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Attaining Fisheries Sustainability: Lessons from a Traditional Fisheries Management Scheme at Mbenji Island, Lake Malawi

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ABSTRACT

Length-weight relationships (LWRs) were used to evaluate the sustainability of the utaka (*Copadichromis* spp) fishery in two parallel management schemes in Lake Malawi. A total of 462 fish samples were collected from fishermen at government-controlled areas (Nkhotakota south, Domira Bay, Senga Bay) and Mbenji Island traditional fisheries in September 2022. Each fish was measured and weighed for its total length (L) and body weight (W) using a measuring board and a digital scale, respectively. The LWRs were computed using the exponential equation: . Data on key water quality parameters were also collected. The LWR parameter 'b' ranged 2.3 - 3.5, with highest values recorded at Mbenji Island, indicating positive allometric growth. Water quality did not differ significantly ($p > 0.05$) between the fishing strata. This shows that fish stocks at Mbenji Island were healthier than at government-controlled areas, suggesting a more sustainable management scheme where communities take greater roles in conservation.

Keywords: length-weight relationship, Utaka, Copadichromis, Malawi, Mbenji island

RÉSUMÉ

Les relations longueur-poids (LWR) ont été utilisées pour évaluer la durabilité de la pêcherie d'utaka (*Copadichromis* spp) dans deux schémas de gestion parallèles du lac Malawi. Un total de 462 échantillons de poissons ont été collectés auprès de pêcheurs dans des zones contrôlées par le gouvernement (Nkhotakota sud, baie de Domira, baie de Senga) et des pêcheries traditionnelles de l'île de Mbenji en septembre 2022. Chaque poisson a été mesuré et pesé pour sa longueur totale (L) et son poids corporel (W) en utilisant une planche de mesure et une balance numérique, respectivement. Les LWR ont été calculées en utilisant l'équation exponentielle : . Des données sur les principaux paramètres de qualité de l'eau ont également été collectées. Le paramètre LWR 'b' variait de 2,3 à 3,5, avec les valeurs les plus élevées enregistrées à l'île de Mbenji, indiquant une croissance allométrique positive.

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La qualité de l'eau ne différait pas significativement (p > 0,05) entre les strates de pêche. Cela montre que les stocks de poissons à l'île de Mbenji étaient en meilleure santé que dans les zones contrôlées par le gouvernement, suggérant un schéma de gestion plus durable où les communautés jouent un rôle plus important dans la conservation.

Mots clés : relation longueur-poids, Utaka, Copadichromis, Malawi, île de Mbenji

Introduction

Fisheries play an important socio-economic role in Southern Africa, generating income, providing food, and critical sources of livelihood (O'Meara *et al*., 2021). However, Africa's inland capture fisheries face the familiar problem of managing a common property and renewable resource – too many boats and too many fishers chasing too few fish, resulting in biological degradation of fish and socio-economic loss (Chan *et al*., 2019). Per capita fish availability is projected to decline in many African countries given it is an area with rapid demographic change, posing a threat to human health and livelihoods. Improved management schemes are required to attain fisheries sustainability. The African Union's Policy Framework and Reform Strategy for Fisheries and Aquaculture advocates for improved management systems to sustain the contribution of capture fisheries to the continent's fish supply (NEPAD, 2016). Lessons for sustainable inland fisheries management systems in Southern Africa are rare (Lewins *et al*., 2014). In this paper we use length-weight relationships (LWRs) to evaluate the health of fish stocks in two parallel management systems at Mbenji Island in Lake Malawi with a view to determine which system appears sustainable and what lessons can be drawn for fisheries policy in Africa.

Instigated by the general decline in Malawi's capture fisheries in the 1990s, the Malawi Government decided to change its fisheries management philosophy in 1993 (Weyl *et al*., 2010; Breuil and Grima, 2014). Before the 1990s, the national fisheries management regime in Malawi focused on top-down and state-dominated governance, which originated in the British colonial period (1891-1963) and vested decision-making powers within the government (McCracken, 1987). Other management regimes continued to exist under the leadership of chieftaincies and communities but these were largely suppressed. In the dominant top-down resource management, the fisheries resources were primarily governed by the state, with no meaningful involvement of local communities in decision-making at the national level. By the early 1990s, this management scheme was considered inadequate as it lacked the local legitimacy and resources needed to enforce it (Njaya, 2002). Consequently, the Government of Malawi began considering sectoral reforms in resource management to promote legitimacy and sustainability through community participation.

