FISH SPECIES COMPOSITION, SIZE STRUCTURE AND DISTRIBUTION IN NON-TRAWLABLE AREAS OF LAKE VICTORIA (TANZANIA) WITH EMPHASIS ON MWANZA GULF AND MORI BAY

[1]JDR Bayona, [2]B Msuku & [3]S Mzighani S
Tanzania Fisheries Research Institute
[1]PO Box 78850 Dar es Salaam
[2]PO Box 475 Mwanza
[3]PO Box 46, Shirati, Tarime

Submitted 29 April; Accepted 02 July 2004

ABSTRACT

Fish diversity studies in littoral non-trawlable areas of Lake Victoria (Tanzania) were undertaken during six systematic surveys (November 2000 to December 2002). Information on fish species composition, size structure as well as spatial and temporal distribution was generated from gill-netting, beach-seining and electric fishing. Lates niloticus, *indicated a declining trend in composition from 78.9% in March 2001 to 5.1% in July 2002. The species, however, increased to 40.6 % in catch composition as of December 2002, exhibiting somewhat inverse trends in distribution with* Oreochromis niloticus *and haplochromines in the lake fisheries. The surveys identified over 50 species for which 42 and 38 species were respectively encountered in Mwanza Gulf and Mori Bay. The two areas registered consistently high Shannon Wiener diversity indices. Subsequent annual monitoring of species richness and rarity in randomly fixed sites (21 in Mwanza Gulf and 13 in Mori Bay) promoted the selection of fish diversity hotspots. Comparatively, many rare and threatened species were encountered in Mori Bay than Mwanza Gulf and resource conservation measures by establishment of an aquatic reserve in Mori Bay as opposed to an aquatic park in Mwanza Gulf are discussed.*

INTRODUCTION

Lake Victoria Environmental Management Project (LVEMP) has received global support in order to restore health of Lake Victoria through appropriate research and conservation programs. The lake which used to support over 500 fish species (Seehausen 1998) is feared to have lost over two thirds of the species through extinction as a result of human intervention (Wanink 1998). Resource over-exploitation, illegal fishing practice, introduction of exotic species, infestation by water hyacinth, environmental perturbations, erosion, siltation and pollution from domestic, agricultural and industrial activities are cited as the major threats (Ogutu-Ohwayo 1990, Craig 1992, Kaufman 1992, Gophen *et al.* 1995, Witte *et al.* 1995, Goldschmidt *et al.* 1993, Ochumba 1990, Bayona & Chande 1999, Mkumbo *et al.* 1999).

While it is believed that species which survived intensive predation and other threats in the pelagic waters took refuge in the non-trawlable littoral microhabitats (Witte *et al.* 1992, Seehausen & Witte 1995), the gap in knowledge is which areas support rare/ threatened and endemic species as well as areas supporting a high population of species for conservation (Bayona *et al.* 2003). Tanzania Fisheries Research Institute (TAFIRI) has since Nov. 2000 to Dec. 2002 accomplished six lake wide surveys in non-trawlable areas of Lake Victoria (Tanzania) under the sponsorship of LVEMP. The surveys did not only yield useful biological and fish diversity information but also portrayed sites which

cater for high concentrations of fish populations and critical areas for threatened species within Mwanza Gulf and Mori Bay. The purpose of this paper is therefore to present and discuss the scientific basis for the observed spatial and temporal distribution of fishes in Mwanza gulf and Mori bay and propose suitable sites for conservation.

MATERIALS AND METHODS

Study Area

Shirati Bay, Mori Bay, Mori River, Mara Bay, Mara River, Magu Bay, Mwanza Gulf, Emin Pasha Gulf and Rubafu Bay (Fig. 1) form the major sampling areas within five fishing zones (SZ1 – SZV) established for studies on fish biology and biodiversity studies in Lake Victoria. Both Figure 1 and Table 1 illustrate characteristics of sampling sites in Mwanza Gulf and Mori Bay, which were selected randomly. Positions of sampling sites were fixed using the Global Positioning System (GPS). Sample collection was restricted to the littoral non-trawlable waters of less than 5m, fringed with rocky, muddy, sandy, riverine and vegetated shores.

