POLICY BRIEF

Urgent need for Enhanced Fisheries Management of Lake Tanganyika

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CLEAT

PROJECTIONS OF CLIMATE CHANGE EFFECTS ON LAKE TANGANYIKA

DFC

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Current Knowledge

1. Climate changes are rapidly changing the lake:
    a. Warming of the lake is reducing mixing of shallow and deep water
    b. The volume of water with oxygen is decreasing
    c. Lake productivity is declining
2. Fish sizes and catches are declining, indicating a decline in fish stocks
3. Fishermen have knowledge about lake changes and their role in declining fisheries
4. Fishermen resist current fishing regulations due in part to a lack of alternative livelihoods
5. There are large post-harvest losses of fish catches
6. Human behavior is complex but has a direct impact on the lake system
7. The lake is projected to continue on this trajectory into the future

Recommendations

1. Minimize human impacts on the lake
2. Protect local fishers by not licensing large fishing vessels to prevent further overfishing
3. Protect breeding grounds and establish a closed season in cooperation with fishing stakeholders
4. Develop alternative livelihoods in collaboration with local fishing stakeholders to reduce fishing pressures on the lake
5. Provide support to help fishers to replace traditional wooden fish boxes with insulated iceboxes to reduce post-harvest loss
6. Train fishermen, fish traders, and processors to handle, process and pack fish to increase quality and shelf life, and thus income of all people
7. Improve food security by investing in land-based aquaculture
8. Provide support for continued monitoring of lake conditions and fisheries, including high-frequency data acquisition technology, electronic catch assessment survey, and hydroacoustic technology

Overview

Fish catches in Lake Tanganyika have declined by almost half over the last three decades (Figure 1). There is strong evidence that climate changes, which cause reductions in regional winds and warming of the lake surface waters, significantly reduce lake productivity and fish growth. In addition, growing human demand for food security from fish and lack of alternative livelihoods has led to intensified fishing pressure which contributes to an overexploitation of available fish stocks. However, it was not clear which among these two (climate change or human pressures) posed a greater threat. Despite government efforts to reverse the situation through monitoring and regulations, it has not been possible to maintain a sustainable harvest. Fishing effort and use of unsustainable fishing methods have continued to increase from year to year, especially in areas that lack alternative livelihoods. Climate change has also contributed to declining conditions for fish productivity. As a consequence of these conditions, households in the lake region remain food insecure.[1] Studies undertaken through the DANIDA (DFC) financed CLEAT project[2] provide further evidence of the vulnerability of the lake's productivity to climate and human induced changes in the complex socio-ecological environment on Lake Tanganyika, which impacts the growth, production, and availability of fish in the lake. Addressing the mitigation of climate effects and related overexploitation of fish resources requires action that engages local stakeholders in the co-development of meaningful policy and management strategies to control unsustainable fishing practices.

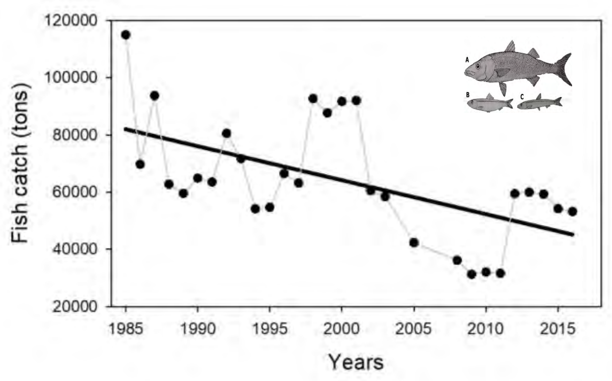

Figure 1. Pelagic fish catches in Tanzania have decreased significantly (*Source*: Fisheries Division, Tanzania)

Findings

Finding 1: Regional climate changes are reducing lake productivity and fisheries

Lake Tanganyika is a large (>600 km long) and deep (max 1470 m) lake, with northern, middle and southern basins. The lake has a water column that is permanently stratified due to large differences in water temperatures between the surface and deep-water layers. Under normal conditions, seasonal winds induce deep mixing and upwelling, bringing deep nutrient-rich waters into close contact with the surface waters, thus stimulating primary production and fish growth (Figure 2a).

