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Assessment of artisanal Chambo fisheries in Mangochi district

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Abstract
An assessment of artisanal Chambo fisheries for Mangochi district (Lake Malawi, the Upper Shire and Lake Malombe) from 2000 to 2015 was done in order to provide the latest insight of the status of the fishery in the district. The results of the study indicate that there were little fluctuations in terms of number of fishers since 2001 and more than 85% of the fishers was contributed by fishing crew members. The results on the catch trends indicated a decline over the whole period under study and more authors attributed this to a number of factors both environmental as well as anthropogenic. The study went further to assess the trends for important gears to Chambo fishery and the gears showed different trend patterns. The study revealed that the Chambo fishery had reached its maximum sustainable yield in 2009 hence some holistic management approach was recommended to resuscitate the fishery.

Keywords: Chambo, gillnets, anthropogenic, fluctuations, CPUE, sustainability

1. Introduction
Mangochi District found in the southern part of Lake Malawi is one of the most important district of southern Lake Malawi, the upper Shire River and Lake Malombe fisheries. The district currently covers 10 administrative minor strata that originated from three major strata (1.0, 2.0 and 3.0) see Figure 1. The district adopted the use of 'Gear-based sampling' termed Malawi Traditional Fisheries (MTF) in 1990 which was introduced by Chambo Fisheries Research Project and targeted Lake Malombe, the upper Shire River and Southeast of Lake Malawi [(1)]. The introduction of gear-based sampling was an effort to reduce inaccuracy of the craft-based sampling known as Catch Assessment System being employed in all other fisheries districts other than Mangochi, [1].

Lake Malawi which is connected to upper Shire River and Lake Malombe is endowed with the highest diversity of fish species than any other water body worldwide [33]. The lake contributes about 14% of the world's fresh water fish with a 4% contribution of the total world fish diversity but this is against the fact that the lake only measures an approximate total area of 28, 800km^2 to 30, 800km^2 [20, 33]. On the other hand, Zweiten *et al.* [34] reported that Lake Malombe with an average depth of 5m measures maximum length of about 30km and 15km wide while covering an area of about 350km^2.

Despite the impressive fact about the fish diversity, Banda and Tomasson [3] and Turner [23] observed a considerable change in the catch composition as a result of the introduction of trawl fishing in 1968. Turner *et al.* [24] noted that large demersal fish species were being replaced by smaller pelagic and certain species that had been extirpated. It was noted in particular that there was also a decline in one of the most economically valuable fish, Chambo [3, 4, 19, 29, 31, 33].

Chambo, maternal mouthbrooding cichlids belong to a subgenus *Nyasalapia* of the genus *Oreochromis* and there are three closely related tilapiine cichlid namely *Oreochromis karongae*, *Oreochromis lidole* and *Oreochromis squamipinnis* and all these are found nowhere else apart from Lakes Malawi, Malombe and the upper Shire River [4, 18, 22]. Although Chambo are primarily phytoplanktivores, zooplanktons also feature in their diets [11, 16]. The fish are mostly found in shallow waters of less than 50m with very few found in waters deeper than 50m [23, 19]. The Chambo breeds in shallow waters including lakeshore inlets, mouths of streams, reedy shores of Shire River as well as rocky and sandy shores, [19]. The breeding behavior makes Chambo more susceptible to overfishing and this cause for a concern to its management.

The susceptibility of the fish to overexploitation is also attributed to its biological parameters like low natural mortality rates, slow growth and high age at maturity coupled with extended parental care [29, 19].

Chambo catch contributed significantly to total catch of Lakes Malawi and Malombe in the early and mid-seventies [9]. More than 30-50% of artisanal and commercial fisheries was contributed by Chambo before 1993 [4]. Of late, there has been a very minimal contribution of Chambo to the total landed catch and according to Bulirani [9] and Banda *et al*. (4) this was attributed to increase in fishing effort that did not correspond with standing biomass, illegal fishing and non-compliance to closed season and overpopulation of lakeshore people with limited alternative livelihood options. Calder *et al*, [10] and Vollmer *et al* [26] noted a 2.7% increase in shoreline settlement by human population that led to a conversion of forests to agricultural lands and a large scale variations in precipitation and these could indirectly contribute to the decline too. Tweddle *et al*. [25] Bell [8] and Lazaro [17] had done Chambo catch analysis for the Mangochi District previously and the main reason for this study was to provide an insight on the current status of the fisheries in terms of Chambo catch and effort data for the Mangochi District with an emphasis on the artisanal fishery as it contributes more than 90% of the total landings [5].

