Effects of bottom gillnetting on demersal fish species and the biology of an abundant benthic cichlid, *Limnotilapia darndennei*, in Kigoma Bay, Lake Tanganyika, Tanzania

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Introduction

The fisheries of Lake Tanganyika are mainly conducted in the pelagic and littoral areas of the lake with a major target of capturing *Stolothrissa tanganicae* (locally known as "dagaa") and *Lates stappersi* ("mgebuka"), which are of commercial importance (Kimirei *et al.* 2006). The pelagic fishery has, therefore, been an important fishery for traditional, artisanal and industrial fishers of the lake for quite a long time. Currently, this fishery provides 25-40% of animal protein for the population of the surrounding countries (Mölsä *et al.* 1999).

Recent data indicated that, the pelagic fish catches are decreasing with increasing fishing pressure (Mölsä et al., 2002; Sarvala et al., 2006; Kimirei et al., 2006). The pelagic fishery of Lake Tanganyika is also threatened by climate changes (Plisnier 1997, 2000, 2004). The climate change has caused increased warming of the surface waters, increasing the stability of the water column and restricting vertical mixing. Consequently, there are reduced nutrients in the water column, reduced primary productivity and expansion of the anoxic hypolimnion (Verburg *et al*. 2003, O'Reilly *et al*, 2003).

The decreasing trend in the pelagic fish catches provides a room for many fishers to invest in the demersal fishery. Unfortunately, they are investing without prior knowledge of management issues for the benthic stock. The available data show that demersal fishery/bottom gillnetting is cheaper and targets the capture of bottom dwelling fish species, especially, *Limnotilapia dardennei* and *Benthochromis tricoti* (Lowe 2006, Kalangali 2006). Many demersal fishers have little understanding on the impact of gillnetting (especially with smaller mesh sizes) on the stock and they may fish even in the breeding areas. If early efforts are not taken to manage the stock, the demersal fishery will most likely collapse.

The objectives of this study were to assess the effects of bottom gillnetting on the demersal stocks, understand the biology of one of the most abundant species (*Limnotilapia dardennei*) and propose some management measures in order to conserve the stock for sustainable fisheries of the demersal fish species.

Materials and methods

Bottom Gillnetting

This was an experimental fishery with the objective of assessing the effects of gillnetting on the demersal fish species. The experimental gillnet consisted of 12 pieces of 45 m joined together to make up 540 m of net. The net had different mesh sizes. These are 1.5", 2", 2.5", 3" to 4". For each mesh size, there was a pair of nets that made the 12 pieces. The net (540m long x 2m wide) was set at different areas covering from Kigoma harbour to Hill Top Beach area. These areas had two remarkable differences on their substrate nature and level of fishing activities. Kigoma harbour had muddy substratum with more submerged macrophytes and there were more fishers than other areas, which had sandy to pebble substrate, fewer/no macrophytes and no fishers. The nets were set in the evening and hauled the next morning using a small boat with 5 HP engine. The landed catch was sorted according to mesh size and identified to species level, according to Konnings (1998) and Eccles (1992). The total number and weight of each fish species were recorded per mesh size.

Biology of Limnotilapia dardennei

This study aimed at understanding some biological aspects of *L. dardennei*, which included length frequency distribution, length-weight relationship, length-at-first maturity, sex composition, fish fecundity and its health (which was assessed by measuring fat content, gonado-somatic and hepato-somatic indexes).

Fish samples for biometric data of *Limnotilapia dardennei* were purchased from Katonga and Kibirizi landing beaches because the test gillnets had poor catch of the fish. The fish bought were kept in an icebox and transported to TAFIRI Kigoma Laboratory. In the laboratory, individual total length and weight were recorded. The fish were cut open ventrally to expose the internal organs. The sex and fecundity (number of eggs) were determined; weights of gonad, liver, and fat were recorded by using a top-pan balance (200 x 0.01g). Gonad maturity stages were also assessed according to Aro (1993).

Data analysis

All the data were entered into Excel for analysis. The gillnet selectivity and catch composition from test gillnets were plotted. The length–weight relationship was calculated and length frequency distributions were constructed. A model by Froese *et al*. (1999, FISHBASE 2004) was used to estimate the asymptotic length and size-at-first-maturity for *L. dardennei*. Friedman Test (Nonparametric Repeated Measures ANOVA) was used to compare the mean catch of fish species in different stations.

