Quantifying fish bycatch in Lake Turkana: Potential for sustainable livelihood diversification

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Abstract

The sustainability of fisheries in Lake Turkana is threatened by the pervasive issue of fish bycatch, wherein non-target species are unintentionally caught in fishing gear. This paper addresses this concern, recognizing its ecological and economic ramifications. Utilizing a mixed-methods approach, data was gathered on fish species diversity, bycatch rates and discard practices from various fishing gear types. Results indicate a predominance of gillnets and longlines in the fishery, with tilapia, silverside, and Nile perch comprising the majority of commercial catches. The species caught in the various nets were *Alestes baremose* (2.5"), *Synodontis schall* (entangled) and *Distichodus niloticus* (4" and above). Mean catch per boat varied depending on the effort group but was highest for motorized sesse boats (SMS) at 21.5 ± 12.3 kg per boat. *Lates longispinis* and catfish contributed over 95% of the bycatch's commercial value. Despite concerns over the potential impact on endangered species, gillnets with single netting remained popular due to perceived selectivity. Importantly, the study identifies the potential for bycatch species to contribute significantly to fishery yields and local economies, emphasizing the need for multispecies management strategies. By quantifying the extent of bycatch and evaluating its economic value, this research informs efforts towards sustainable livelihood diversification and fishery management in Lake Turkana.

Keywords words: bycatch, commercial viability, gear selectivity, target catches

Introduction

The issue of fish bycatch in Lake Turkana fishery is a growing concern (Cohen *et al.,* 1996; Odada *et al.,* 2003 Gownaris *et al.,* 2015) that poses significant challenges to the sustainable management of the fishery. According to the studies, one of the main challenges in the fishing industry is overfishing, which is exacerbated by the issue of fish bycatch. Fish bycatch refers to the unintentional catch of non-target fish species and other marine creatures in fishing nets or gear. This problem is particularly prevalent in Lake Turkana, where there are indications of destructive fishing methods due to increased presence of illegal fishing gears (Mgana *et al.*, 2019). These destructive methods, such as the use of inappropriate fishing gear or techniques, contribute to the high levels of fish bycatch in the Lake. The high fishing pressure in Lake Turkana also contributes to the issue of fish bycatch (Kolding, 1995). As a result of fish bycatch, there is a decline in catch per unit effort in certain areas of the lake. This not only affects the population of target fish species, but also leads to the depletion of non-target species and disrupts the balance of the ecosystem.

The challenge of fish bycatch in the Lake Turkana fishery extends beyond ecological concerns by having economic implications. The high levels of bycatch translate to a significant loss of potential income for fishers, particularly those who depend heavily on the fishery. Fishing for a certain target species frequently leads to the capture and killing of non-target species. Discarded fish often include juveniles of commercially valuable species, further hindering the fishery's long-term health and overall productivity (Mwanjela, 2011). This economic strain can incentivize less selective fishing practices to maintain income, creating a vicious cycle of declining fish stocks and increased bycatch. Bycatch can have serious effects on populations, food webs, and ecosystems in numerous forms. The economic impact of bycatch can have a significant impact not only on fisheries' yields, but also on allocations among competing fisheries. It is estimated that worldwide, 27 million tons of bycatch is caught every year, accounting for 40 percent of the world's annual marine catch (Davies *et al.*, 2009). The lack of extensive monitoring systems in most places to assess bycatch and integrate it into population and multispecies models makes it difficult to fully comprehend the impacts of bycatch and the efficacy of mitigation efforts (Read *et al.*, 2006).

The scientific understanding of Lake Turkana has benefitted greatly from past research on limnology, fish biology, and aquatic ecology. However, crucial knowledge gaps remain. While development plans hinge on a comprehensive understanding of the Lake's current state, aspects like species and quantity dynamics, socioeconomics and water balance are not well documented (Kolding, 1993; Muška *et al.*, 2012). Fish bycatch is a particular area of concern, with limited data on rates across species, fisheries, and lake basins. The effectiveness of existing mitigation measures and the demographic responses to bycatch are also poorly understood. With being majority artisanal fishers, it is likely that bycatch forms part of their 'daily bread' for consumption rather than being discarded. However, quantitative data to document this is scarce (Seto, 2017). To address this knowledge gap, this study aims to assess the status of fish bycatch in Lake Turkana. By identifying key bycatch issues, collecting quantitative and qualitative data, and finally determining the commercial value of bycatch, this research seeks to explore its potential as an alternative source of income for fishers.

