



Kenya  
VISION 2030

**KENYA MARINE AND FISHERIES RESEARCH INSTITUTE**  
**FRESH WATER SYSTEMS**

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**ASSESSMENT OF THE USE OF HOOK AND LINE ON THE FISHERY  
OF LAKE NAIVASHA, AND RECOMMENDATIONS OF AN  
ALLOWABLE NUMBER AND SIZE FOR FISHERIES SUSTAINABILITY  
AND MANAGEMENT**

**TECHNICAL REPORT**

**KMF/RS/2021/C827(2)**

**FEBRUARY 2020**

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## DOCUMENT CERTIFICATION

### Certification by Director Freshwater Systems

I hereby certify that this report has been done under my supervision and submitted to the Director.

**Name:** Dr. Christopher Mulanda Aura (PhD)

**Signature:** 

**Date:** 12<sup>th</sup> February 2021

### Certification by Director General KMFRI

I hereby acknowledge receipt of this report

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**Signature :** 

**Date:** 23<sup>rd</sup> February 2021

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**Acknowledgement**

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## **Abstract**

This study aimed to assess the use of hook and line on Lake Naivasha's fishery and provide recommendations of an allowable number and size for fisheries sustainability and management in Lake Naivasha. A survey was conducted in the lake in November 2020 to determine compositions of fish species. The mean catch rates and catch per unit effort (CPUE) were determined. Results show about 20 boats (with 7 to 12 crew) are involved in hook and line fishing using hooks sizes number 11 and 12. The sampled fishing duration was about four hours, yielding an average catch of 69.3 kg/boat; catch rate of 16.8 kg/hr; daily catch of 1386 kg and an estimated annual catch of 415.8 tons. Catch composition of target species comprised *O. niloticus* (91%), *C. carpio* (8%) and *C.gariepinus* (1%). Mean sizes of *O. niloticus* and *C. carpio* were undersize ( $19.6 \pm 0.1$  and  $26.9 \pm 0.9$  respectively). The wide range of selection and high catch rates of the target species has potential adverse impacts on the long term sustainability of Lake Naivasha fishery. Therefore, hook and line fishery may not be sustainable in its current mode of operation and without proper legal framework to guide the method.

## **Key words:**

Hook, Fish species, size structure, catch rates, CPUE

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## 1.0 INTRODUCTION

Lake Naivasha is a shallow freshwater lake situated 80 kilometres northwest of Nairobi in the Kenyan Rift Valley. The lake initially contained only one species, the endemic *Aplocheilichthys antinorii* (Vinc), which was last recorded in 1962 and believed to have disappeared (Elder, 1972; Muchiri and Hickley, 1991). Since 1925, there have been numerous introductions of various fish species, both for economic and ecological value. Natural intruders from the catchment rivers are documented in the literature (Njiru et al. (2017)). The present composition of fish species in the lake includes the earlier species: the Blue-spotted tilapia, *Oreochromis leucostictus*; Red-bellied Tilapia *Coptodon zillii* (formerly called *Tilapia zilli*); largemouth bass *Micropterus salmoides*; Louisiana red swamp crayfish *Procambarus clarkii*; a river cyprinid *Barbus paludinosus*. Other late entrants into the fishery, since 2001, are the common carp *Cyprinus carpio*; Nile Tilapia, *Oreochromis niloticus* and the African sharptooth catfish *Clarias gariepinus*.

The fishery of Lake Naivasha, since its inception in 1959, was predominantly gillnets based and targeted the cichlids and the Black bass, but the common carp and Africa catfish have also been targeted in the recent years. The fishermen obtain annual fishing licenses from the Fisheries Department that allowed them access to the resource using a maximum number of 10 nets (approximately 2.5x100 m) with not less than 4 inch (100 mm) stretched mesh sizes (Waithaka et al. 2015; Morara et al. 2021). Occasionally, the bass was taken by a tourist using hook and line under a temporary sport fishing permit valid for two weeks (14 days). The maximum daily number of fish caught per license was restricted to five (Waithaka et al. 2019). These measures were geared towards a sustainable exploitation rate of the fish resource while allowing for stock replenishment.

In the late 1990s, poor fishing methods resulted in the drastic decline of fish stocks to unsustainable levels, leading to the fishery's collapse by 2000 (Hickley et al. 2015). Despite the various management interventions for the stocks recovery, including the control of fishing effort, the resource has experienced high exploitation pressure in recent years. The pressure is partly due to the increasing human population around the lake (Onywere et al. 2012), causing increased demand for fish in Naivasha town and other neighbouring urban centres (Njiru et al. 2017). Another probable reason for the high fishing pressure on the fish resource is the limited seasonal employment opportunities found within the flower farms, hotels and other industries around Lake Naivasha. The dropouts from these jobs usually revert to illegal fishing as an alternative source of

livelihood. Somehow, this criminal engagement in illegal, unregulated and unreported (IUU) fishing, regardless of its damage to the resource, provides daily livelihoods for many people's households (Morara et al. 2021).

Since 2013, Lake Naivasha's fisheries management has increased the yearly number of fishing licences by nearly four-fold from 50 to 176 boats (Waithaka et al. 2019; Morara et al. 2021). This desperate measure was to control IUU fishing incidences by accommodating a segment of the fishermen who felt left out of the resource's benefits. Therefore, the fisheries management conducts annual fish stock enhancement by restocking *O. niloticus* fingerlings to sustain the high effort. Nonetheless, there is an influx of unlicensed fishing activities in Lake Naivasha using hooks and lines. Hook and rod fishing, previously a principal sport fishing activity that targeted the black bass, has recently turned into a commercial venture involving many fishers who target *C. carpio* and *O. niloticus*. Waithaka et al. (2017) recorded angling method as an emerging fishery in Lake Naivasha, and the trend was likely to increase.

The demand to increase the number of fishing licenses in Lake Naivasha has generated a debate among the various stakeholders about the stock sizes and optimal fishing effort for the resource sustainability. While hook and line fishing is a recent emerging fishery in the lake (Waithaka et al. 2017) the County Government of Nakuru seeks to consider the feasibility of this method being an alternative and sustainable legal fishing practice in the lake. Therefore, this study aimed to assess the use of hook and line on Lake Naivasha's fishery and provide recommendations of an allowable number and size for fisheries sustainability and management. The specific objectives of this study were:

- i. To assess the characteristics of the hook and line fishery in Lake Naivasha
- ii. To determine the number and sizes of hooks used by various fishers in Lake Naivasha
- iii. To determine the total catch and percentage composition of fish species caught by hook and line fishery
- iv. To calculate the mean catch rates, catch per fishing crew, and catch per unit effort (CPUE)

- v. To examine the size structure, length-weight relationship and condition factor of fish samples from the various hooks.

## **2.0 MATERIALS AND METHODS**

### **2.1 Study area**

Lake Naivasha is one of the shallow freshwater bodies in Kenya, although the second largest after the gulf part of L. Victoria. The lake lies on the eastern Rift Valley floor ( $0^{\circ} 46'S$ , and  $36^{\circ} 20'E$ ) at about 1890 m above sea level (Fig. 1). Its surface area varies between 110 and 160 km<sup>2</sup> during the dry and wet spells, respectively. The primary inflow is from River Malewa, with a catchment area of about 1730 km<sup>2</sup> which discharges about 90 % of the lake's water. The rest of the recharge comes from River Gilgil, with a catchment area of 420 km<sup>2</sup> and other small ephemeral streams.

The lake basin consists of three distinct water bodies – the Main Lake, Oloidien Lake and Crater Lake (Sonachi). The Main Lake is the largest and freshest of the three, with conductivity values being mostly below 400  $\mu\text{Scm}^{-1}$ . It hosts the highest aquatic biodiversity and various species of introduced fish, forming the lake's bedrock. Oloidien Lake is connected to Main Lake through underground flows, but the occasional connection on the surface during high water levels is possible. Therefore this study was conducted in the nearshore waters of Main Lake at Korongo and Malewa river mouth area (Fig. 1), where most of hook and line fishers were located.