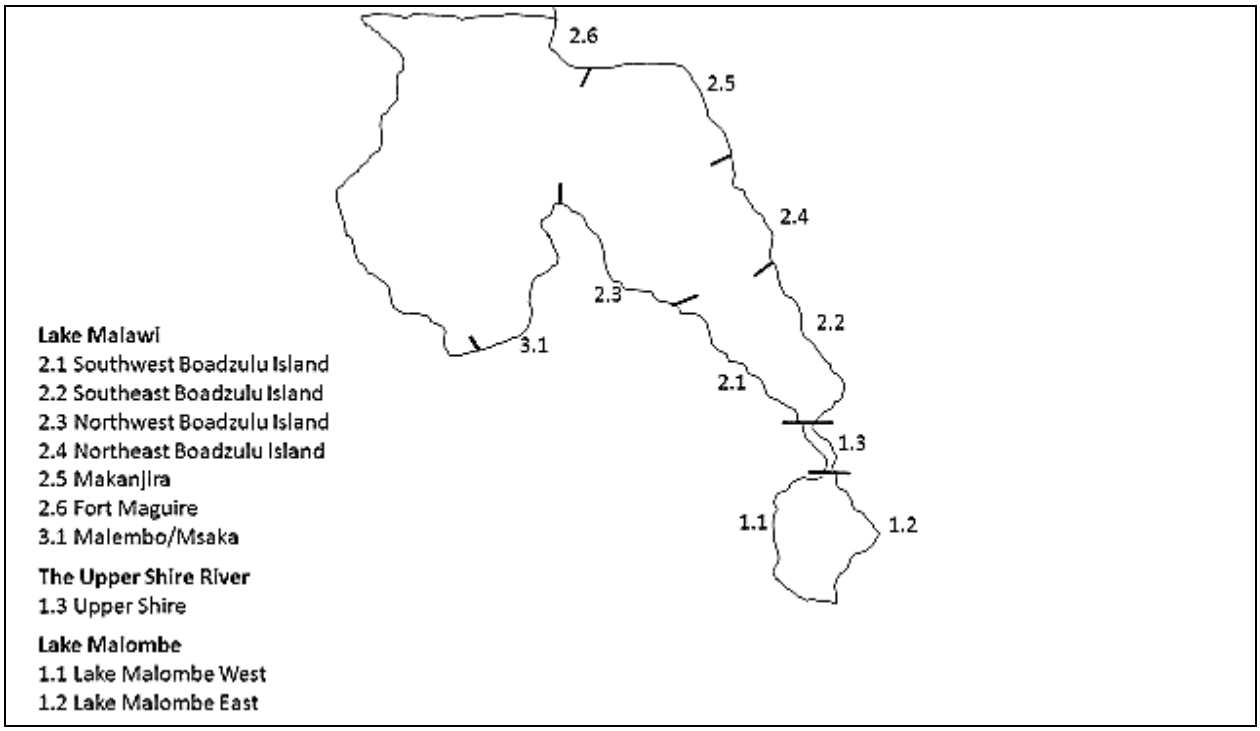

Fig 1: Map showing minor strata for Southern Lake Malawi, upper Shire River and Lake Malombe in Mangochi district

2. Materials and Methods

Chambo catch and effort data covered in Malawi Traditional Fisheries (MTF) was collected at Mangochi District Fisheries Office and was compiled and analysed at Monkey Bay Fisheries Research Station of the Department of Fisheries in Malawi. Methods described by Bazigos [6 7] Walker [27, 28] and Alimoso [2] were applied in the preparation and analysis of the catch and effort data.

Data for the trends of fishers and fishing gears were generated from frame survey reports and these again were collected at Mangochi District Fisheries Office. The study as advised by Sparre and Venema [21] used normalized effort generated from weighted catch per unit effort since different gears were used to come up with a single total effort.

