Research Article

Changes in fish diversity and fisheries in Ziway-Shala basin: The case of Lake Ziway, Ethiopia

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Abstract

Lake Ziway is an economically important lake in the country. However, the physico-chemical parameters of the lake seem to be threatened by anthropogenic and climatic factors, which in turn affect biotic factors as reflected in fish catch. A study was made to assess the status and trends of fish diversity and fishery during October 2012 to September 2014 in Lake Ziway. Ten fish species were identified with low species diversity for the lake (H value of 1.67). The composition of the fishes has undergone some changes as compared to the last few decades. For instance, *Carassius auratus* and *Labeobarbus microterolepis* were not caught in this study. In addition, *Cyprinus carpio*, which was never reported in earlier catch earlier, attained the highest relative frequency (25.19 %) in this study, next to *Oreochromis niloticus* (27.88 %), and then followed by *Carassius carassius* (20.71%) and *Clarias gariepinus* (20.51%). Canonical correspondence analysis showed that the average abundance of *C. carpio*, *C. carassius* and *C. gariepinus* were positively correlated with nutrients, whereas the abundance of *Labeobarbus ethiopicus* and *Labeobarbus intermedius* had negative correlation with most of the physico-chemical variables. The fish catch of Lake Ziway currently declined from 3180 tons in 1997 to 1157.14 tons in 2014. Most of the threats resulted from the anthropogenic impacts on the lake including pressure of fishing. Currently, plenty of pumps are abstracting fresh water from the lake by state and private commercial farms throughout the year that are critically impacting the water level of Lake Ziway. As a result, the lake ecosystem is being affected by catchment degradation and siltation. The study suggested that if nutrient levels continue to increase and water levels continue to decline, further changes in fish composition can be expected in the lake, especially with a shift towards fish that are mainly turbidity-tolerant species such as *C. carpio*. Hence, appropriate management is an urgent requirement that could assist in sustainable exploitation of the resources, so that the resource could contribute to food security in the study area in particular and in the country in general.

Keywords: Abundance, catch, fish composition, physico-chemical factors, Lake Ziway

1. Introduction

Ethiopia has a number of lakes and rivers with substantial quantity of fish stocks. Many artificial water bodies have also been stocked with fish for fishery. Most of the lakes are located in the Ethiopian Rift Valley, which is part of the Great East African Rift Valley system. Lake Ziway is one of the lakes in the rift valley used for multiple purposes like irrigation, fishing, domestic water supply, transportation, recreation, supply of fresh water to Lake Abijata through the out flowing Bulbula River and most recently indoor flower farming.

There are seven indigenous fish species in Lake Ziway comprising *Barbus paludinosus, Garra dembecha, Garra makiensis, Labeobarbus ethiopicus, Labeobarbus intermedius, Labeobarbus microterolepis* and *Oreochromis niloticus* (Golubtsov *et al.,* 2002; Abebe Getahun, 2010). Of these, *L. ethiopicus, G. makiensis* and *L. microterolepis* were reported as endemic to the lake (Golubtsov *et al.*, 2002 and Abebe Getahun, 2010). The lake also harbors five exotic fish species (*Tilapia zillii, Cyprinus carpio, Carassius carassius* and *Carassius auratus)* which were introduced to enhance its production, and *Clarias gariepinus* that slipped into the lake accidentally (Abebe Getahun and Stiassny, 1998; Golubtsov *et al.,* 2002). Therefore, the lake has several important fish species for fisheries. The fish yield potential of of the lake estimated from 3000 to 6680 tons per year (FAO, 1982) and the fisheries production has been the second largest from the Rift Valley lakes, which accounted for 3180 tons, next to Lake Chamo that produced 4500 tons per year (LFDP, 1998). However, according to Yared Tigabu (2003), there was a continuous decline in the annual catch of some fish species like *O. niloticus* from the lake since 1997, but on the other hand an increase of *C. gariepinus* was observed in the fishermen catches since 2010 (Mathewos Hailu, 2011). In the same way, very recently increase in the catches of *C. carpio* was recorded (Lemma Abera *et al.*, 2014).

For all these there are several evidences in the lake, such as decline in phytoplankton biomass (Getachew Beneberu and Seyoum Mengistou, 2009), increase in dominance of toxin-producing blue-green algae (Girma Tilahun, 2006), imbalance between water inflow and outflow (Tenalem Ayenew and Dagnachew Legesse, 2007) and decreased lake water volume (Girum Tamire and Seyoum Mengistou, 2012). Also commercial fish production in the lake was intensified through the support acquired from Lake Fisheries Development Project and onwards, the fish stocks of the lake have declined for a variety of reasons.

Although several studies were conducted on Lake Ziway on various aspects, the changes on the lake are fast and hence the information on the lake gets obsolete quickly. Therefore, regular updating, monitoring and control are essential and this study becomes important and relevant for better management and sustainable use of the resources. Therefore, this paper attempts to assess the variations in some physico-chemical factors that influence the fish community structure; to update the species composition, distribution and relative abundance of the fishes; and finally to assess the trends of the commercial catch in relation to some environmental factors that were recorded earlier.

2. Methodologies

2.1. Location of the study area

Lake Ziway belongs to the Central Ethiopian Rift. On the average, the lake is located at an elevation of 1650 meter above sea *level,* $7^0 89'$- $8^0 05'$ N latitude and $38^0 72'$ - $38^0 92'$ E longitude located at about 163 km south of Addis Ababa. The lake is shallow and has an open water area of 434 km^2, shoreline length of 137 km and an average depth of 2.5 m (Von Damm and Edmond, 1984). The maximum length and width of the lake is 32 km and 20 km, respectively (LFDP, 1997).