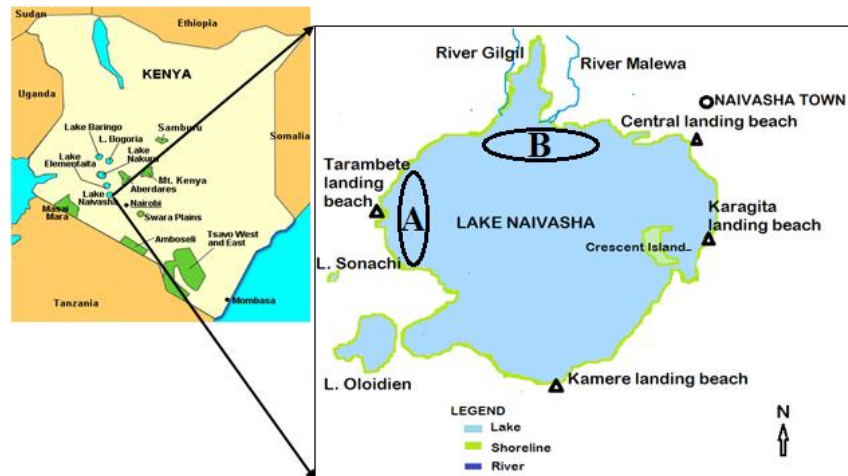


Figure 1 Map of Lake Naivasha showing the main landing sites and sampling site

## 2.2 Sampling design and data collection

A survey was conducted in November 2020 Lake Naivasha and targeted the hook and line fishers. This was preceded by a reconnaissance survey that was to predetermine the locations frequented by the anglers and time of arrival. During the definitive sampling (plate 1.)the following data were collected from each boat:

- Location of fishing area and durations (start and finish time)
- Sizes of hooks used
- Number of hooks per crew member
- Number of crew per boat
- Total catch per species per boat
- Length-weight data of fish sampled



Plate 1: KMFRI staff undertaking a survey on hook and line fishery in Lake Naivasha

### 2.3 Data analysis

The study analyzed the following:

- Areas fished and the average fishing duration
- Mean sizes and weight of fish caught by various hooks
- Average crew size = Total crew of sampled boats / Total number of boats sampled
- Fish catch rates (kg/hr) = Total weight of fish caught / fishing duration (hours)
- $CPUE_B$  (kg/boat) = Total weight (kg) of fish sampled / Total number of boats sampled
- $CPUE_C$  (kg/crew) = Total weight (kg) of fish sampled / Total crew of sampled boats
- Size structure of target fish species (Length frequency analysis)
- Length-weight relationship (Regression analysis;  $W = aL^b$ )
- Condition factor of sampled fish species ( $K = 100W/L^3$ )

### 3.0 RESULTS AND DISCUSSIONS

#### 3.1 Characteristics of the hook and line fishery in Lake Naivasha

The study found that the hook and line fishery is mostly dominated by male youths who have either dropped out of school or have lost their jobs. The investment in hook and line is comparatively cheaper than gill net fishing and so far the fishery is not regulated. Therefore, entry into this fishing is free as opposed to the previously sport fishing activity where one had to acquire a provisional permit valid for two weeks with a maximum allowable catch (five pieces of fish). The sheltered bays and near shore shallow areas below 1.2m were the most targeted fishing areas (plate 2). The areas were accessed by groups of fishers either using canoes with motorized engines (80%) or paddled type of propulsion (20%). Besides, there were individual foot fishers distributed along the shoreline, but these were not easily targeted for the interview and data collection. The fishing grounds frequently targeted are the prescribed fishing grounds – Crescent Island; Malewa river mouth; Korongo; Oserian bay and other shallow areas of less than 1m around the lake (Yongo et al., 2013; Waithaka et. al., 2017; Nzioka et. al., 2017). It was observed that these areas have schools of fingerlings and juveniles of mostly tilapia species hence confirming the critical nature of the habitat for fish reproduction.



Plate 2: Hook and line fishers fishing in shallow near shore areas (Korongo)

#### 3.2 Number and sizes of hooks

The study found that most fishers used a single hook and line of size number 11 and 12. This sizes were preferred for their wide size selection range of the various fish species. The hooks were either single or multiples of two to three hooks. These hooks were baited using earthworms which were acquired from peat and marshlands around the lake. The hook and line fishery has created a market for the earthworm baits with many women who are engaged in sourcing for the bait and sell a kilo at Ksh.100 (plate 3).

The fishing duration usually lasts for about 9 hours daily with most fishers starting at 7 a.m and ending at 4 p.m. The fishing continues non stop unless the fishers have to relocate to other site in search of schooling fish.



Plate 3: A sample of earthworms harvested for bait in the hook and line fishery of Lake Naivasa

### **3.3 Total catches and percentage composition of fish species**

#### **3.3.1 Catch and effort**

The hook and line fishers did not have designated landing sites. Therefore, their catches were not captured in the daily fisheries records taken at the landing beaches. This implies a huge amount of fish from lake Naivasha was unaccounted for. The survey found that about 20 fishing boats engaged in the fishery with varying number of crew of between (7 to 12) per boat. On average the sample fishing duration was about four hours, yielding an average catch of 69.3 kg/boat and an average catch rate of 16.8 kg/hr. Considering an average crew of 7 persons, the CPUE was 9.9 kg/crew (Table 1). This results imply a total daily catch of about 1386 kg fished by 20 boats (this study) the catch is slightly about a half of the total daily landings from the gill net fishers (Waithaka et. al., 2019). In a period of one year, with the daily fishing rate the fishery has the potential of losing 415.8 tons as an unaccounted catch. The current level of resource harvesting using gill net fishing, as at 2019, is 3146 tons. This variance casts doubts on the sustainability of the fishery given that the current stock is maintained through regular restocking.

Table 1. Catch and effort descriptive parameters of hook and line fishery in Lake Naivasha.

Variables	Range	Averages
No crew (person)	6 - 12	7
Fishing duration(hours)	3 - 5	3.9
Total catch (kg/boat/day)	24.1 - 219.7	69.3
Catch rate (kg/hr)	8.0 - 43.9	16.8
CPUE (kg/ crew/day)	4.0 - 21.2	9.9

### 3.3.2 Catch composition

Figure 2 shows the catch proportions of the various hooks deployed in the hook and line fishery. Clearly hook number 11 and 12 were the most preferred and had the highest proportion of catch when used singly than paired (11-12) hooks. However, the proportion of fish caught by hook number 11 was higher than the .

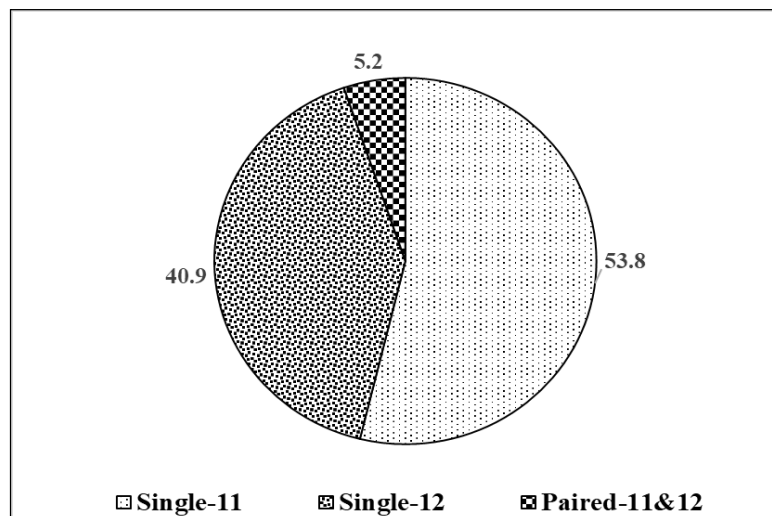


Figure 2. Proportion of total fish catches by the various hook sizes

Results of the catch composition (number and percentage) by species are provided in table 2(a) and 2(b) respectively. The study found that *O. niloticus* (91%) and *C. carpio* (8%) comprised the most targeted species in the hook and line fishing. The African catfish comprises a mere 1% of the catches. This results corroborates the trends observed in the gill net fishery where *O. niloticus* dominates the catch followed by the *C. carpio* and trailed by *C. gariepinus*.

