mesh size increase. This five *Labeobarbus* species were selected based on their catch composition from the total catch.

The recommended mesh size of each species except *L. brevicephalus* were found between 9 cm and 10 cm so the recommended the mesh size of all of the 15 *Labeobarbus* species should be 10 cm. Increased mortality due to high fishing pressures can result in maturity at a smaller size [19, 20, 21]. An attempt was made during the 1993 to 1994 spawning seasons to determine the FL50% for *B. acutirostris, B. macrophtalmus,* and *B. tsanensis* [2]. Fishing mortality due to strict mesh size regulations might even cause negative genetic changes in population productivity, such as reduced growth. Recruitment overfishing might occur due to severe and unregulated overfishing of spawning aggregations resulting in a dramatic decrease of recruits [21]. In Lake Tana, recruitment overfishing potentially threatens the survival of the unique *Labeobarbus* species flock. The decline of fish catch from the lake appears to be due to fishing during breeding season, using destructive fishing gear and open access nature of the resource. Fishers must use gillnets of 10 cm and above stretched mesh size. Licensing of fishers must be immediately materialized. Enforcement of management measures, effective training and extension work should incorporate active participation of the fisher community.

The reproductive strategy of African *Barbus*, that is, as total spawners undertaking single yearly migrations, renders them vulnerable to overexploitation as many cyprinid fisheries are centered on these spawning migrations. This study is in agreement with [8] reported, the most recommended mesh size of *Labeobarbus Megastoma* would be 100 mm, even though this net catches less fish than 80 mm net, assuring more protection for the juveniles. Previously, [6] reported that 100 mm stretched mesh is adequate or appropriate. In the current study, the fishermen used 80 mm net and our sampling area encompassed almost all parts of the lake, so the 100 mm mesh of gillnet recommendation as a minimum mesh size for *Labeobarbus* fisheries in Lake Tana is appropriate. It will give an opportunity for fish to spawn, at least once, before being exploited. Recruitment overfishing might occur due to severe and unregulated overfishing of spawning aggregations resulting in a dramatic decrease of recruits [21].

5. Conclusions

Fishing mortality due to strict mesh size regulations might causes negative genetic changes in population productivity. The highest number of catch was collected in the smallest mesh size of gillnet and the number of individuals caught during the fishing period decreased with the increase of mesh size. The mean length of all of the five *Labeobarbus* fish species was almost linearly proportional to the increasing mesh size and the range of selectivity of gillnets increased with increasing mesh size. A few fish which was caught in larger mesh size of gillnet can substitute many fish which was caught in smaller mesh size of gillnet. The recommended mesh size of each species except *L. brevicephalus* was found between 9 cm and 10 cm, so the recommended the mesh size of all of the 15 *Labeobarbus* species should be 10 cm. So 10 cm stretched mesh is adequate for all *Labeobarbus* fish species of Lake Tana. Generally the highest number of catch for all the five *Labeobarbus* fish species of Lake Tana were obtained at a gillnet mesh size of 6 cm and 8 cm this indicates when the fishermen use 6 and 8 cm mesh size of a gillnet all 15 *Labeobarbus* fish species of Lake Tana will exploited. Most of the time the fishermen uses this small mesh size of gillnet when the amount of catch is low.

6. Recommendations

- There is some change in regional fisheries regulation and proclamation at spawning migration seasons and grounds especially around Bahir Dar and Kunzla but there are some fishermen who didn't stop fishing during spawning migration seasons at Nabega site, there for, the government should be take some measurement at this side.
- The community, governmental and non-governmental organizations, policy makers and fishers should be aware the reproductive strategy of the migratory fishes and human impacts for sustainable utilization of the resources.
- Lake Tana *Labeobarbus* species need to be conserved and protected so the government should be continue the starting fishery management measure like, close area, close season measure but it should be included other management measures like; gear restriction, gear selection and other management measure that needed for fishery management.
- Only effort control regulations, limiting the gillnet fishery in spawning seasons and/or areas, will be appropriate to prevent the *Labeobarbus* fish species of Lake Tana from undergoing the same fate as the cyprinids in other African lakes.
- There are some fishermen who use mesh size of 4 and 6 cm and 8 cm monofilament at all part of the lake so these fishermen and other fishing corporation should be restricted from using a gillnet of 4, 6 and 8 cm mesh size.