The lake region in general is arid and even during the rainy seasons dry periods of several weeks are common. According to the data obtained from National Meteorological Agency, during the study period the mean monthly minimum air temperature ranged from 11.9 to 16.4 ^{0}C, while the maximum mean monthly air temperature varied from 24.6 to 29.8 ^{0}C (Fig.1). Monthly total rainfall also varied from 1.9 mm (November 2013) and 249 mm (July 2014) (Fig.1).
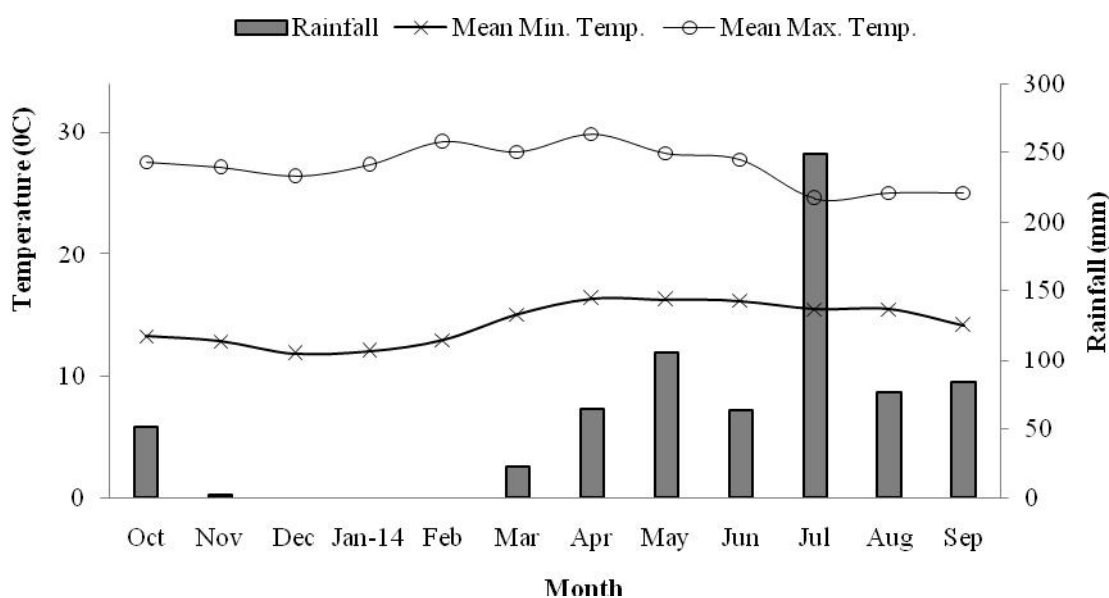
Fig.1. Monthly total rainfall; mean minimum and maximum air temperature of the lake region (From October 2013 to September 2014) (Source: National Meteorological Agency).

2.2. Site selection

To assess the variation in physico-chemical factors that influences the fish community structure of the lake, six sampling sites were selected based on geographical proximity and/or habitat similarity, their distance from human settlements and anthropogenic effects. Based on these, the detailed characteristics of each site are described as follows:

Site 1: The site is located in the western part of the lake and the shoreline is characterized by intensive cultivation with horticulture and field crops including flower farm. The depth was between 1.5 to 2.9 meter and on average the vegetation cover around the shoreline is degraded. *Site 2*: The site is located around the river mouth of Bulbula in the area between intensively and moderately cultivated shorelines. The depth was between 1.5 to 2.3 meters. *Site 3*: It is located on eastern part of the lake in Ziway Dugda district in between Yerera landing site and Tulu Gudo Island. The sampling site depth was between 1.5 to 3.10 meter and the vegetation cover around the shoreline is almost conserved woodland. *Site 4*: It is located around the river mouth of Ketar. As is the case with the other sites, the area is also characterized as

moderately cultivated. The depth was between 1.5 to 3.20 meters. *Site 5*: The site is located at the northern part of the lake and characterized by high human interference with horticulture and field crop activities next to site one. The water depth of the sampling site was 1.5 to 2.9 meter. Finally, *Site 6*: It is located almost at the center of the lake at a depth of 3.2 to 4.8 meters. The site was characterized by the activities of some fishermen using gillnets and long-lines.

2.3. Field sampling and measurements

2.3.1. Physico-chemical parameters

Physico-chemical parameters of the water were measured monthly from each site for two consecutive years (October 2012 to September 2014). Temperature, pH and conductivity of the lake were measured *in situ* during sampling periods at each sampling site. Transparency was measured with a Secchi disc of 20 cm diameter. Depth was also recorded at each sampling station. Water samples were collected from each site in dark plastic bottles, washed with acid and rinsed with distilled water several times in duplicates for nutrient analysis.

2.3.2. Fish parameters

Parallel to the physico-chemical sampling, every month the fishes were collected at all sites using variety of fishing gears, which included gill nets of various mesh sizes (6, 8, 10 and 12 cm stretched mesh size), monofilament nets with various stretched mesh sizes (5 mm to 55 mm stretched mesh size) and multiple long-lines with hooks of different size (9, 10, 11 and 12). The gears were set in the afternoon (4:00 pm) and were collected in the following day (7:00 am). Immediately after capture, some morphometric measurements were measured and the fish samples were put in plastic jars containing 10 % formalin and labeled with all necessary information. Then the preserved specimens were soaked in tap water for many days to wash the formalin away. Then, they were transferred to 75 % ethanol before species identification was conducted. The specimens were identified to species level using taxonomic keys of Shibru Tedla (1973), Golubtsov *et al.* (1995); Witte and Wim (1995); Stiassny and Abebe Getahun (2007); Redeat Habteselassie (2012) and figures from Fish base.