Maximum sustainable yield (MSY) and effort level for MSY (fMSY) estimation methods were obtained from Sparre and Venema [21] to fit Schaefer (Graham 1935) model to the catch and effort data.

Schaeffer Model

$Y(i)/f(i) = a + b^* f(i)$ when $f(i) \leq -a/b$

Where b is the slope which must be negative if the catch per unit effort, Y/f is decreasing with an increase in effort, f. a is an intercept and is the Y/f value obtained after the very first boat fishes the stock for the first time. The intercept is supposed to be positive. The –a/b is therefore positive and Y/f is equal to zero when f= -a/b. Since a negative value of catch per unit effort is absurd, this model therefore only applies to f values lower than –a/b.

3. Results

Figure 2 shows the trend of artisanal fishers from 2001 to 2015 for the Mangochi District. According to the figure, little fluctuations have happened during the study period, though a peak comprising 2, 490 gear owners and 17, 517 fishing crew members (20, 001 fishers) was reported in 2009. The lowest number of fishers according to Figure 1 was recorded in 2011 where a total of 15, 329 fishers contributed by 2, 280 gear owners and 13, 049 crew members was reported. The figure further shows the contribution of crew members to the total number of fishers and it can be noted that crew members' contribution ranged from 85 to 87%. According to 2015 annual frame survey of the artisanal fisheries, Mangochi contributed 27% of fishers countrywide as such this is the reason why Mangochi is the most important fisheries district in Malawi.

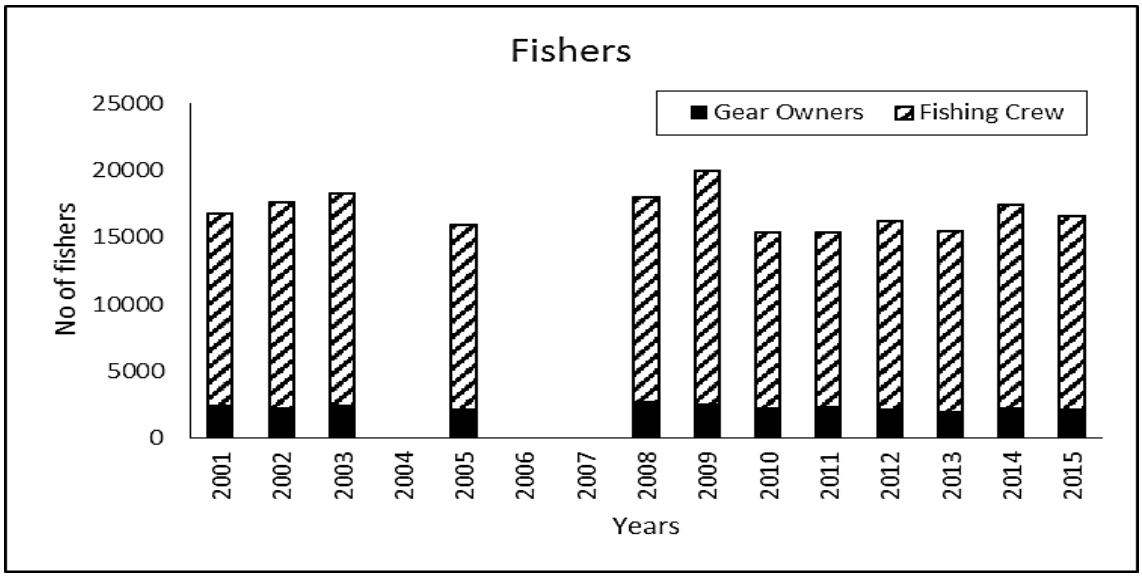

Fig 2: Trend of number of artisanal fishers in Mangochi district

The production trend for the Chambo fishery from 2000 to 2015 in different fishing gears is shown in Figure 3. The figure shows great fluctuations over time with a highest landed catch of about 3000 metric tons being recorded in 2003. It is worth noting that generally, the fishery had been doing well until 2008 where a very big drop was registered which was then followed by a further drop in 2009 to somewhere around 700 metric tons. From the total of 10 fishing gears that reported Chambo catch during the period of study, gillnets contributed significantly to the total landed catch by registering mean annual landings of 1, 221 metric tons. Chilimira, an open water seine net, FAO, [11] reported the second highest and its contribution was very significant from 2000 to 2003 although a very big drop was observed in 2002. It is interesting to note that the Chambo seine which primarily targets Chambo is conspicuously having a little contribution to the fishery just like the case of Fishtrap. Small contributions were also reported in Handlines, Kandwindwi, Kambuzi seine, Longlines, Usipa/Mosquito net and Nkacha seine net.