Results

Bottom Gillnetting

<u>Catch Composition</u>

A total of 44 fish species belonging to 7 families were identified from the test gillnetting during the study period (Table 1). The most abundant species by number were *Chrysichthys spp.* (18.7%) and *Cardiopharynx schouteleni* (18.3%) at Bangwe, Petrochromis *sp.* (16.0%) and *Lamprologus mondabu* (10.3%) at the Tanganyika Beach Hotel site and *Aulonocranus dewindti* (16.5%) and *Lamprologus mondabu* (12.1%) at the Harbour site.

The Tanganyika Beach Hotel site was the richest in number of fish species identified (34), followed by Bangwe (31) and Harbour (21) (Table 1). A similar trend was also observed for total catch weight for the three stations, where by Tanganyika Beach Hotel site had 3163.44 g, followed by Bangwe site 2604.21 g and 666.07 g at the Harbour site (Fig 2). Friedman Test indicated a significant difference in the mean catch between the sites ($Fr = 9.60$, $P=0.0082$). The difference was especially marked between Tanganyika Beach Hotel and the Harbour ($P < 0.01$).

The percentage composition of different families by number and weight is given in Figure 1. The family Cichlidae led at all sites, with its composition ranging from 56% to 83%.

Gillnet Selectivity

The gillnets of 1 and 1.5 inches mesh size had more catch both by number and weight in all sites (Fig. 2). The larger mesh sizes (2 – 3”) had fewer individuals but of relatively large weights. The 4” net had only one very small fish (5.53g) that was entangled by its mouth. In general, Fig. 2 indicates that the catch decreased in number and weight with increasing mesh sizes. In simple words smaller individuals are more abundant in the study areas than larger ones. On the other hand, the Harbour site is much more exploited than the other two sites, which are closer and had similar sandy to pebble substrate. This is indicated by its poor catch as compared to the two sites (Fig 2).

Biological aspects of Limnotilapia dardennei (Kungura)

A total of 197 individuals were bought from Katonga and Kibirizi and analysed for length frequency distribution, length-weight relationship, length-at-first maturity, sex composition, fish condition and fecundity.

Length frequency distribution

Length frequency distribution of *L. dardennei* is presented in Figure 3a for Kibirizi and Katonga and Figure 3b for both (overall). At Kibirizi there were about three class intervals in length (110 – 160, 160-220, 220-270mm) that had maximum frequencies (Fig. 3a). At Katonga there was only one maximum peak, which was observed at 150-170mm class interval, and thereafter, frequencies decreased with increasing fish length. The overall length distribution had higher frequencies at 140-200mm class interval, and then gradually decreased with increasing fish length (Fig. 3b).

Length-weight relationship

Limnotilapia dardennei was found to grow isometrically, that is every increase in length results in increase in weight. Its growth therefore followed the equation $Wt\ (g) = 7E^{-5}TL\ (mm)^{2.6737}$, ($R^2 = 0.9631$), where Wt is weight in grams, TL is total length in millimetre.

Length- at-first maturity

Lengths-at-first maturity (Lm) for male and female *L. dardennei* was 113.9 and 120.8 mm for Kibirizi, and 116.9 and 128 mm for Katonga respectively. Unsexed Lm was 125.1 and 128.4 for Kibirizi and Katonga, with an overall Lm being at 128.4 mm (Table 2a). The minimum, maximum and average catch lengths are also given in Table 2(a).

Sex composition

The sex ratio at all sites was 1 male for 2 females (Table 2b).

Fecundity

The average number of eggs per female was calculated to be 126 for Kibirizi and 106 for Katonga, with an overall average of 116 (Table 2b).

Fish Condition

The overall Gonado-somatic Index (GSI), Hepato-somatic index (HSI), Lipido-somatic index (LSI) and Condition Factor (K) of the fish, were 0.56,1.43, 0.68 and 0.12 respectively (Table 2b).

Discussion

According to the results from test gillnetting, the shallow inshore waters of Lake Tanganyika are richer in fish species (Table 1), although species richness seems to differ from one site to another in relation to nature of substratum, macrophytes and level of fishing activities. This study witnessed differences in catch between the different sites in relation to the above named factors (Fr = 9.600 P=0.0082). The Harbour (with muddy substratum, a lot of submerged macrophytes and higher level of fishing activities) had poor diversity and abundance of the fish species (Table 1 and Fig. 2). Despite its attracting natural environment for breeding, many disturbances at the Harbour from gill-netters seem to be the major influencing factor. During our sampling, many fishers were fishing (setting and hauling) their nets at the site; some nets were even set over our nets. On the other hand, the two sites, Bangwe and Lake Tanganyika Beach Hotel (with sandy to gravel/pebble substrate, some submerged macrophytes and less/no fishing activities) had relatively higher catch.