Materials and methods

Lake Turkana, situated within the northern Kenyan Rift Valley, is the largest of the Country's lakes measuring about 250km long, 30km wide

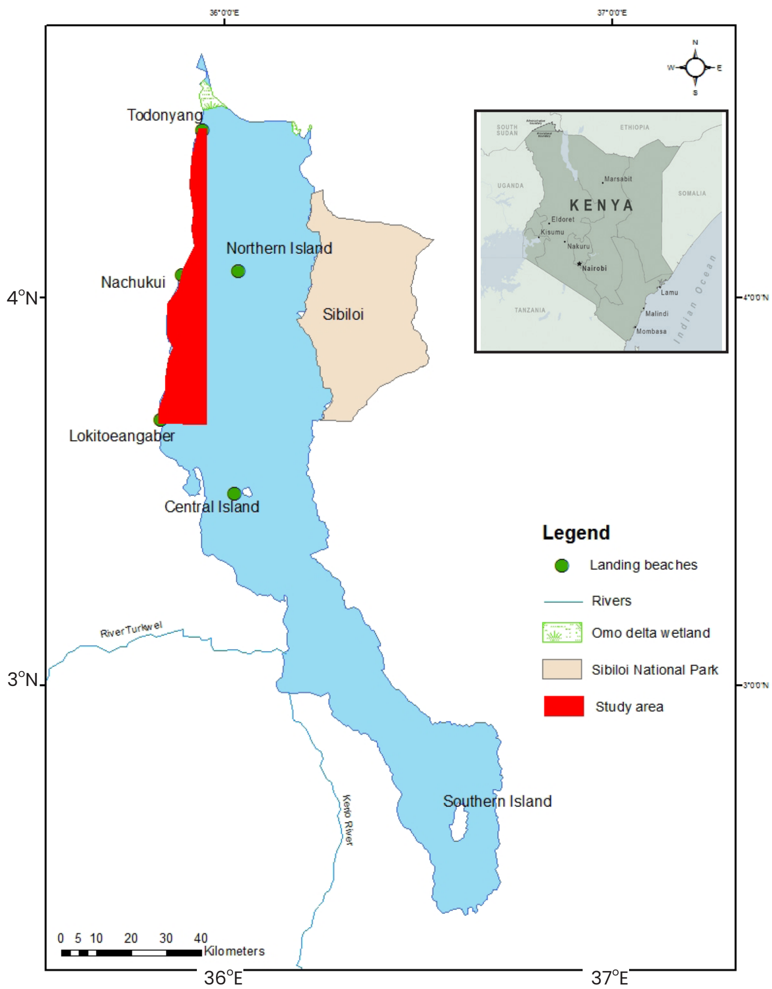

Figure 1. Map of Lake Turkana showing the study area (Source: Author).

and a surface area of 7,000 km². With a maximum depth of 125 meters and an average depth of 35 meters, it holds the distinction of being the world's largest permanent desert lake. The predominant inhabitants of the basin surrounding Lake Turkana are the Turkana people, who have historically practiced pastoralism, with a focus on livestock rearing and handicraft production. However, due to increasing incidences of erratic rainfall patterns and extended droughts, a growing segment of the Turkana population has turned to fishing as a primary source of livelihood. This shift in alternative resource utilization has raised concerns regarding the long-term sustainability of Lake Turkana's fish stocks, necessitating studies into the fishing practices on the Lake to determine whether they are sustainable for the continued well-being of both the Lake's ecosystem and the communities dependent on the lake.

Figure 1 shows the areas of Lake Turkana where this study was conducted. This was predominantly on the Western shores of the lake since this is where most fish is landed. This study aimed at collecting both qualitative and quantitative data. Data on fish species diversity, bycatch and discards was obtained from gillnet, purse seine and beach seine gears used by fishermen. The number of nets was estimated by counting the number of nets joined together while mesh size was measured using a tape measure to obtain the full mesh distance between the centres of the two opposite knots of a stretched mesh. Fish were sorted into target catch, bycatch and discards. Data was collected at designated fishing sites using a team of locally hired data recorders and KMFRI staff visited the landing sites to administer questionnaires by orally interviewing local fishermen and conducting key informant discussions. Vessels were categorized into five groups namely Sesse Motorised Canoes (SMS), Sesse Paddled Canoes (SP), Parachutes (PA), Rafts (RT) and Fibre Fishing (FF), while fishing gears were grouped into two, namely, gillnets and hook and line. Data collected included catch weight, composition by species and size, fishing gears and methods, craft type and length, value of catch and fishing frequency.