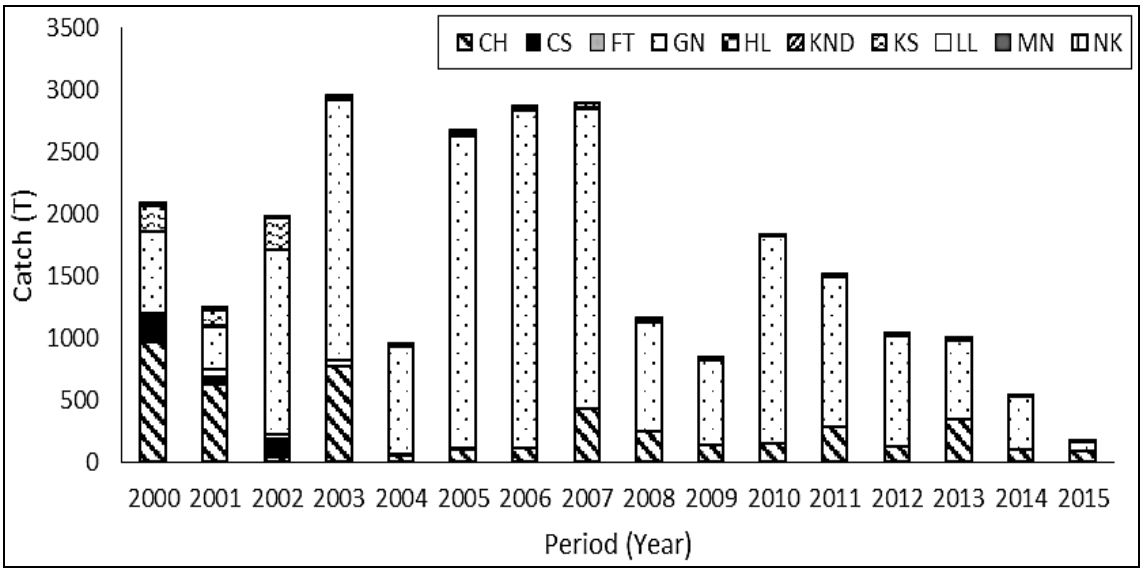

Fig 3: Contribution of fishing gears to the annual total Chambo catch

Total landed catch, effort and CPUE of artisanal Chambo fishery in the southern Lake Malawi, the Upper Shire River and Lake Malombe is shown in Figure 4. The general trend of the total landed catch according to Figure 4 demonstrates that catch had been increasing from 2000 to 2007 with some troughs in 2001 and 2004. After 2007 the trend appears to decline to its lowest point of 200metric tons in 2015. Although the effort was very low from 2000 to 2002, the behavior of the effort closely followed the general trend of the total landed catch of the Chambo with its highest point (1, 600) being registered in 2006 (Figure 4). In normal circumstances, it is expected that the effort will be stable or increasing with time, but this was not the case from 2013 to 2015. That period according to Figure 4 registered the lowest units of effort which is unusual. The trend for catch per unit of effort (CPUE) which is an index of population is also shown in the figure. There were big variations from 2000 to 2002 in the CPUE records as the fishery registered the highest CPUE of 18tonnes/effort unit in 2002. After that peak, the CPUE drastically dropped to 2tonnes/effort unit and had been stable up until 2013 where a significant increase to 6tonnes/ unit effort was reported. The abnormal increase in CPUE inversely relates to the unusual showing of the effort trend.

