



KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

FRESH WATER SYSTEMS

A technical report on the mapping and monitoring of the major point sources of pollution and assessment of their effect on fish ecology in Ferguson's Gulf of Lake Turkana



TECHNICAL REPORT
KMF/GOK/2021/C8221(2)

June 2021

DOCUMENT CERTIFICATION

Certification by Director Freshwater Systems

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

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Date: 16th June 2021

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Cover photo:

Indiscriminate waste dumping and open defecation at Longech

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EXECUTIVE SUMMARY

Pollution is the introduction of contaminants into the natural environment that cause adverse change. It is a point source pollution when contaminants from a specific source enter a water body and non-point pollution when the contaminants come from diffuse sources. Pollution reduces water quality affecting health and diversity of aquatic organisms including fish. Lake Turkana found in the north west of Kenya is endorheic. It has a surface area of 7,500 km² making it the largest lake in Kenya, the world's largest permanent desert lake and the world's fourth-largest salt lake. Ferguson's Gulf, which is the focus of this study, is connected to Lake Turkana through the mouth of the gulf. The intermittent River Kalotum and numerous ephemerals also provide inflows. It is one of the most productive areas of the lake with high fish landings and high human population. Six sites at Ferguson's Gulf with varying degrees of pollution were identified and their coordinates marked using Raymarine Dragonfly-7 Pro Sonar/GPS. Water quality measurements were taken in situ using YSI Professional Plus handheld multiparameter meter while fish samples were collected using monofilament gill nets of variable mesh sizes. Questionnaires were administered to fisheries stakeholders including fishermen. Data was analysed using Microsoft Excel 2013. Results indicate high levels of faecal and plastic pollution in the gulf. A total of 135 fish representing 12 species were recorded in the Gulf. There was no major overlap between fish species found in Ferguson's Gulf and the open lake. Environmental parameters, namely, dissolved oxygen, water temperature, and pH seemed to have no significant difference within the Gulf hence their influence on diversity and abundance was negligible. Most of the interviewed fishermen (62%) were aware of the proper disposal methods for oil, plastic and fish waste but the main challenge they are facing is lack of designated disposal areas. They listed Longech as the most polluted area (39%) followed by Natirae (22%). It can be concluded that faecal, plastic and engine oil wastes are the main contributors to pollution at Ferguson's Gulf but are yet to have any major impact on water quality, and diversity and abundance of fish in the Gulf. In-depth analysis on microplastics on

fish and effects of plastics on feeding and reproduction by demersal fish is highly recommended.

Keywords: Pollution; point sources; Ferguson's Gulf, Lake Turkana.

TABLE OF CONTENTS

DOCUMENT CERTIFICATION	i
ACKNOWLEDGEMENT	ii
EXECUTIVE SUMMARY	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
INTRODUCTION	1
MATERIALS AND METHODS	4
2.1 Study Area	4
2.2 Data Collection and Analyses	5
RESULTS AND DISCUSSION	6
3.1 Water Quality	6
3.2 Faecal and Plastic Pollution	9
3.3 Fish Abundance and Diversity	10
3.4 Perception of Key Stakeholders on Pollution in Ferguson’s Gulf	11
CONCLUSION AND RECOMMENDATIONS	14
REFERENCES	15
APPENDICES	17

LIST OF TABLES

Table 1: Water quality parameters at selected areas in the Gulf in the dry season	6
Table 2: Water quality parameters at selected areas in the Gulf in the wet season	7

LIST OF FIGURES

Figure 1: A graph showing water quality parameters at in the gulf during the dry season	8
Figure 2: Unplanned settlement at Natirae and Longech aiding in pollution in Ferguson’s Gulf.....	8
Figure 3: Indiscriminate waste dumping and faecal pollution at Longech	9
Figure 4: Fish diversity and relative abundance in numbers at Ferguson’s Gulf	11
Figure 5: Awareness on proper waste disposal	12
Figure 6: Status of pollution in the Gulf.....	13
Figure 7: Rate of waste disposal into the Gulf	13

APPENDICES

Appendix 1: Dissemination letter to Turkana County Government, Directorate of Fisheries	17
Appendix 2: Dissemination letter to Kenya Fisheries Service.....	19
Appendix 3: Dissemination letter to Lake Turkana BMU Network.....	22
Appendix 4: Fact sheet.....	24
Appendix 5: Forwarding letter by Director FWS to Director General.....	30
Appendix 6: Forwarding letter by Station Coordinator to Director FWS.....	31
Appendix 7: Memo for facilitation of fieldwork	32
Appendix 8: Pollution perception questionnaire.....	34

INTRODUCTION

Pollution is defined as the introduction of contaminants into the natural environment that cause adverse change or simply to make something impure—in this case, the waters in the lotic and lentic systems. Pollution therefore affects water quality in lakes and other aquatic ecosystems around the globe. It can take many forms from industrial, agricultural, or municipal sources; a few common examples include pesticides, herbicides, sewage, and litter. The pollution of water restricts its use for some human need or a natural function in the ecosystem. Lentic systems often contain high pollution levels relative to the surrounding landscapes and environment. Rivers and streams drain pollutants from the landscape where they concentrate in lakes and other water bodies. Some pollutants don't readily dissolve and dilute in water and are instead taken up into some aquatic organisms such as fish leading to bioaccumulation. Some species of aquatic organisms are particularly sensitive to pollution; they are used as indicators of pollution and are called bioindicators. Because lakes drain a large surrounding landscape, they reflect the processes and actions that operate around them. When chemicals are spilled, they can drain into nearby streams and be transported downstream into lakes.

Pollution is generally categorized by how it enters a water body. When contaminants that enter a water body can be traced back to a specific source or location, it is referred to as a point source pollution while non-point pollution is when the contaminants come from diffuse sources and often enter the water body in small amounts but get concentrated after some period. Point source pollution is generally easier to manage compared to non-point source pollution. Examples of point source pollution include dumping of industrial waste, effluent from sewage treatment facilities, illegal dumping of garbage, and other hazardous chemical deposition. Non-point source pollution includes agricultural runoff (pesticides, fertilizers, manure), acid rain, nitrate deposition, and leaching from septic tanks. Without an identifiable source, this type of pollution is often difficult to manage; it is harder to estimate how much pollution is actually occurring and what sort of impacts it is having. Non-point source pollution accounts for most of the contamination in water systems.

