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An Urgent Call for Application of Output Controls alongside Current Input Controls in Commercial Fisheries Management System of Inland Lakes: Case Study of Malawi

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Abstract
Fisheries resources continue to decline globally and in Malawi amidst ever increasing human population. This study was conducted to assess catch composi+tion, species composition and catch per unit effort (CPUE) among commercial fishers. Secondary catch data (2000 to 2021) obtained from Department of Fisheries was used. Trend of fish species composition over the 21-year period was initially dominated by *Lethrinops* species and Utaka (*Copadichromis* species) until 2002 when Ndunduma (*Diplotaxodon* species) started to become prominent. Pattern of Utaka appears to be more cyclic as three- or four-year peaks were followed by about four years troughs. Dominance of Ndunduma which in most years was above 50% demonstrates economic importance of the fishery in commercial trawl industry. Dominance of Pelagic Utaka and Ndunduma is attributed to the increased adoption of midwater trawl nets by the fishery with very few units operating bottom trawl nets. In 2021, the pair trawlers contributed 52% of landings than stern trawlers. Scramble for fishing by commercial fishers may lead to tragedy of commons. It is recommended to allocate to individual fishers catch quotas (output control). By employing input controls and this output control, commercial fishers will be prudently managed in a very sustainable way.

Keywords: commercial fishery, largescale fishery, food security, Malawi.

1.0 INTRODUCTION

Fisheries resources continue to decline globally amidst ever increasing human population to 7.8 billion in 2020 from 6 billion in 1999 (Population Reference Bureau, 2020). Malawi is not spared as the recent biomass assessment survey has shown that most of economically important fish species maximum sustainable yield (MSY) and populations are dwindling (Malawi Government 2020). In response, the Government of Malawi has instituted a closed season for commercial fishers from 1st December to 28th of February (1st November to 31st January for small scale fishers) to allow fish population rejuvenate. The large-scale fishery which is categorised into commercial (Stern trawlers) and semi-commercial (Pair trawlers) fishery dates back to late 1960s after some successful biomass assessment trials in mid 1960s. The fishery which used to be concentrated in the Southern Lake Malawi has witnessed shifting of fishing effort to central Lake Malawi chiefly due to depleted stocks in the southern part (Turner 1992).

As a way of input controls on Lake Malawi, fishing by commercial fishers is restricted to designated fishing areas which run parallel from south to north (A to N) as allocated during fishing license issuance. Pair trawlers are restricted to a combined 90 horse power, and a maximum of 386 horse power for a stern trawler. The allowable mesh size at the code end is 38mm. In addition to all these input controls commercial fishers are demanded to report monthly catches to the Department of Fisheries. These figures are the ones used to report the production of commercial fishers in Malawi. The commercial fishers seriously under report the catches for different reasons resulting to under reported national fisheries production of this sector.

These input controls are monitored regularly but not in most cases not daily. In this regard they are easy to implement. These input controls are relatively a good measure of the actual landings as their increase in number or efficiency usually result into an increase in landings. However, this scenario offers for another challenge in fisheries management regarding 'tragedy of commons' as the fishers generally scrambles for the limited resources within the fishing season. This poses a risk of exploiting the fisheries resources beyond the maximum sustainable yield. This challenge is solved by employing output controls.

Unlike input controls, output controls are direct limits on the amount, species or size of landings. In simple terms output controls are tools that limits tonnage of fish landed. This is very important to make checks and balances on exploitation levels that it should not surpass the maximum sustainable yield of the exploited stock. This is done by ensuring that we are exploiting only total allowable catch. The restriction on by-catch can be regarded as output control however, discards that did not survive might defeat the whole purpose of catch management strategies (Alverson, Freeberg, Murawski and Pope 1994; Pope, 2009).

Why is it important to employ both input and output controls?

The paramount objective of any fisheries management is to sustainably exploit fisheries resources. It is in most cases difficult to arrive at the point of sustainable exploitation as most fisheries resources do not have adequate data to make accurate reference points such as MSY and MEY. For this reason most data poor fisheries are not managed accordingly. As such it important to employ several fisheries management strategies in managing data deficient fisheries resources. This is a form of precautionary fisheries management system advocated by FAO. This is the reason it is important to employ both input and output controls to stand a better chance of properly managing a fishery. However, it must be known that policing regulations formulated around the input and output controls is paramount. Partial controls leave space for the uncontrolled part of a fishery to expand into areas not under any fisheries management control. The Fisheries Code of Conduct encourages managers to take measures for all areas of a fishery resource management under their jurisdiction (FAO, 1995; Pope, 2009).