By 1995, the first co-management scheme was established in Malawi, with decision-making powers shared between the Government and the local fishing communities (Njaya *et al*., 2012). Pomeroy and Berkes (1997) have defined fisheries co-management as "the sharing of responsibility and authority between the government and the community of local fishers to manage a fishery". During the same period, many countries in Southern Africa were undergoing sectoral reforms in fisheries governance, with trends towards community participation, away from state-dominated regimes bequeathed to them from the Western colonial era (Lewins *et al*., 2014). In some cases, these reforms brought minor successes in the management of fisheries resources. For example, the participatory governance improved fishing gear licensing, vessel registration and coordination among stakeholders in Tanzania's Lake Victoria (Nunan *et al*., 2018).

In Mozambique's Kwirikwidge region, co-management brought harmony between previously warring large- and small-scale fishers and increased compliance to management measures (Benkenstein, 2013). Napier *et al*. (2005) reported increased collaboration among stakeholders through co-management in South Africa's KwaZulu-Natal province.

However, co-management has generally not resulted in successful fisheries management in Southern Africa (Lewins *et al*., 2014). The power for decision-making, including the setting of objectives, in many co-management arrangements still predominantly lies with the Government, with little or no consideration for the interests of the local communities (Hara *et al*., 2002; Bene *et al*., 2009). As a result, these remain rooted in the dominant management principles and priorities established at a Governmental level. Given the failure of co-management as a strategy for successful fisheries management in Southern African inland fisheries, it becomes crucial to explore more viable approaches to sustainable fisheries management (Kapembwa, 2021).

In contrast to the management regimes led by the national government, Mbenji Island's traditional fishery in Lake Malawi is governed primarily through Senior Chief Makanjira. In collaboration with his subordinate village leaders, the Chief has upheld traditional fishing rules around the island based on ancestral beliefs enforced since the colonial era in 1951 (Sato and Pemba, 2022). One fishing rule includes an annual closed fishing season from December to April, intending to allow fish stocks to breed and recover. During the close season, all forms of fishing are not allowed. The Mbenji fishery, and the government-controlled fisheries near it, is based primarily on *Copadichromis* spp. (locally known as utaka), the non-mbuna haplochromines consisting of endemic zooplanktivorous cichlids. In the government managed fisheries, the close season lasts for two months, from November to December every year, and only beach seine nets are discouraged while fishing with other gears remain allowed. Enforcement of fishing rules is strict in the traditionally managed fisheries whereas it is relaxed in government managed fisheries. However, as neither the government nor the communities collect fishery data at Mbenji, there have been questions about the status of the fish stocks and which fishery management system appears more sustainable (Haambia *et al*., 2013). This study used the length-weight relationship (LWRs) to evaluate the status of utaka fish stocks at Mbenji traditional fishery and the surrounding waters which fall under government management regime. The length of the fish (L) is related to its body weight (W) by the equation (Le Cren, 1951). The exponent 'b' is an index of fish growth as dictated by its environmental conditions. When b = 3, growth is isometric; when 'b' is different from 3, growth is allometric (positive if $b > 3$, negative if $b < 3$). Isometry and positive allometry indicate good health of fish that are sustainably managed (Froese *et al*., 2018; Famoofo and Abdul, 2020).

Materials and Methods

The study area. This study was conducted in Domira Bay (stratum 4.2), Senga Bay (stratum 4.1) in Salima district, and Nkhotakota south (stratum 5.1) in Lake Malawi between longitude 34.30 – 34.60 and latitude 13.30 S – 13.70 S. Sampling sites included Chiluwa, Makukuta, Chikombe, Mbenji Island, Lifuwu, and Senga Bay (Fig 1). Mbenji island and its waters cover an area of 32 km^2, spanning a radius of 5 – 7 km from the island. This area, located in the Domira Bay stratum, is dominated by underwater rocky pinnacles and is the focus of the traditional fisheries management scheme under Senior Chief Makanjira. The other areas are predominantly under government management regime. The underwater habitats comprise rocky, sandy and muddy bottoms. The shore is interspaced with sandy and muddy beaches, species. Sandy beaches, some of which are visited regularly by government agents for extension, enforcement and data collection of fish catches, are important docking sites for fishing vessels. Small-scale fishers operating artisanal fishing crafts and gears dominate the fishing population of the study area, catching diverse fish species, principally the utaka (*Copadichromis* spp.)