Regardless of the source, pollution can disrupt aquatic life in many ways. In general, pollution reduces water quality. It can also reduce the diversity of wildlife, especially sensitive species. When nutrients wash into waterways through storm runoff, they deplete oxygen in the water that fish need to survive. Nitrogen and phosphorus typically enter streams and lakes from fertilizers, animal waste, and other sources. Over time, these nutrients build up in the water and promote algae and water plant growth, and as they decay, they lower oxygen levels in the water. Algal blooms can be harmful to fish as they feed upon algae, toxins accumulate within the fish, and when a predator fish consumes that fish, they too are consuming higher toxin levels. Pesticides and heavy metals that enter waterways can also harm or kill fish. Synthetic pesticides used for weed and bug control are toxic in even small amounts. Heavy metals created when fossil fuels are burned enter the atmosphere or through industrial runoff, eventually making their way into bodies of water. Exposure to heavy metals can impair a fish's ability to smell, disrupting its ability to locate food and protect itself from predatory animals and fish. Heavy metals can also find their way into the food chain of fish causing illness or death to fish or their predators including humans. Sediment washed away from construction activities and urban or agricultural activity enter lakes, reducing water clarity and water quality, and can be lethal to aquatic organisms by becoming trapped in gills. Finally, atmospheric pollutants — from car exhaust pipes or industrial power generation can enter lakes as acid rain or other forms of acidic precipitation.

Plastic pollution has become one of the most pressing environmental issues, as rapidly increasing production of disposable plastic products overwhelms the world's ability to deal with them. Once in the lake, sunlight, wind and wave action break down plastic waste into small particles. These microplastics are spread throughout the water column. Microplastics are breaking down further into smaller and smaller pieces. Plastic microfibers, meanwhile, have been found in municipal drinking water systems and drifting through the air. Ingested microplastic particles can physically damage organs and leach hazardous chemicals—from the hormone-disrupting bisphenol A (BPA) to pesticides—that can compromise immune function and stymie growth and reproduction. Both microplastics and these chemicals may accumulate

up the food chain, potentially impacting whole ecosystems, including the health of fish which are consumed by humans.

During the last two decades, significant achievements have been made nationally in the protection and enhancement of water quality in Kenya's lotic and lentic systems. Much of this progress, however, has resulted from controlling point sources of pollution mainly from urban populations bordering water bodies. Pollutant loads from nonpoint sources continue to present problems for achieving water quality goals and maintaining designated uses in many parts of the country. Lake Turkana has a geologically special character of being endorheic, it has inflow from rivers but no outflow. It also has coarse ground under the lake basin making the lake water seep easily into the underground. This is reason enough to maintain the ecological integrity of the lake water for a more productive ecosystem.

This study seeks to map the major point sources of pollution at Ferguson's Gulf in Lake Turkana and to assess effects on fish ecology. The study is crucial since Ferguson's Gulf is one of the most productive areas of the lake with high fish landings and also has the highest population along the lake.

MATERIALS AND METHODS

2.1 Study Area

Lake Turkana is Kenya's northernmost lake lying within the Great Rift Valley. It is an endorheic lake meaning it occurs in a closed basin with no visible outlet. Having a surface area of 7,500 km² makes it the largest lake in Kenya, the world's largest permanent desert lake and the world's fourth-largest salt lake. The lake is 250 km long, has an elevation of 360 m above sea level and has a maximum depth of 120 m making it the longest, lowest lying and deepest lake in Kenya. The Omo, a perennial river, flows southwards from the Ethiopian Highlands for a distance of about 2,000 km into Lake Turkana. Omo River provides over 90% of the water for the lake while the rest is from rivers Turkwel, Kerio, fresh water springs and seasonal rivers. Despite its large size, Lake Turkana is a highly pulsed, variable system as a result of its closed-basin nature, arid surroundings, and its strong dependence on one river for the majority of its inflow (Ojwang et al). The reported yields of Lake Turkana's fisheries have fluctuated greatly over the years. Annual yields from 1993 to 2016 ranged from approximately 900 to 11,000 metric tons, averaging close to 5,000 metric tons (Gownaris *et al.*, 2017).

Ferguson's Gulf, which is the focus of this study, has its source from the main Lake Turkana through the mouth of the gulf, the intermittent River Kalotum and numerous ephemerals. Its water has a pea soup green colour due to the high density of phytoplankton dominated by cyanophyta and bacilliophyta. Zooplankton is dominated by the carnivorous Cyclopoid copepod (*Mesocyclops ogunnus*). The gulf is the most important tilapia habitat in Lake Turkana, especially for the indigenous tilapia species *Oreochromis niloticus*. The Gulf generally experiences annual water level fluctuations of 0.5–1.5 m, but has also dried up completely three times in the last 25 years. The Gulf, which is approximately midway down the lake's western shoreline east of Kalokol market, is protected from the open lake's wave action and direct mixing by the Longech/Namukuse spit. The relatively calm waters of the Gulf support

a different phytoplankton community from the rest of the lake, with primary production rates up to three orders of magnitude higher than in the open lake (Källqvist et al. 1988). Intensive fishing activities conducted using small mesh beach seine, set gillnets, and purse seines are rampant in the area.

The fishery is characterized by boom and bust cycles that are largely dependent on the Omo River's floods. The invasive shrub, *P. juliflora*, heavily covers the shores of the Gulf. Its thick interlocking thorny canopy blocks access to previously important fishing grounds and certain landing beaches.

2.2 Data Collection and Analyses

Six sites at Ferguson's Gulf with varying degrees of pollution were identified and their GPS locations marked using the Raymarine Dragonfly-7 Pro Sonar/GPS. They are; mouth of the gulf, Natirae, Longech, Impressa docking site, middle of the gulf and Kalotum River Mouth. Water quality measurements were taken in situ using the YSI Professional Plus handheld multiparameter meter in the dry season (December) and wet season (May). Fish samples were collected using monofilament gill nets of variable mesh sizes (1-10 inches) from 3 sites. The nets were set and then hauled after 2 hours. Immediately after retrieving the nets, each fish caught was weighed in grams using an electronic weighing scale. The total length of each fish was measured to the nearest centimeter using a measuring board. The composition and diversity of the fish was recorded for each sampling site.

Structured interviews were conducted to learn about the perceived challenges in the region according to each stakeholder institution and also to fishermen in Kalokol and Longech. One interview was conducted for each institution and each fisherman. Stakeholders were interviewed about the sources, effects and challenges in reducing pollution, and mitigation of the challenges. Interviews can provide a rich description of participant perspectives regarding specific challenges and the drivers of these challenges. Data was analyzed using Microsoft excel 2013.