2.3.3. Catch and effort

Catch and effort data were recorded from the landing sites of the lake between October 2012 and September 2014. Data collection was done by the staff members of Ziway Fishery Resource Research Center as well as the selected cooperative in each district (Adami Tullu Jiddo Kombolcha, Dugda and Ziway Dugda). Total landing by species in kg, the number and type of gears used for fishing and the number of settings for each gear were recorded. The number of gears in a community was monitored by the data collector responsible for it. Total effort per gear type was estimated based on the number of gears (gill net and hooks), settings (beach seine) and time (the number of days the gear was deployed in the month). The number of gears and settings in relation to fish catch in each gear were obtained through interviews with the fishermen. These data were also used as raising factor

in the estimation of annual yield. A review was also made on the long-term trend of fish production from various published results and unpublished data collected by Ziway Fisheries Resource Research Center.

Some previous physico-chemical variables were reviewed to assess the effects on the fish production. Monthly and yearly rainfall and temperature for the study area was obtained from National Meteorological Agency. Surface water level was also measured by a standard calibrated vertical scale to refer surface level gauge.

2.3.4. Data analysis

Species abundance at each sampling station was presented as a numerical contribution by each species. This was determined by calculating the percentage of each species represented in the total catch for each station. Redundancy analysis was performed to observe the relation of species abundance data to environmental factors using CANOCO for windows 4.5 version software. Fish species diversity in the lake was computed using Shannon and Wiener Diversity Index following Shannon and Wiener (1963). Descriptive statistics were also used to analyze the remaining collected data using SPSS software (SPSS V.19.0).

3. Results and Discussion

3.1. Distribution and and diversity of fishes

Ten species of fishes in the Families Cyprinidae, Clariidae and Cichilidae were identified from the different sites in the lake (Table 1). The species were *B. paludinosus, C. carassius, C. carpio, G. dembecha, G. makiensis, L. ethiopicus* and *L. intermedius* from the Family Cyprinidae, *C. gariepinus* from the Family Clariidae and *O. niloticus* and *T. zillii* from the Family Cichilidae. The status (presence/absence) of the species from the sampling sites is provided in Table 1.

Table 1. Fish species identified from the study sites of Lake Ziway (Present (+), Absent (-))

Family	Fish species	Sampling Sites					
		S1	S2	S3	S4	S5	S6
Cyprinidae	*Barbus paludinosus*	+	+	+	+	+	+
	Carassius carassius	+	+	+	+	+	+
	Cyprinus carpio	+	+	+	+	+	+
	Garra dembecha	+	+	+	-	-	-
	Garra makiensis	+	+	+	+	-	-
	Labeobarbus ethiopicus	-	+	-	+	-	+
	Labeobarbus intermedius	+	+	+	+	+	+
Clariidae	*Clarias gariepinus*	+	+	+	+	+	+
Cichilidae	*Oreochromis niloticus*	+	+	+	+	+	+
	Tilapia zillii	+	+	+	+	+	-

A total of 7741 fish specimens were recorded from the three families during the study period. The species were *B. paludinosus, C. carassius, C. carpio, G. dembecha, G. makiensis, L. ethiopicus* and *L. intermedius* from the family Cyprinidae (50.73 %); *O. niloticus* and *T. zillii* from the family Cichilidae (28.76 %); and only *C. gariepinus* from the family Clariidae which accounts 20.51% (Fig. 2). Among the species that have been currently captured *C. carpio, C. carassius, C. gariepinus* and *O. niloticus* are commercially important fishes. *Oreochromis niloticus* was the major species of the sample accounting for 94 % in previous studies (Schroder, 1984). However, the contribution of the fish has gradually declined to 89.3 % of total catch in 1994, 50.9 % in 2010 and 42 % in 2010 (Mathewos Hailu, 2013); and 31 % in 2012 (Lemma Abera *et al.*, 2014) and 27.88 % in this study (Fig.3). On the contrary, the catch composition of *C. gariepinus* was 8.1 % in 1994 and increased to 41.8 % in 2010 (Mathewos Hailu, 2013) and currently decreased to 20.51 % (Fig. 3).
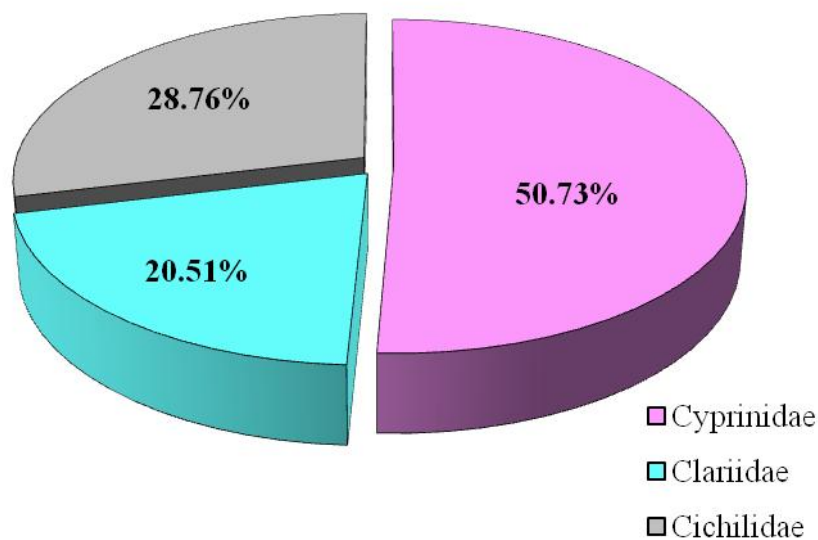

Fig. 2. Composition of fish at family level in the lake (%)

The fish species diversity of Lake Ziway was low (H value in between 1.51 to 1.67 on different sites) (Table 2) compared with some published data of similar works on lake (H' value in between 1.9 to 2.4) (Sylvester and John, 2010). Sylvester and John (2010) also reported that homogeneity of habitats favored lower diversity of fishes in water courses of Uganda.

The lower fish diversity around the two inlets of the rivers was due to both lower fish abundance. On the other hand, relatively higher fish diversity was observed at the southern part of the lake (S2) around the outlet of Bulbula River, and this may be due to the relatively high densities of fishes.