Water quality. Data on water quality were collected on physical and biological parameters in June and November 2022 to determine any spatial variations in environmental conditions in the study area. Depth-integrated physicochemical sampling was carried out to collect data on temperature, pH, specific conductivity, Secchi disk visibility depth, total dissolved solids, dissolved oxygen and soluble reactive phosphorous (SRP). At each sampling stratum, pH, temperature, dissolved oxygen, salinity and conductivity were measured in-situ using Hydrolab Multi-parameter Sonde (Hach, Model MS5 series, USA). Transparency was determined by manual deployment of the Secchi disk (a white and black disk with a 30 cm diameter attached to the measuring line).

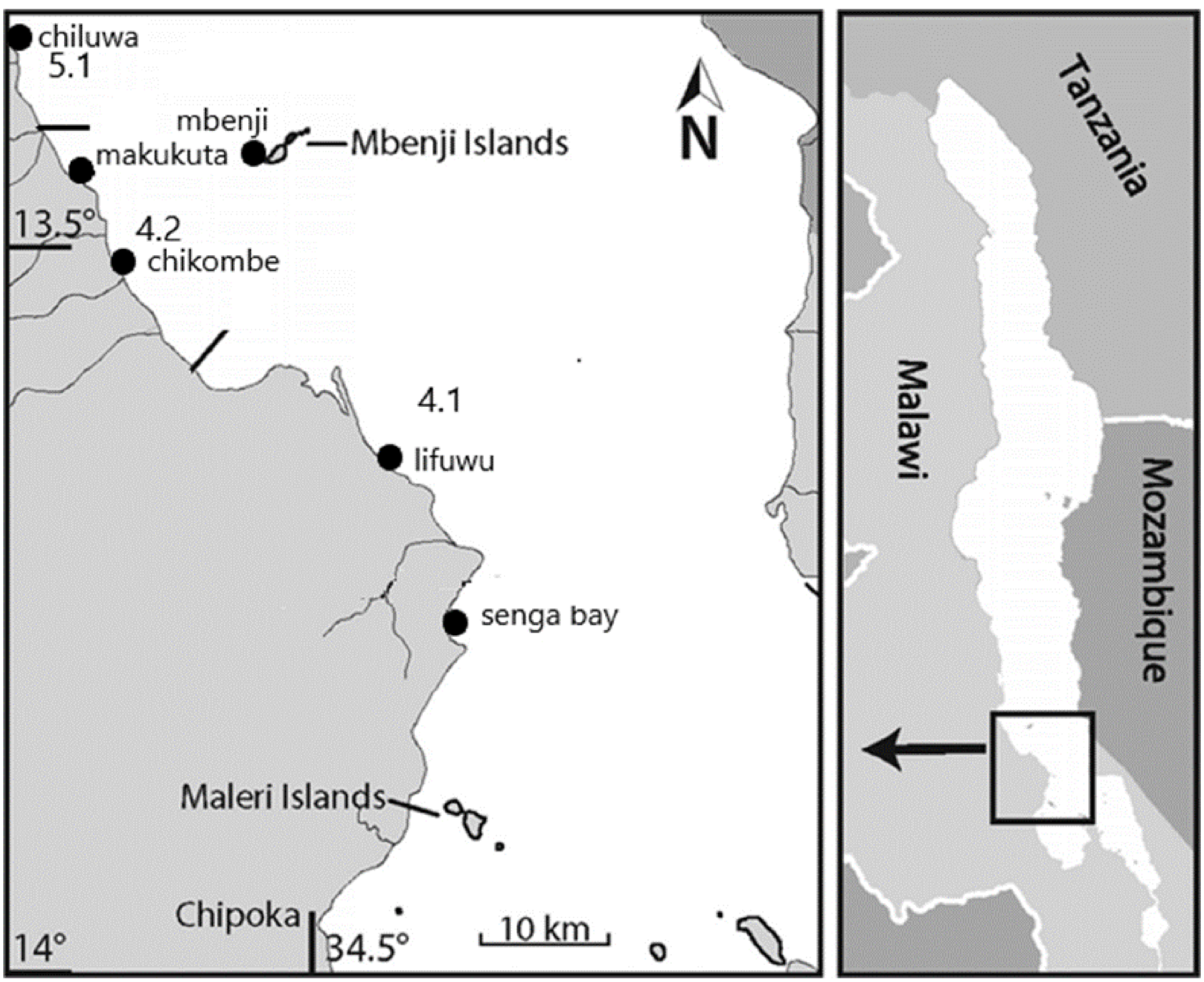

Figure 1. Map of Lake Malawi showing Mbenji Island and other sampling sites (●).