Results

Number, type, distribution and size of fishing vessels and gear

Thirty fishing vessels were enumerated at the 11 fish landing sites within the six beach management units (BMUs) located in Turkana North subcounty. Figure 2 shows the proportion of each vessel type used in the Lake Turkana fishery. Sesse Motorized Canoe (SMS) was the most dominant fishing vessel used at Keriakar in Loarengak BMU. Fishers from Lowarengak fish at the Omo River delta, which is an insecure, conflict prone zone, and fishers must use motorized boats due to limiting weather conditions. Raft fishers dominated landing sites such as Lomekwi and Loropio as most fishers lack fishing gear. Table 1 shows the mean length of the vessels deployed at the selected landing beaches. Fishing rafts had the shortest length (2.8 ± 0.1 cm). This is because they are mainly operated by a single fisher and constructed shorter for ease of handling.

Fishers in Lake Turkana deploy mainly gillnets and longlines. The size of the commonly used gillnets ranges is from 2.5″ (84 mm) stretched mesh to 7″ (180 mm). The 4″ (101 mm) mesh was the most deployed (35.7%) followed by 3.5″ (89 mm) and 2.5″ (84 mm) nets. The three gillnet sizes constitute 75.1% of all the nets deployed in the Northern part of Lake Turkana. The species targetted using the various nets are *Alestes baremose* (2.5″), *Synodontis schall* (entangled) and *Distichodus niloticus* (4″ and above). As shown in Fig. 3, mean catch per boat varied depending on the effort group but was highest for motorized sesse boats (SMS) at 21.5 ± 12.3 kg per boat. Sesse paddled canoes (SP) fished daily during the week, had the highest number of crew per boat and spent less time in the lake as compared to the other effort groups. Sesse motorized boat had the highest catch per unit effort (CPUE) at 48.2 kg boat^{-1} day^{-1} while raft fishers recorded the lowest CPUE.

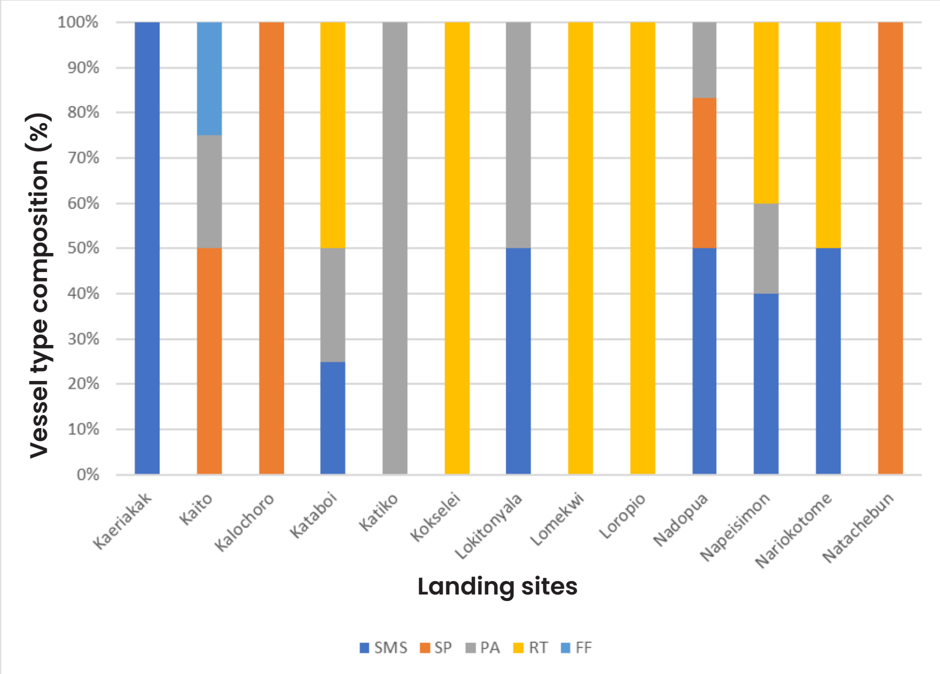

Figure 2. Percentage occurrence of various types of fishing vessels enumerated along north western Lake Turkana. The gear types were: Sesse Motorised Canoes (SMS), Sesse Paddled Canoes (SP), Parachutes (PA), Rafts (RT), and Fibre Fishing Boats (FF).