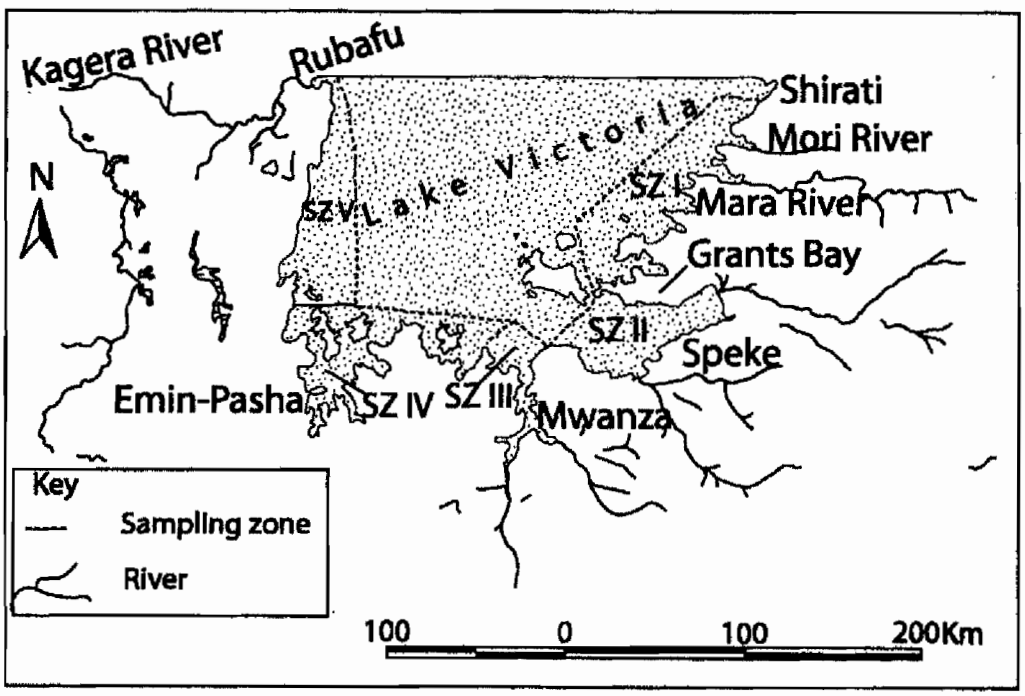

Figure 1: Sketch map of Lake Victoria showing sampling areas

Field Sampling

Beach-seining, gill-netting and electric fishing were the three major methods employed for sample collection. The methods were deployed in the fixed sites of the two target areas as opposed to the randomised operations in the other areas. A fibre- glass boat, propelled by a 40Hp Tohatsu outboard engine was used for electric fishing whereas wooden or fibreglass canoes, mounted with a 25Hp engine were used for beach-seining and gill-netting. Both multifilament and monofilament gillnets were used. Monofilaments of mesh sizes 35 and 50 mm compared to multifilament of mesh sizes 25, 35, 50, 62, 76, 88, 101, 114, 127, 139 and 155 millimetres were used. Usually each mesh specification was constituted of four nets and the entire gear was set in two gangs. A beach-seine, however, was 60m long with cod-end and wing mesh sizes of 25 and 88 millimetres, respectively. It was equipped with towing ropes of 100m in length and its operation required a work force of 8 – 10 field assistants or hired crew. Electric fishing was conducted using a portable system model WFC7 – HV comprised of a GB-Generator Type HXMB. 3.5, a control box, a transformer, a cathode terminal, two anode controls with rings of sizes 320mm and 400mm in diameter.

Landed catches were sorted into species using the FAO identification sheets according to Eccles (1992) and LVFRP species identification guide (Okaranon *et al.* 1997). Haplochromines were identified using the taxonomic guide by Seehausen (1996) and Witte and Van Oijen (1990). Some samples of haplochromines were photographed and electronically posted to Leiden University for confirmatory taxonomic work. Individuals of each species were then counted and both length and weight taken. Only weights and numbers were recorded in the case of haplochromine species. Lengths were measured to the nearest 0.1cm and weights were recorded to within 0.1g accuracy. Altogether individuals were sex-checked and their maturity stages established.

Data Analysis

Species composition based on beach-seine landings for the March 2002 and Dec. 2002 surveys were calculated and compared with results from previous surveys. Shannon Wiener diversity indices based on gill-net catches were calculated for all sampling areas (March 2002 and July 2002) and compared with indices for previous surveys. Shannon Wiener Index (H^1) along gill-net fishing transects was of the form:

$$H^1 = - \Sigma^S Pi \log Pi \quad \ldots\ldots\ldots(1)$$

Where: S = number of species in the sample

Pi = relative importance values, the squared ratio of ni and N

ni = value of S individual species

N = total value for all species in the sample

Diversity indices for different surveys and in different areas were compared by Kruskal Wallis test.

From site species composition Tables for Mwanza Gulf and Mori Bay both species values (rarity) and population values (species abundance) were calculated by the method of diversity rating followed by ranking of the sites. Fish numbers for each species were used to calculate percentage fish composition relative to the area total (numbers summed for all species in all sites of a given area). Length frequency information for catadromous species and other dominant species was plotted to portray growth modes and size structure.

Table 1: Characteristics of sampling sites in Mwanza Gulf and Mori Bay during surveys of non-trawlable areas in Lake Victoria (March 2002, July 2002 and December 2002)