Table 2 (a) Composition (number) of fish species caught by various hook sizes (On – *O. niloticus*; Cc - *C. carpio*; Cg - *C. gariepinus*; Cz - *C. zillli*)

Hook size	On	Cc	Cg	Cz	Total
Single - 11	828	55	2	1	886
Single - 12	590	73	11	-	674
Paired -11&12	84	2	-	-	86
Total	1502	130	13	1	1646

Table 2 (b) Composition (percentage) of fish species caught by various hook sizes (On -*O. niloticus*; Cc - *C. carpio*; Cg - *C. gariepinus*; Cz - *C. zillli*)

Hook size	On	Cc	Cg	Cz	Total
Single -11	50	3	-	-	54
Single -12	36	4	1	-	41
Paired -11&12	5	0	-	-	5
Total	91	8	1	-	100

However, this results highlight *O. niloticus* being the most vulnerable to capture by the selected sizes of hooks. Its worth noting the same species, targeted by the gill nets experinces considerable pressure leading to its stock depletion. This is evident from the annual restocking of the lake with *O. niloticus* which is conducted by various stakeholders. Its unlikely that without the regular restocking program the huge amount of effort both hook and line, and gill netting, would be sustained in the long term. Previous studies have shown that lake’s maximum sustainable yield (MSY) under natural recruitment conditions is < 500 t yr<sup>-1</sup> with fishing effort of < 55 boats (Muchiri and Hickley, 1991; Hickley et. al., 2002). Literature show maximum recorded fish yield during the boom and bust phase of the fishery development (1970s) was about 1150 t yr<sup>-1</sup>. However, since 2014 the yearly total fish yields have remained above 900 t and a maximum of 3146 t recorded in 2019, a likely attribution to the restocking programmes in Lake Naivasha.

### 3.3.3 Size structure, length-weight relationship and condition factor

Results show the size of *O. niloticus* and *C. carpio* caught by hook and line method had mean lengths of  $19.6 \pm 0.1$  and  $26.9 \pm 0.9$  respectively (Table 3 a & b). The detailed length frequency analysis for *O. niloticus* and *C. carpio* is provided in figure 3 and 4 respectively. A wide range of fish sizes were caught by the hooks (11 and 12). The size distribution shows the non selective

nature of the hooks despite their high efficiency. These sizes confirm exploitation of juvenile fish. It should be noted *O. niloticus* length at first maturity ( $L_{m50}$ ) is 28cm TL cm (Waithaka et al., 2020). On the other hand, *C. carpio* length at first maturity ( $L_{m50}$ ) is between 36 cm and 54 cm TL cm (Ojouk et al., 2007; Nyaboke et al., 2014; Mutethya et al., 2020). The probable reason for the lower mean sizes of the two target species could be the location targeted by the fishermen, which are shallow fish breeding areas. Field observations noted that even smaller sizes could be caught by the hooks but these were discarded, showing the harm to the stock.

It was noted that the length – weight relationship of *O. niloticus* was nearly isometric ( $b = 2.96$ ) for samples in both hook number 11 and 12. allometric growth conditions. However, the length – weight relationship of *C. carpio* was allometric ( $b = 2.26$  and  $2.66$ ) for samples in hook number 11 and 12.

Table 3 (a) Length, weight and condition factor of *O. niloticus* caught by hook #11

<i>O. niloticus</i>			
Variable	N	Range	Mean
Total length (cm)	828	12 - 30	19.6 ± 0.1
Weight (g)	828	19 - 523	153.9 ± 2.8
Condition factor (K)	828	0.3 - 7.9	1.9 ± 0.02

Table 3(b) Length, weight and condition factor of *C. carpio* caught by hook #11

<i>C. carpio</i>			
Variable	N	Range	Mean
Total length (cm)	55	18.1 - 52	26.9 ± 0.9
Weight (g)	55	94 - 1888	343.7 ± 38.3
Condition factor (K)	55	0.39 - 2.29	1.6 ± 0.04

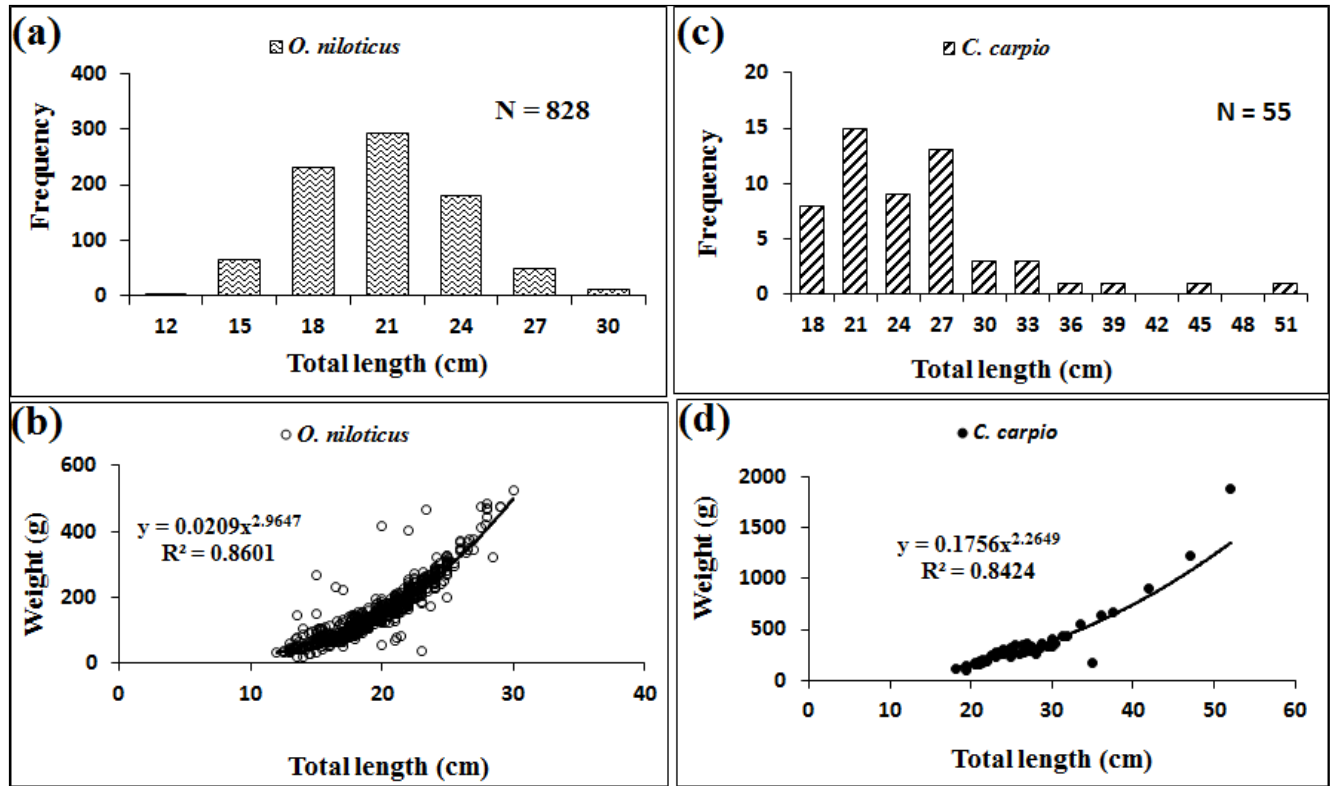


Figure 3. Size structure and length-weight relationship of *O. niloticus* (a,b) and *C. carpio* (c,d) caught in Lake Naivasha using hook number 11.