The monitoring of catch and effort statistics from 2000 to 2021 targeted all the units across all designated landing sites was conducted with an aim to assess the performance of the sub-sector. The study was specifically conducted to evaluate the current catch composition by trawl type. The study further aimed at assessing the status of Chambo (*Oreochromis* species) fish in the commercial industry landings. The study also wanted to analyse the performance of the fishery in terms of catch, effort and catch per unit effort (CPUE) to show if there is a need to introduce output controls alongside the current input controls in place.

2.0 MATERIALS AND METHODS

Study Area

The study was conducted using information from Lake Malawi. The fishing areas were demarcated and named using alphabetical letters (Fig. 1). Fishing of commercial trawl operators is restricted to designated fish areas as allocated during fishing license issuance. Administratively, no fishing by commercial trawlers is allowed in Area A. There is a cautious allocation of units in Area B since it shares boundaries with Area A. As indicated in Fig. 1, Mangochi is covered by Area A through Area D which is shared by Dedza District. Areas E, F, G and H are located in Salima while Nkhotakota has Area N and part of Area H.

Data

The study used secondary data of fish catches and effort by commercial fisheries on Lake Malawi The data was collected from the Department of Fisheries in the Ministry of Natural Resources and Climate Change in Malawi. The data covered a period of 21 years, from 2000 to 2021. The fish catches in the secondary data used in this study were measured in kilograms and converted to tonnage annually. The fish catch weight is a wet weight. The catch was recorded at the fishing landing site as soon as the fishers arrive before they sale their catch. Total catch from all commercial fishers was summed up respective of individual species to come up with specific fish species landings in a particular year. Fishing effort data was recorded as number of fishing days.

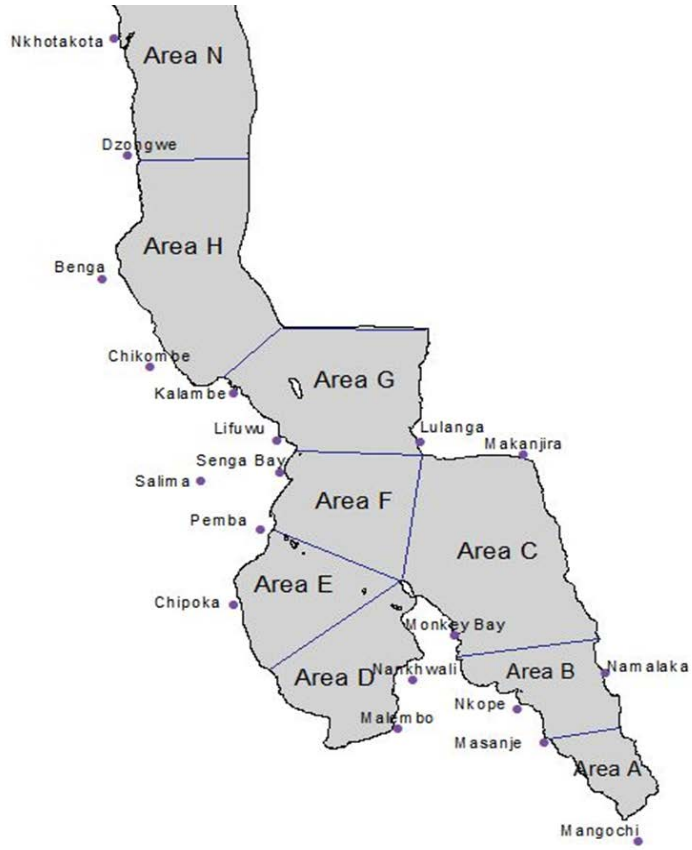

Fig 1: Map showing fishing zones and landing sites for the commercial fisheries in Malawi.

Data Analysis

Data on catch and effort of the commercial industry were entered and analysed in Microsoft Excel 2021. Data analysis toolpak activated in the Microsoft Excel was used in most of the analysis conducted. All the graphs were plotted using the same package.