Similar research conducted last year observed a large number of juvenile *Lates mariae* at the Harbour site, with total lengths ranging from 8.7cm to 18.5cm, and were all caught by a net of 1" mesh size (Kalangali 2006). None was caught from the site during this year's study. This may be due to several possible factors ranging from high fishing pressure with the use of smaller mesh size that has reduced the abundance of this stock, disturbance at the harbour that has affected the spawning potential of the *L. mariae* to poor environmental conditions deeming the site unsuitable for them. Last year, there was no replication in this area.

The catch composition from test gillnetting also indicates that cichlids dominated the fish populations in the shallow inshore waters of Lake Tanganyika (Fig. 1). Other researchers have also reported similar findings (Kuwamura 1987, Bayona 1991, Ndaro 1992). This indicates that cichlids are most important fish for the inshore fishery of Lake Tanganyika. Another important family (by numbers) was the Bagridae (Fig. 1). The bagrids caught were smaller but abundant. When left to grow, the inshore waters may have a great fish resource potential (like the bagrids) for future fisheries. The high occurrence of smaller individuals suggests that the sites are the breeding areas for the different species.

Gillnets are usually very selective in harvesting fish resources. The selectivity of gillnets makes the gear useful in harvesting required/desired size of fish for management purposes. According to this study, the smaller the mesh a gill net had, the smaller the fish and weight it caught (Fig 2). This suggests that smaller mesh sizes are harmful to the inshore fishery as the shallow waters are used as breeding sites (Konnings 1998). So the small mesh will only select small/juvenile fishes which are left in shallow areas to grow before are recruited into adult stocks. If this occurs for a long time, the inshore fish resources are likely to be depleted. The fish caught from 2.5 inches mesh size, though were less abundant, had higher weights (Fig. 2) and were mature.

When looking at the length frequency distribution of *L. dardennei* (Fig 3a) the fishers at Kibirizi caught more fish that had three different class intervals (110 – 160, 160-220 and 220-270 mm TL). This implies that they use gillnets of different mesh sizes. The interviewed fishers at Kibirizi had gillnets ranging from 1.0" to 5.0" (mode 1.5"). But on the other hand, it can mean that the population of *L. dardennei* at Kibirizi was composed of different year classes. A different situation was found at Katonga where many fishers interviewed had gillnets with 1.75 to 4" (mode 2") mesh sizes; that is why they got medium sized fish (150-170mm). According to Konnings (1998), *L. dardennei* can attain a maximum total length of about 260 mm. In the current study a maximum total length of 269 mm was recorded at Katonga and the length-at-first maturity was 128mm. It means that, fishers are catching individuals that are at their early stages of breeding; and when looking at figure 3b, less fish were caught above 200mm TL. The 150-200mm class belongs to the active spawners and are most harvested individuals (Fig. 3b). Over harvesting of spawners for *L.dardennei* may be dangerous because the fish's fecundity is smaller, 116 eggs (Table 2b); Konnings (1998) reports fecundity of than 100 eggs.

During this study, 53.75% and 58.12% of all specimens investigated from Kibirizi and Katonga respectively were mature, above stage III, with total length ranging from 158 – 269 mm for males and 135 – 249 mm females. For management purposes, the harvest of individuals above 200 mm total length is proposed as this size would have, at least, spawned several times. That is possible, for example, at Kibirizi some fishers target the capture of such class (Fig. 3a) by having nets with larger mesh sizes above 2.5".

Generally the *L. dardennei* caught were healthier with more fats and relatively big index value (Table 2b); and they grew isometrically (Fig 4). It implies that the fish had enough food items and that the environment was conducive to support growth and spawning.

Conclusion and suggestions

The fish resources of inshore waters of Lake Tanganyika like Kigoma Bay, need to be protected from illegal fishing especially the use of smaller mesh sizes as such sites are potential breeding and probably nursery areas . If possible, a closed season is highly recommended for that matter, especially during the spawning season that is June to July.

The recommended mesh size for gillnetting near the shore waters is the one that targets the capture of large-sized individuals. For *L dardennei*, the proposed large size individual is that above 200 mm total length, which can be caught in nets with more than/equal to 2.5 mesh sizes. However, because the inshore fishery is a multi-species fishery, it is difficult to propose recommended mesh size by just studying one species, thus more research should be conducted in order to find an appropriate mesh size that will assure the sustainable fisheries of all species and wise use of the resources.