7. Acknowledgements

I would like to thank major advisor Dr Wassie Anteneh, Co – advisor Mr. Shewit Gebremedhin (Assistant Professor) and, 3rd Co –advisor: Dr Gebeyehu G/Michaiel, all Bahir Dar University Fisheries Wetlands and Wildlife management staff members, Biniam Hailu and finally my family. The Exploratory Fishery Sampling Program was funded by International Foundation for Science (IFS) and Critical Ecosystem Partnership Fund (CEPF)

8. Reference

1. Kornfield I, Carpenter KE. Cyprinids of Lake Lanao, Philippines: taxonomic validity, evolutionary rates and speciation scenarios. In: *Evolution of Fish Species Flocks*, (Echelle, A.A. and Kornfield, I., eds), Orono Press, Maine. 1984, 69-83.
2. Nagelkerke LAJ. The barbs of Lake Tana, Ethiopia: morphological diversity and its implications for taxonomy, trophic resource partitioning and fisheries. PhD thesis, Agricultural University Wageningen, The Netherlands, 1997.
3. Nagelkerke LAJ, Sibbing FA. The large barbs (*Barbus* spp., Cyprinidae, Teleostei) of Lake Tana (Ethiopia), with a description of a new species, Barbus osseeinsis. Netherlands Journal of Zoology. 2000; 50:179-214.
4. Valdéz-Pizzini M, Acosta A, Griffith DC, Ruiz Perez M. Assessment of the Socio-economic impact of the fishery management options upon gillnets and trammels net Fishermen in Puerto Rico: An interdisciplinary approach (anthropology and fisheries Biology) for the evaluation of management alternatives. Final Report NOAA/NMFS, Grant #NA17FL0100-1. Un pub. MS, 1992.
5. Hansson S, Rudstam LG. Gillnet catches as an estimate of fish abundance: comparison between vertical gillnet catches and hydroacoustic abundance of Baltic Sea herring (*Clupea harengus*) and sprat (*Sprattus sprattus*). Can. J. Fish. Aquatic *Sci*. 1995; 52:7583.
6. de Graaf M, Machiels MAM. Tesfaye Wudneh Sibbing FA. Length at maturity and gillnet selectivity of Lake Tana's *Barbus* species (Ethiopia): Implications for management and conservation. Aquatic Ecosyst. Health. 2003; 6(3):325-336.
7. Armstrong DW, Ferro RST, MacLennan DN, Reeves SA. Gear selectivity and the conservation of fish. J. Fish. Biol. 1990; 37(suppl. A):261-262.
8. Tesfaye Wudneh T. Biology and management of fish stocks in Bahir Dar Gulf, Lake Tana Ethiopia. PhD. Thesis, Wageningen. 1998.
9. de Graff M, Marcel AM, Machiels M, Tesfaye Wudneh Sibbing FA. Declining stocks of Lake Tana's endemic *Barbus* species flock (Pisces: Cyprinidae): natural Variation or human impact? Biol. Cons. 2004; 1(16):277-287.
10. Mohr PA. The geology of Ethiopia. University College of Addis Ababa Press, Addis Ababa, Ethiopia, 1962.
11. Abebe Getahun, Eshete Dejene. *Fishes of Lake Tana, a Guide Book*, Addis Ababa University Press, Ethiopia, 2012.
12. Ayalew Wondie, Eshete Dejen, Minwyelet Mengistu S, Vijverberg E. Seasonal variation in primary production of a large high altitude tropical lake (Lake Tana, Ethiopia): effects of nutrient availability and water transparency. Aquatic Ecol. 2007; 41:195-207.
13. Gordon MS, Tadesse. Marketing systems for fish from Lake Tana, Ethiopia: opportunities for improved marketing and livelihoods, 2007.
14. Teshale Aragaw B, Lee R, Zawdie G. Development initiatives and challenges for sustainable resource management and livelihood in the Lake Tana region of Northern Ethiopia. Proceedings of the wetland awareness creation and activity identification workshop in the Amhara National Regional State. 23rd January, Bahir Dar, Amhara National Regional State, Wetlan Action/EWNRA. 2001, 33-45.
15. Nagelkerke LAJ, Sibbing FA. The large barbs (*Barbus* spp., Cyprinidae, Teleostei) of Lake Tana (Ethiopia), with a description of a new species, Barbus osseeinsis. Netherlands Journal of Zoology. 2000; 50:179-214.
16. Sparre Venema. two-step approach to estimating selectivity and fishing power of research gillnets in Greenland waters. Can. J. Fish. Aquatic. Sci. 1992; 53:1007-1013.
17. Mello *et al*., Truffles: much more than a prized and local fungal delicacy, 1999.
18. Diamond *et al.*, the Hereditary Leader of De Beers Pursues Post-Apartheid Growth, 1989.
19. Rochet. Bordeaux Retrospective Alphabetical Listing, 1998.
20. Gabriel WL, Sissenwine MP, Overholtz WJ. Analysis of spawning stock biomass per recruit: an example for Georges Bank haddock. N. Am. J. Fish. Man. 1989;

9:383-391.
21. Craig. The Constitution and Accountability for *Public* Functions, 1992.