Calculating catch per unit effort (CPUE)

A convention model shown below was used to derive catch per unit estimates from the data. It is important to report that values for the effort in days were not standardised hence its reliance should take into account this weakness. The simple model shown below was used where CPUE, catch per unit effort in Tons per Day, Y is catch in Tons and f is the fishing effort in Fishing Days.

$$\text{CPUE} = \frac{Y}{f}$$

3.0 RESULTS

Current catch composition and contribution by trawl type

The commercial fishery in Malawi is split into stern trawlers and pair trawlers. The commercial fishery in Malawi landed 2,493.2 tons in 2021. According to Fig. 2, the pair trawlers contributed 52% of the landings leaving the stern trawlers with the remaining 48%. The fishery continues to be dominated by Ndunduma. With fish landings of 1,097 tons, the fish contributed 44% of the overall landings during the 2021 fishing season. Bottom dwellers Chisawasawa and zooplankitivous Utaka were second and third highest with 550 tons and 500 tons, respectively contributing 22% and 20%. Chambo which is targeted by this review was among the least contributors with 52 tons contributing about 2%. Within the two trawl types, pair trawlers landed more of Ndunduma, Chambo, Utaka, Mbaba and Mcheni. Stern trawlers on the other hand reported higher landings over pair trawlers on Chisawasawa, Kampango, Mlamba and other fish species. Pair trawlers that operate mid-water trawlers dominated in the pelagic fish while the bottom dwellers were prominent in stern trawlers where most of the bottom trawlers are found.

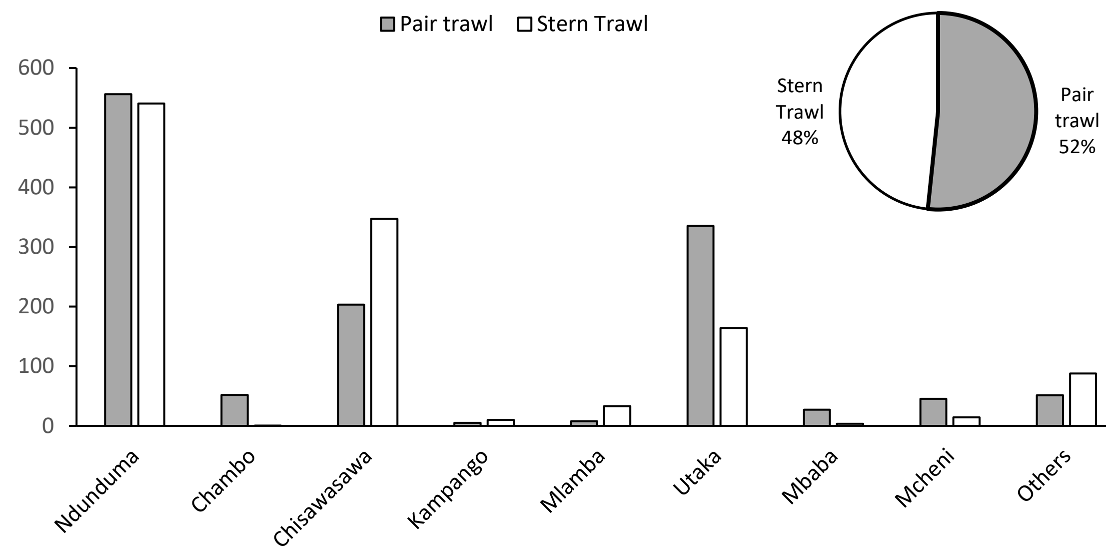

Fig 2: Catch composition in pair and stern trawlers recorded in the 2021 fishing season

Trends in catch composition

The trend of fish composition over the 21-year period is displayed in Fig. 3. The fishery according to the graph was initially dominated by Chisawasawa and Utaka until 2002 when Ndunduma started to become prominent. The pattern of Utaka appears to be more or less like cyclic as three- or four-year peaks are followed by about four years troughs. The dominance of Ndunduma which in most years was above 50% demonstrates the economic importance of the fishery in the commercial trawl industry. Besides Ndunduma, Utaka and Chisawasawa follow in importance.