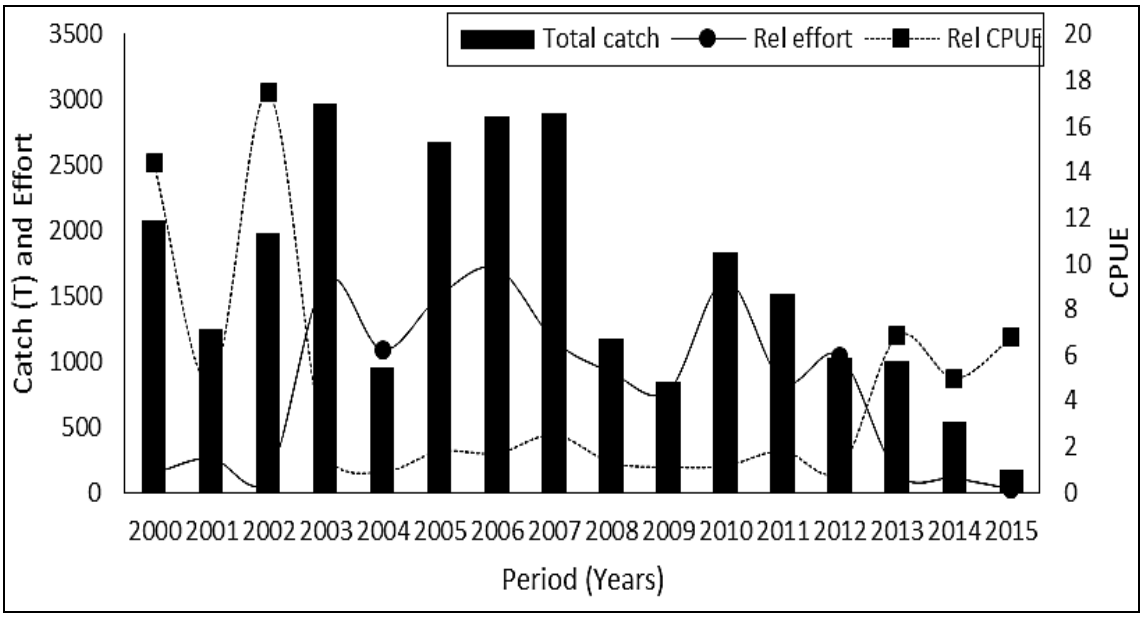

Fig 4: Chambo catch, effort and CPUE from artisanal fisheries in Mangochi

The trends of four fishing gears that significantly contributed to the Chambo fishery is shown in Figure 5. The trend of gillnets indicates a continuous decline since 2001. From about 12, 000 units of gillnets reported in 2000, the trend reached its minimum level in 2015 of less than 500 units. However, the case of gillnets is a contrary to the behavior of Chambo seine net. According to Figure 5, the trend has been increasing since the year 2000 of about 20 units to about 80 units in 2015 and its peak of about 100 Chambo seine units was realized in 2012. While gillnets were declining and Chambo seine increasing, the trend of Chilimira was rather stable during the same period as it had been revolving between 600 and 700 units with an observable drop to 400 units in the year 2011. Fish traps just like gillnets demonstrated a declining trend and the fluctuations of the trend line reached the minimum in the last three years of the period covered by the study.

It is very important to note that the graphs in Figure 2 and Figure 5 were supposed to start from the year 2000 as it is the case with the catch and effort data, but there are information gaps in that year just like in 2004, 2006 and 2007 as there were no frame surveys in the aforementioned years.