river mouths, and shallow vegetated coves, which form essential breeding and nursery grounds for diverse fish. The depth at which the disk was no longer visible was the Secchi depth. In addition, biological sampling was conducted to collect data on chlorophyll-a as a measure of primary production that drives the aquatic food chain on which fish productivity depends. Water samples from each sampling station were collected from different depths using a Niskin bottle and then transferred into a 1250 ml sample collection bottle. The samples were kept in a cooler box packed with ice and transported to Senga Bay Fisheries Limnological Laboratory to analyse chlorophyll-a and SRP. An integrated Global Position System (Lowrance, Model HDS-9, USA) fitted with a triple shot skimmer transducer was used to collect depth (m) information and corresponding coordinates at each site. The collection and processing of water samples and their subsequent laboratory analyses followed the procedures of Murphy and Riley (1962), Stainton *et al*. (1977), Wetzel and Likens (2000).

Fish sampling and measurements. A total of 462 fish samples belonging to the endemic cichlid genus *Copadichromis* (utaka) were collected randomly from artisanal fishermen in September 2022. Only fish specimens collected from Chilimira seine were used in the study to remove the effects of gear selectivity to allow comparison of size distributions among the fishing strata. The fish were weighed and measured in the field within two hours of collection. First, the total length of the fish was recorded. Total lengths (±0.1cm) were measured from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board. Then the fish body weight was measured with a top-loading digital scale (Teraoka, Model SF-400, RSA) and recorded to the nearest (±0.1) gram.

Length-weight relationships (LWRs). The relationship between the length (L) and weight (W) of the fish specimens was expressed by Le Cren's (1951) non-linear growth equation (Eq.):

$$W = a\,L^b \quad \text{(Eq. 1)}$$

where

W = weight of fish in gram (g);

L = total length of fish in centimetres (cm);

a = constant (intercept) or the scaling coefficient;

b = slope (i.e. change in weight per unit change in length) or the shape parameter.

The parameters '*a*' and '*b*' were calculated from a linear regression of the log-transformed length and weight data of Eq. (1) (Zar, 1999):

$$ln(W) = ln(a) + a\,ln(L) \quad \text{(Eq. 2)}$$

To determine LWRs for environmental and management variations that can affect *b* (Zargar *et al*., 2012), the fish were grouped according to the stratum where they were collected (Nkhotakota south or 5.1, Domira Bay or 4.2, Senga Bay or 4.1, and Mbenji Island). The parameter *b* may vary from the "ideal value" of 3 that represents an isometric growth because of environmental circumstances or the condition of the fish themselves (Nazek *et al*., 2018). When *b* is less than 3, fish become slimmer with increasing length, and growth will be negatively allometric. When *b* is greater than 3.0, fish become heavier showing a positive allometric growth and reflecting optimum conditions for growth.

Relative condition factor (Kn). Kn was determined to evaluate the condition of the fish stocks according to the equation:

$$Kn = W/(a\,L^b) \quad \text{(Eq. 3)}$$

where W is the observed weight and is the calculated weight (Le Cren, 1951).

The health status of the fish stocks is considered to be in good condition when Kn >1, while the fish has poor condition compared to an average fish with the same length when Kn < 1.

Statistical analysis of data. Exploration of depth-integrated data showed no thermal stratification at the sampling sites. Therefore, site mean values for each parameter were used to visualise water quality variations between the fishing strata. Analysis of variance (ANOVA) using Microsoft® Excel 2016 was applied to evaluate any significant differences between sampling strata at a significance level of $p < 0.05$. In the case of significant ANOVA outcomes, the post hoc Tukey test was used to locate the differences between the means at a significance level of $p < 0.05$.

To evaluate the LWRs data, ANOVA was used to determine the statistical significance of the regression model at $p < 0.05$ (Gokce *et al.*, 2010). The coefficient of determination (R2) denotes the quality of a linear regression's prediction, with a value close to 1 representing a better model. To determine whether b of fish from each stratum was statistically significantly different from the consensus for isometric growth (b = 3), a student t-test was done according to the equation of Sokal & Rohlf (1995):

$$t_s = (b - 3)/SE \qquad \text{.................. (Eq. 4)}$$

where t_s is the *t*-test value, *b* is the slope, and SE is the standard error of slope *b*.