Sampling gears	Sampling sites	Position GPS	Habitat type	Sampling sites	Position GPS	Habitat type
	Mwanza Gulf			**Mori Bay**		
Beach-seine	Mhanzi -BSM_1	$02^0$44.505	Muddy	Lyamanganga	$1^0$20.946S	Sandy/
		$32^0$52.35E		$BSMR_1$	$32^0$59.05E	Vegatated
	Kirumba- BSM_2	$02^0$42.45S	Muddy			
		$32^0$53.09E		Mchangani $BSMR_2$	$01^0$20.27S	Sandy
	Mihale- BSM_3	$02^0$47.92S	Sandy/Muddy		$33^0$57.58	
		$32^0$56.68E		Mchangani $BSMR_2$	----------	----------
	Masuha- BSM_4	$02^0$49.01S3	Sandy/Muddy			
		$2^0$56.23E		Rabulu $BSMR_3$	$1^0$20.22S	Muddy
	Nyahiti- BSM_5	$02^0$49.65S	Sandy		$13^0$59.11E	
		$32^0$66.83E		Rabulu $BSMR_3$	----------	Muddy
	Kibula- BSM_6	$02^0$50.50S	Sandy/Muddy			
		$32^0$54.93E		Nyabugongwe	$1^0$18.11S	Muddy
	Kihandu- BSM_7	$02^0$46.25S	Sandy	$BSMR_4$	$33^0$57.09E	
		$02^0$43.07S				
	Ikalu- BSM_8	$02^0$43.07S	Sandy	Nyabugongwe	----------	Sandy
		$32^0$53.82E		$BSMR_4$		
	Nyabusaru- BSM_9	$02^0$50.01S	Sandy/Muddy			
		$32^0$52.41E		Ollo- $BSMR_5$	$1^0$18.14S	Sandy
	Ihogoro- BSM_{10}	$32^0$49.38E	Sandy		$33^0$56.40E	Muddy
		$32^0$51.38E		Kyawigoro $BSMR_6$	$1^0$09.53S	Sandy
					$34^0$02.09E	
Gill-net Sites	Nyamasare –GNM_1	$2^0$48.50S	Sandy	Lyamanganga	----------	Muddy
		$32^0$53.10E	Vegetated	$GNMR_1$		Vegatated
	Bulima –GNM_2	$2^0$50.437S	Sandy/Muddy	Busanga $GNMR_2$	----------	Rocky
		$32^0$52.042E				Muddy
	Nyabusaru –GNM3	$2^0$52.5.90S	Muddy			Sandy
		$32^0$49.97E				
	Nyambogo –GNM_4	$02^0$44.39S	Muddy			
		$32^0$52.35E	Vegetated			
Electric fishing sites	Mhanzi –EFM_1	$02^0$42.25S	Vegetated	Lyamanganga	$1^0$20.18S	Rocky
		$32^0$53.09E		$EFMR_1$	$32^0$59.05E	Vegetated
	Kirumba-EFM_2	$02^0$48.00S	Vegetated			
		$32^0$56.35E		Mahembe-$EFMR_2$	$1^0$18.173S	Rocky
	Mihale-EFM_3	$02^0$45.25S	Rocky		$32^0$56.872E	Vegetated
		$32^0$54.41E	Vegetated	Mubage/Maunya	$1^0$20.099S	Rocky
	Chole-EFM_4	$02^0$48.06S	Sandy	$EFMR_3$	32^0.58.775E	Vegetated
		$32^0$51.46E	Vegetated	Baraki-$EFMR_4$	$1^0$20.48S	Sandy
	Mulaga-EFM_5	$02^0$42.38S	Rock		$33^0$57.96E	Vegetated
		$32^0$50.16E	Vegetated	Busanga-$EFMR_5$	$1^0$20.48S	Sandy
	Mkomba-EFM_6	$02^0$49.797S	Muddy/Sandy		$33^0$57.96E	Rocky
		$32^0$50.601E	Vegetated			

RESULTS

Area Species Composition / Diversity

Fish species composition during the different surveys using a beach-seine is illustrated in Table 2. Landed catches were more composed of *Lates niloticus* by weight than the rest of the species. The species, however, indicated a declining trend in composition from 78.9% in March 2001 to 31.39% in March 2002. The species declined to very low level in July 2002 when it composed the catches by only 5.1% and slightly picking up to 40.6% in December 2002. The reverse in catch composition is observed for *Oreochromis niloticus,* which increased from 8.9% in March 2001 to 46.11% in March 2002 and thereafter declined to 8.2% in Dec. 2002.

Whilst catches were more composed of haplochromines during the dry/short rains period than the long rains, a reciprocal trend was observed for catadromous species. Temporal trends in distribution of *Lates niloticus, Orechromis niloticus*, haplochromines and catadromous species in non-trawlabe areas are illustrated in Fig. 2. However, Kruskal Wallis test, using the SYSTAT 10 programme, did not show any significant difference in seasonal composition of the catches by haplochromines and catadromous species ($p < 0.406$).

Shannon-Wiener diversity indices in different surveys/ seasons are illustrated in Table 3. Mori Bay (including Mori River) has the highest diversity of species, ranging from H^1 =0.610 to H^1 =0.983. Though with highest species richness, Mwanza Gulf ranks the second in species diversity, ranging from H^1 =0.503 to H^1 = 0.975. Shannon – Wiener indices, however, increased considerably in almost all the areas from March 2002 than previously.