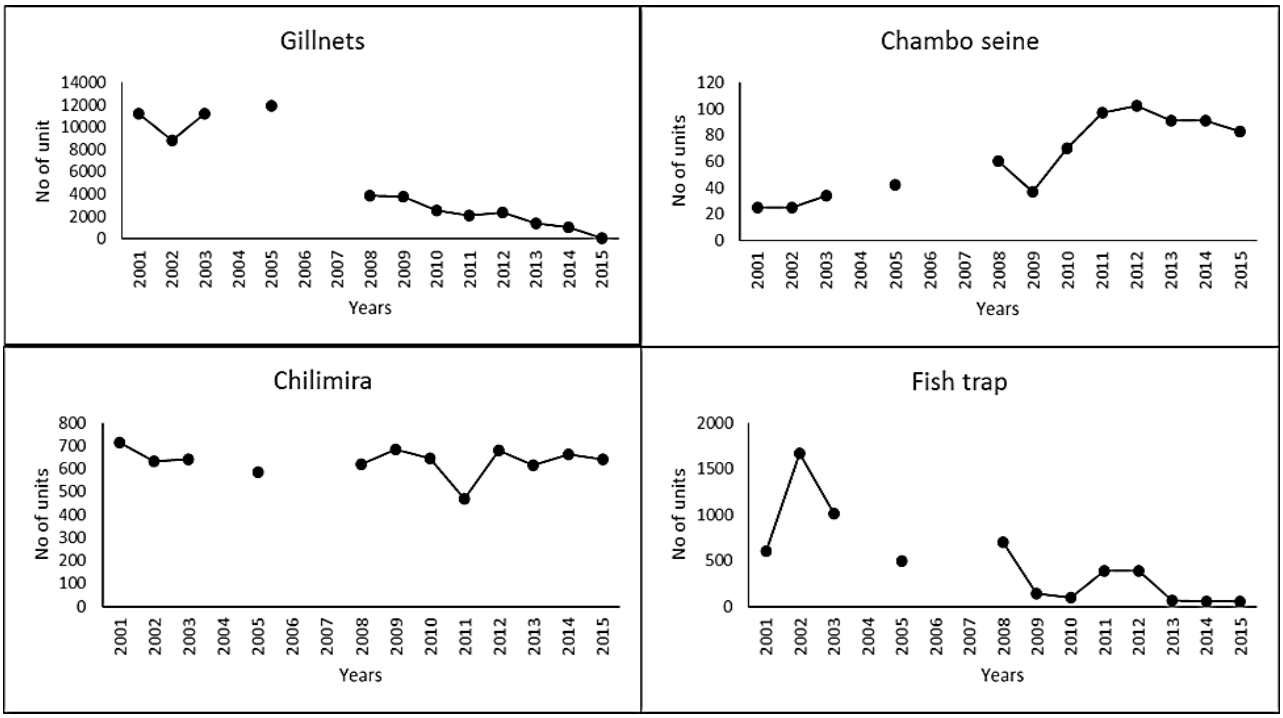

Fig 5: Trend of selected fishing gears that contributed greatly to Chambo catch

3.1 Estimation of Maximum Sustainable Yield (MSY)

Schaeffer Model under Surplus Production Models was used to estimate MSY using total catch data, relative effort and relative CPUE. The relationship between relative CPUE and relative effort was tested and there was a significant correlation between the two ($P<0.05$). Figure 6 demonstrates that there was a strong relationship ($R^2 = 0.7128$)) between the relative effort and relative CPUE.