Table 4 (a) Length, weight and condition factor of *O. niloticus* caught by hook #12

<i>O. niloticus</i>			
Variable	N	Range	Mean
Total length (cm)	590	10.5 - 36	18.83 ± 0.2
Weight (g)	590	20 - 604	141.3 ± 3.6
Condition factor (K)	590	0.5 - 4.4	1.9 ± 0.01

Table 4(b) Length, weight and condition factor of *C. carpio* caught by hook #12

<i>C. carpio</i>			
Variable	N	Range	Mean
Total length (cm)	73	15.5 - 66	28.3 ± 1.05
Weight (g)	73	60 - 5000	423.5 ± 74.4
Condition factor (K)	73	1.00 - 3.6	1.5 ± 0.06

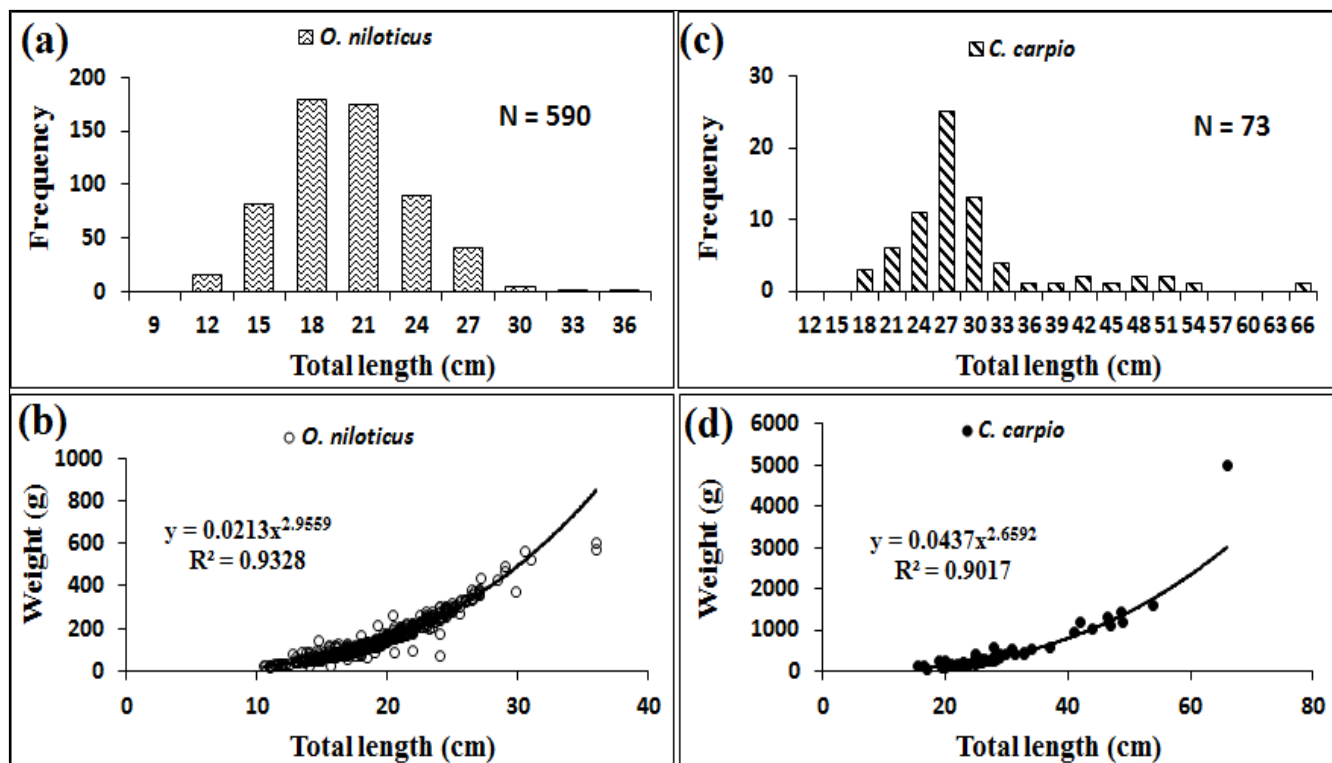


Figure 4. Size structure and length-weight relationship of *O. niloticus* (a,b) and *C. carpio* (c,d) caught in Lake Naivasha using hook number 12.

## 5.0 CONCLUSION AND RECOMMENDATIONS

The followings conclusions were drawn from the results:

- Hook and line fishing currently takes place in shallow water, which are critical breeding and nursery sites for fish, especially the tilapia species of Lake Naivasha.
- More than 140 hook and line fishers are engaged in this emerging fishery with a average daily catch of more than 6.
- The preferred hook sizes were number 11 and 12, which showed a wide ranges of size selection, including the juvenile and mature fish.
- The continuous fishing carried out using hook and line, with high catch rates and CPUE was both unregulated and unreported. Hence the fishery comprises the lake's IUU fishing aspects.
- The wide range of selection and high catch rates have significant potential adverse impacts on the long term sustainability of Lake Naivasha fishery.

Therefore the study suggests the following recommendations:

- A consideration that the hook and line fishery may not be sustainable in its current mode of operation and without a proper legal framework to guide the method of fishing. Such a legal framework ought to consider the feasibility of introducing limit reference points (LRPs) such as the total allowable catches.
- Any contemplation to legalize hook and line fishing in lake Naivasha precautiously should be evaluated along with its contradiction and adverse impacts on the already established policy protecting the critical habitats for fish breeding and nursery grounds in the lake.
- The hook and line fishery merits an experimental study, catch assessment survey (CAS), involving a fixed number of hook and line fishers. This is to provide substantial amount of data for further analyses and conclusive recommendations. Such a short term study, at least three months to reflect the spatial and temporal variability, should be in a participatory collaborative manner, and preferably involving teams from KMFRI, Fisheries Department and BMUs.

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## 7.0 ANNEXES

Annex 1: Submission Letter to Assistant Director Fresh Water Systems

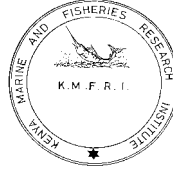
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Station Coordinator



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Ag. Deputy Director  
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### **RE: SUBMISSION OF PERFORMANCE CONTRACTING REPORT FOR 2020-21 FY**

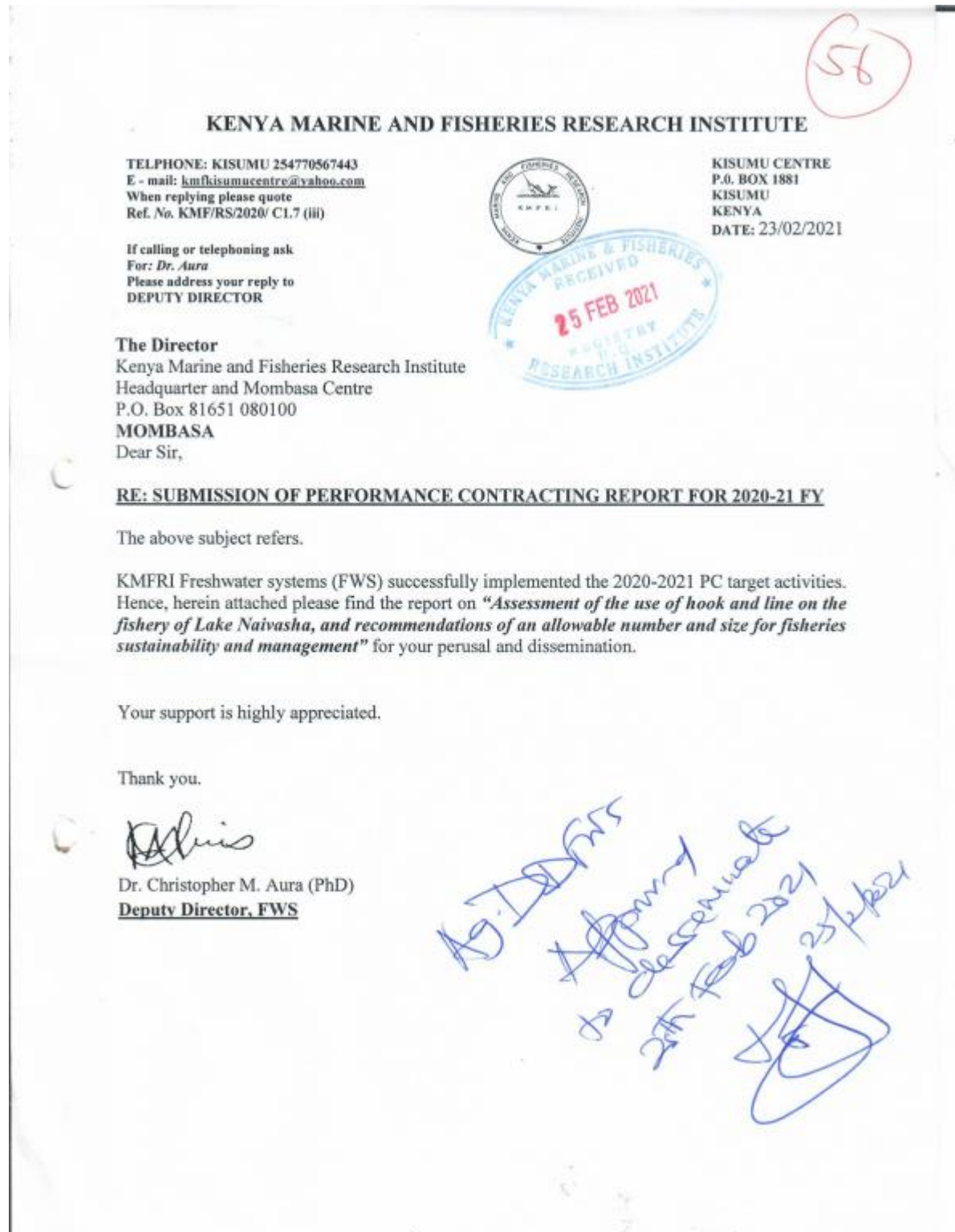
KMFRI Freshwater systems (FWS) successfully implemented the 2020-2021 PC target activities. Hence, herein attached please find the report on "Assessment of the use of hook and line on the fishery of lake Naivasha, and recommendations of an allowable number and size for fisheries sustainability and management".