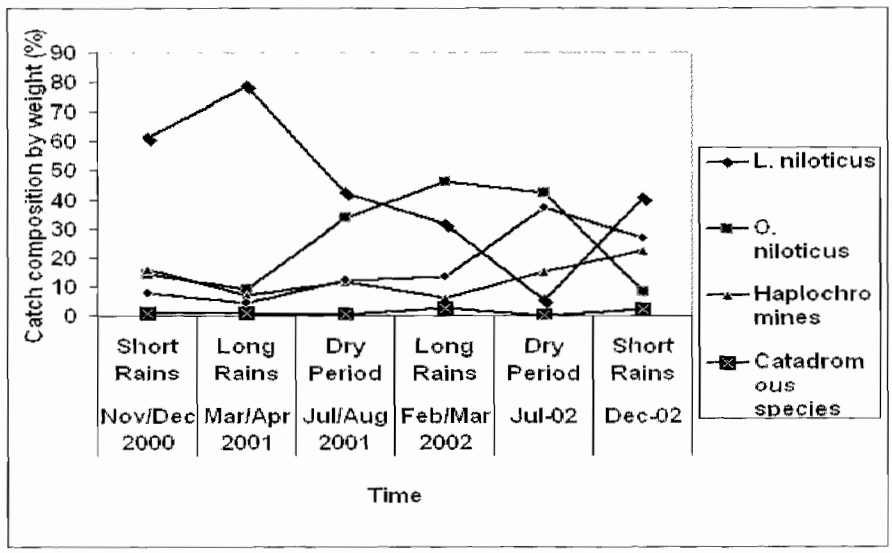

Figure 2: Catch composition of fishes in non-trawlable areas of Lake Victoria

Site Distribution of Species

The distribution of different species in different sites within Mwanza Gulf and Mori Bay are illustrated in Table 2 of the survey progress report (TAFIRI 2003). About 50 species were recorded in the two areas during the three surveys (March, July and Dec. 2002). Over 42 species were recorded within some sites in Mwanza Gulf compared to 38 species in Mori Bay. It is illustrated in Table 4 that 9 species were common in most sites of Mwanza Gulf compared to 5 species *in* Mori Bay. Observations further indicate that 3 species were not recorded in any of the sites in Mwanza Gulf and similarly 6 species were not recorded in Mori Bay.

Table 2: Catch composition of fishes in non-trawlable areas of Lake Victoria based on beach-seine catches.

Major fish species or groups	Percentage catch composition by weight based on the beach-seine					
	Nov./ Dec. 2000 Short Rains	March/April 2001 Long Rains	July / Aug 2001 Dry Period	Febr. / March 2002 Long Rains	July 2002 Dry Period	Dec 2002 Short Rains
1. *Lates niloticus*	61.3	78.9	42.3	31.39	5.1	40.6
2. *Oreochromis niloticus*	14.4	8.9	33.7	46.11	42.2	8.2
3. Haplochromines	15.9	6.9	1.5	6.19	15.3	22.4
4. Catadromous species	0.8	0.82	0.4	2.76	0.01	2
5. Others	7.6	4.48	12.1	13.55	37.3	26.8

In Mwanza Gulf, almost all stations were equally strong in terms of species richness with a diversity rating of 4 out of the maximum 5 scores as illustrated in Table 5. Exceptionally many species were recorded in Mihale (16 species), Nyahiti (16 species), Nyabusaru (16 species) and Bulima (15 species). Whilst the rating for species rarity varied considerably among sites, the preceding sites remained outstanding both as diversity hotspots and in terms of percentage composition by numbers. Out of 21 randomly fixed sites in Mwanza Gulf, only 8 sites yielded the highest diversity values and potential for aquatic protection of fish populations. These included: Bulima - GNM_2, Nyahiti – BSM_5, Mihale – BSM_3, Nyamasare – GNM_3, Nyabusaru – GNM_3, Ihogoro BSM_{10}, Kirumba – BSM_2 and Mkomba – EFM_6

Table 3: Shannon Wiener fish diversity indices (H^1) for different non-trawlable areas of Lake Victoria based on gill-net catches.

Time of the survey	Diversity indices (H^1) in different areas										
	1	2	3	4	5	6	7	8	9	10	11
Nov-Dec 00 (Short Rains)	0.549	0.707	0.614	-	0.501	0.803	-	0.693	0.542	0.447	0.332
March-April 01 (Long Rains)	0.127	0.610	0.639	0.615	0.442	0.676	0.445	0.503	0.747	0.476	0.857
July-Aug. 01 (Dry Period)	0.326	0.720	0.880	0.646	0.538	0.538	0.628	0.611	0.584	0.477	0.474
March 02 (Long Rains)	0.157	0.983	0.983	0.795	-	-	0.602	0.975	0.517	0.201	0.502
July 02 (Dry Period)		0.80	0.9	-	0.45	-	-	0.74	0.84	0.31	0.52

Areas:

1. Shirati Bay, 2. Mori Bay, 3. Mori River, 4. Mara Bay, 5. Mara River, 6. Grants Bay, 7. Speke Gulf, 8. Mwanza Gulf, 9. Emin-Pasha Gulf, 10. Rubafu Bay, 11. Kagera River

Table 6 illustrates the ranking of sites in Mori Bay with accent on diversity values. Of the total 13 sites, only 6 sites habour an average of 9 – 17 species and are selected as diversity hot spots. These included: Lyamanganga – $GNMR_1$, Busanga - $GNMR_2$, Mubage – Maunya – $EFMR_3$, Baraki – $EFMR_4$, Nyabugongwe – $BSMR_4$ and Mchangani $BSMR_2$

Table 4: Relatively common species and unrecorded species in the two sampling areas during the three surveys in March, July and December 2002.

Sampling sites / area	Common species	Un-recorded species
Mwanza Gulf	*Brycinus jacksoni* *Bycinus sadleri* *Clarias gariepinus* *Oreochromis niloticus* *Protopterus aethiopicus* *Synodontis afrofischeri* *Schilbe intermedius*	*Pundamilia nyererei* *Mormyrus kannume* *Marcusenius rheni*
Mori Bay	*Lates niloticus* *Oreochromis niloticus* *Labeo victorianus* *Tilapia rendelli* *Lithochromis rubripinnis*	*Bagrus docmak* *Petrocephalus catastoma* *Protopterus aethiopicus* *Mbipia mbipia* Haplochromis "fish eater"

Table 5: Site distribution of fishes in Mwanza Gulf showing diversity hotspots during March, July and Dec. 2002 surveys.