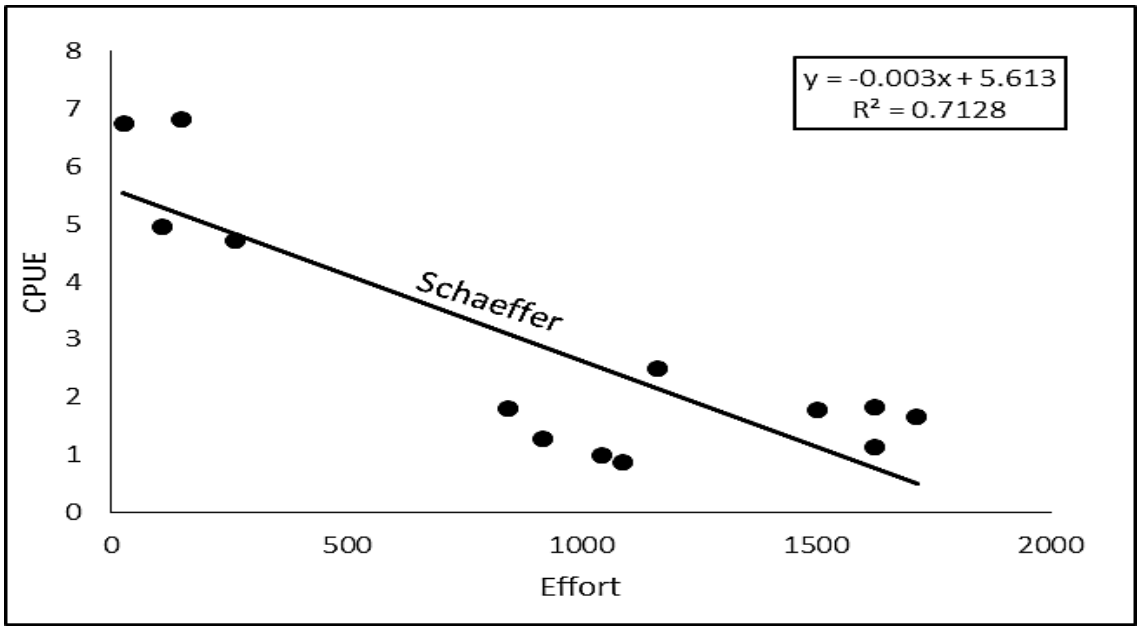

Fig 6: Relationship between relative effort and CPUE

Estimation of the point at which the fishery could be exploited sustainably (MSY) with its corresponding effort (fMSY) is shown in Figure 7. The MSY was estimated to be 2505 metric tons and its corresponding effort at MSY was 945 and this is demonstrated in Figure 6 with some dotted lines. It should be noted that the MSY was reached way back in 2009 and according to Figure 7, the fishery is being exploited unsustainably and this is cause for concern for all the Chambo fisheries stakeholders.

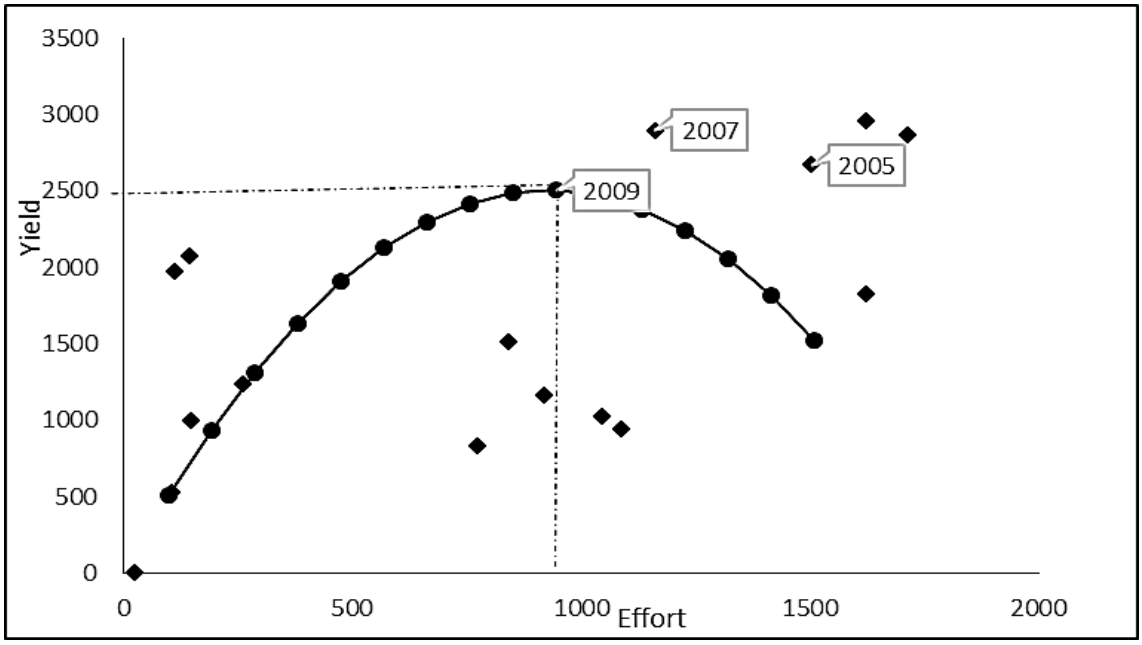

Fig 7: Estimation of MSY and fMSY using Graham Schaeffer Model

4. Discussion

The study has revealed in Figure 2 that the trend of artisanal fishers has been moderately stable which is against the overall understanding that the fishing population keep on increasing as reported by other authors [13, 14]. The stability is in contrast with few authors who attributed an increase in fishing effort as one of the primary contributors of the decline in fisheries resources [4, 9, 26]. The number of fishers may be stable like in this context, but the fishing gears and/or craft owned by each individual fisher may be increasing and this was revealed in 2015 annual frame survey results where a single fisher could own more than 10 boats with engines for certain gears such as open water seine nets called Chilimira.