sought-after commodity, worth more than five times the price of bulk *L. niloticus* and *O. niloticus* at over KShs. 150 per kg. Tilapias are targeted in shallow areas using seine nets and are an especially important fishery resource during years of high production. Ferguson's Gulf, for example, with an area of only 10 km^2, produced about 16,000 tonnes of tilapia at its peak in 1976 (Kimani *et al.,* 2018).

Table 1. Mean length fishing vessel types encountered along the northwestern side of Lake Turkana. The vessel types were: - Sesse Motorised Canoes (SMS), Sesse Paddled Canoes (SP), Parachutes (PA), Rafts (RT), Fibre Fishing (FF).

Vessel type	SP	FF	SMS	PA	RT
Mean Length (m)	7.8	7.1	8.1	7.5	2.8
Standard Error	0.5	0.2	0.3	0.3	0.1
95% C.L.	+/-1.0	+/-0.3	+/-0.6	+/-0.5	+/-0.3

Fish Species composition and commercial importance

Even though there are about twelve commercially exploited fish species in Lake Turkana (Table 3), tilapias are particularly targeted because of their popularity both in the local communities and markets around the country. Top predators also target tilapia as a key component of their diet. *Lates niloticus* and *Oreochromis niloticus*, two of the most important species by volume in the Lake Turkana Fishery, are also the most commercially valuable. The swim bladder of *L. niloticus* is a highly

Bycatch fish prices and their commercial viability

The presente study revealed that tilapia, silverside, and Nile perch dominate commercial catches, making up over 80% of the total haul. Interestingly, the most common bycatch species were the dwarf Lake Turkana robber and the dwarf perch (Table 4). The study identified potential for the dwarf robber to be specifically targeted for industrial fish feed production, given its significant bycatch volumes. Another interesting finding was the lack of data on the dwarf perch, despite annual bycatch reaching nearly 1000 tons, contributing to the gap in its IUCN categorization. Gillnets with single netting were found to be the most commonly used fishing gear, likely due to the belief in their selectivity for specific fish sizes. However, the study raises concerns about the potential for these nets to also catch endangered species in certain areas. To address this, researchers recommend further studies to develop methods for reducing unintended catch of endangered fish, particularly in breeding and habitat areas of the lake. It's important to note that this study acknowledges limitations in its analysis, as it did not consider variations in gillnet construction that can also influence bycatch.

Table 2. Catch per unit effort of Lake Turkana and characteristics of vessels used on the fishery.

	Parachute Paddled / Motorised	Raft	Sesse Motorized	Sesse paddled
Catch (Kg boat^{-1})				
Mean	16.5	3.7	21.5	14.5
SE	5.5	1.2	12.3	8.4
CL	10.7	2.4	24.0	16.5
Days fished week^{-1}				
Mean	6.3	6	5.2	7
SE	0.8	1	1.4	0
CL	1.5	2.0	2.8	
Hours fished Day^{-1}				
Mean	12	12	6.5	9.5
SE	0	0	2.0	2.5
CL			3.9	4.9
Crew Boat^{-1}				
Modal	4	1	4.0	6.0
CPUE (Kg Boat^{-1} Day^{-1})				
CPUE	**37.0**	**8.3**	**48.2**	**32.5**

Table 3. Commercial fishes of the Lake Turkana Fishery. Source: Own data collection.