RESULTS AND DISCUSSION

3.1 Water Quality

Table 1: Water quality parameters at selected areas in the Gulf in the dry season

Location	Impressa	Mouth of Gulf	Longech	Middle of Gulf	Natirae
GPS	N: 3 32'52.1"	N: 3 33'07.9"	N: 3 33'02.7"	N: 3 32'13.5"	N: 3 31'44.3"
	E: 35 53'11.1"	E: 35 54'32.6"	E: 35 55'04.7"	E: 35 54'58.5"	E: 35 53'32."
Temperature (°C)	30.1	29.1	29.5	31.6	32.8
Dissolved oxygen (mg/L)	3.63	2.20	4.33	5.16	5.03
Conductivity (µS/cm)	4045	3354	3389	3560	3998
TDS (ppt)	2392	2021	2028	2080	2255.5
Salinity	1.92	1.61	1.62	1.66	1.8
PH	9.75	9.43	9.93	9.58	10.39
ORP (mV)	-86.7	-84.6	-81.2	-82.7	-94.8

Monitoring physico-chemical parameters is very important for studying the influence of these parameters on the distribution of various fish species in aquatic systems. Water quality is influenced by geological, hydrological, climatic and anthropogenic factors such as pollution. All water parameters measured showed no major variations from one site to the other except Oxidation Reduction Potential (ORP) at Natirae which were lower compared to the other five sites. ORP is an important parameter to observe in pollution since it measures the ability of the lake to cleanse itself or break down waste products, such as contaminants and dead plants and animals. It can provide additional information of the water quality and degree of pollution. When the ORP value is high, oxygen present in the water is also in high amount. This means that bacteria that decompose dead tissue and contaminants can work more efficiently. In general, the higher the ORP value, the healthier the lake or river is. In healthy freshwater lakes and rivers, ORP should be relatively between 300-500 mV. However at Ferguson's Gulf it ranged between -81.2 and -94.8 in the dry season and, -68.2 and -91.1 in the wet season. This markedly low levels of ORP could be due to dead and decaying material in the water that cannot be cleared or decomposed.

The situation is exacerbated by the closed nature of the gulf which slows down the process of mixing with the fresher waters of the main lake and the dense human population at Natirae and Longech. The low ORP levels at the gulf could influence the form and persistence of certain contaminants, which affects their toxicity to aquatic life. These conditions can negatively impact fish and other aquatic organisms. Only organisms such as the blue green algae which can tolerate such conditions are thriving in the gulf.

Table 2: Water quality parameters at selected areas in the Gulf in the wet season

	Mouth of Gulf			Natirae			End of Gulf		
Depth	5.3M			3.4M			2.5M		
GPS	N:03°33'.031''			N:03°31'.678			N:03°29'.876		
	E:035°54'577			E:035°54'.171			E:035°54'608		
	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Temperature (°C)	30.1	29.7	29.1	29.7	29.6	29.6	30.3	30.1	30.1
Dissolved oxygen (mg/L)	4.87	4.56	3.94	5.86	5.18	4.82	6.83	6.25	6.03
Conductivity (µS/cm)	3444	3432	3449	3556	3354	3380	3572	3560	3558
TDS (ppt)	2041	2047.5	2080	2119	2002	1976	2112.5	2106	2106
Salinity	1.62	1.63	1.66	1.69	1.59	1.57	1.68	1.68	1.68
PH	10.24	10.26	10.28	10.35	10.26	10.06	10.45	10.42	10.37
ORP (mV)	-68.8	-68.2	-70.2	-87.1	-88.7	-91.1	-80.2	-81.8	-87.5

ORP is often measured in addition to dissolved oxygen which is one of the key parameters that determine life in water. Dissolved oxygen was lowest at the mouth of the gulf (2.20) and highest in the middle of the gulf (5.16) during the dry season. The highest values in the wet season were at the surface waters at the end of the gulf (6.83), followed by Natirae (5.86). Mouth of the gulf had the lowest levels at 4.87. Dissolved oxygen concentrations were found to be higher during the wet season, as compared to the dry season. This is probably due to the increased volume of water during the wet season hence high aeration due to turbulence brought about by storm water and wind action.

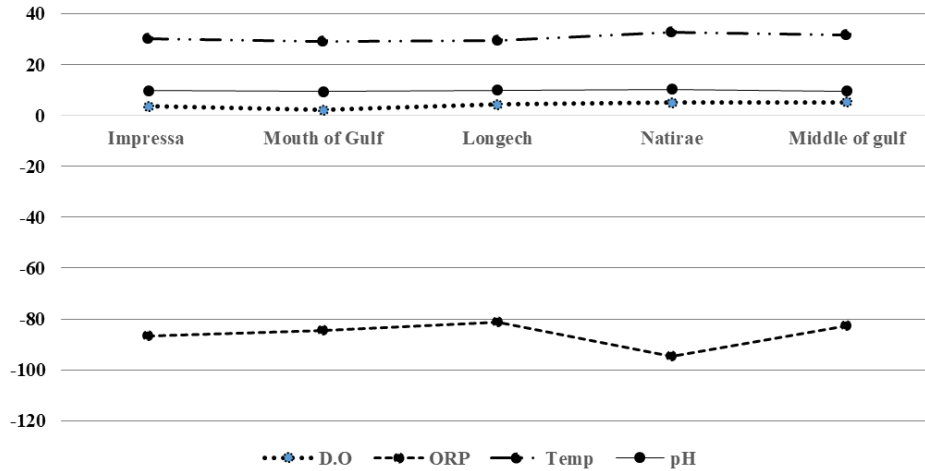


Figure 1: A graph showing water quality parameters at in the gulf during the dry season

The pH values obtained in this study in the dry season ranged from 9.43 to 10.39 which are similar to earlier studies in the gulf (Gownaris et al, 2015; Malala et al, 2019). High pH values recorded at Natirae may be attributed to faecal waste from the Natirae village. A similar range was also recorded in the wet season. The trend for Total Dissolved Solids (TDS) values was similar to that observed for electrical conductivity. This is expected, since most dissolved solids in water are ionic species which tend to increase electrical conductivity. Therefore, TDS values predictably increase with increase in electrical conductivity. TDS and conductivity values were similar to findings by Malala et al (2019).



Figure 2: Unplanned settlement at Natirae and Longech aiding in pollution in Ferguson’s Gulf

3.2 Faecal and Plastic Pollution

Rampant open defecation is still being practiced in Kalokol and Longech area. The residents of the two areas do so either because they do not have a toilet readily accessible or due to traditional cultural practices. Open defecation is the human practice of defecating in the open rather than into a toilet. The practice is common where sanitation infrastructure and services are not available. Sometimes, the infrastructure may be present but not being utilized. Behavior change efforts may still be needed to promote the use of toilets. Ending open defecation is an indicator being used to measure progress towards the Sustainable Development Goal Number 6 (Clean water and sanitation for all). The open defecation the area especially next to the Ferguson’s Gulf has led to a polluted environment with a foul smell in the air. This can cause health problems and diseases such as cholera to the residents. It can also affect the fish directly or indirectly through increased algal blooms in the Gulf.