Table 2. Shannon Weiner diversity index, H', value and number of fish species, N, in the lake

	Sites					
	S 1	**S 2**	**S 3**	**S 4**	**S 5**	**S 6**
N	9	10	9	9	7	7
H'	1.5472	1.6681	1.5473	1.5213	1.5142	1.5127

3.2. Abundance of fish species in relation to environmental variables

The numerical abundance from the three families that exist in the lake, *O. niloticus*, *C. carpio*, *C. carassius* and *C. gariepinus* each as a group contributed to the bulk of the fishes (Fig. 3) The details of the remaining species were also described in Figure 3.
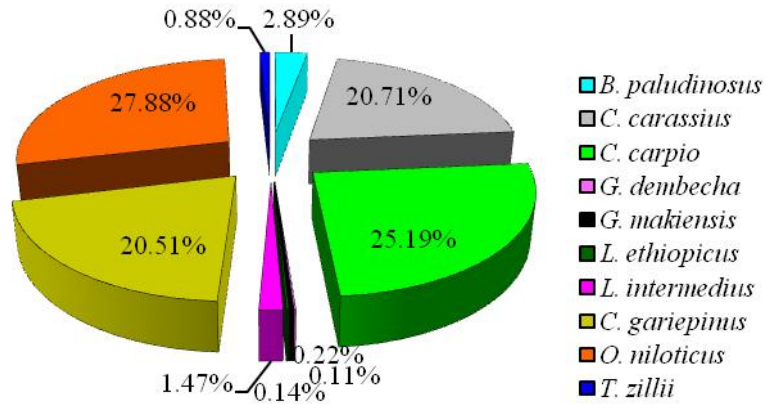

Fig.3. Fish species composition by number (%)

The RDA ordination of the species-environmental association indicated that nitrate, conductivity, nitrite, SRP, Chl-*a*, temperature and pH were negatively correlated with the first axis. Secchi depth was positively correlated to *L. ethiopicus* and *L.* *intermedius* with the axis, which contributed 88.4% of this variance (Table 3 and Fig. 4). The remaining environment factors and fish species were negatively correlated with this axis (Table 3 and Fig.4).

Table 3. Result of redundancy analysis of abundance of the fishes and physico-chemical associations including eigenvalues and percentage variance explained by the first two axes, as well as the correlations between environmental variables and the axes (strong correlations are marked bold)

	Canonical coefficients	
Variables	Axis 1	Axis 2
Eigenvalues	0.884	0.093
Cumulative percentage variance of species-environment relation	0.884	0.977
Temperature	-0.0289.	-0.4912
Secchi depth	0.0263	**-0.7482**
Nitrate	**-0.5869**	0.3866
Nitrite	**-0.6302**	0.5450
SRP	**-0.9191**	-0.335
Chlorophyll-*a*	-0.4406	-0.4658
pH	-0.0853	-0.4518
Conductivity	-0.4804	0.3651

The second axis was positively correlated with the environmental variables nitrite, nitrate and conductivity that were associated with relatively high abundance of the two carp species (*C. carpio* and *C. carassius*) (Table 3; Fig. 4). The remaining fish species (*O. niloticus, T. zillii, C. gariepinus* and the two *Garra* species) were negatively correlated with the two axes of the environment variables such as Chl-*a*, SRP, pH and temperature.
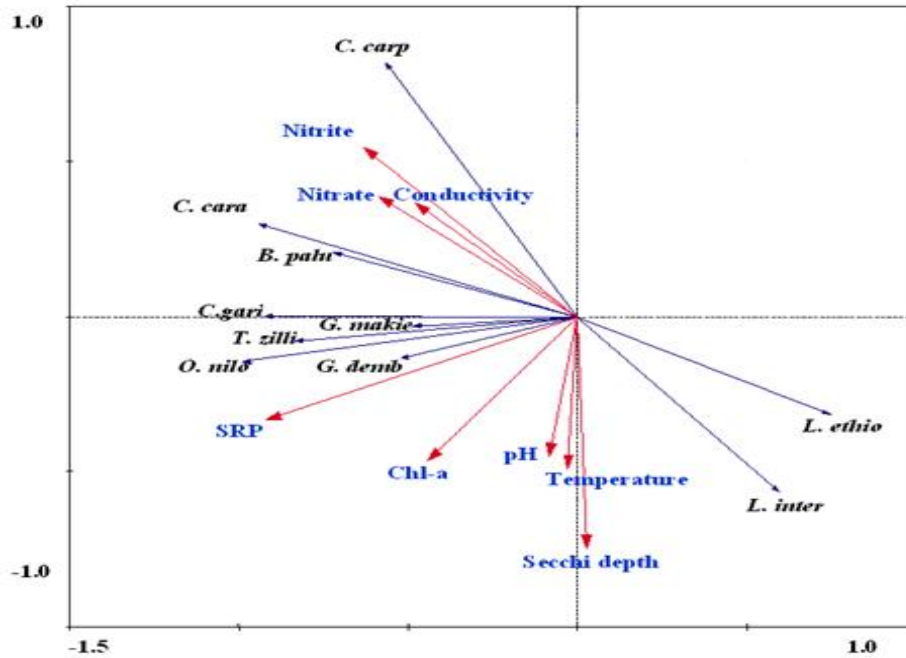

Fig.4. Biplots of the first two axes of correspondence analysis showing the association of fish species numerical abundance and environmental variables (Abbreviation: *L.ethio. - Labeobarbus ethiopicus, L.inter.- Labeobarbus intermedius, B.palu.- Barbus paludinosus, G.makie.-Garra makiensis, G.demb.- Garra dembecha, O.nilo.- Oreochromis niloticus, C.carp.-Cyprinus carpio, C.cara.- Carassius carassius* and *C.gari.- Clarias gariepinus* and SRP - Soluble Reactive Phosphate).