Thank you.

A handwritten signature in blue ink, appearing to read "Waithaka Edna".

Waithaka Edna  
**Station Co-ordinator**

Annex 2: Submission Letter to the Director



Annex 3: Dissemination to Subcounty Fisheries Officer

**KENYA MARINE AND FISHERIES RESEARCH INSTITUTE**

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When replying please quote  
Ref: no:  
and date:  
If calling or telephoning ask  
For:  
Please address your reply to:  
The DIRECTOR



HEADQUARTERS  
P.O. Box 81651  
MOMBASA  
KENYA

KMF/TECH/RPTS/20-21

Date: 24<sup>th</sup> February 2021

To: Sub County Director Fisheries

Dear Sir/Madam,

RE: ASSESSMENT OF THE USE OF HOOK AND LINE ON THE FISHERY OF LAKE NAIVASHA, AND RECOMMENDATIONS OF AN ALLOWABLE NUMBER AND SIZE FOR FISHERIES SUSTAINABILITY AND MANAGEMENT

Kenya Marine and Fisheries Research Institute (KMFRI) is a state corporate body, established in 1979 under the Science and Technology Act (Cap 250), which has since been repealed by the Science, Technology and Innovation Act No. 28 of 2013. KMFRI is under the Ministry of Agriculture Livestock and Fisheries. The institute is empowered to carry out research in marine and freshwater fisheries, aquatic biology, aquaculture, environmental chemistry, ecological, geological and hydrological studies, socio-economical as well as chemical and physical oceanography.

In this regard, KMFRI conducted a number of research expeditions in 2020-2021 financial year in freshwater systems in Kenya in Lake Naivasha and came up with technical report and Fact sheet/brief.

The purpose of this letter is to share the findings on "Assessment of the use of hook and line on the fishery of Lake Naivasha, and recommendations of an allowable number and size for fisheries sustainability and management", as information for possible management and conservation measures of the aforementioned systems.

Attached herewith please find the technical reports and Fact sheet/brief for your perusal and further action.

Yours Sincerely,

Dr. Christopher M. Aura (PhD)

For: Director KMFRI

cc. AD Fisheries, KeFS



Received

Annex 4: Dissemination to Kamere Beach

**KENYA MARINE AND FISHERIES RESEARCH INSTITUTE**

Telephone 020-8021560/1  
020-2353904  
Mobile: 0712003853  
FAX: 020-2353226  
E-mail: director@kmfri.co.ke  
When replying please quote  
Ref: no:  
and date:  
If calling or telephoning ask  
For:  
Please address your reply to:  
The DIRECTOR



**HEADQUARTERS**  
P.O. Box 81651  
MOMBASA  
KENYA

**KMF/TECH/RPTS/20-21**

**Date: 24<sup>th</sup> February 2021**

**To: Beach Management Unit (BMU) Chairman**  
**P.O. Box Kamere**

**Attn: Wesley Kimutai**

**Dear Sir/Madam,**



**RE: ASSESSMENT OF THE USE OF HOOK AND LINE ON THE FISHERY OF LAKE NAIVASHA, AND RECOMMENDATIONS OF AN ALLOWABLE NUMBER AND SIZE FOR FISHERIES SUSTAINABILITY AND MANAGEMENT**

Kenya Marine and Fisheries Research Institute (KMFRI) is a state corporate body, established in 1979 under the Science and Technology Act (Cap 250), which has since been repealed by the Science, Technology and Innovation Act No. 28 of 2013. KMFRI is under the Ministry of Agriculture Livestock and Fisheries. The institute is empowered to carry out research in marine and freshwater fisheries, aquatic biology, aquaculture, environmental chemistry, ecological, geological and hydrological studies, socio-economical as well as chemical and physical oceanography.

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Attached herewith please find the technical reports and Fact sheet/brief for your perusal and further action.

Yours Sincerely,

A handwritten signature in blue ink, appearing to read 'Chris'.

Dr. Christopher M. Aura (PhD)

**For: Director/KMFRI**

*Received by chairman*  
A handwritten signature in blue ink, appearing to read 'Wesley Kimutai'.

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE  
P.O BOX 837-20117  
NAIVASHA



Attendance list

Dissemination of "Assessment of the use of hook and line on the fishery of Lake Naivasha, and recommendations of an allowable number and size for fisheries sustainability and management" at Kamere beach on 24<sup>th</sup> February 2021

S/No	Name	Organization	Contacts	Sign
1	Tom O. NYOKA	K.M.F.R.I.	0720389770	
2	Wilson Mwangi	Fisheries	0720319771	
	Fredrick Wandera	B.M.U	0718969423	
	KENNEDY AKULA	B.M.U	0718385161	
	Mutaba Christopher	B.M.U	0729017032	
	Achieng Carren	B.M.U	0725694930	
	Samuel Mwangi	B.M.U	0790526188	
	James Njenga	B.M.U	0757154705	
	Benson Karanja	B.M.U	0770757593	
	Darius Ashali	FISHERIES	0296267256	
	Simon Kimani	B.M.U	0725279633	
	JOSECK N. MIRUKA	K.M.F.R.I.	0704170199	

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE  
P.O BOX 837-20117  
NAIVASHA



NAME	ORGANISATION	CONTACTS	SIGN
ALICE MUIE	KMFRI	0721767162	
EDNA WAIHAKA	"	0721208953	
GERGE MORARA	KMFRI	0718053335	
Raphael Maina	KEFVOR	0710162328	
Pilly Achieng		0725481382	
Everline Kangu		0725076039	
KENNEDY OLUOTH	"	0746056248	
VINCENT ODANLLO	"	07992228741	
PAMELA MBOYA		0711747582	
DORCAS NJIRO	"	0720473925	
Joseph Kiarie		0723446934	
Joseph Wamalwa		0798271788	
SILAS NJONGESA		0723120347	
Judson K. KUCHAR	KAMERE B. BUREAU	0724785510	
SOSPETER OLUOYE	KAMERE B	0713885018	
JAMES MURARA	KAMERE C	0759167116	
Wesley Kimtai	Charlman Bonu	0729701666	



Annex 5: Dissemination to Central Beach

**KENYA MARINE AND FISHERIES RESEARCH INSTITUTE**

Telephone 020-8021560/1  
020-2353904  
Mobile: 0712003853  
FAX: 020-2353226  
E-mail: director@kmfri.co.ke  
When replying please quote  
Ref: no:  
and date:  
If calling or telephoning ask  
For:  
Please address your reply to:  
The DIRECTOR



HEADQUARTERS  
P.O. Box 81651  
MOMBASA  
KENYA

**KMF/TECH/RPTS/20-21**

**Date: 25<sup>th</sup> February 2021**

**To: Beach Management Unit (BMU) Chairman  
P.O. Box Central**



**Attn: Mr. Olweny Paul**

**Dear Sir/Madam,**

**RE: ASSESSMENT OF THE USE OF HOOK AND LINE ON THE FISHERY OF LAKE NAIVASHA, AND RECOMMENDATIONS OF AN ALLOWABLE NUMBER AND SIZE FOR FISHERIES SUSTAINABILITY AND MANAGEMENT**

Kenya Marine and Fisheries Research Institute (KMFRI) is a state corporate body, established in 1979 under the Science and Technology Act (Cap 250), which has since been repealed by the Science, Technology and Innovation Act No. 28 of 2013. KMFRI is under the Ministry of Agriculture Livestock and Fisheries. The institute is empowered to carry out research in marine and freshwater fisheries, aquatic biology, aquaculture, environmental chemistry, ecological, geological and hydrological studies, socio-economical as well as chemical and physical oceanography.