Figure 3: Indiscriminate waste dumping and faecal pollution at Longech

The prevalence of open defecation is strongly related to poverty and exclusion particularly in rural areas and informal urban settlements as in the case of Kalokol and Longech. Open defecation can lead to water pollution when rain flushes feces that are dispersed in the environment into surface water.

Plastic pollution is most visible in Kalokol and Longech area where garbage collection systems are inefficient. All the plastic trash in Lake Turkana flows from land either through rivers, seasonal streams and wind action. Once in the Lake, much of the plastic trash remains at Ferguson’s Gulf but once caught up in the underwater currents in the lake, it can be

transported to other areas. These plastics may end up settling at the bottom of the lake and take a very long period to decompose. The microplastics from the decomposition can be ingested by fish and end up being harmful to human beings through bioaccumulation. Plastic at the bottom of the lake especially in the inshore areas may end up choking the nesting grounds for fish leading to depressed fish population in the lake.

3.3 Fish Abundance and Diversity

Lake Turkana contains more than 50 described fish species among which 12 are endemic to the lake. The lake has received relatively less human impact compared to other African lakes. The lake, however, still remains vulnerable to pollution and there are currently few efforts being made to conserve its biodiversity. During the study, a total of 135 fish representing 12 species were recorded in the Gulf. There was no major overlap between fish species found in Ferguson's Gulf and the open lake, corroborated by a study by Olilo *et al* (2020). Generally, dominant fish species included *Synodontis schall* (22.2%), *Chrysichthys auratus* (16.3%), *Brycinus nurse* (14.1%) and *Oreochromis niloticus* (12.6%). The fish species are not tolerant to polluted waters. The least dominant were *Schilbe uranoscopus* (0.7%), *Sarotherodon galileus* (2.2%) and *Labeo horie* (2.2%). Environmental parameters, namely, dissolved oxygen, water temperature, and pH seemed to have no significant difference within the Gulf hence their influence on diversity and abundance was negligible. This could ascertain the fact that the variation in the fish abundance and diversity did not depend on the water quality parameters (level of pollution), but probably due to mainly other factors such as location of the sites.

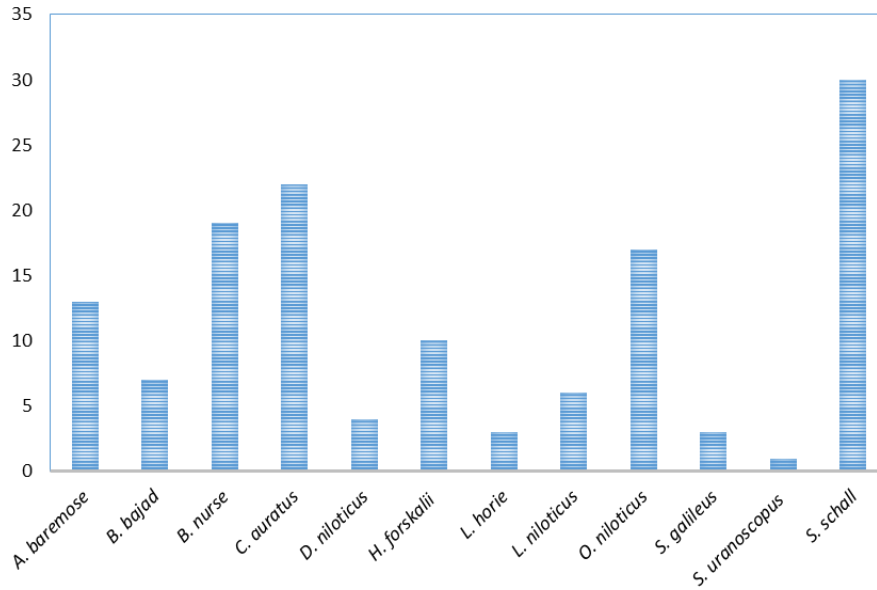


Figure 4: Fish diversity and relative abundance in numbers at Ferguson's Gulf

3.4 Perception of Key Stakeholders on Pollution in Ferguson's Gulf

Knowing the perceptions of local stakeholders regarding the most significant sources of pollution in Lake Turkana allows policymakers to align their policy or adapt information provisions accordingly. This not only ensures a recommendation or policy is widely supported, but also opens the door for policymaker–stakeholder collaborations to more effectively address the challenges in reducing pollution of the lake.

In this study, individual fishermen and representatives of the following regulatory and resource management institutions were interviewed;

1. Turkana County Government, Directorate of Fisheries
2. Turkana County Government, Directorate of Public Health
3. National Environmental Management Authority (NEMA)
4. Kenya Fisheries Service (KeFS)

These institutions are tasked to manage or monitor a certain sector of the environment which includes Lake Turkana. All of them noted that the Ferguson's Gulf is highly polluted by faecal and plastic wastes mainly due to the indiscriminate dumping and open defecation. Use of the prohibited plastic bags is still rampant and NEMA is facing enforcement challenges brought about by political interference. There exists no infrastructure for solid and liquid waste

management around the gulf leading to all wastes being dumped near the lake. The problem is exacerbated by the strong winds in the area which blows the plastic into the gulf. High levels of illiteracy in the area is also a big factor hindering proper waste disposal. Public awareness is key in helping to change mindsets. Another aspect is that human settlements around the gulf are among the most populated in Turkana County with some even occupying riparian land. It is therefore important for relevant authorities to take up the matter and demarcate riparian land to deter encroachers and reduce settlements.

Most of the interviewed fishermen (62%) were aware of the proper disposal methods for oil, plastic and fish waste (Figure 5) but the main challenge they are facing is lack of proper designated disposal areas. Longech was listed as the most polluted area (39%) followed by Natirae (22%) (Figure 6). They suggested that such facilities should be availed to them and an awareness campaign on proper disposal of waste conducted.