Hence, abundance of fish species in the lake was probably affected by changes in physico-chemical properties of the lake. Some parameters were correlated significantly with the abundance of fish species (Table 3 and Fig.4). Similar trend was highlighted by other authors (Schoener, 1988; Whitefield, 1990) who suggested that physico-chemical parameters influence the aquatic system.

3.3. Species composition of the commercial catch

Very recently, the catch composition of the most commercially important fishes is estimated to be about 42.5 % *O. niloticus*, 27.1 % *C. carpio*, 16.4 % *C. carassius* and 14.1 % *C. gariepinus* (Table 4). The long-term trends of the species composition of the catch are described in Figure 5.

Table 4. Catch percentage of fishes by species and gears in 2013/2014.

| Gear | Total catch (metric tons) | | | | | |
	O. niloticus	*C. gariepinus*	*C. carassius*	*C. carpio*	Total	Catch size with gears (%)
Gill net	80.06	14.91	28.42	46.73	170.12	14.7
Beach Seine	411.48	94.97	161.2	266.37	934.02	80.72
Long line	0	53	0	0	53	4.58
Total	491.54	162.88	189.62	313.1	1157.14	100
Species composition (%)	42.48	14.08	16.39	27.06		

Currently, the commercial catch composition has changed with a decline in *O. niloticus*, but a progressive increase in the proportion of *C. carpio* and *C. carassius* and became significant part of the landings (Fig. 5). The catch composition of *C. gariepinus* was 176 tons in 1994 and increased to 1046 tons in 1999 then decreased to 163 tons in 2014 (Fig. 5). In general, currently the contribution of the fishes to the catch has decreased (Table 4 and Fig 5). The decrease in catch trend since 2011 (Fig 6) is due to an excessive increase in effort with gill nets, beach seines

and number of hooks in long line (Table 5). The catch of *O. niloticus* and *C. gariepinus* decreased from 575.82 to 491.54 tons and 487.09 to 162.88 tons during 2011/12 to 2013/14, respectively. That of carps was increasing from 93.8 to 502.72 tons (Fig. 5). This could be due to overfishing of selected fish species with inappropriate gears and degradation of the catchment area that breeding of some fish species that take place. All these leads to decline in species like Nile tilapia.
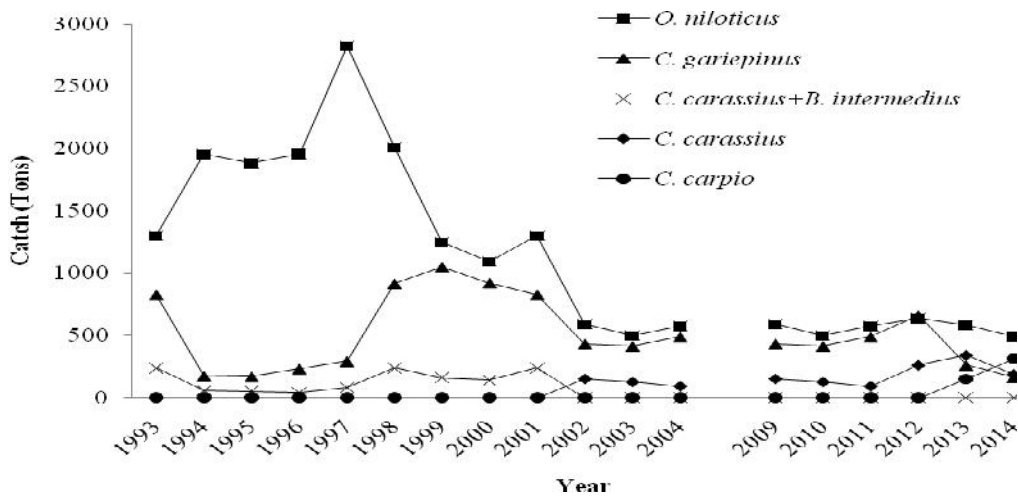

Fig. 5. Trends in species composition of catch from Lake Ziway (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011; Brook Lemma, 2012, and the current study).

3.4. Annual fish catch

The annual fish catch of the lake shows different trends with time (Fig. 6). The first fishing phase was before 1994, which was a period of fisheries where the catch has been stable with a mean annual catch of 780 tons. The second phase was the growth period between 1994 and 2000, which was a period when yield increased dramatically to 2500 tons which has exceeded the recommended annual catch of 2163 tons. The third phase was the period in which fish catch declined with an average of 1200 tons in 2010, and currently, in this study years the catch again decreased to 1157.1 tons (Table 4 and Fig. 6).
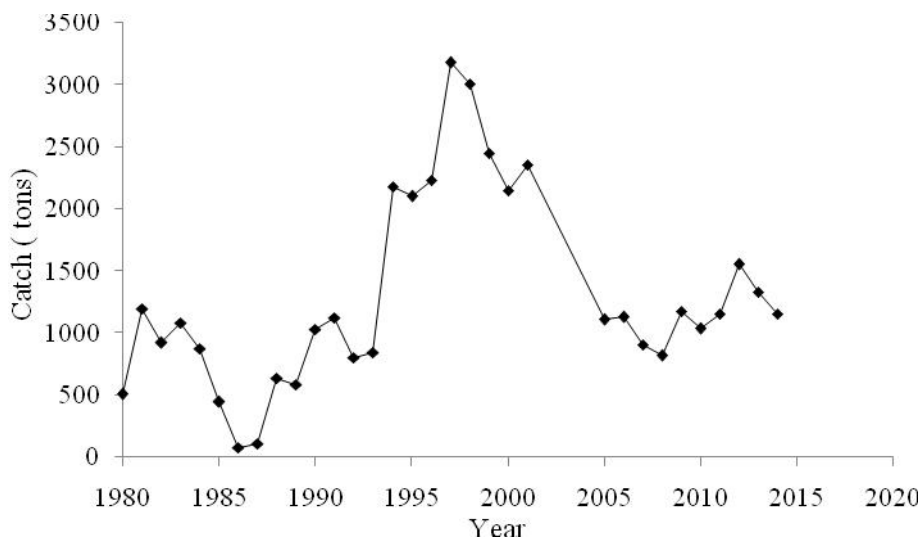

Fig. 6. Change in total anual fish catch from Lake Ziway between 1980 and the present (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011, Brook Lemma, 2012, and the present study).