Sampling sites in Mwanza Gulf	Recorded number of species	%ge composition by fish numbers	Species Richness rating	Species Rarity rating	Total rating	Rank	Rating key
Mhanzi - BSM_1	13	5.8	4	13	17	15	A.Species Scores
Kirumba – BSM_2	11	2.4	4	23	27	7	>20 = 5
Mihale – BSM_3	16	4.5	4	33	37	3	10 – 19= 4
Masuha – BSM_4	13	2.6	4	19	23	12	5 – 9 = 3
Nyahiti - BSM_5	16	11.0	4	34	38	2	3 – 4 = 2
Kibala – BSM_6	12	7.7	4	20	24	10	1 – 2 = 1
Kihandu – BSM_7	9	4.9	3	14	17	16	B.Rarity/Scores
Ikalu – BSM_8	9	1.3	3	10	13	19	≤1 = 5
Nyabusani – BSM_9	16	8.3	4	20	24	11	2 – 3 = 4
	15	6.8	4	24	28	6	4 – 5 = 3
Ihogoro – BSM_{10}	11	1.5	4	14	18	14	6 = 2
Mhanzi – BSM_1	11	1	4	21	25	8	>7 = 1
Kirumba – BSM_2	8	3.5	3	9	12	20	
Mihale – BSM_3	12	12.9	4	12	16	17	
Chole – BSM_4	10	1.5	4	15	19	13	
Mulaga – BSM_5	11	2.2	4	21	25	9	
Mkomba – BSM_6	8	1.0	3	11	18	18	
Buyagu – BSM_7							

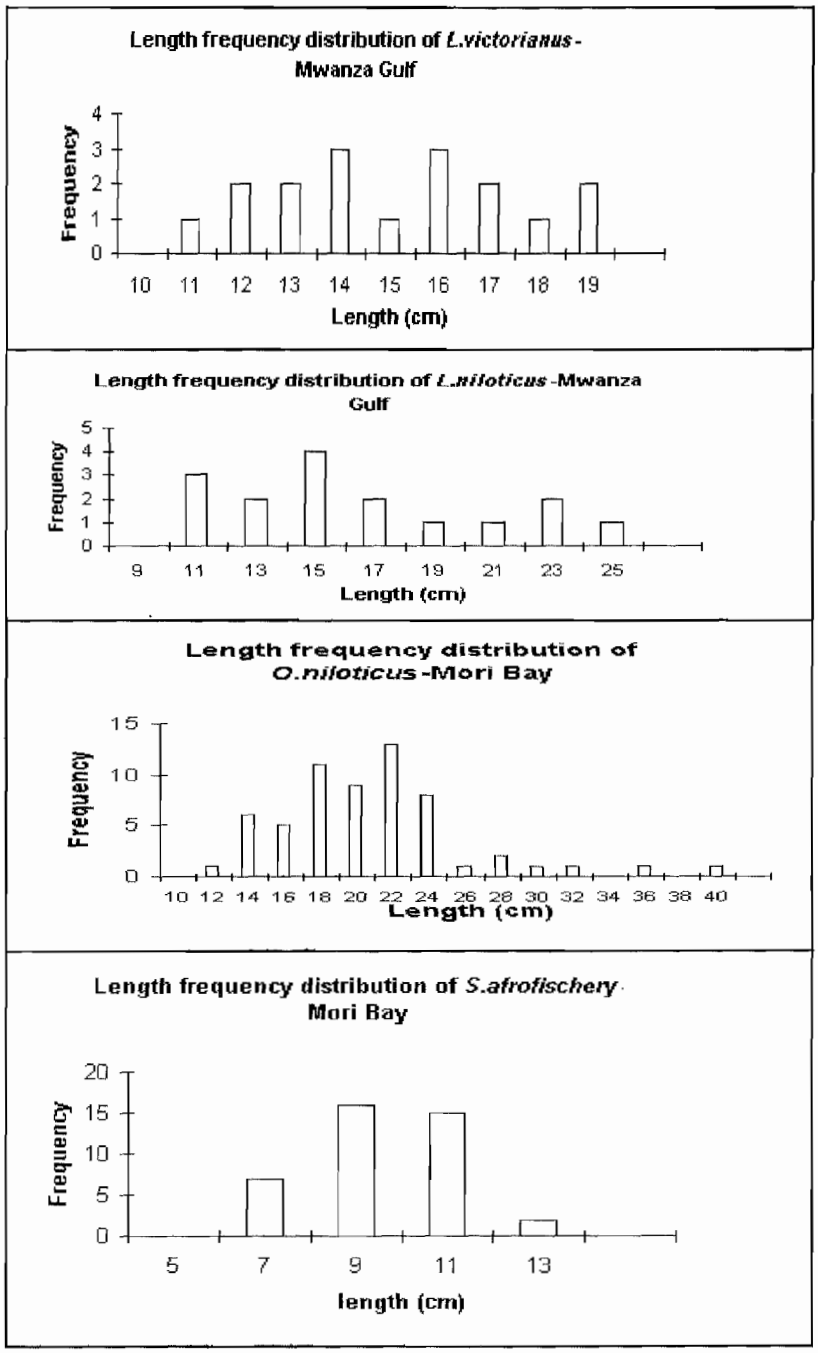

Figure 3: Length frequency distribution of some fish species collected from Mori Bay and Mwanza Gulf, March 2002.

Table 6: Site distribution of fishes in Mori Bay, indicating fish diversity hotspots as based on surveys of March, July and December 2002.