Over the last 3-4 decades, the regional climate has warmed, resulting in a significantly more stable water column and less vertical mixing of

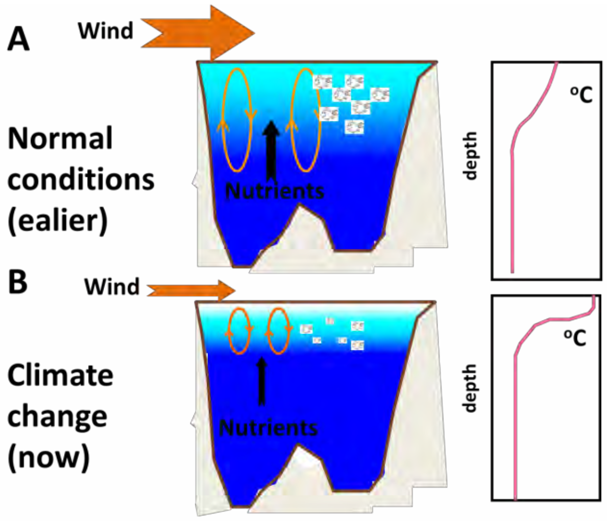

Figure 2. Under normal climate conditions (A), seasonal deep mixing stimulates productivity in the upper light exposed waters. During climate changes (B) reduced winds and warmer surface waters, reduces mixing and the upper mixed productive layer becomes shallower and less productive, with implications for growth and stocks of pelagic fish.

the surface and deep-water masses/layers (Figure 2b). Reduced winds have further amplified the situation and the upper mixed productive layer has become shallower, with less primary production to feed higher trophic levels and sustain large pelagic fish stocks.

The upper warm layer is a less dense (lighter), well-mixed oxygen rich zone also called the epilimnion (Figure 3).

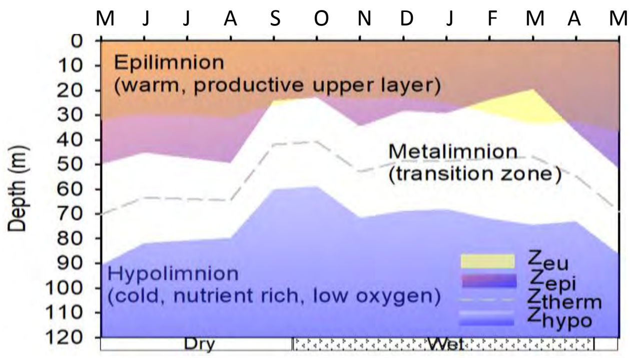

Figure 3. Monthly variations in the depths (m) of the euphotic zone (Zeu; indicated by the shaded areas) with sufficient light for primary production to occur. The lower depth of the epilimnion (Zepi), the thermocline (Ztherm) and upper limits of the colder and oxygen free hypolimnion (Zhypo) in Kigoma Bay in the north. Data from[2]

[1] WFP, **2010**. United Republic of Tanzania Comprehensive Food Security and Vulnerability Analysis. Rome, Italy
[2] Mziray, P., I.A. Kimirei, P.A. Staehr, C.V. Lugomela, W.L. Perry, D. Trolle, C.M. O'Reilly, H.F. Mgana. **2018**. Seasonal patterns of thermal stratification and primary production in the northern parts of Lake Tanganyika. Journal of Great Lakes Research Vol. 44(6), 1209-1220. https://doi.org/10.1016/j.jglr.2018.08.015

This epilimnion is about 50 m deep during the dry season (May to August) and it is between 20-40 m during the wet season from September to April. Below the epilimnion is a transition zone (metalimnion) where temperatures rapidly decrease with depth. This layer is located between 60 m and 70 m deep during the dry season but it moves up during wet season to between 40 m and 65 m.