3.5. Factors that affect the fish production

3.5.1. Fishing gears

The fishing activity of Lake Ziway was operated by three types of gears: beach seines, gillnets and long-lines (Table 5). Beach seine was the most common fishing gear used, whose presence increased from about 116 in 1993-1995 to 5596 in 2001/02 (Table 5) that most of the catch were recorded (Fig.6). During this study, the assessment done has indicated that the number of beach seines have decreased to 127 only (Table 5). The decline in the number of beach seines was associated with decrease in catch, which led some fishermen to move Lakes Langano, Koka and Fincha (Personal observation). The recommended minimum beach seine mesh size in the cod end was 6 cm, minimum mesh size in the wings was 8 cm, and maximum allowed length 150 meters for Lake Ziway (LFDP, 1997). However, Megersa Endebu et al. (2013) reported that the beach seines operating currently are twice as long as the recommended length. About 56.3 % of the fishermen use beach seine whose wing mesh size is less than 8 cm and 42% of the fishermen use beach seine whose cod end mesh size is less than 6 cm. that directly affect the production of the fish.

Table 5. Summary of fishing gears trend involved in Lake Ziway in different years (in number)

Years	Gill nets	Beach seines	Long-line(Hooks)	Reference
1993-1995	1,810	116	1,056	LFDP, 1996
1996-1998	2,470	124	1,413	Felegeselam Yohannes, 2003
2000-2001	1,098	5,596	399,995	Yared Tigabu, 2003
2009-2010	104	68	56,070	Mathewos Hailu, 2013
2012-2013	1,445	127	400,461	Current study

The number of gill nets has also decreased drastically from 2470 in 1996 -1998 to 104 (2009/10) and then increased during this study period to 1445 (Table 5). The decrease in gillnet could be due to the decrease in tilapia catch in the lake's fishery. In the management plan of Lake Ziway set during LFDP 1997, the minimum stretched mesh size of gillnet was 8 cm in the first year, 9 cm in second year and 10 cm thereafter, with maximum length of 60 m. (Megersa Endebu *et al*. ,2013). Also Megersa Endebu *et al*. (2013) reported that 41.9 % of gill net users were confirmed to use gill nets whose mesh size is less than 8 cm very recently that influence the production.

In contrast to beach seines and gill nets, the number of hooks utilized in long-lines have increased from 1,056 in 1993/95 to 399,995 in 2000/01(Table 5) and also catch were more during this period (Fig.5). Again the number of the hooks decreased in 2009/2010 to 56,070 and currently the number increased and reached 400,461 (Table 5). The appearance of the long-line and its expansion was after the increase in *C. gariepinus* population, which was exotic to the lake. The increase in long-line fishery is associated with low labor and capital investment requiring only one person and just a raft, while using a beach seine requires three or more persons to operate with a wooden boat.

3.5.2. Lake water level

Currently, plenty of pumps are abstracting freshwater from the lake by the state, investors and private commercial
farms throughout the year (Personal observation). Even during the rainy seasons water for horticultural crops is collected from the lake. Hence, the current irrigation practices in the upstream areas have considerably reduced the volume of the inflowing water from Meki and Ketar River and the lake itself, critically impacting the water level of Lake Ziway. As a result, the lake ecosystem is being affected by catchment degradation, siltation, imbalance between water inflow and outflow. Even if there were high anthropogenic pressures in Lake Ziway, abundant fish species were collected when the water level of the lake increased (Fig. 7).
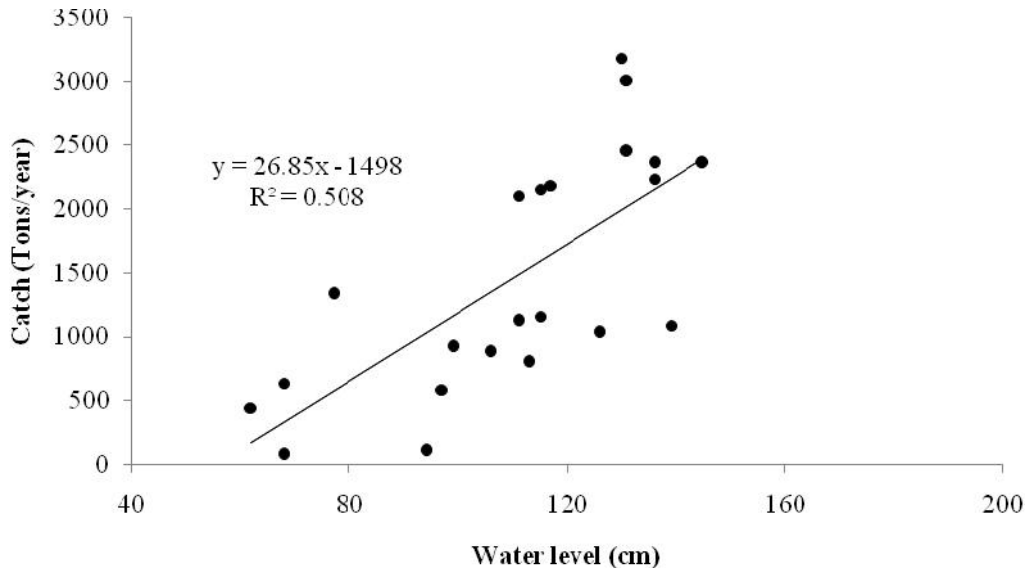

Fig.7. Relationship between water level and fish catch in Lake Ziway (1982-2014) (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011; Brook Lemma, 2012 and the current study).