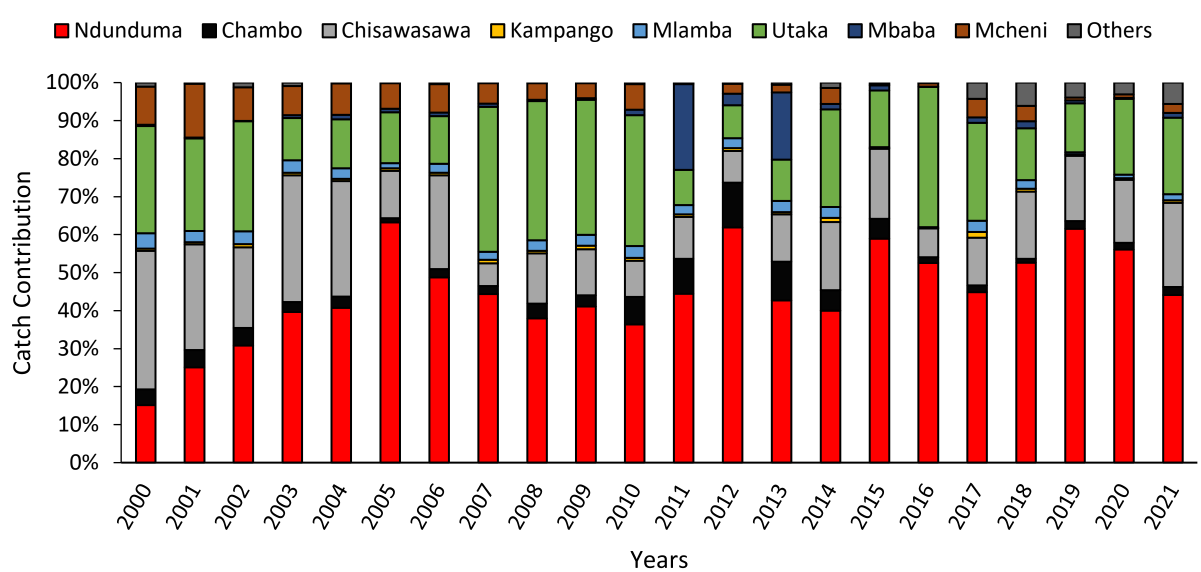

Fig 3: Catch composition trends in the commercial trawl industry between the 2000 and 2021

The dominace of Pelagic Utaka and Ndunduma is attributed to the increased adoption of midwater trawl nets by the fishery with very few units operating bottom trawl nets with the common one being the RV Ndunduma. As it can be appreciated from Fig. 3, Chambo's contribution to the total catches has been very minimal and its performance can hardly be appreciated.

Performance of the fishery- catch, fishing effort and CPUEs

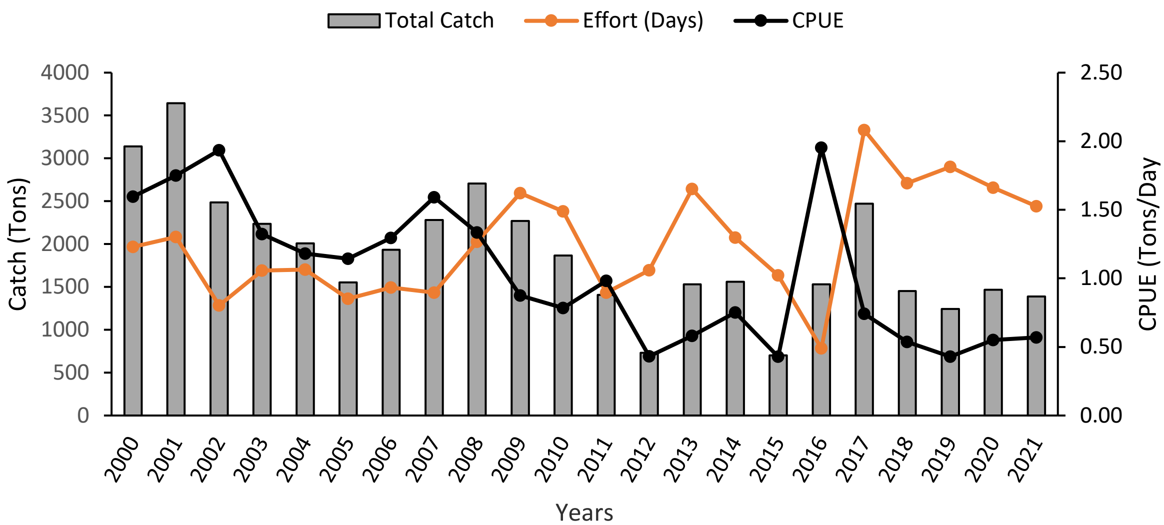

Fig. 4: Trend of catch, effort and CPUE of the Commercial trawl fishery in Lake Malawi