It is a generally accepted fact that the trend of Chambo has never been the same after the introduction of trawl fishing in 1968 as previously reported. It is therefore imperative that the trend of the Chambo catch in Figure 3 keeps on declining with the lowest point being observed in 2015. Many authors have cited many factors as contributing to the decline in the Chambo catch, [4, 5, 9, 17]. Lazaro [17] further predicted a continued declining trend in the next ten years for Lake Malawi Chambo fishery despite intervention programs delibarately set aside to restore the stocks. Bell et at. [8] reported a positive correlation between Chambo catch and some environmental factors like water level, which primarily originated from rainfall and higher wind velocities. Therefore,

little or inconsistent rainfall could be another reason for the decline in the Chambo catch [8].

The contribution of the gillnets to total Chambo catch has been very minimal as it can be observed in Figure 3 and this can be attributed to the fact that the fishers are slowly abandoning the use of legal gillnets whose minimum meshsize for Lake Malawi is 8.9cm (Personal observation). Fishers are now migrating to the use of illegal undermeshed gillnets termed Ngongongo which of late has witnessed over flooding of undermeshed gillnets made of monofilament. This is the case as it is being alleged that the fishers can no longer catch enough fish with the legal gillnet and this contributes to growth and recruitment overfishing as reported by Banda *et al*. [4]. Followed by gillnets were the Chilimira seine nets whose contribution have been on a declining phase since the department of fisheries banned the use of light attraction (Kauni) fishing targeting Chambo. This was a deliberate measure to control the Chambo fishery from being wiped out. The Chilimira fishery which can sometimes target *haplochromine species* is now harvesting *Engraulicypris sardella* (Usipa), hence its decline in contribution to the Chambo catch.

It has been reported that the trend in the total Chambo catch has been declining and mostly this corresponds with an increasing trend in fishing effort. Therefore, the low levels of effort in Figure 4 is attributed to the quality of the data being used and this was also reported by Gulland [15]. Despite having poor quality data, FAO [12] encourages a wide use of precautionary approach to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. Lack of good quality data should never be an excuse for failing to manage the fishery resource [12].

The trends for gillnets, Chambo seine, Chilimira and Fish trap shown in Figure 5 demonstrate varying behavior which have a bearing on the total landed catch for Chambo. Gillnets whose contribution to the total Chambo catch has been declining in Figure 3 agrees with the trend in the numbers of gillnet units in Figure 5. The decline in the numbers is attributed to the migration of the operators to the undermeshed gillnets (Ngongongo). Therefore, the decline in the legal gillnet should translate into an increase in the use of illegal undermeshed gillnets and this is in agreement with the results of the 2015 annual frame survey where there was an increasing trend of Ngongongo. The increase in illegal gears like Ngongongo was reported by Bulirani [9] and Banda *et al.* [4] as being one of the main reasons contributing to the decline of the Chambo catch. Contrary to the decrease in gillnets is an increasing trend in the Chambo seine over the same period. The increase can only be attributed to the effort by the fishers to diversify to other fish species like smaller *Lethrinops* species (Kambuzi) that seem to be common in the landed catch. The diversification of the Chambo seine net is the main reason why the contribution of the gear to total Chambo landings is very small.

There is stability in Chilimira fishery that has recently experienced massive use of Light Emitting Diode (LED) bulbs to replace Tilly lamps (Personal Observation). Many Chilimira nets are now targeting small Lake Malawi sardine, Usipa and this explains the decline in the contribution to the total catch of Chambo as observed in Figure 3. Fishtraps were also decreasing in numbers which is in contrast with the general trend of the Fishtraps countrywide according to 2015 annual frame survey report.

The study has also revealed in Figure 6 and 7 unsustainable exploitations of the artisanal Chambo fishery and this very worrisome. According to Figure 7, the fishery is being exploited beyond its sustainable capacity as it has been reported that the maximum sustainable yield of 2505 with its corresponding effort of 945 was realized in 2009.

5. Conclusion

The study has demonstrated the status of the artisanal Chambo fishery in Mangochi district whose water bodies are southern Lake Malawi, the upper Shire River and Lake Malombe and the situation is what has already been reported by many authors about an alarming declining trend in the Chambo catch. It has been revealed that the decline in the artisanal Chambo fishery is attributed to many environmental as well as anthropogenic factors and as such, a holistic approach is required to reverse the current situation.

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