3.5.3. Water quality

Aside from problems related to decreasing water level of the lake, water abstraction started to induce salinity, due to loses of freshwater from the lake. Simultaneously, the application of agrochemicals (Personal observation) and fertilizers due to intensification of irrigation practices around the lake has increased and affected the water chemistry of the lake (Table 6).

Table 6. Trends in some physico-chemical factors of Lake Ziway

Parameters	Unit	Amount		General
				trend
		Previous	**Present study**	
Secchi depth	cm	40 -106 (Girma Tilahun, 1988)	17.8-22.1	Decreasing
pH	-	8.5 (Elizabeth Kebede *et al.*, 1994)	8 - 8.4	Decreasing
D. Oxygen	mg/L	7.1 (Adamneh Dagne, 2010)	3.4 - 6	Decreasing
Chl-*a*	μg/L	150 - 212 (Girma Tilahun, 1988)	37 - 54.5	Decreasing
Nitrate	μg/L	28 (Girma Tilahun, 1988)	30.1 - 61.7	Increasing
SRP	μg/L	5.5-16.2 (Girma Tilahun, 1988)	38.2 - 64.7	Increasing
Ammonium	μg/L	36.4 (Elizabeth Kebede *et al.*, 1994)	64.17- 258.92	Increasing
Conductivity	μS/cm	347- 400 (Girma Tilahun, 1988)	361.5 - 484.5	Increasing

Hence, currently, the high concentration of SPR, Ammonium and nitrate were recorded in the lake (Table 6). The farm lands located near the shore use fertilizers which are rich in nutrients, especially phosphates and nitrates, and hence can increase the concentration of SRP (Table 6). On the other hand the increment in turbidity was measured by the low Secchi depth measured during the study period as compared to previous records (Table 6). The lower Secchi depth can be partly caused by the rising levels of siltation as conductivity increased. Hence, on this line some of the physico-chemical features of the lake water were changed and some of them may affect the aquatic organisms, such as fish kills occurring at the outlets of the flower farm effluents (Personal observation). Also evidence from other lakes in Ethiopia show that the longer term impact of human induced changes like deforestation increases the risk of flooding such as Hawassa Lake or even complete degradation of the lake like in the case of Haramaya (Brook Lemma, 2011).

4. Conclusion and Recommendations

Lake Ziway has shown some undesirable changes in terms of some physico-chemical factors and shift in catch composition of fish species. The fish fauna of Lake Ziway is dominated by Cyprinids. Of the total 12 species recorded in the lake only 10 species were sampled with the three families. Seven species from Cyprinidae and the rest are included in the Families Clariidae and Cichlidae. Clariidae is represented by only one species (*C. gariepinus*) and Cichlidae by two

species (*O. niloticus* and *T. zillii*). *C. auratus* and *L. microterolepis* were not encountered during the study. *Oreochromis niloticus*, *C. carpio*, *C. carassius* and *C. gariepinus* were the most abundant in number, and commercially the most important fishes of the lake. Based on percentage composition, *O.niloticus* is relatively the most dominant fish in L. Ziway, which contributed to 27.88 % of the total catch. Among the Cyprinids, *C. carpio* and *C. carassius* contributed 25.19 % and 20.71 %, respectively, of the total fishes. *Clarias gariepinus* contributed 20.51 % of the samples from the lake.

Abundance of fish species in the lake was related to water quality of the lake. For instance, *C. gariepinus*, *C. carassius,* and *C. carpio* were found in relatively nutrient-rich sites. The major cause for the accelerated water quality changes in the lake was identified as human impact in the catchment of the lake. This includes land use changes, particularly removal of vegetation cover, irrigation, diversion of inflows and industrial use of the water were taken as the cause for the decline in water quality and quantity that directly have an effect on the current change in fish catch composition and abundance.

Therefore, sustainable utilization and conservation measures should be taken. Like, in Lake Ziway, large numbers of small sized fish of all species are being exploited and proper management actions are required to protect the immature fish. Particularly, capture size of the stock should be determined taking into consideration the size at first maturity of fishes.

Therefore, the fishery management plan such as prohibiting fishing on spawning ground during the breeding season is needed for the lake before the fishery resource is overexploited. Thus, management tools like closed seasons, catch quota restriction, mesh size regulations, gear restrictions and limits on the number of fishers has to be for sustainable exploitation of the stocks. The development of aquaculture and other related alternative fisheries (Integrated-fish-horticulture-poultry farming and Aquaponics technology) to reduce the pressure on the natural system should be encouraged.

5. Acknowledgments

6. References

Abebe Getahun (2010). *Labeobarbus ethiopicus*. The IUCN Red List of Threatened Species. Version 2015.1. <www.iucnredlist.org>. Down loaded on 12 June 2015.

Abebe Getahun and Stiassny M. (1998). The freshwater biodiversity crisis: the case of the Ethiopian fish fauna. *SINET*: *Ethiop. J. Sci*., **21**: 207-230.

Adamneh Dagne (2010). Zooplankton community structure, population dynamics and production in relation to abiotic and biotic factors in Lake Ziway, Ethiopia. Ph.D. Dissertation, Vienna University, Austria, Pp.148.

Brook Lemma (2012). Report on the Value Chain Assessment of the Fishery Sector in Ethiopia. Food and Agriculture Organization Sub-Regional Office for Eastern Africa Addis Ababa .Pp.131.

Elizabeth Kebede, Zinabu Gebremariam and Ahlgren I. (1994). Ethiopian rift valley lakes: chemical characteristics of a salinity alkalinity series. *Hydrobiologia*, **288**:1-12.