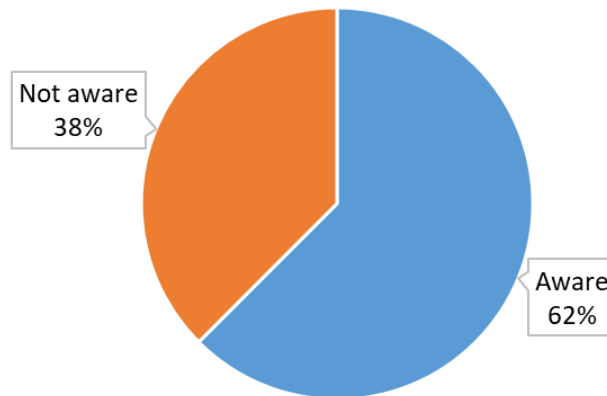


Figure 5: Awareness on proper waste disposal

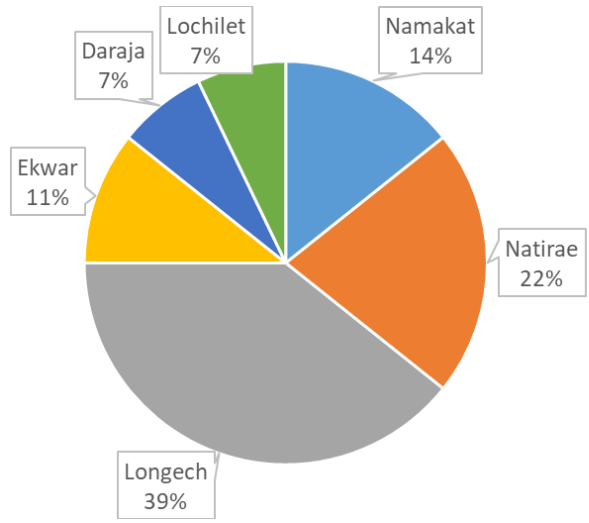


Figure 6: Status of pollution in the Gulf

Fishermen owning engine propelled boats dispose oil waste either in shallow pits near the shore or simply pouring it in the lake. The disposal rate varies from one fishermen to another with most doing it on a daily basis (75%). Heavy metals in oil and lubricants may end up destroying fish habitats and also bio-accumulating in the flesh of fish. Those interviewed said that most of the landing beaches are indeed polluted by plastic, oil, fish waste or faecal matter.

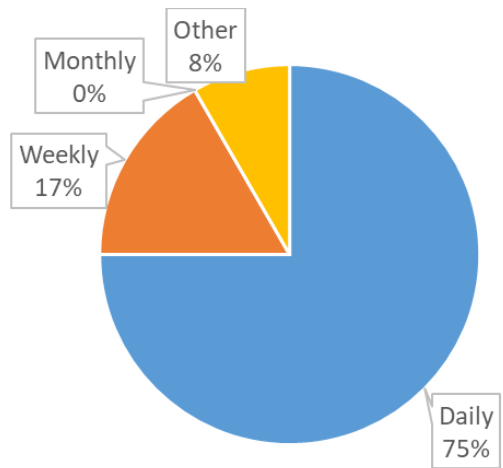


Figure 7: Rate of waste disposal into the Gulf

CONCLUSION AND RECOMMENDATIONS

It can be concluded that faecal, plastic and engine oil wastes are the main contributors to pollution at Ferguson's Gulf but are yet to have any major impact on water quality, and diversity and abundance of fish in the Gulf. These wastes get to the lake mainly through strong winds, flowing water during the rainy season, and during repairs of boat engines. Turkana being one of the counties with high poverty indices in the country coupled with extreme climatic conditions lacks industries or major agricultural practices around the gulf making fertilizers and toxic industrial waste matters of no concern. This study recommends in-depth analysis on microplastics and effects of plastics on feeding and reproduction by demersal fish. Collaboration between Government and communities to embark on sensitization and promotions in proper waste disposal and consistent use of toilets as way of abolishing open defecation is one of the key strategies in checking the levels of pollution in the Gulf.

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The persistence of open defecation in fishing communities of Lake Victoria; A reflection on inconsistent use of toilets in Ukerewe Island, Tanzania <https://catalog.ihsn.org/index.php/citations/84118>

Water encyclopedia, <http://www.waterencyclopedia.com/Oc-Po/Pollution-of-Lakes-and-Streams.html#ixzz6u03POwUL>

APPENDICES

Appendix 1: Dissemination letter to Turkana County Government, Directorate of Fisheries

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 52-30500
Lodwar
TURKANA COUNTY
KENYA



KMF/RS/2021/ C2.1. (i)

To: County Director of Fisheries
Ministry of Pastoral Economy and Fisheries
Turkana County Government
P.O. Box 52 – 30500
Lodwar

Dear Sir,

RE: SHARING 2020-21 FY FACT SHEET/BRIEF

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 mandated to carry out research in marine and freshwater fisheries, aquatic biology, aquaculture, environmental chemistry, ecological, geological and hydrological studies, socio-economics as well as chemical and physical oceanography.

In this regard, KMFRI conducted a number of research expeditions in 2020-2021 financial year on "*Map and monitor major point sources of pollution and assess their effect on fish ecology in Ferguson's Gulf of Lake Turkana*" and came up with technical report and Fact sheet/brief.

The purpose of this letter is to share the findings in a summarised fact sheet/brief 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,

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

Dr. Christopher M. Aura (PhD)

For: Director/CEO, KMFRI

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE



LAKE TURKANA STATION
P.O. BOX 205-30500
LODWAR



MEETING: Dissemination of PC target C 21 ii
DATE: 24th June 2021
VENUE: County Director of Fisheries office - Lodwar

	NAME	ORGANIZATION	DESIGNATION	PHONE NUMBER	SIGNATURE
1.	Namwaya David W.	Tea-Fisheries	DDF	071668381	<i>[Signature]</i>
2.	John D-NAPAEA	KMFR1	SRS	077049722	<i>[Signature]</i>
3.	Jeanes Loat Kagumbor	KMFR1	RS II	0723303573	<i>[Signature]</i>
4.	Enrice V. Davis	KMFR1	MF. 1	0721161923	<i>[Signature]</i>
5.	Casimero D. Dillo	KMFR1	RS I	0721413725	<i>[Signature]</i>
6.	Maurice Obirew	KMFR1	RS II	0719517205	<i>[Signature]</i>
7.					
8.					
9.					
10.					
11.					

Appendix 2: Dissemination letter to Kenya Fisheries Service

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/RS/2021/ C2.1. (i)

Date: 21st June 2021

To: Kenya Fisheries Service (KeFS)
Turkana Regional Offices
P.O. Box 47 – 30500
Lodwar

Dear Sir,

RE: SHARING 2020-21 FY FACT SHEET/BRIEF

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 mandated to carry out research in marine and freshwater fisheries, aquatic biology, aquaculture, environmental chemistry, ecological, geological and hydrological studies, socio-economics as well as chemical and physical oceanography.

In this regard, KMFRI conducted a number of research expeditions in 2020-2021 financial year on “*Map and monitor major point sources of pollution and assess their effect on fish ecology in Ferguson’s Gulf of Lake Turkana*” and came up with technical report and Fact sheet/brief.