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Attached herewith please find the technical reports and Fact sheet/brief for your perusal and further action.

Yours Sincerely,

A handwritten signature in blue ink, appearing to read "Chris".

Dr. Christopher M. Aura (PhD)  
**For: Director/KMFRI**

Received A handwritten signature in blue ink, appearing to be a stylized "J" or "G".

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE  
P.O BOX 837-20117  
NAIVASHA



Attendance list

Dissemination of "Assessment of the use of hook and line on the fishery of Lake Naivasha, and recommendations of an allowable number and size for fisheries sustainability and Management" at Central beach on 25<sup>th</sup> February 2021

S/No	Name	Organization	Contacts	Sign
1	ALICE MUTIE	KMFRI	0721764162	
2	GEORGE MORARA	KMFRI	0718053335	
3	EDNA WATHARA	"	0721-200553	
4	JOHN O. NYONGO	KMFRI	0710389710	
5	JOSECK N. MIRUKET	KMFRI	0704170199	
6	BICHANHA ELEXIEL HEZRON	KMFRI	0710545853	
7	Johna Chemuyoi	KMFRI	0741413642	
8	LUCAS AUMA.	B.M.U.	0726521172	
9	Edmund Ndinare	B.M.U.	0711421351	
10	JOSITHA OKUMU OURA	B.M.U.	0728207601	
11	ROSE GLOYO OKUMU	B.M.U.	0728207601	
12	MILICANT AKINYI	B.M.U.	0736392497	
13	ATANKS AUMU	B.M.U.	0722362252	

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NAIVASHA



1	GRACE ALACHO	BMU	0720036715	ca
2	EVALINE AGUIN	BHU	0714 437341	ca
3	LEVINAH OCHENO	BHU	0919 850381	ca
4	SELINA ODIDO	BHU	0754 5899110	ca
5	ISAAC OMWITA	BMU	0720058111	ca
6	LILIAN OMARE	BMU	0749919737	ca
7	EVERLINE KYUMA	BMU	0700715526	ca
8	VIVIAN IMAI	BMU	0703572973	ca
9	ROSE HELIDA	BMU	0707774122	ca
10	SYDRESE ANINO	BMU	0714060657	ca
11	LILIAN ACHIENG	BMU	0724 034217	ca
12	WAMOTHO EDWIN	BMU	0703547385	ca
13	MESHACK MUGANDA	BMU	0710950891	ca
14	AGNETTA ACHIENG	BMU	0715737063	ca
15	Hyacinth Datta	BMU	0726977666	ca
16	STEPHE OUMA	BMU	No 1	ca
17	Jane Akoth	BMU	0792324465	ca
18	BENTA OMONDI	BMU	0720835073	ca
19	noirne AKIYI	BMU	0719608264	ca



Annex 5: Fact Sheet on Hook and line fishery in Lake Naivasha



**KENYA MARINE AND FISHERIES RESEARCH INSTITUTE**

**FRESH WATER SYSTEMS**

**FACT SHEET**

**KMF/RS/2021/ C.1.7 (iii)**

**ASSESSMENT OF THE USE OF HOOK AND LINE ON THE  
FISHERY OF LAKE NAIVASHA, AND RECOMMENDATIONS OF  
AN ALLOWABLE NUMBER AND SIZE FOR FISHERIES  
SUSTAINABILITY AND MANAGEMENT**



February 2021

This study aimed to assess the use of hook and line on the fishery of Lake Naivasha and recommend the allowable number and size for fisheries sustainability and management in Lake Naivasha.

**AUTHORS**

Morara, G.N.,  
Waithaka, E.,  
Boera, P.,  
Mutie, A.,  
Loki P.,  
Nyamweya, C.,  
Aura, C.M.

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## INTRODUCTION

The fishery of Lake Naivasha, since its inception in 1959, was predominantly gillnet based and targeted the cichlids and the Black bass, but the common carp and Africa catfish have also been targeted in the recent years. The fishermen obtain annual fishing licenses from the Fisheries Department that allowed them access to the resource using a maximum number of 10 nets (approximately 2.5x100 m) with not less than 4 inch (100 mm) stretched mesh sizes. In the late 1990s, poor fishing methods resulted in the drastic decline of fish stocks to unsustainable levels, leading to the fishery's collapse by 2000. Despite the various management interventions put in place for the stocks recovery, including the control of fishing effort, the resource has experienced high exploitation pressure in recent years. The pressure is partly due to the increasing human population around the lake, causing increased demand for fish in Naivasha town and other neighbouring urban centres, and the limited seasonal employment opportunities in the flower farms, hotels and other industries around Lake Naivasha causing the dropouts from the jobs to revert into illegal fishing as an alternative source of livelihood. The demand to increase the number of fishing licenses in Lake Naivasha has generated a debate among the various stakeholders about the stock sizes and optimal fishing effort for the resource sustainability. While hook and line fishing is a recent emerging fishery in the lake, the County Government of Nakuru seeks to consider the feasibility of this method being an alternative and sustainable legal fishing practice in the lake.

### Objectives

- ✓ To assess the characteristics of the hook and line fishery in Lake Naivasha.
- ✓ To determine the number and sizes of hooks used by various fishers in Lake Naivasha.
- ✓ To determine the total catch and percentage composition of fish species caught by hook and line fishery.
- ✓ To calculate the mean catch rates, catch per fishing crew, and catch per unit effort (CPUE).
- ✓ To examine the size structure, length-weight relationship and condition factor of fish samples from the various hooks.

## METHODOLOGY

### What data was collected?

- ✓ Census of hook and line fishing boats
- ✓ Fishing locations
- ✓ Fishing crew
- ✓ Hook sizes and numbers
- ✓ Fishing duration (hours)
- ✓ Total catches
- ✓ Length-weight data by hook size



### What was analyzed?

- ✓ Hook and line fishery characteristics
- ✓ Fishing boats and crew per boat
- ✓ Fish catch by hook sizes
- ✓ Fish catch rates
- ✓ Catch per unit effort (CPUE)
- ✓ Fish size structure by hook size

**Important calculations**

*Average crew size* =  $\frac{\text{Total crew of sampled boats}}{\text{Total number of sampled boats}}$  .....1

*Average fishing duration* =  $\frac{\text{Total fishing hours of sampled boats}}{\text{Total number of sampled boats}}$  .....2

*Catch per boat* =  $\frac{\text{Total weight (kg) of fish sampled}}{\text{Total number of sampled boats}}$  .....3



*Catch per crew* =  $\frac{\text{Total weight of fish sampled}}{\text{Total number of crew of sampled boats}}$  .....4

*Length-weight relationship regression equation: W = aL<sup>b</sup>* .....5  
*W = weight; L = Length; a = constant y-intercept; b = slope of the equation.*

*Fish condition factor equation: K =  $\frac{100W}{L^3}$*  .....6  
*K = condition factor; W = weight of individual fish; L = total length of fish*

**STUDY'S KEY FINDINGS**

*L. Characteristics of the hook and line fishery in Lake Naivasha*

Hook & line fishing sites	Korongo bay; Malewa river mouth; Crescent Island, Oserian bay; nearshore areas	
Site descriptions of the fishing areas	Shallow waters including the demarcated fish breeding areas	
Fishers	Mostly youth and unemployed	
Fishing boats, hooks, crew and duration	Observed No. boats	20 canoes
	Propulsion type	Engine (80%) and Paddle (20%)
	Hook sizes used	11; 12 and 11-12 paired
	Baits preferred	Earthworms
	Normal fishing duration	7 am - 4.00 pm (≈ 9 hours)
	Sampled fishing duration	Range (3-5 hours); Average 3.9 hours
		Earthworms for baits
		

**STUDY'S KEY FINDINGS**

*ii. Catch-effort and fish species composition analyses*

Table 1. Catch and effort descriptive parameters of hook and line fishery in Lake Naivasha.