Sampling sites in Mori Bay	Recorded number of species	%ge composition by numbers	Species richness rating	Species rarity rating	Total rating	Rank	Rating key
Lyamanganga BSM_1	12	0.75	4	37	41	5	A. Species Scores
Mchangani BSM_2	9	1.4	3	21	24	9	>20 = 5
Rubula BSM_3	4	0.54	2	8	10	12	10 – 19 = 4
Nyabugongwe BSM_4	10	5.4	4	23	27	8	5 – 9 = 3
Ollo BSM_5	5	1.4	3	10	13	11	3 – 4 = 2
Kyawigoro BSM_6	2	0.3	1	2	3	13	1 – 2 = 1
Nyamanganga $GNMR_1$	17	36.9	4	60	64	1	B. Rarity/Scores
Busanga $GNMR_2$	17	13.5	4	55	59	2	≤ 1 = 5
Lyamanganga $EFMR_1$	16	12	4	42	46	3	2 – 3 = 4
Mahembe $EFMR_2$	8	4.5	3	17	20	10	4 – 5 = 3
Mubage-Maunya $EFMR_3$	17	4.7	4	39	43	4	6 = 2
Baraki $EFMR_4$	9	4.9	3	29	32	6	>7 = 1
Busanga $EFMR_5$	10	13.7	4	26	30	7	

Population Size Structure

Fig. 3 indicates length frequency distribution of some fishes collected from both Mori Bay and Mwanza Gulf during long rains. The species observed in March 2002 included *Labeo victorianus, Synodontis afrofischeri, Oreochromis niloticus* and *Lates niloticus,* which respectively had sizes of 10 - 19cm, 7 – 11cm, 10 – 30cm and 9 –25cm. *O. niloticus, L. niloticus* and *S. afrofischeri* collected in December 2002 had respective size ranges of 2.5 – 42.5cm, 6.5 – 11.5cm and 2.5 – 12.5cm.

DISCUSSION

Fisheries Applications and Ecological Importance

In planning for wetland conservation and marine protected areas both Denny (1995) and Kelleher & Kenchington (1992) considered naturalness of aquatic systems, biogeographic, ecological, economic, social and scientific importance, apart from national or international values of the systems. The authors considered ecological importance as that which contributes to maintenance of essential ecological processes or life support systems, containing a variety of habitats for endemic, unique, rare or endangered species and habitats for feeding, breeding, refuge and nursery of juveniles. Ecological importance is further elaborated as the capacity of preserving genetic diversity, in terms of species diversity or abundance. This suggests that studies on species composition / diversity, site distribution of species and population structure in both Mwanza Gulf and Mori Bay are the tools for probing the ecological importance of the two areas for conservation.

Species Composition / Diversity

Temporal distribution of fishes in the littoral non-trawlable areas of Lake Victoria seems to be mostly governed by levels of human exploitation and the predator Nile perch, among other factors. The declining trend in composition of Nile perch has been registered both in trawlable and non-trawlable waters since 2001 (Bayona *et al.* 2003). Mkumbo *et al.*(2002), among others, associated this decline in Nile perch to very high levels of fish exploitation and advised that 50% of the current fishing effort must be reduced for appropriate stock renewability and sustenance. The observations of July 2002 and December 2002, however, indicate that Nile perch in the non-trawlable areas of the lake dropped to very small levels of composition in July and suddenly increased considerably in December 2002. Consequently other species including O. *niloticus* and haplochromines,

which increased in catch composition, probably at the expense of relaxed predation, registered a sharp decline. If the upsurge of Nile perch composition in December 2002 is not merely coincidental to spatial success in post spawning nursery then predator-prey oscillations may be imminent in the lake. Despite the fact that *O. niloticus* is not a major food source for Nile perch, the species lateral avoidance behaviour for Nile perch by plunging into papyrus and areas of low oxygen concentration (Bwathondi and Mwamsojo 1993) may reduce its vulnerability to fishing gears. As a result, catches of *O. niloticus* may decline as composition of the predator increases. In Lake Tanganyika, predator-prey relationship between *Lates stappersii and Stolothrissa tanganicae* are reported as the major cause of pelagic biomass displacement among prey and predator fish components at intervals of 3 to 5 years (Pearce 1988, Roest 1988 and Bayona 1993).

Consistently high diversity indices for both Mori Bay and Mwanza Gulf confirm that no adverse changes have taken place in the environment and that these areas support many assemblages of species (Pianka 1974, Denny 1995, Kelleher and Kenchington 1992). Since fish survival can be linked to availability of conducive environment with adequate food resources and habitats for spawning and refuge (Coulter 1991) the colonization of one area by diverse species must be dependent on the availability of diverse habitats and microhabitats. This includes rocky shores, sandy bottoms, muddy bottoms, riverine and vegetated beaches. Mwanza Gulf is bigger than Mori Bay, possibly embracing a lot of habitats and microhabitats that support a comparatively higher number of species. Nevertheless, the two areas are ecologically important in support of big assemblages of species that are worthy protection or conservation effort.

Fish diversity studies in non-trawlable waters of Lake Victoria have registered comparatively high values of indices since March 2002 than in previous surveys. This observation, however, does not suggest any significant ecological change. It is a reflection of success in identifying haplochromines to lowest taxon (species) level possible. Whilst the baseline studies in non-trawlable areas yielded species counts of 24, 22 and 22 for respective periods of long rains, short rains and dry season (Bayona *et al.* 2003, Bayona et al. "in press") the current observed species count for Mwanza Gulf is about 42 species. Both Mwanza Gulf and Mori Bay seem to harbour over 25 species of haplochromines, identified under this study. Since both species composition and diversities have been noted to vary significantly among areas and between long rains, short rains and dry period, meteorological data on rainfall was not necessary to justify seasonality.