The purpose of this letter is to share the findings in a summarised fact sheet/brief 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/CEO, KMFRI



KENYA MARINE AND FISHERIES RESEARCH INSTITUTE



LAKE TURKANA STATION

P.O. BOX 205-30500

LODWAR

ASSISTANT DIRECTOR OF FISHERIES
TURKANA REGIONAL OFFICE
P.O. BOX 47 LODWAR

MEETING: Dissemination of PC target C21j
 DATE: 24th June 2021
 VENUE: Kenya Fisheries office Lodwar

	NAME	ORGANIZATION	DESIGNATION	PHONE NUMBER	SIGNATURE
1.	JOHN O. NAKARA	KMFR1	SRS	0716487020	<i>[Signature]</i>
2.	James East Keyombe	KMFR1	RSTP	0723303373	<i>[Signature]</i>
3.	Nithyas Omire	KMFR1	MS-1	0701161972	<i>[Signature]</i>
4.	Gasianes O. Dillo	KMFR1	RS1	0721413728	<i>[Signature]</i>
5.	JOSEPH VASUTI	KEFS	PFO	092135590	<i>[Signature]</i>
6.					
7.					
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9.					
10.					
11.					

Appendix 3: Dissemination letter to Lake Turkana BMU Network

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

Telephone 020-8021560/1
020-2353984
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/RS/2021/ C2.1. (i)

Date: 21st June 2021

To: Chairman
Lake Turkana Beach Management Unit (BMU)
P.O. Box 11 – 30500
Lodwar

Dear Sir,

RE: SHARING 2020-21 FY FACT SHEET/BRIEF

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 mandated to carry out research in marine and freshwater fisheries, aquatic biology, aquaculture, environmental chemistry, ecological, geological and hydrological studies, socio-economics as well as chemical and physical oceanography.

In this regard, KMFRI conducted a number of research expeditions in 2020-2021 financial year on “Map and monitor major point sources of pollution and assess their effect on fish ecology in Ferguson’s Gulf of Lake Turkana” and came up with technical report and Fact sheet/brief.

The purpose of this letter is to share the findings in a summarised fact sheet/brief 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/CEO, KMFRI

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE



LAKE TURKANA STATION
P.O. BOX 205-30500
LODWAR



MEETING: Dissemination of PC target on Mapping & Monitoring Major point sources of pollution
 DATE: 23/06/21
 VENUE: BMU OFFICE

	NAME	ORGANIZATION	DESIGNATION	PHONE NUMBER	SIGNATURE
1.	John O. Njoroge	KMFR I	SRS	071048770	<i>[Signature]</i>
2.	Jeanes Kait Kogoube	KMFR I	RS II	0723303373	<i>[Signature]</i>
3.	Omira Vitaris	KMFR I	RS I	0721161923	<i>[Signature]</i>
4.	Casiano D. Ojilo	KMFR I	RS I	072143728	<i>[Signature]</i>
5.	Maurice Ojien	KMFR I	RS II	0719517205	<i>[Signature]</i>
6.	Stephen Eka Ekuoh	BMU Network Turkana	CHAIRMAN	0713385061	<i>[Signature]</i>
7.					
8.					
9.					
10.					
11.					



KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

FRESH WATER SYSTEMS

FACT SHEET

KMF/GOK/2021/C21.i



Map and Monitor Major Point Sources of Pollution and Assess their Effect on Fish Ecology in Ferguson's Gulf of Lake Turkana

June 2021

Pollution is the introduction of contaminants into the natural environment that cause adverse change. It reduces water quality affecting health and diversity of aquatic organisms including fish.

AUTHORS

Keyombe J.L.A.
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Olilo C.O.
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KMFRI Headquarters

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KMFRI Lake Turkana Station

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What is Pollution?

- Pollution is the introduction of contaminants into the natural environment that cause adverse change. It is a point source pollution when contaminants from a specific source enter a water body and non-point pollution when the contaminants come from diffuse sources.
- Pollution reduces water quality affecting health and diversity of aquatic organisms including fish.

Why Ferguson's Gulf?

- Lake Turkana found in the north west of Kenya is endorheic, has a surface area of 7,500 km² making it the largest lake in Kenya, the world's largest permanent desert lake and the world's fourth-largest salt lake.
- Ferguson's Gulf, which is the focus of this study, is connected to Lake Turkana through the mouth of the gulf. The intermittent River Kalotum and numerous ephemerals also provide inflows.
- This study sought to map the major sources of pollution at Ferguson's Gulf and to assess effects on fish ecology. It is crucial since the Gulf is the most densely populated area along the lake with high fish landings.

How was the Study Conducted?

- Six sites at Ferguson's Gulf with varying degrees of pollution were identified and their coordinates marked using Raymarine Dragonfly-7 Pro Sonar/GPS.
- Water quality measurements were taken in situ using YSI Professional Plus handheld multiparameter meter.
- Fish samples were collected using monofilament gill nets of variable mesh sizes.
- Structured interviews were conducted to learn about the perceived challenges in the Gulf according to each stakeholder institution and fishermen.
- Data was analysed using Microsoft Excel 2013.

Key Findings

- Results indicate high levels of faecal and plastic pollution in the gulf.



Figure 1: Indiscriminate waste dumping and faecal pollution at Longech

- Rampant open defecation is still being practiced in Kalokol and Longech area. The residents of the two areas do so either because they do not have a toilet readily accessible or due to traditional cultural practices. Behavior change efforts may still be needed to promote the use of toilets.
- Plastic pollution is most visible in Kalokol and Longech area where garbage collection systems are inefficient. All the plastic trash in Lake Turkana flows from land either through rivers, seasonal streams and wind action. Once in the Lake, much of the plastic trash remains at Ferguson's Gulf but once caught up in the underwater currents in the lake, it can be transported to other areas.
- These plastics may end up settling at the bottom of the lake and take a very long period to decompose. The microplastics from the decomposition can be ingested by fish and end up being harmful to human beings through bioaccumulation. Plastic at the bottom of the lake especially in the inshore areas may end up choking the nesting grounds for fish leading to depressed fish population in the lake.
- Environmental parameters, namely, dissolved oxygen, water temperature, Oxidation Reduction Potential (ORP) and pH seemed to have no significant difference within the Gulf hence their influence on diversity and abundance was negligible. However, at Natirae ORP levels were lower compared to the other five sites.
- ORP is an important parameter to observe in pollution since it measures the ability of the lake to cleanse itself or break down waste products, such as contaminants and dead plants and animals.
- In general, the higher the ORP value, the healthier the lake or river is. In healthy freshwater lakes and rivers, ORP should be relatively between 300-500 mV. However at Ferguson's Gulf it ranged between -81.2 and -94.8 in the dry season and, -68.2 and -91.1 in the wet season. This markedly low levels of ORP could be due to dead and decaying material in the water that cannot be cleared or decomposed