There is a horizontal plane within the metalimnion called a thermocline. This is the depth of greatest water temperature change. As the epilimnion warms up, the metalimnion becomes more resistant to wind mixing. Beneath the metalimnion and extending to the lake bottom is the colder, denser (heavier), oxygen free, and nutrient rich water mass called the hypolimnion. This layer begins at around 80 m and 90 m depth during the dry season but moves up to between 60 m and 85 m during the wet season (Figure 3).

The CLEAT project[2] results show that temperatures within the epilimnion waters (0-5 m) have warmed by 0.8°C since 2003, and that the upper 100 m water layer has warmed by 0.4°C since 1994. Results also indicate a shallowing of the thermocline by 13.4 m and 4.8 m during the dry and wet seasons, respectively, over a period of 21 years, reducing the depth of the oxygen-rich upper waters.

As the surface waters warm during the wet season, the ability of winds to cause deeper mixing becomes greatly reduced. This is because rapid vertical changes in temperature and density within the metalimnion acts like a physical barrier between the epilimnion and hypolimnion. Although it is not an absolute barrier, it requires a lot of energy to disrupt it.

The results from the CLEAT Project show that climate-driven changes are affecting water temperatures and water mixing conditions, which subsequently affects nutrient inputs into the productive layer, thus affecting primary production of the lake. New insights gained through monthly monitoring during the CLEAT project sampling program, however, suggest that the reduction in primary production in the epilimnion mixed waters may be compensated by deeper production within the metalimnion. This production happens during the wet season, when thermal stability is strongest. Furthermore, modelling of water and nutrient circulation in the lake, indicate that a significant part of the nutrients driving lake primary production and ultimately fish production may originate from inflowing rivers, and from the atmosphere via particles and rain. Ultimately, however, model projections with continued climate change show that the lake will continue to change in ways that will contribute to reduced productivity.

The seasonal changes in temperature, mixing events, and primary production influence the growth of the commercially important fish species that live in the pelagic section of the lake. Cool temperatures favor fast growth rates while the opposite is true for hot conditions. Cool seasons coincide with the upwelling events followed by elevated primary productivity and abundance of immature fishes. Minimizing fishing activities could be targeted during these important months (May, June, July, and August).

Key finding 2: Pelagic fisheries are currently very unsustainable

The pelagic fishery of Lake Tanganyika used to consist of six fish species. However, over the past 3 decades, only three species dominate the catches (Figure 4).

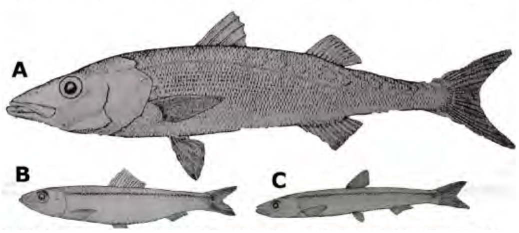

Figure 4. Three fish species dominate the pelagic fish catches in Lake Tanganyika A) *Lates stappersii* (migebuka), B) *Limnothrissa miodon* (dagaa) and C) *Stolothrissa tanganicae* (dagaa).

While the disappearance of the large *Lates* species has been linked to overfishing by purse seiners, the persistence of the dagaa and migebuka is mostly related to their life histories. The dagaa live for a maximum of 2 years and are highly resilient. Mgebuka on the other hand, live for about 5 years, which makes them somewhat resilient and able to recover from exploitation compared to the large *Lates* species, which have life spans of more than 10 years. However, climate-induced reduction in lake productivity makes the resilience of dagaa and migebuka unpredictable. Uncertain food availability, therefore, can cause the fish population to crash, especially when recruitment fails as a result of changing climate conditions.

There has been a significant decline in pelagic fish landings of about 40% since 1985, despite an increase in the number of fishing units from about 5,000 to 11,500 and a doubling in the number of fishermen to 26,000 in 2015. The increase in the number of fishermen, which is an indication of fishing intensity, is related to increasing demand of fish protein due to population growth and the lack of stable alternative livelihoods for many lakeshore communities.