Site Distribution of Species

The sites in both Mori Bay and Mwanza Gulf identified as diversity hotspots were monitored during long rains, short rains and dry period, in order to ensure that annual variations in species distribution are taken into account. All sites are more or less equally strong in terms of species richness rating but differ considerably in terms of rarity values. This implies that rare and threatened species that were distributed in unique sites critically influenced or boosted diversity ratings, increasing the probabilities of selecting the sites for conservation activities within the studied areas of Mori Bay and Mwanza Gulf. The rare species ,for example, that appeared in only one or two sites in Mori Bay included: *Haplochromis sauvagei, Hippopotamyrus grahami, Marcusenius rheni, Platytaeniodus degeni, Clarias alluaudi, Haplochromis 'redcarp', Haplochromis 'red belly', Haplochromis 'pseudoblue', Haplochromis 'large eye black', Haplochromis obliguidens* and *Neochromis pseudonignicans*. The pertinent sites registered very high scores and were therefore selected as diversity hotspots for

conservation measures. The method of richness and rarity ratings to assess biodiversity values or diversity hotspots has received wide applications in Uganda, especially for inland water bodies or wetlands as reported by Fuller et al. (1997).

Population Size Structure

Most of the species observed in the inshore non-trawlable waters are immature especially *L. niloticus* whose juveniles are commonly found in the littoral non-trawlable areas of the lake during long rains. Nearly the entire catch of *L. niloticus* (over 80%) is composed of immature individuals of less than 50cm, the size at which 50% maturity is observed for males compared to females which mature later at much bigger size (Mkumbo *et al.* 2002). Most of the catadromous species especially *Labeo victorianus, Synodontis afrofischeri* and *Schilbe intermedius* were above the established size of 50% maturity according to Rinne and Wanjala (1983). This is because catadromous species, reside in riverine, littoral areas before their upstream "runs" to spawn during short or long rains.

Hence, the most important feature of the littoral non-trawlable areas is that the identified sites are potentially important for fish nursery and spawning apart from conferring refuge. Since fish diversity hotspots are distributed in a wide area of Mwanza Gulf, it is recommended that the area encircling the selected sites be protected as an Aquatic Park for zoning and multi-use management. Mori Bay, however, is harbouring many rare and threatened species within a small portion of the bay (area encompassing fish diversity hotspots), the scenario which necessitates full protection. It is therefore prudent to declare the relevant portion of the bay an Aquatic Reserve, strictly allowing fish exploitation outside the Reserve. These recommendations, however, assume that other considerations cited by Denny (1995) and Kelleher & Kenchington (1992) are tenable for the two areas.

ACKNOWLEDGEMENTS

This study is among several regional initiatives under LVEMP that were funded by the World Bank. The Regional Executive Secretary of LVEMP, The Director General of TAFIRI and The TAFIRI Project Coordinator are behind the success of this study for which we recognise their contributions and guidance. Data collection and processing were very tedious but the team spirit demonstrated by all participating, Researchers, Technicians, Fishermen, Drivers and Regional collaborators in Mara, Mwanza and Kagera portions of Lake Victoria was overwhelmingly the tool for high quality performance.

REFERENCES

Bayona JDR 1988 A review of the biological productivity and fish predation in Lake Tanganyika. In: Lewis D (ed.) *Predator-prey relationships, population dynamics and fisheries productivities of large African Lakes. CIFA Occas. Pap.* **15**: 1-17.

Bayona JDR 1993 Variation in abundance and distribution of *Limnothrissa miodon* in the Tanzanian sector of Lake Tanganyika : the need for continued stock assessment. In: Marshall be and Mubamba R (eds) *Paper presented at the symposium on biology, stock assessment and exploitation of small pelagic fish species in the African Great Lakes Region. Bujumbura, Burundi, from 25 to 28 November 1992. CIFA Occasional Paper* **19** : 121–140.

Bayona JDR and Chande AI 1999 Environmental degradation due to beach-seining. TAFIRI *Research Bulletin* **4**: 55-71.

Bayona JDR, Mzighani S, Bipa J, Kishe J and Komakoma J 2003 Aspects of fish biology and status of fish diversity in the littoral non-trawlable areas of Lake Victoria (Tanzania). In: Ndaro SGM and

Kishimba M (eds) Proceedings *of the LVEMP* Tanzania *2001 scientific conference.* LVEMP, Dar es Salaam. Jamana Printers Ltd. Pp 64 –82.

Bayona JDR, Mzighani S, Komakoma JD and Bipa J "in press" Applicability and effectiveness of some fishing gears in assessing fish diversity and richness in non-trawlable areas of Lake Victoria (Tanzania). Proceedings of the 1st LVEMP Regional Scientific Conference held 3-7th December, 2001. Kisumu, Kenya.

Bwathondi POJ and Mwamsojo GUJ 1993 The status of the fishery resources in the wetlands of Tanzania. In: Kamukala GA and Grafter SA (eds) Wetlands of Tanzania. The IUCN Wetlands Programme, Gland. Pp 49-60.

Coulter GW (ed) 1991 Lake Tanganyika and its life. London, British Museum (Natural History) and Oxford University Press. 354 p.

Craig JF 1992 Human induced changes in the composition of fish communities in the African Great Lakes. *Reviews in Fish Biology and Fisheries* **2**: 93-124.