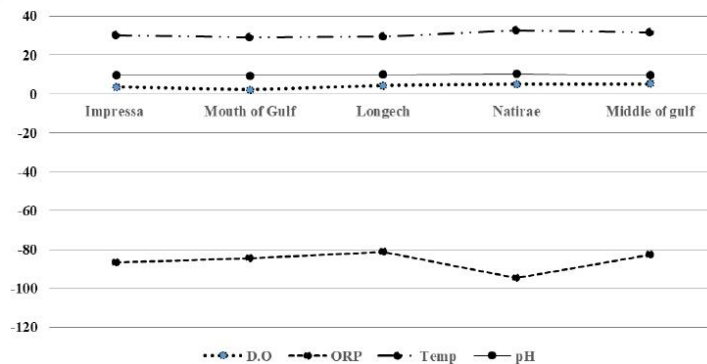


Figure 2: A graph showing water quality parameters at in the gulf during the dry season

- A total of 135 fish representing 12 species were recorded in the Gulf. There was no major overlap between fish species found in Ferguson’s Gulf and the open lake. Generally, dominant fish species included *Synodontis schall* (22.2%), *Chrysiichthys auratus* (16.3%), *Brycinus nurse* (14.1%) and *Oreochromis niloticus* (12.6%). The fish species are not tolerant to polluted waters. The least dominant were *Schilbe uranoscopus* (0.7%), *Sarotherodon galileus* (2.2%) and *Labeo horie* (2.2%).

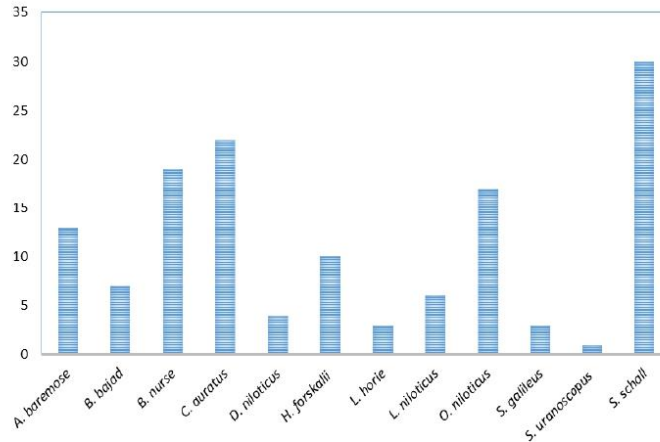


Figure 3: Fish diversity and relative abundance in numbers at Ferguson’s Gulf

- Stakeholder Institutions (Turkana County Government, Directorate of Fisheries and Directorate of Public Health, National Environmental Management Authority (NEMA), Kenya Fisheries Service (KeFS)) noted that Ferguson’s Gulf is highly polluted by faecal and plastic wastes mainly due to the indiscriminate dumping and open defecation. Use of the prohibited plastic bags is still rampant and NEMA is facing enforcement challenges brought about by political interference. There exists no infrastructure for solid and liquid waste management around the gulf leading to all wastes being dumped near the lake. The problem is exacerbated by the strong winds in the area which blows the plastic into the gulf. High levels of illiteracy in the area is also a big factor hindering proper waste disposal. Public awareness is key in helping to change mindsets.
- Most of the interviewed fishermen (62%) were aware of the proper disposal methods for oil, plastic and fish waste but the main challenge they are facing is lack of designated disposal areas. They suggested that such facilities should be availed to them and an awareness campaign on proper disposal of waste conducted.

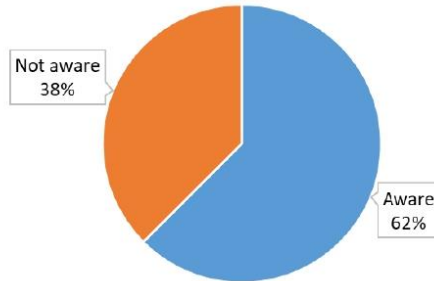


Figure 4: Awareness on proper waste disposal

- They listed Longech as the most polluted area (39%) followed by Natirae (22%).

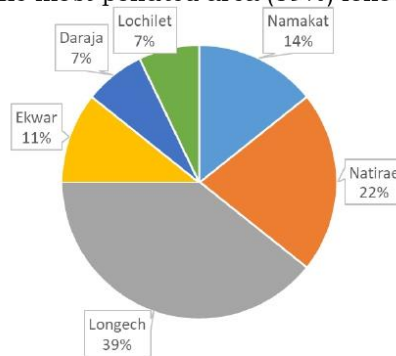


Figure 5: Status of pollution in the Gulf

- Fishermen owning engine propelled boats dispose oil waste either in shallow pits near the shore or simply pouring it in the lake. The disposal rate varies from one fishermen to another with most doing it on a daily basis (75%). Heavy metals in oil and lubricants may end up destroying fish habitats and also bio-accumulating in the flesh of fish.

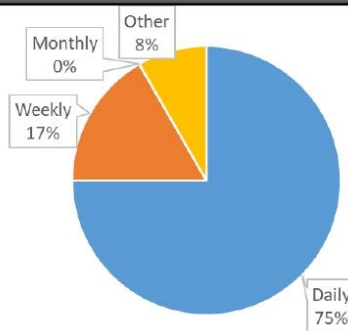


Figure 1: Rate of waste disposal into the Gulf

Conclusion

- ❖ Faecal, plastic and engine oil wastes are the main contributors to pollution at Ferguson’s Gulf but are yet to have any major impact on water quality, and diversity and abundance of fish in the Gulf. These wastes get to the lake mainly through strong winds, flowing water during the rainy season, and during repairs of boat engines.
- ❖ Turkana being one of the counties with high poverty indices in the country coupled with extreme climatic conditions lacks industries or major agricultural practices around the gulf making fertilizers and toxic industrial waste matters of no concern.

Recommendations

- ❖ This study recommends in-depth analysis on microplastics and effects of plastics on feeding and reproduction by demersal fish.
- ❖ Collaboration between Government and communities to embark on sensitization and promotions in proper waste disposal and consistent use of toilets as way of abolishing open defecation is one of the key strategies in checking the levels of pollution in the Gulf.

Appendix 5: Forwarding letter by Director FWS to Director General

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

TELEPHONE: KISUMU 254770567443
E - mail: kmfkismucentre@yahoo.com
When replying please quote
Ref. No. KMF/RS/2020/ C21.i
If calling or telephoning ask
For: Dr. Aura
Please address your reply to
Ag. DIRECTOR



KISUMU CENTRE
P.O. BOX 1881
KISUMU
KENYA
DATE: 16/06/2021



The Director General
Kenya Marine and Fisheries Research Institute
Headquarter and Mombasa Centre
P.O. Box 81651 080100
MOMBASA

RE: SUBMISSION OF TECHNICAL REPORT FOR PC PERIOD 2020-21

The above refers,

KMFRI Freshwater systems (FWS) have successfully implemented the 2020-2021 PC on **“Mapping and Monitoring Major Point Sources of Pollution and Assess their effect on fish Ecology in Lakes Victoria, Baringo and Turkana”**.