The commercial fisheries catch and CPUE trend from 2000 to 2021 is shown in Fig. 4. Accordingly, the fishery has continued its downwards trends since 2000 for both catches and the CPUEs while the effort appears to lack a definite pattern. Over the 21year period, the fishery reported the highest landings in 2001 of about 3,643 tons while lowest catches of less than 1000 tons were recorded in 2012 and 2015. The trend of its corresponding effort reached a peak in 2017 before starting to show a declining pattern. The trend of catch per unit effort closely followed the pattern of the catches though at different scales. The fishery reported its peak CPUE in 2016 of 1.95tons/Day followed by the CPUE values reported in 1.93tons/Day. The fishery according to Figure 4 has experienced poor catches of less than 1,500 tons since 2018.

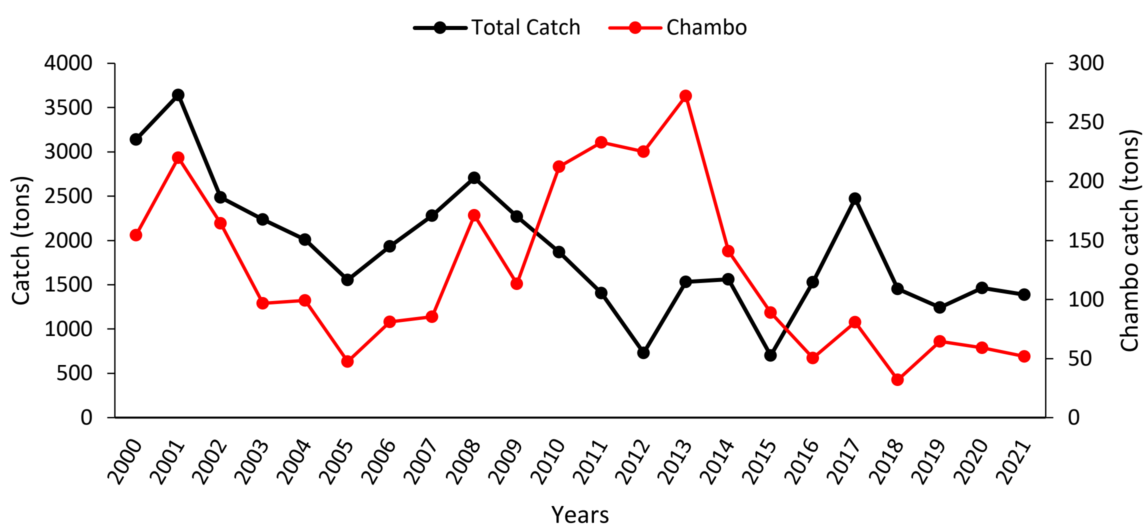

Fig 5: Catch, effort and CPUE for 2020-2021 commercial catch returns

Figure 5 compares the performance of total catches against the Chambo over the period under review. As it can be noted, the pattern of Chambo follows the trend of the total catches. The Chambo catches whose average for the last three years was 59 tons thereby contributing about 4% of the average total catches continues to contribute marginally to the fishery. One of the reasons behind this performance could be because of the movement of many fishing boats such as Maldeco Fisheries vessels from Mangochi to Salima. The same trend can be seen of the total catches as the migrated fishers do not submit their catch returns to the Research Institutions as per requirement by their licenses.

Figure 6 shows the detailed trend of the Chambo contribution to the total catches from 2000 to 2021. As it can be noted, the Chambo has been contributing less than 10% for most of the years with an above average contribution from 2010 to 2015 with the highest contribution of 31% being enumerated in 2012. Overall, the Chambo contribution to the total catches averaged 8%. Though the landings for the fish have dwindled in the commercial trawl fishery, it is strongly believed that the catches of the fish are greatly under-reported as witnessed during the routine monthly monitoring surveys. This mostly occurs because the fish are caught in restricted areas either in Protected Area A or in the shallow water below the recommended water depth of 18m.