Denny P 1995 Proceedings of the International Conference, Wetlands: Archaeology and Nature Conservation, University of Bristol, U.K., April 1994. Pp.249 -274.

Ecles DH 1992 A Field Guide to the Freshwater Fisheries of Tanzania. FAO Species Identification Sheet for Fishery Purpose. 145pp.

Fuller RM, Groom GB, Mugisha S, Ipulet P, Pomeroy D, Katende A, Bailey R and Ogutu-Ohwayo 1998 The integration of field and remote sensing for biodiversity assessment: a case study in the tropical forests and wetlands of Songo Bay, Uganda. *Biological Conservation* **86**: 387 p 391.

Goldschmidt T, Witte and Wanink J 1993 Cascading effects of the introduced Nile perch on detritivorous / phytoplanktivorous species in the sub littoral areas of Lake Victoria. *Conservation Biology* **7**(3):687-700.

Gophen M, Ochumba PBO and Kaufman LS 1995. Some aspects of perturbation in the structure and biodiversity of the ecosystem of Lake Victoria (East Africa). *Aquatic Living Resources* **8**: 27-41.

Kaufman L 1992 Catastrophic change in species rich freshwater ecosystems: The lessons of Lake Victoria. *Bio* Science **42**: 846-858.

Kelleher G and Kenchington R 1992 *Guidelines for Establishing Marine Protected* Areas. A Marine Conservation and Development Report. IUCN, Gland, Switzerland. Vii + 79 Pp.

Mkumbo OC, Msuku BS, Nsinda PE, Kishe MA, Ezekiel CN, Medard M, Katunzi EFB, Budeba YL, Bayona JDR, Nhwani LB, Bwathondi POJ and K. I. Katonda 1999 Report of the biological and socio-economic study of the fisheries of Mwanza and Speke Gulfs following the ban of the use of non-selective gear TAFIRI *Research Bulletin* **5**: 1-36.

Mkumbo OC, Ezekiel C, Budeba YL and Cowx IG 2002. Analysis of exploitation patterns for Nile perch, *Lates niloticus*, in Lake Victoria. In: Cowx IG (ed.) *Management and ecology of lake and reservoir fisheries.* Fishery News Books, Blackwell Science Ltd, London. Pp 84-95.

Ochumba POB 1990 Massive fish kills within the Nyanza Gulf of Lake Victoria, Kenya. *Hydrobiologia* **208**: 93-99.

Ogutu Ohwayo R 1990 The decline of the native fishes of Lake Victoria and Kyoga (East Africa) and the impact

of introduced species. In: Pitcher TJ and Hart PJB (eds) The Impact of Species Changes in African Lakes. Chapman and Hall, London. Pp. 59-81.

Okaranon JO, Katunzi EFB and Asila AA 1997 Fish species identification guide for Lake Victoria: Enumerators field guide. LVFRP (TACP-RPR-372). 39pp.

Pearce MJ 1988 Some effects of Lates species on pelagic and demersal fish in Zambian waters of Lake Tanganyika. In: Lewis D (ed) *Predator – prey relationships, population dynamics and fisheries productivities of Large African Lakes. CIFA* Occasional *Paper* **15**: 69-87.

Pianka ER 1974 Evolutionary Ecology. Harper and Row Publishers, New York, Evanston, San Francisco and London. 356p.

Rinne JN and Wanjala B 1993 Maturity, fecundity and breeding seasons of the major catfishes (suborder; Siluroidea) in Lake Victoria, East Africa. *Journal Fish Biology*. **23**: 357-363.

Roest FC 1988. Predator – prey relations in Northern Lake Tanganyika and fluctuations in the pelagic fish stocks. In : Lewis D (ed) *Predator – prey relationships, population dynamics and fisheries productivities of Large African Lakes CIFA Occasional Paper* **15** *:* 104 -129.

Seehausen O 1996 Lake Victoria Rock Cichlids Taxonomy, Ecology and Distribution: Key to identification of rock dwelling cichlids. Key to subgenera species complexes. Verduyun Cichlids Germany.

Seehausen O and Witte F 1995 Extinction of many, survival of some. The current situation of the endemic cichlids in southern Lake Victoria. *Tropical Fish Hobbyist* XIII **7**: 96-105.

TAFI RI 2003 Report on Fish Biology and Status of Biodiversity within the Non-trawlable Areas of Lake Victoria based on the Surveys of July and December 2002. 75pp.

Wannink JH 1998 The pelagic cyprinid *Rastrineobola argentea* as a crucial link in the disrupted ecosystem of Lake Victoria. Dwarf and Giants – African Adventures, Ponsen and Looijen B.V. Wageningen. The Netherlands.

Witte F and Van Oijen 1990 Taxonomy,ecology, and fishery of haplochromine trophic groups. *Zool. Verh. Leiden* **262**: 1-47.

Witte F, Goldschmidt PC, Goudswaard PC, Ligtvoet W, Van Oijen MJP and Wanink JH 1992 Species extinction and concomitant ecological changes in Lake Victoria. *Netherlands Journal of Zoology* **42**: 214 -232.

Witte F, Goldschmidt PC and Wanink JH 1995. Dynamics of the haplochromine cichlid fauna and other ecological changes in the Mwanza gulf of Lake Victoria. In: Pitcher TH and Hart PJB (eds): *Impact of species change in African lakes*. Chapman & Hall, London, pp. 83-110