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References

Aro, E. 1993. Guidelines for sampling pelagic fish catches on Lake Tanganyika. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika. GCP/RAF/271/FIN-FM/04

Bayona J. D. R., 1991. Species composition and some observations on the littoral fishes based on beach seining in the Kigoma region, eastern coast of Lake Tanganyika. *African study monographs, 12(2): 75-86.*

Eccles, D.H.1992. Field Guide to the Fresh Water Fishes of Tanzania. United Nations Development Programme Project URT/87/016.

Kalangali A.N.M 2006. Demersal Fish Resources from Test Gillnetting in Lake Tanganyika, around Kigoma Town, Tanzania. Nyanza Annual Report, 2006

Kimirei, IA, Mgaya YD, Plisnier PD, and Chande AI. Changes in species composition and abundance of commercially important pelagic fish species in Kigoma area, Lake Tanganyika, Tanzania. *Aquatic Ecosystem Health and Management Society* (in review).

Konnings A. (1998). Tanganyika Cichlids in their Natural Habitat. Cichlid Press.

Kuwamura T. 1987. Distribution of fishes in relation to the depth and substrate at Myako, East-middle coast of Lake Tanganyika . *African study monographs, 7: 1-14.*

Lowe, B. 2006 A Survey of the Demersal Fishery in the Kigoma Area. Nyanza Annual Report, 2006

Molsa, H., Reynolds, JE, Coenen, EJ & Lindqvist, OV. 1999. Fisheries research toward resource management on Lake Tanganyika. Hyrobiologia 407,1-24

Mölsä, H., Sarvala, J., Badende, S., Chitamwebwa, D., Kanyaru, R., Mulimbwa, N., and Mwape, L., 2002. Ecosystem monitoring in the development of sustainable fisheries in Lake Tanganyika. *Aquatic Ecosystem Health and Management*, **5**: 267-281.

Ndaro, S.G.M. 1992. Nearshore Fish Resources and Fisheries Around Kigoma, Eastern Coast of Lake Tanganyika. Naga, The Iclam Quartely April, 1992.

O'Reilly CM, Alin SR, Plisnier P,-D, Cohen A.S and McKee BA 2003. Climate change decreases aquatic productivity in Lake Tanganyika, Africa. *Nature,* 424:766-768.

Plisnier, P.D. 1997. Climate, limnology and fisheries changes of Lake Tanganyika. FAO/FINNIDA Research for the Management of Fisheries on Lake Tanganyika GCP/RAF/271/FIN-TD/72 (En): 50 pp.

Plisnier, P, D, 2000. Recent climate and limnology changes in Lake Tanganyika. *Verhandlungen der Internationalen Vereinigung Limnologie*, 27: 2670-2673

Plisnier, P, D, 2004. Probable impact of global warming and ENSO on Lake Tanzania. *Bulletin de l'Academie des Sciences d'Outere-Mer* 50 (2004-2): 185-196.

Sarvala, J., Langenberg, V. T., Salonen, K., Chitamwebwa, D., Coulter, G. W., Huttula, T., Kanyaru, R., Kotilainen, P., Makasa, L., Mulimbwa, N., and Mölsä, H., 2006. Fish catches from Lake

Tanganyika mainly reflect changes in the fishery, not climate change. *Verhandlungen Internationale Vereinigung für Limnologie*, 29: 1182-1188.

Verburg, P., Hecky, RE and Kling, H. 2003. Ecological consequences of a century of warming in Lake Tanganyika. *Science*, 301:505-507.

TEST GILLNETTING

Table 1: List of fish families showing number of genera and species caught during test gillnetting at different sites July 2007

		BANGWE		KIGOMA		HABOUR	
		GENERA	SPECIES	GENERA	SPECIES	GENERA	SPECIES
1	Bagridae	2	2	4	4	1	1
2	Centropomidae	1	2	1	2	0	0
3	Cichlidae	18	23	15	25	12	18
4	Cyprinidae	0	0	1	1	0	0
5	Mastacembelidae	1	1	0	0	1	1
6	Mochokidae	1	2	1	1	1	1
7	Polypteridae	1	1	1	1	0	0
	TOTAL	**24**	**31**	**23**	**34**	**15**	**21**