Because of the decreasing landings and the increasing number of fishermen, the landing per fisherman has declined from approximately 7 tons per fisherman per year to 2 tons per fisherman per year.

Moreover, adding to the declining catches, the fishery has a 35% post-harvest loss, meaning that 35% of all catches landed are spoiled before consumption. This is a result of some fishing methods as well as poor handling immediately after capture on the lake and landing at the beach. Presently, the fishers use wooden boxes that are not properly customized for long-term storage. Proper fish boxes should be insulated plastic which can support the use of ice for immediate preservation after the catch is landed on the boat (Figure 5). The post-harvest losses are causing further decreases of earnings by the fishermen. This may be driving increasing fishing pressures in order to offset the effects of declining catches and increased post-harvest losses.

Figure 4. An example of an insulated fish boxfish with a volume capacity around 70 liters. Storing fish on ice will reduce post-harvest losses, increase fish quality and raise fish value.

Due to the declining catches, fishermen are using smaller mesh sizes in their lift nets to increase their catch. While the legal mesh size in lift nets is 8-10 mm, many fishermen have been using smaller sizes measuring 6 mm, with some as small as 4 mm. Whether the 4 mm mesh catches more biomass than an 8- or 10-mm mesh size net is unknown; however, the 4- or 6-mm mesh puts a higher pressure on the juvenile fish, which if allowed to grow, would fetch higher prices and help to improve productivity. The reduction in mesh sizes used in the pelagic fishery of Lake Tanganyika has the greatest consequences to the migebuka (*L. stappersii*), which is caught in the same lift-net fishery as the dagaa (*S. tanganicae and L. miodon*).

While fishing pressure can explain some of the trends in the fishery, a significant portion can also be explained by climatic and environmental changes in the lake ecosystem. Findings from the CLEAT Project indicate that both the migebuka and dagaa have better growth rates during the cool dry period when water temperatures are lower, even though there appears to be abundant food during the warmer wet season. Fish sizes have also been decreasing, which indicates both pressure on the fish populations as well as slower growth rates.

Therefore, continued warming of the lake and increased fishing pressure may be working in tandem to reduce fish growth, recruitment, stocks and catches in Lake Tanganyika.

Key finding 3: **Fishermen are aware of their negative impact on the fish populations, but see no alternatives**

Fishing communities have, through a long history of interaction with the lake and fish resources, gained valuable knowledge about lake functioning, fish biology and the impacts of changing fisheries. Specifically, they provide detailed accounts of the seasonal occurrence of different species, perceived fish abundance and declines, changes in lake conditions (such as decreased wind velocity and rainfall), and other related impacts (i.e. changing fishing gears and population pressures). Fishermen have noticed how their catches have been reduced and understand how this has come about. One critical transition that has been noted by fishermen occurred when they shifted their livelihood base from agriculture to fishing around the 1980s. This change was motivated by perceptions of higher benefits generated from the fishery as compared to benefits from agriculture. The perceived benefits from fisheries has attracted more people, thereby increasing fishing pressure. Fishers have also devised different mechanisms to continue to access fish resources, despite reductions in lake productivity and increased oversight by fisheries officials. These mechanisms include intentional monitoring and avoidance of regulatory actions/officials (i.e.: using mobile phones to monitor location of fisheries officials at landing sites), keeping juvenile fish, and the use of beach seine, which they acknowledge is harmful to the long-term viability of the fishery. Fishermen argue that given the perishability of fish and their lack of alternative livelihoods, they have to harvest more fish to be able to generate even basic incomes.

An assessment of their fishing practices confirms that:

a) Fishermen have considerable knowledge about changing conditions on the lake
b) Potential alternative livelihoods such as land-based aquaculture and integrated sustainable agriculture have not been fully explored and could improve food security.
c) Post-harvest losses could be reduced using insulated plastic fish boxes on the fishing boats combined with better storage (chill stores, ice, drying).