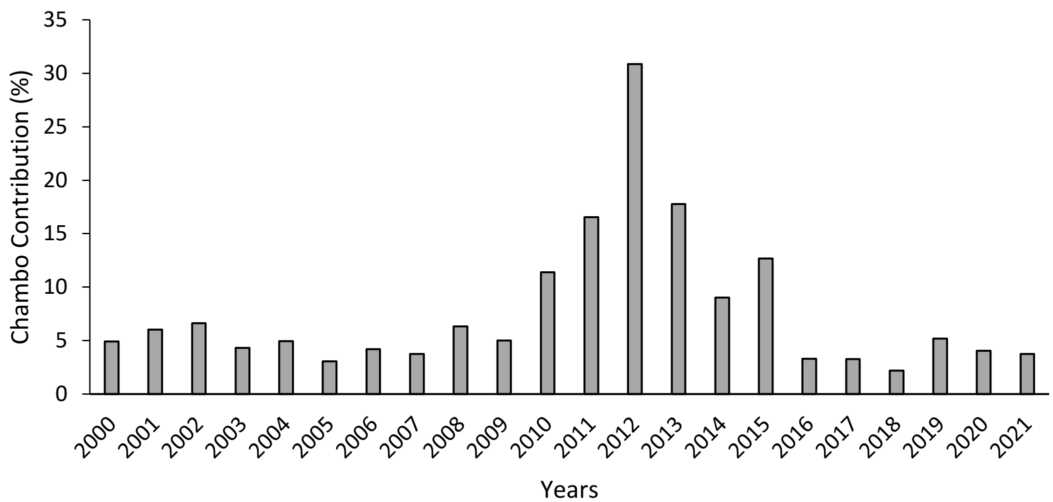

Fig 6: Detailed Chambo contribution to the total catches from 2000 to 2021

4.0 DISCUSSION

The commercial fishery in Malawi is primarily categorised into stern trawlers and pair trawlers and this study has reported prominence of pair trawlers as they contributed about 52% of the landings while the most powerful stern trawlers reported the remaining 48%. Pair trawlers are known for being less powerful as they use pair engines of not more than 90Hp. This category is allowed to fish in the waters between 18m to 50m and their performance is restricted by both the engine size and boat size (Turner, 1977; Banda, 2001). The stern trawlers on the other hand are very powerful vessel whose engine goes up to 360Hp plying their fishing business in the deeper waters (Banda, 2001). The superiority of the pair trawlers on the total catches was therefore attributed to increased number of pair trawlers in comparison with the stern trawlers. The pair trawl sub-industry is also known for increased cases of non-compliance (Kanyerere & M'balaka, In Press) and their increased yields is as a result of the adoption of environmentally destructive fishing approaches (Weyl, et al., 2010).

The composition of fishes in the landings of commercial data returns is continues to be dominated by the Ndunduma followed by Chisawasawa and Utaka as these three species categories contributed to more than 80% of the catches. This composition has been the same for over 20 years which only indicates that the Ndunduma, Chisawasawa and Utaka are the three economically important fish in the trawl industry (GoM, 2021). The dominant performance of Ndunduma in the commercial fishery was already revealed by Thompson and Allison (1997) when they conducted hydroacoustic survey on the lake. It therefore not surprising to note that the introduction of the commercial fishery closed season aims at protecting recruitment and growth overfishing of Ndunduma as reported by preliminary breeding seasonality study conducted whose results concur with the findings of Kanyerere et. al., (2005). Chambo which was targeted by this review was among the least contributors with about 2% of the total landed catches. The worrisome minor contribution has been widely reported by a number of scientists notably Banda et. el., (2005), Hara (2006), Bell et. al., (2012), Hara and Njaya (2016) and Makwinja and M'balaka (2017) and the causes are both anthropogenic and climate change induced.