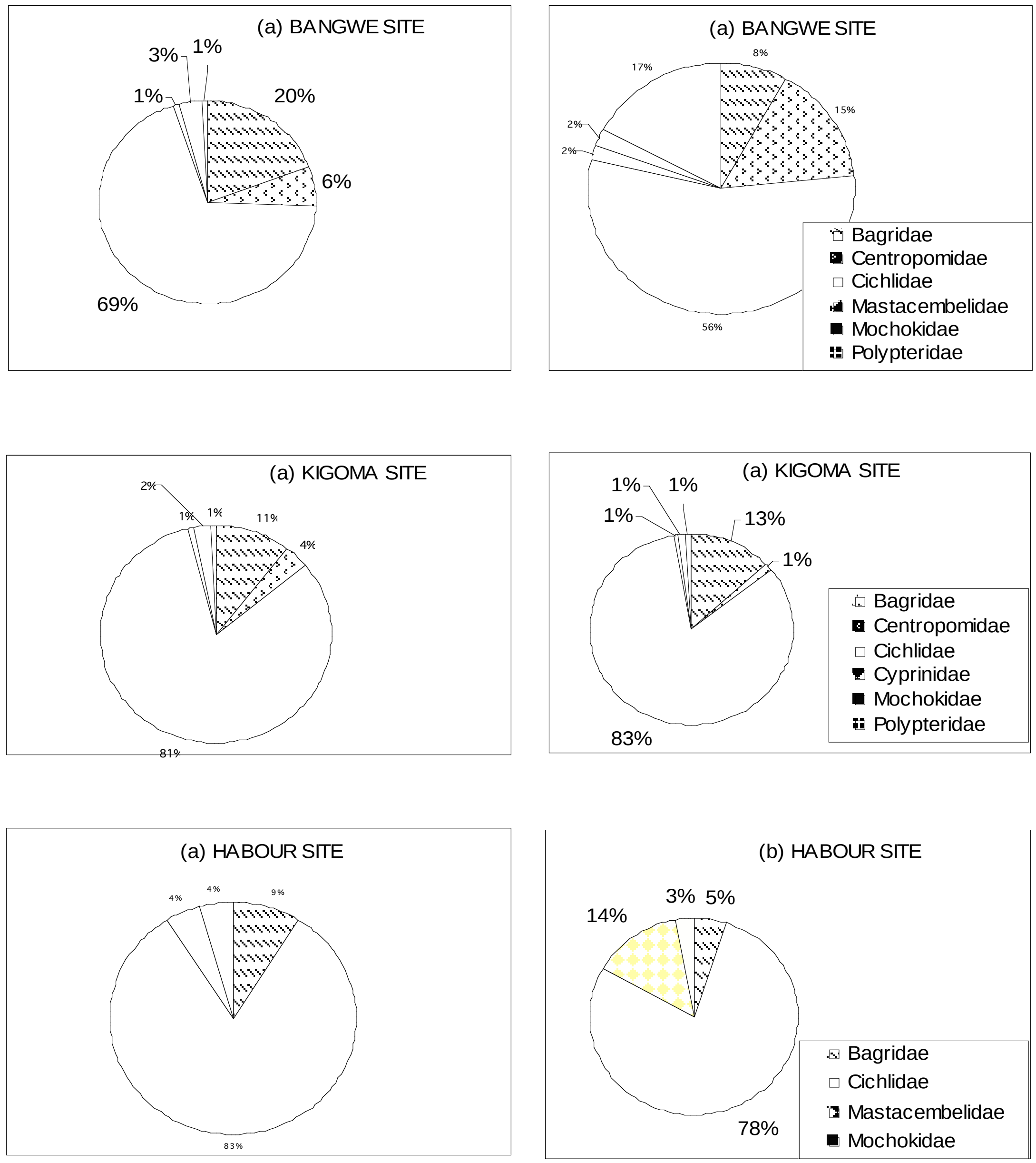


Figure 1: Percentage composition by (a) number and by (b) weight of fish family for each study site, July 2007