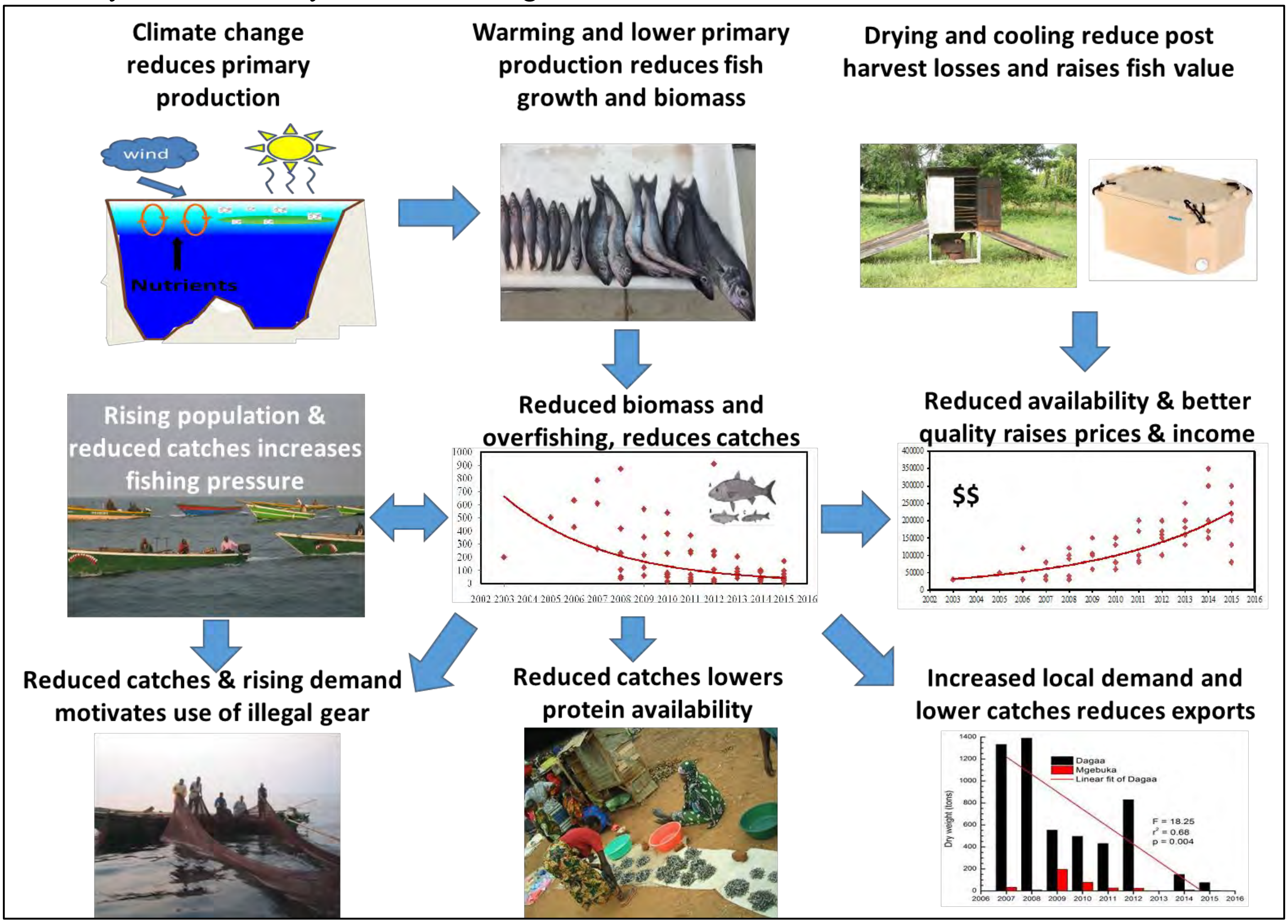

Figure 5. Schematic figure of important factors interacting to affect the fish catches and income from fisheries in Lake Tanganyika.

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