	Fish scientific name	Common name	Local name	Average Monthly Landings 2021 (Tonnes)	Percentage of Total Commercial Landings (2021)
1	*Oreochromis niloticus*	Tilapia	Kokine	595.10	45.2%
2	*Alestes baremose*	Silverside	Juse	321.17	24.4%
3	*Lates niloticus*	Nile Perch	Iji	134.52	10.2%
4	*Synodontis schaal*	Catfish	Tir	92.98	7.1%
5	*Bagrus bayad*	Black Nile catfish	Loruk	68.75	5.2%
6	*Labeo horie*	Turkana carp	Chubule	62.45	4.7%
7	*Hydrocynus forskalii*	Tigerfish	Lokel	41.50	3.2%
	TOTAL			1,223.50	100%

Untargeted fish from Lake Turkana form a crucial part of the fish catches that are landed from the fishery annually (Table 5). The Lake Turkana fishery bycatch is composed of species including *Brycinus minutus, Lates longispinis, Schilbe uranoscopus, Labeobarbus bynni, Clarias gariepinus* and *Distichodus niloticus* which are commercially viable. These species make up more than 3,000 metric tonnes or 16% of the Lake Turkana fish catch as per the modelled total catch of 19,000 metric tonnes from January 2021 to December 2021. With Davies *et al.* (2009) establishing that marine bycatch accounts up to 40% of total marine catch, the Lake Turkana bycatch of below 20% falls within the sustainable bycatch threshold according to Pillai *et al.* (2014). Most literature under-estimated the tonnage of bycatch from Lake Turkana, but the study established that more fish was being landed from the Lake Turkana fishery than was being officially documented.

Lates longispinis, a commercially valuable relative of Nile Perch, comprised a significant portion (20%) of the gillnet bycatch. This species fetches prices similar to fresh Nile Perch (KShs. 75 kg^{-1}), exceeding tilapia's value. Notably, unlike these, most bycatch species have limited market appeal beyond local consumption due to low demand and preference for fresh consumption. This minimizes spoilage concerns and renders post-harvest preservation techniques like drying or salting ineffective in increasing value. Despite fetching lower prices, bycatch provides crucial supplementary income for fishers and a valuable protein source for

Table 4. Fish landings from Lake Turkana Fishery that are categorized as bycatch and their IUCN Status.

	Fish scientific name	Common name	Local name	December 2021 – December 2022 Landings (Tonnes)	IUCN Status
1	*Brycinus minutus*	Dwarf Lake Turkana robber	Lochakolong	2,100	Least Concern
2	*Lates longispinis*	Dwarf perch	Iji	750	Data deficient
3	*Schilbe uranoscopus*	Butter catfish	Iyinte	200	Least concern
4	*Labeobarbus bynni*	Nileharb	Momwara	50	Least concern
5	*Clarias gariepinus*	African sharptooth catfish	Kopito	25	Least concern
6	*Distichodus niloticus*	Cowfish	Golo	5	Least concern

Table 5. Computation of commercial value derived from fish categorized as Lake Turkana bycatch from July 2020 to June 2021. 1USD = KES 125.

	Species	Price per Kilo (Fresh) KES	Total Annual Value (Fish sold at the Beaches) '000 (KES)
1	*Lates longispinis*	75	56,250
2	*Brycinus minutus*	15	31,500
3	*Schilbe uranoscopus*	12	2,400
4	*Labeobarbus bynni*	20	1000
5	*Clarias gariepinus*	25	625
6	*Distichodus niloticus*	10	50
	TOTAL		**91,825**

local communities. This finding highlights the importance of multispecies management plans, particularly for the vulnerable catfish resource. Future efforts should focus on developing such plans to ensure sustainable practices across gillnet and longline fisheries and prevent overexploitation of target and bycatch species.

Conclusion and recommendations

The presence of significant bycatch species, such as the dwarf Lake Turkana robber and dwarf perch, underscores the need to consider the entire catch composition in fisheries management planning. The commercial viability of these bycatch species suggests opportunities for maximizing economic returns and minimizing waste. The study suggests that bycatch levels are currently sustainable. However, the presence of valuable bycatch species and potential for endangered species bycatch necessitates the development and implementation of multispecies management plans. Overall, the findings of the study stress the importance of adopting sustainable management practices that address gear selectivity, bycatch reduction, and the conservation of vulnerable species. Such policies should be grounded in scientific evidence and aim to balance ecological conservation with socio-economic needs, ensuring the long-term sustainability of Lake Turkana's fishery for present and future generations.

These plans should ensure sustainable practices across all fisheries to prevent overexploitation of both target and bycatch species. Implementing these recommendations can promote a balanced approach to Lake Turkana's fishery, considering both commercial interests and the conservation of aquatic life and local livelihoods.

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