The FAO Code of Conduct for Responsible Fisheries is at the center of fisheries conservation so as to meet the SDGs, regional and national goals. It is therefore very important to limit the intensity of fishing as it is a key tool of conservation as outlined in Code of Conduct, Paragraphs 7.1.8 and 7.6.1. There is a need to limit both inputs (fishing effort) and outputs (catch) (FAO, 1995; Pope, 2009). Currently Malawi has only input controls in fisheries management both on small scale and largescale fisheries. For the largescale fisheries the input controls for fisheries conservation area as follows:

a. The 1st December to 28th February is closed fishing period
b. 38mm or above code end mesh size for trawl nets is allowed
c. No more than combined 90 horsepower is allowed on pair trawlers while for stern trawlers is 386.
d. Fishing only offshore beyond 50m depth is allowed
e. Fishing time is during the day time.
f. Fishing should only be done in fisher's located fishing areas.
g. Provision of fishing licences

Input controls are so popular among fisheries managers worldwide as they are easy to implement and manage. Most of these input controls are restricted on entry usually at the beginning on a fishing season for instance through licensing or recommended fishing gears and crafts. In more specific context the input controls refer to restrictions on the number and size of fishing vessels, the amount of time fishing vessels is allowed to fish or the product of capacity and usage. In other words these are fish capacity controls, vessel usage controls and/or fishing effort controls (FAO, 1995; Pope, 2009). Some other factors such as fuel, marine engines and their parts high prices may as well be regarded as input controls. In Malawi ban of monofilament gillnets usages as well as importation can be regarded as an input control.

These input controls are monitored regularly but not in most cases not daily. In this regard they are easy to implement. These input controls are relatively a good measure of the actual landings as their increase in number or efficiency usually result into an increase in landings. However, this scenario offers for another challenge in fisheries management regarding 'tragedy of commons' as the fishers generally scrambles for the limited resources within the fishing season. This poses a risk of exploiting the fisheries resources beyond the maximum sustainable yield.

Unlike input controls, output controls are direct limits on the amount, species or size of landings. In simple terms output controls are tools that limits tonnage of fish landed. This is very important to make checks and balances on exploitation levels that it should not surpass the maximum sustainable yield of the exploited stock. This is done by ensuring that we are exploiting only total allowable catch. The restriction on by-catch can be regarded as output control however, discards that did not survive might defeat the whole purpose of catch management strategies (Alverson *et al.*, 1994; Pope, 2009).

The drop in the CPUE over the years can be attributed to many factors and the common ones are the increased cases of under-reporting of catches, non-remittance of the data returns as well as the newly introduced three months close season. Regarding the immediate impact of closed season, a random interview with the fishers on why they were having poor catches after the lake was opened, most of them attributed it to the under-water currents that greatly impacted on the movement of fishing as well as fishing net dynamics. The research division however plans to assess impact of the introduced closed season after attaining three years after inception.

The paramount objective of any fisheries management is to sustainably exploit fisheries resources. It is in most cases difficult to arrive at the point of sustainable exploitation as most fisheries resources do not have adequate data to make accurate reference points such as MSY and MEY. In this regard, it becomes risky in fisheries management of rely on only input controls from a single reference point.

The input controls could as well be strengthened by employing them alongside output controls to directly control the amount landed with respect to the total biomass. This will ensure that increased efficiencies of fishing gears would not land more what is sustainable to specific fishing areas. In this regard the output control will act as a plus to the input control measure for improved sustainable exploitation of fisheries resources in Malawi. These output controls will provide policy maker opportunity to make evidence-based policy options in ensuring that our fisheries resources are sustainably exploited.

This study has further assessed the performance of the Chambo of the years. It has been observed that in bigger part of the 21 years, Chambo has been contributing to less than 10% of the landings having an average of 8%. The Chambo under-performance despite several initiatives to resuscitate was attributed to the non-inclusion of other equally important aspects like social, economic, political and institutional drivers that dictate the exploitation patterns of the fish (Hara, 2006). It is therefore important to consider other important aspects while coming up with initiatives that would be back the Chambo glory rather than re-inventing the wheel as put in by Hara (2006).

5.0 CONCLUSION

The assessment of the catch and effort statistics from the commercial industry has revealed dominant contribution of pair trawler despite their sizes. The fishery continues to be dominated by Ndunduma while being followed by Chisawasawa and Utaka. The contribution of Chambo to the fishery remains insignificant indicating that the Chambo fishery is still Over-exploited and efforts to bring it back to its glory haven’t yielded the required results. This therefore calls for more effort that should be eco-system based in encompass other equally important drivers of the industry.

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6.0 RECOMMENDATIONS

Since the input controls have proven to be inadequate for the commercial fisheries of Malawi, it is important to complement them with output control fisheries management systems. Implementing both input controls and output controls has a great potential to sustainably exploit the commercial fishery.

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