FAO (Food and Agriculture Organization of the United Nations) (1982). The production of fish meal and fish oil. Fishery industries division. FAO fishery technical paper 142.

Felegeselam Yohanes (2003). *Management of Lake Ziway fisheries in Ethiopia*. M.Sc Thesis, University of Toromso, 60 pp.

Getachew Beneberu and Seyoum Mengistou (2009). Oligotrophication trend in Lake Ziway, Ethiopia. *SINET Ethiop. J. Sci*., **32**:141-148.

Girma Tilahun (1988). A seasonal study on primary production in relation to light and nutrients in Lake Ziway, Ethiopia. M.Sc. Thesis, Addis Ababa University, Addis Ababa. 62 pp.

Girma Tilahun (2006). Seasonal variation in species composition, abundance, size fractionated biomass and primary production of phytoplankton in lakes Ziway, Awassa and Chamo. PhD. Dissertation, Addis Ababa, Ethiopia, 200 pp.

Girum Tamire and Seyoum Mengistou (2012). Macrophyte species composition, distribution and diversity in relation to some physicochemical factors in the littoral zone of Lake Ziway, Ethiopia. *African Journal of Ecology,* **51**: 66 -77.

Golubtsov A, Dgebuadze Y, and Mina M. (2002). Fishes of the Ethiopian rift valley. In: *Ethiopian rift valley Lakes.* pp. 167-256 (Tudorance, C. and Taylor, W.D. eds). Backhuys publishers, Leiden.

Golubtsov A., Darkov A, Dgebuadze Y. and Mina M., (1995). *An artificial key to fish species of the Gambella region*: *the White Nile Basin in the limits of Ethiopia*. Joint Ethio–Russian Biological Expedition, Addis Ababa (JREBE) pp. 84.

Lemma Abera, Abebe Getahun and Brook Lemma (2014). Composition of commercially important fish species and some perspectives into the biology of the African Catfish *Clarias gariepinus* (Burchell), Lake Ziway, Ethiopia. *International Journal of Advanced Research,* **2**: 864-871.

LFDP (1996). *Proceedings of the National Fisheries Seminar,* Ziway. *Lake Fisheries Development Project Working Paper no. 21.* Ministry of Agriculture. Addis Ababa.

LFDP (1997). *Lake Management Plans*. *Lake Fisheries Development Project, Phase II:* Working Paper 23. Ministry of Agriculture, Addis Ababa.

LFDP (1998). *Fisheries Report, Phase II.* Animal and Fisheries Resources Developmen Department (MOA). Addis Ababa, Ethiopia, 61 pp.

Mathewos Hailu (2011). Ecosystem structure, trophic link and functioning of a shallow rift valley lake: the case of Lake Ziway (Ethiopia). M. Sc. Thesis, Addis Ababa University, Addis Ababa, 63 pp.

Mathewos Hailu (2013). Reproductive aspects of common carp (*Cyprinus carpio* L, 1758) in a tropical reservoir (Amerti: Ethiopia). *Journal of Environmental Microbiology,* **1**: 114-118.

Megerssa Endebu, Alemu Lemma, Tilahun Genet, and Assefa Mitike (2013). Fisheries Baseline Survey: A Tool to Design Community-based Fisheries

Management of Lake Zeway, Ethiopia. In: *Water Reservoirs in Ethiopia: Ecology and Their Benefits*. Paper presented at the 6th Annual Conference of the Ethiopian Fisheries and Aquatic Sciences Association (EFASA), Mekelle, Pp 409-449.

Redieat Habteselassie (2012). Fishes of Ethiopia Annotated Checklist with Pictorial Identification Guide. 250pp.

Schroder, R. (1984). An attempt to estimate the fish stock and the sustainable yield of Lake Ziway and Lake Abaya, Ethiopian Rift Valley. *Arch. Hydrobiol,* **3:**411-441.

Schoener T. (1988). Ecological interactions. In: Myer AA, Giller PS (eds.) Analytical biogeography. Chapman and Hall, London, 255-299 pp.

Shannon C. and Weiner W. (1963). *The Mathematical Theory of Communication*. University of Illinois Press, Urbana, IL, 117 pp.

Shibru Tedla (1973). Fresh water fishes of Ethiopia. Haile Selassie I University, Addis Ababa, Ethiopia, 107 pp.

SPSS (2002). Stastical package for Social Science, Inc. (SPSS) for window (version 19.0) Chicago, Illinois, USA.

Stiassny, M. and Abebe Getahun (2007). An overview of labeonin relationship and the phylogenetic placement of the Afro-Asian genus *Garra* Hamiltin, 1922 (Teleostei: Cyprinidae), with the description of the five new species of Garra from Ethiopia,and a key to all African species. *Zoological Journal of the Linnran Society,* **150**:41-83.

Sylvester B. and John S. (2010). Fish species diversity and relative abundance in Lake Albert-Uganda. *Aquatic Ecosystem Health & Management*, **13**:284-293.

Tenalem Ayenew and Dagnachew Legesse (2007). The changing face of the Ethiopian rift lakes and their environs: call of the time. *Lakes & Reservoirs: Research and Management,* **12**: 149-165.

Von Damm K. and Edmond I. (1984). Reverse weathering in the closed basin lakes of Ethiopian Rift. *Amer. J. Sci.,* **284**:835-862.

Whitfield A. (1990). Distribution of fishes in the Mblanga estuaries in relation to food resources. *African Journal of Zool*., **15**:159-165.

Witte F. and Wim L. (1995). *Fish stocks and Fisheries of Lake Victoria*: A handbook for field observations. Wageningen Agricultural University, 404 pp.

Yared Tigabu (2003). The current status of Lake Ziway. In: *Wetlands and Aquatic Resources of Ethiopia: Status, Challenges and Prospects*. Proceeding of the workshop organized by Biological Society of Ethiopia, Addis Ababa, Ethiopia. Pp. 1-10.