Variables	Range	Averages
No crew (person)	6 - 12	7
Fishing duration(hours)	3 - 5	3.9
Total catch (kg/boat/day)	24.1 - 219.7	69.3
Catch rate (kg/hr)	8.0 - 43.9	16.8
CPUE (kg/ crew/day)	4.0 - 21.2	9.9

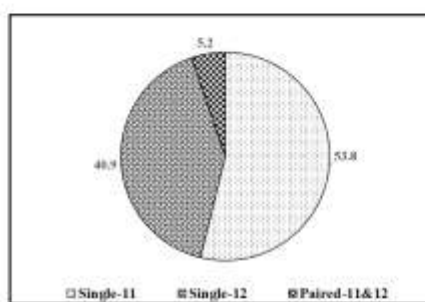


Fig. 1 Proportions of total fish caught by the various hook sizes

Table 2 (a). Composition (number) of fish species caught by various hook sizes (On – *O. niloticus*; Cc - *C. carpio*; Cg - *C. gariepinus*; Cz - *C. zillii*)

Hook size	On	Cc	Cg	Cz	Total
Single - 11	828	55	2	1	886
Single - 12	590	73	11	-	674
Paired -11&12	84	2	-	-	86
Total	1502	130	13	1	1646

Table 2 (b). Composition (percentage) of fish species caught by various hook sizes

Hook size	On	Cc	Cg	Cz	Total
Single -11	50	3	-	-	54
Single -12	36	4	1	-	41
Paired -11&12	5	0	-	-	5
Total	91	8	1	-	100

**STUDY'S KEY FINDINGS**

iii. Size structure of fish caught by various hook sizes

Table 3 (a) Length, weight and condition factor of *O. niloticus* caught by hook #11

<i>O. niloticus</i>			
Variable	N	Range	Mean
Total length (cm)	828	12 - 30	19.6 ± 0.1
Weight (g)	828	19 - 523	153.9 ± 2.8
Condition factor (K)	828	0.3 - 7.9	1.9 ± 0.02

Table 3(b) Length, weight and condition factor of *C. carpio* caught by hook #11

<i>C. carpio</i>			
Variable	N	Range	Mean
Total length (cm)	55	18.1 -52	26.9 ± 0.9
Weight (g)	55	94 - 1888	343.7 ± 38.3
Condition factor (K)	55	0.39 - 2.29	1.6 ± 0.04

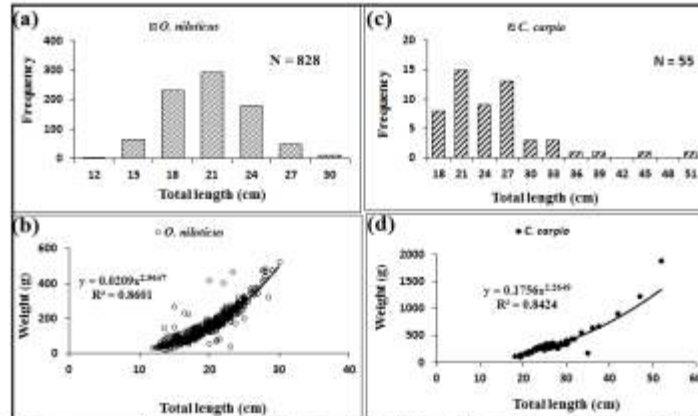


Fig 2. Size structure and length-weight relationship of *O. niloticus* (a,b) and *C. carpio* (c,d) caught in Lake Naivasha using hook number 11.

Table 4 (a) Length, weight and condition factor of *O. niloticus* caught by hook #12

*O. niloticus*

Variable	N	Range	Mean
Total length (cm)	590	10.5 - 36	18.83 ± 0.2
Weight (g)	590	20 - 604	141.3 ± 3.6
Condition factor (K)	590	0.5 - 4.4	1.9 ± 0.01

Table 4(b) Length, weight and condition factor of *C. carpio* caught by hook #12

<i>C. carpio</i>			
Variable	N	Range	Mean
Total length (cm)	73	15.5 - 66	28.3 ± 1.05
Weight (g)	73	60 - 5000	423.5 ± 74.4
Condition factor (K)	73	1.00 - 3.6	1.5 ± 0.06

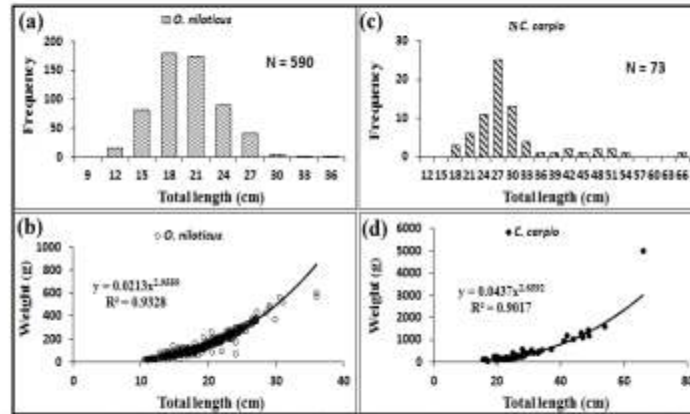


Fig 3. Size structure and length-weight relationship of *O. niloticus* (a,b) and *C. carpio* (c,d) caught in Lake Naivasha using hook number 12.

Results show a wide range of fish sizes selection by both hook number 11 and 12. A majority of fish caught were immature with the mean sizes of *O. niloticus* and *C. carpio* being below the length at 50% maturity.

### **CONCLUSIONS**

Based on this study, the estimated number of hook and line fishers are more than 140 using hook number 11 and 12. The estimated daily and annual catches of these fishers is about 1.386 t and 415.8 t, assuming 300 fishing days in year. The estimated amount of catch is considered illegal, unreported and unregulated.

### **RECOMMENDATIONS**

- i. A proper legal framework is need to guide the hook and line fishery as it may not be sustainable in its current mode of operation. Such a legal framework ought to consider the feasibility of introducing limit reference points (LRPs) such as the total allowable catches (TAC).
- ii. Any contemplation to legalize hook and line fishing in lake Naivasha precautiously should be evaluated along with its contradiction and adverse impacts on the already established policy protecting the critical habitats for fish breeding and nursery grounds in the lake.
- iii. The hook and line fishery merits an experimental study, catch assessment survey (CAS), involving a fixed number of hook and line fishers. This is to provide substantial amount of data for further analyses and conclusive recommendations. Such a short term study, at least three months to reflect the spatial and temporal variability, should be in a participatory collaborative manner, and preferably involving teams from KMFRI, Fisheries Department and BMUs.

## Annex 7: Planning meeting minutes

Research meeting at the Naivasha station Library on 10/11/2020

### Members present

1. Edna Waithaka
2. George Morara
3. Alice Mutie
4. Patrick Loki
5. Dickson Odongo
6. Tom Nyolo

### Agenda

1. PC Targets 2020/2021
2. Monthly sampling

The meeting was opened by a word of prayer from George Morara at 10.00am.