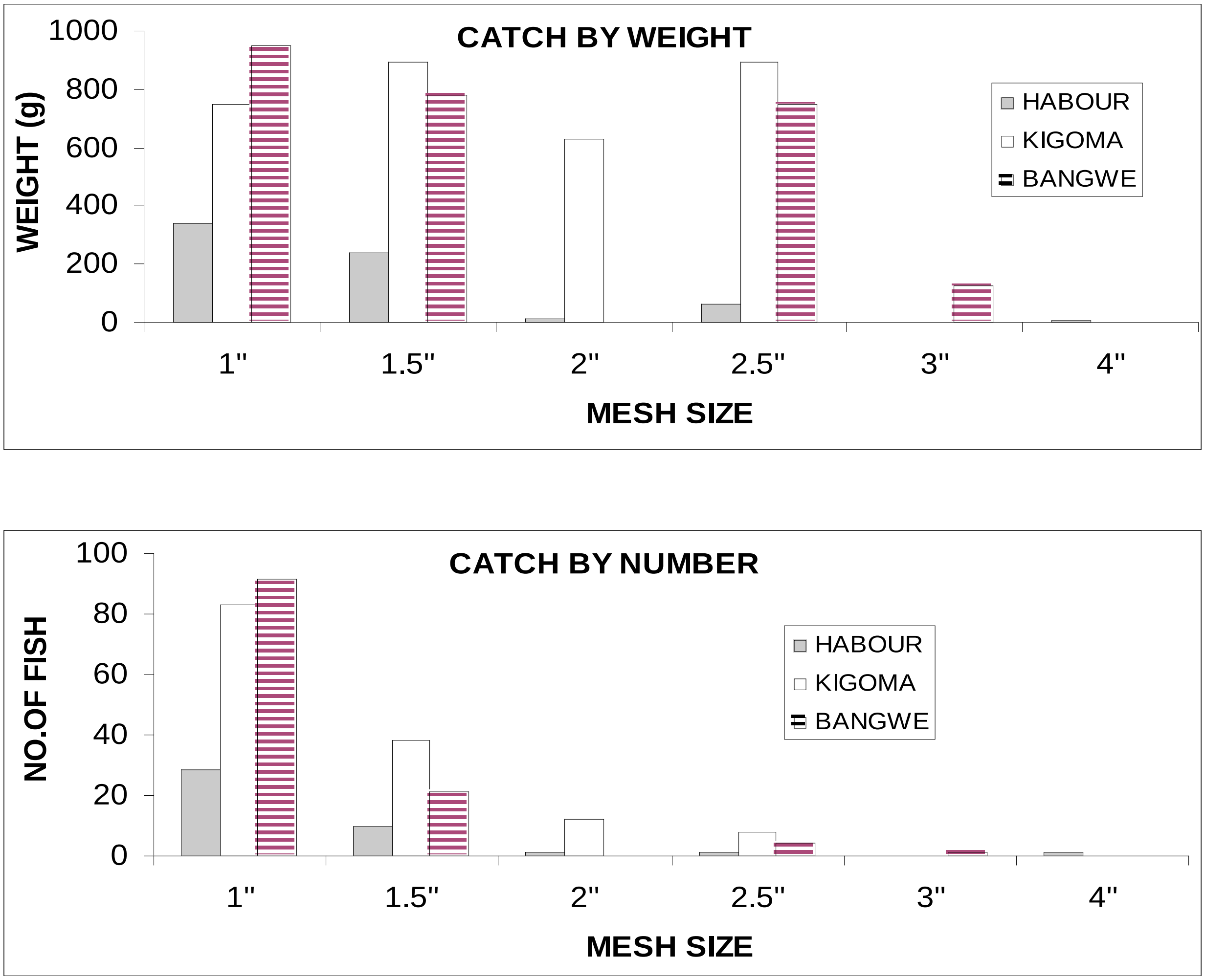


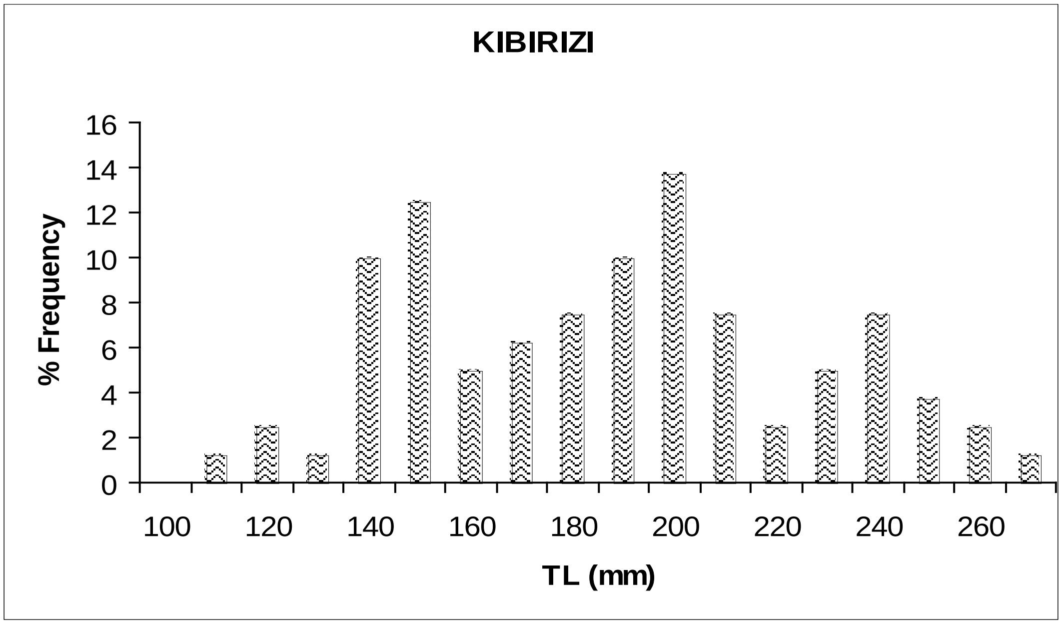
Figure 2: Total number and weight of fish caught per mesh size per station at Kigoma Bay, July 2007