Herein attached is the technical report and fact sheet, which highlights activities involved.

We therefore submit this report and fact sheet for your perusal and dissemination to the relevant stakeholders. Your support is highly appreciated.

Thank you.

Dr. Christopher M. Aura (PhD)
Ag. Director - FWS

*AS Director FWS
Disseminate
18/6/2021*

Appendix 6: Forwarding letter by Station Coordinator to Director FWS

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

TEL: +254 710 487 520
FAX:
E-mail: kmfriturkana@yahoo.com
When replying please quote
Ref: no.
and date
If calling or telephoning ask
for
Please address your reply to
STATION COORDINATOR



TURKANA STATION
P.O. Box 205
LODWAR 30500
KENYA

KMF/TUR/CON/AD/44/

14th June 2021

The Director-General,
KMFRI,
P.O. Box 81651,
MOMBASA.

THROUGH

The Director (Fresh Water Systems),
KMFRI,
P.O. Box 1881-40100,
KISUMU.

**RE: SUBMISSION OF 2020/2021 TECHNICAL REPORT ON
PERFORMANCE CONTRACT TARGET NO. C21 (i) FOR LAKE
TURKANA**

Sir, please find attached a technical report on the implementation of above referred target category on Stock Assessment and Ecology of Key Commercial Fisheries of Freshwaters titled: “**Map and monitor major point sources of pollution and assess their effect on fish ecology in Ferguson’s Gulf of Lake Turkana and prepare a technical report C21 (i).**” for your information and further attention. Kindly consider sharing it with various stakeholders

Thank you

A handwritten signature in blue ink, appearing to read 'J. Malala', is written above the printed name.

John Malala
Station Co-ordinator
KMFRI – TURKANA.

**BUDGET FOR MAPPING AND MONITORING MAJOR POINT SOURCES OF
POLLUTION AND ASSESS THEIR EFFECT ON FISH ECOLOGY IN FERGUSON'S GULF
OF LAKE TURKANA**

A. Travel & Communication	Qty	Unit	Unit cost (KShs)	Total cost (KShs)
Vehicle fuel	60	Litres	110	6,600
Boat fuel	50	Litres	115	5,750
2T Oil	1	Litres	1,000	1,000
Sub-total				13,350
B. Staff Allowances	Lunch Allowance	No. of days	DSA (1 day)	Total
John Malala	1,500	3	8,400	12,900 ✓
Casianes Olilo	1,000	3	7,000	10,000 ✓
James Last Keyombe	1,000	3	7,000	10,000 ✓
Maurice Obiero	1,000	3	7,000	10,000 ✓
Mathew Moruessa	750	3	4,200	6,450
Justus Long'ok	750	3	4,200	6,450
Thomas Kebo	750	3	-	2,250
Pius Alal	750	3	-	2,250
Vitalis Omire	750	3	4,200	6,450
Abraham Onchari	500	3	4,200	5,700 ✓
Sub-total				72,450
C. Other expenses				
Stationery				2,000
Drinking water	7	bales	500	3,500 ✓
Purchase of fresh fish specimen				5,000
Hire of local labour	7		1,000	10,000
Nose masks	2	boxes	1,000	2,000 ✓
Sanitizer	2	Bottles	1,000	2,000 ✓
Sub-total				24,500
GRAND TOTAL (A+B+C)				110,300

Appendix 8: Pollution perception questionnaire

**KENYA MARINE AND FISHERIES RESEARCH INSTITUTE
LAKE TURKANA STATION
P.O. BOX 205-30500
LODWAR**

**MAPPING AND MONITORING MAJOR POINT SOURCES OF POLLUTION AND ASSESS
THEIR EFFECT ON FISH ECOLOGY IN FERGUSON'S GULF OF LAKE TURKANA**

This interview is being conducted by Kenya Marine & Fisheries Research Institute (KMFRI) to gauge the perception of stakeholders on the major sources of pollution and their effect on fish ecology in Ferguson's Gulf of Lake Turkana for informed management decisions.

All information given will be treated with utmost confidentiality and strictly used for the purpose of this study. Your cooperation in this study is therefore highly appreciated. Thank you in advance for agreeing to this interview.

Questionnaire No.:	
Interview Date:	
Enumerator's Name:	
Respondent's Name:	
Name of landing beach	
Name of BMU:	

PART A: FISHERMEN/ENGINE REPAIRERS/FISH PROCESSORS/RETAILERS/HOTEL OPERATORS

1. How do you dispose gearbox oil/fish waste/cooking oil/plastic waste?

2. How often do dispose gearbox oil/fish waste/cooking oil/ plastic waste?

(a) Daily (b) One week (c) One month (d) Other _____

3. Do you know the proper way of disposing gearbox oil/fish waste/cooking oil/ plastic waste?

(a) Yes. How? _____

(b) No

4. Do you think your way of waste disposal has any effect on fish in Lake Turkana?

(a) Yes. How? _____

(b) No

5. Have you noticed any changes on the water or fish/fish population at the point of waste disposal? If yes, explain

6. Which challenges do you encounter making you to dispose improperly gearbox oil/fish waste/cooking oil/ plastic waste?

7. Which recommendations would you make to ensure proper waste disposal along Ferguson's Gulf?

8. Which area within Ferguson's Gulf do you consider the most polluted?

PART B: LOCAL LEADERS (CHIEF, HEALTH OFFICIAL, BMU OFFICIALS)

9. Which area within Ferguson's Gulf do you consider the most polluted?

10. Which are the main sources of pollution in Ferguson's Gulf?

11. Does your organization/partners have any interventions to ensure proper waste disposal? If yes, explain

12. Are there any recorded arrests in 2020 for people who are improperly disposing wastes? If yes, how many

13. Have you witnessed/recorded any cases of fish kills/major pollution in the Gulf? If yes, when?

14. How many outbreaks of waterborne diseases have occurred this year and in which year?

15. Which recommendations would you make to ensure proper waste disposal along Ferguson's Gulf?

PART C: KEY STAKEHOLDERS (COUNTY FISHERIES DIRECTOR, ASDP, KENYA FISHERIES SERVICE)

16. Which area within Ferguson's Gulf do you consider the most polluted?

17. Which are the main sources of pollution in Ferguson's Gulf?

18. Does your organization have policies guiding waste disposal along Lake Turkana?

19. Do you think the current rate of waste disposal along Ferguson's Gulf has any effect on fish in Lake Turkana?

(c) Yes. How? _____

(d) No

20. Which recommendations would you make to ensure proper waste disposal along Ferguson's Gulf?