Summary of the discussion are shown below:

PC Target	Activity	Date
Assess the use of the hook and line on the fishery of Lake Naivasha, and recommend an allowable number and size for fisheries sustainability and management by 20 <sup>th</sup> February, 2021	The team shall set experiments and engage fishermen who are currently using hooks to obtain the necessary data	12 <sup>th</sup> to 17 <sup>th</sup> Nov. 2020
Investigate the fishery status of Lake Ol Bolossat and Lake Nakuru to inform Management by 29th May, 2021	-Stock assessment: Composition, maturity, length weight -Water quality	30th Nov. to 3 <sup>rd</sup> Dec 2020 (L. Nakuru) 4 <sup>th</sup> to 5 <sup>th</sup> Dec (L. Ol Bolossat)
Assess the socio-economic effect of illegal fishing on the Lakes Victoria and Naivasha fisheries and make recommendations for management by 31 <sup>st</sup> May, 2021	-A tool to be developed by 24 <sup>th</sup> Nov 2020 -The team will have focus discussion group with key informants in fisheries sector to generate data	7 <sup>th</sup> to 10 <sup>th</sup> Dec 2020


The monthly sampling activity was scheduled for 20<sup>th</sup> to 27<sup>th</sup> Nov 2020.

Being no any other business, the meeting ended at 1.00 pm

Chairperson  
Edna Waithaka

Secretary  
Alice Mutie

Sign 

Sign 

## Annex 8: Memo for sampling

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE  
NAIVASHA STATION

(189)

### INTERNAL MEMO

FROM: RESEARCH

TO: STATION CO-ORDINATOR

KMF/NSA/RES/I Vol. II/

DATE: 10/11/2020

#### RE: SAMPLING FOR PC TARGETS 2020-2021

This is to seek for your authority to carry out sampling in the lake to accomplish our PC targets 2020-2021 on "Assessment of the use of Hook and Line on the Fishery of Lake Naivasha and recommend an allowable number and size for fisheries sustainability and management". Sampling will take 4 days as from -12<sup>th</sup>, 13<sup>th</sup>, 16<sup>th</sup>, 17<sup>th</sup> and 18<sup>th</sup> - November, 2020.

#### **BUDGET**

A.	Allowances				
	Name	Per No.	Lunch (Kshs.	Days	Total
1	Dickson Odongo	1479	1000	4	4000
2	Alice Mutie	2064	1000	4	4000
3	Patrick Loki	1275	1000	4	4000
4	George Morara	1468	1000	4	4000
5	Edna Waithaka	1842	1000	4	4000
6	Tom Nyolo	1006	1000	4	3000
7	JosecMiruka	1750	750	4	3000
8	Mark Asiago	1549	750	4	3000
9	Nicholas	F/officer	1000	4	4000
	<b>Total</b>				<b>41 000</b>

Annex 9: Work ticket

Date	Driver's No.	Details of Journey and Route in full	No. and Signature of person authorizing Journey		Oil drawn (Litres)	Fuel drawn (Litres)	Voucher No. or L.P.O. No. or Cash Voucher No.	Time		Speedo Reading end of Journey	Kilometres of Journey
			No.	Signature				Out	In		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
14/12/20	1	Katbi NWS Office - Tarambatta	(R) 2	[Signature]				10:00 AM	5:35 PM	137230	79
15/12/20	1	Katbi NWS Office - Tarambatta	(R) 2	[Signature]				8:14 AM	1:26 PM	137222	88
15/12/20	1	Katbi NWS Office - NWS Town	(R) 2	[Signature]				1:30 PM	2:31 PM	137340	18
15/12/20	1	Katbi NWS Office - NWS Town	(R) 2	[Signature]				3:45 PM	4:21 PM	137356	16
15/12/20	1	Katbi NWS Office - Kayole	(R) 2	[Signature]				4:36 PM	5:41 PM	137381	25
16/12/20	1	Katbi NWS Office - Kayole - B.H.H.	(R) 4	[Signature]				6:41 AM	10:21 AM	137440	79
16/12/20	1	Katbi NWS Office - NWS Town	(R) 2	[Signature]				10:37 AM	11:11 AM	137455	15
16/12/20	1	Katbi NWS Office - NWS Town	(R) 2	[Signature]				1:35 PM	2:17 PM	137476	21
16/12/20	1	Katbi NWS Office - Kayole	(R) 4	[Signature]				5:35 PM	6:40 PM	137506	30
17/12/20	1	Katbi NWS Office - Kayole - B.H.H.	(R) 4	[Signature]				6:30 AM	8:51 AM	137533	27
17/12/20	1	Katbi NWS Office - Kayole	(R) 2	[Signature]				9:51 AM	10:50 AM	137557	24
17/12/20	1	Katbi NWS Office - Kayole	(R) 2	[Signature]				3:15 PM	5:08 PM	137584	28
17/12/20	1	Katbi NWS Office - Kayole	(R) 4	[Signature]				6:08 PM	7:41 PM	137615	29
18/12/20	1	Katbi NWS Office - Kayole - B.H.H.	(R) 4	[Signature]		65.2	11779	7:13 AM	8:47 AM	136642	37
18/12/20	1	Katbi NWS Office - Oshana	(R) 2	[Signature]				8:51 AM	11:10 AM	136684	42
18/12/20	1	Katbi NWS Office - NWS Town	(R) 2	[Signature]				11:52 AM	1:21 PM	137704	20
18/12/20	1	Katbi NWS Office - Kayole	(R) 2	[Signature]				2:03 PM	3:33 PM	137730	26
18/12/20	1	Katbi NWS Office - Kayole - Kayole	(R) 2	[Signature]				4:10 PM	6:20 PM	137822	92
21/12/20	1	Katbi NWS Office - Kayole - Jirch	(R) 4	[Signature]				6:38 AM	10:11 AM	137854	32
21/12/20	1	Katbi NWS Office - Delemara	(R) 2	[Signature]				2:28 PM	3:42 PM	137873	19

DRIVER'S REPORT OF DEFECTS			SUMMARY OF WORK TICKETS	
Date	Defects	Action taken by Officer i/c	Totals - Fuel and Oil drawn	Ltr. (Fuel) Ltr. (Oil)
				Certified all entries checked. Details entered in Vehicle Log Book.
			Fuel in Tank, to be carried forward	Ltr.
			Total Distance (km)	Designation
			Miles per litre (Fuel)	Station
			Miles per litre (Oil)	

Annex 10: Requisition form

**KENYA MARINE AND FISHERIES RESEARCH INSTITUTE**  
**PROCUREMENT REQUISITION**

(136)  
Form S14

FROM RESEARCH DEPT/SECTION RESEARCH STATION COORDINATOR

Please purchase for us the following materials:-

(1) No	(2) ITEM DESCRIPTION	(3) QTY		(5) QTY REQ.	(6) UNIT COST	(7) TOTAL COST
		QTY	BAL			
1.	Manilla rope (4x200m)	Pc		4	500	2000
2.	Twine (4x(3 <sup>1</sup> / <sub>2</sub> , 4, 5, 6))	Pc		16	100	1600
3.	Hook. 2x(9, 10, 11, 12)	Pc		8	500	4000
4.	Bait (worms, fish)					1000
5.	Bread.	Pc		84		2100
6.	Soda.	Crate		3		1800

VOTE ITEM \_\_\_\_\_ ITEM A/C No. \_\_\_\_\_

(1) DEPARTMENT Research

(a) Requisitioning officer's name Dr. Samuel M. Mwangi Signature [Signature]  
 Designation Senior Lab. Asst. Date 11/11/2020

(b) Purpose of application / use for the requested item for K.M.F.R.I. on Hook & Line Sampling at Lake Naivasha

(c) Why are the items needed (by Head of Section) \_\_\_\_\_

Name Alie M. Mwangi Signature [Signature]  
 Date 11/11/2020

(2) STORES

(a) Source of prices indicated in column (7) Franchise General Store  
 (b) Sampling done by Dumbo R. as at 11/11/2020

(3) Comments by Chief Supplies Officer/Supplies Officer on Procurement Plan

Recommended for research activities

Signature [Signature]  
 Date 11/11/2020  
 Designation Senior II

(4) APPROVED BY SECTION

(a) \_\_\_\_\_ as the vote item as per previous payment \_\_\_\_\_

(b) \_\_\_\_\_ included \_\_\_\_\_

Officer's Signature \_\_\_\_\_  
 Designation \_\_\_\_\_

(5) Comments by Accountant on cash flow position Funds available

Signature [Signature]  
 Date 11/11/2020

(6) All items have been **APPROVED/NOT APPROVED** for purchase.

STATION COORDINATOR [Signature] DATE 11/11/2020