Table 2a: Length at first maturity of L. dardennei

Length in mm	KIBIRIZI	KATONGA	OVERAL
L- Min	108	135	108
L- Max	261	269	269
L- Average	182.8	197.2	190.0
SD	37.7	34.2	33.5
SE	4.2	3.2	2.4
L-Min-Male	165	150	165
L-Max-Male	261	269	269
L-Min -Female	108	135	108
L-Max-Female	234	249	249
Lm-Male	**113.9**	**116.9**	**116.9**
Lm-Female	**120.8**	**128**	**128**
Lm-Unsexed	**125.1**	**128.4**	**128.4**

Table 2b. Sex ratio, fecundity and health indexes of L. dardennei at Kibirizi and Katonga, L. Tanganyika, TZ

		KIBIRIZI	**KATONGA**	**OVERAL**	**SAMPLE SIZE**
SEX RATIO	*M*	1	1	1	61
	F	1.75	1.54	1.62	99
FECUNDITY		126	106	116	19
GSI		0.60	0.52	0.56	152
HSI		0.98	1.89	1.43	191
LSI		0.64	0.72	0.68	81
CF		0.14	0.10	0.12	197



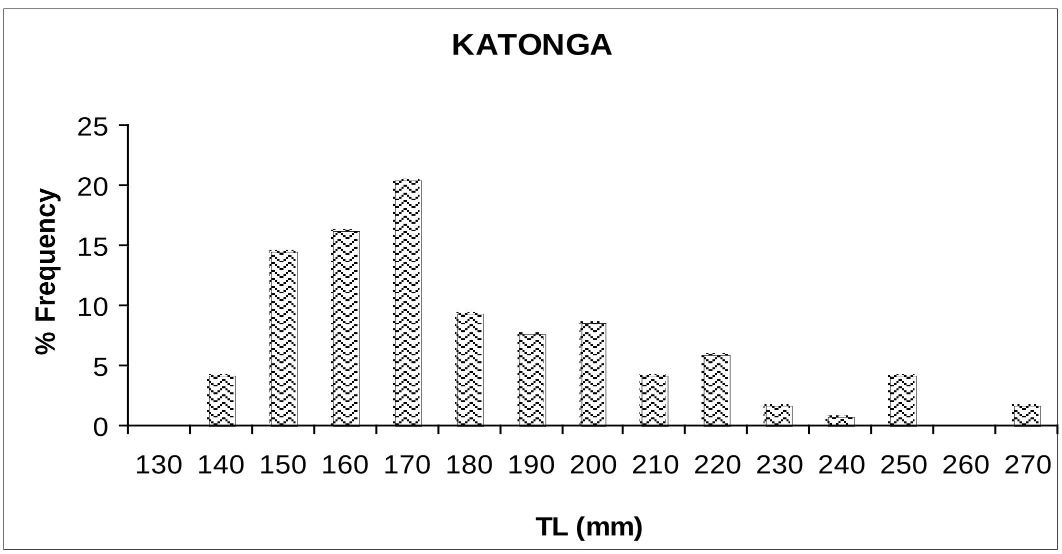


Figure 3 (a) Length frequency distribution of L. dardennei at Kibirizi and Katonga, July 2007

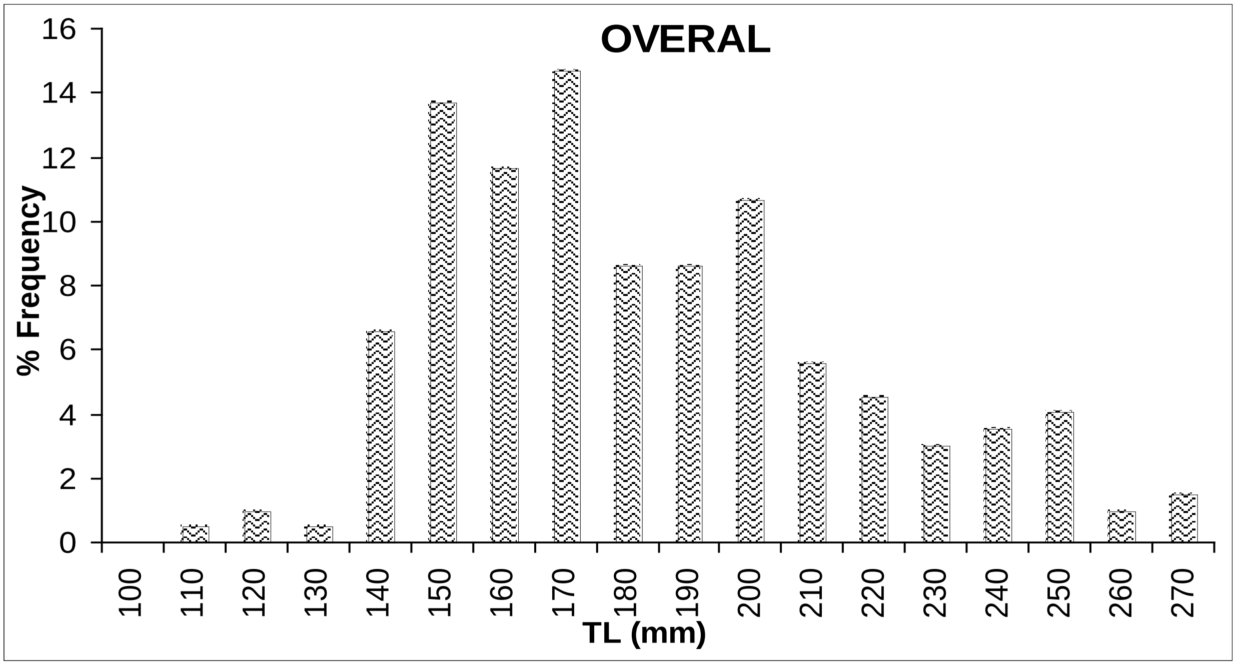


Figure 3 (b): Overal Length frequency distribution of L. dardennei at Kibirizi and Katonga, July 2007

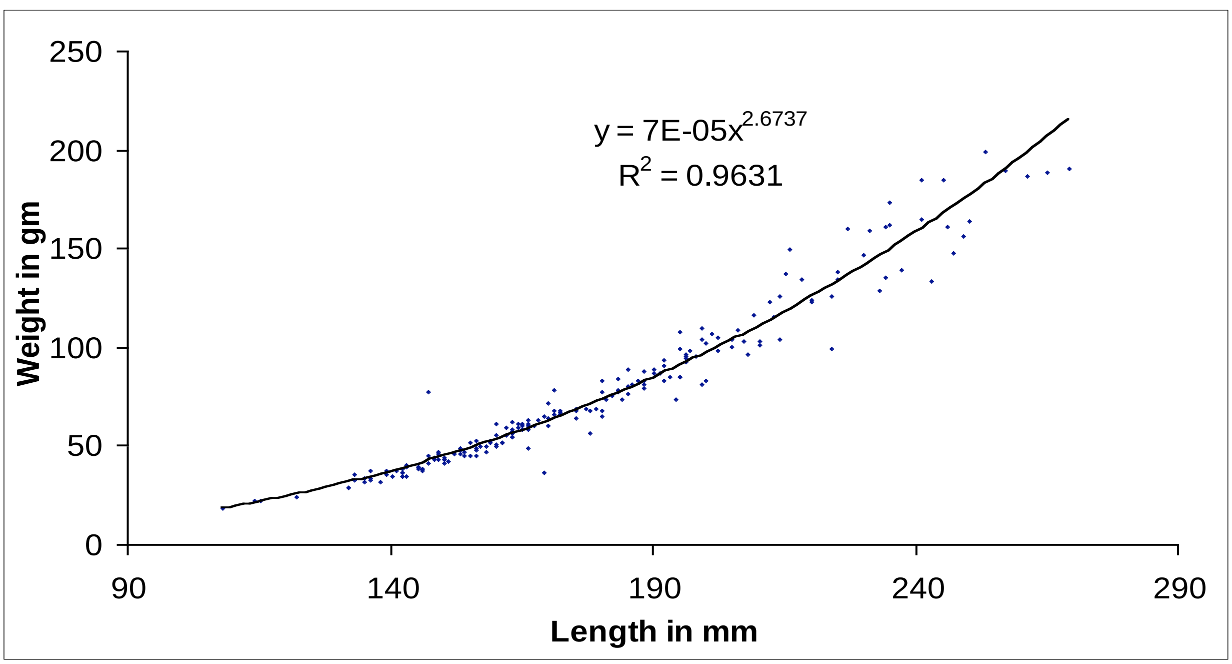


Figure 4: Length-weight relationship of L. dardennei at Kibirizi and Katonga, July 2007