The growth of fish is considered isometric when *b* is not statistically different from 3 ($p > 0.05$). In contrast, a statistically significant difference of *b* from 3 indicates an allometric growth, either positive or negative ($p < 0.05$) (Yilmaz *et al.*, 2012). The 95% confidence limits (CL 95%) for *b* were computed using the equation:

$$CL = b \pm (1.96 \; x \; SE) \qquad \text{......... (Eq. 5)}$$

where SE is the standard error of *b*. Natural log values of length (*L*) and weight (*W*) were used to draw a scatter plot for each fishing stratum. A trend line was added to each scatter plot, and linear regression equations were obtained. All data was analysed and scatter-plotted using Microsoft® Excel 2016.

Results

Water Quality. The temperature ranged from 24.3 to 24.4oC; pH: 8.2 to 8.4; DO: 7.4 to 8.5 mg L-1; Secchi disk, ZSD: 4.5 to 6.2 m; Cs: 243.6 to 246.3 µS cm-1; TDS: 0.26 to 0.29 g L-1; SRP: 2.7 to 4.5 µmol L-1; Chl-a: 1.2 to 1.8 µg L-1. These findings were representative of Lake Malawi's pelagic ecosystem and generally reflected good water quality conditions for fish growth (Macuiane *et al.*, 2016). There were no significant differences in the values of water quality parameters between the fishing strata ($p > 0.05$; Table 1).

Length-weight data

Descriptive statistics. Four hundred sixty-two fish specimens of *Copadichromis* (locally known as utaka) were analysed for this research study. The sample size, minimum and maximum length and body weight (observed and calculated) are shown in Table 2. Table 3 presents the means and standard error of the total length and body weight, along with the results of the ANOVA between fishing strata. Regarding total length, the fish did not differ significantly between fishing strata ($p = 0.334$). However, they differed significantly in terms of body weight ($p < 0.001$), with the fish from Mbenji Island being heavier.

Table 1. Water quality parameters (*ANOVA, F*-values and mean ±SD) in the sampling strata of Mbenji and surrounding waters.

	Unit	N	Fishing strata 5.1	4.2	4.1	Mbenji	*F*-value	*p*-value
Temp	°C	82	24.3±0.4	24.5±0.3	24.2±0.3	24.4±0.2	1.76	0.15
DO	mg L^{-1}	82	7.4±0.1	8.2±0.2	8.3±0.4	8.5±0.6	1.01	0.09
Z_{SD}	m	30	6.2±2.4	4.8±1.5	5.8±1.7	4.5±2.4	1.14	0.12
pH	-	82	8.3±0.1	8.4±0.2	8.2±0.2	8.4±0.1	1.20	0.12
Cs	µS cm^{-1}	82	243.6±4.8	245.8±7.1	244.3±9.2	246.3±8.5	3.75	0.17
TDS	g L^{-1}	82	0.26±0.1	0.28±0.1	0.27±0.1	0.29±0.1	1.03	0.09
SRP	µmol L^{-1}	30	2.7±0.3	3.8±1.1	2.8±1.5	4.5±1.0	2.28	0.10
Chl-a	µg L^{-1}	30	1.2±0.4	1.4±0.3	1.7±0.5	1.8±0.6	2.19	0.12

Stratum 5.1: Nkhotakota south; Stratum 4.2: Domira Bay; Stratum 4.1: Senga Bay. Temp: temperature; DO: dissolved oxygen; Cs: specific conductivity; Z_{SD}: Secchi disk visibility; TDS: total dissolved solids; SRP: soluble reactive phosphorus; Chl-a: chlorophyll-a. N: number of observations.

Length-weight relationships (LWRs). The length-weight equation and the relationship parameters (a, b and R^2) of the studied populations of the genus Copadichromis are shown in Table 4. Fish from all the sampling strata were observed to have a significant length-weight relationship (p = 0.000). Further, the length-weight relationship was very strong in fish from all sampled strata, with the coefficient of determination ranging from 0.848 to 0.987, indicating good linear regression close to 1 and suggesting reasonable adjustment between the length and weight of the fish. Although the relative condition factor was higher at Mbenji, it was also high in other strata and did not significantly differ between them (p > 0.05). According to slope (b) of the regression line, the fish from Mbenji Island showed positive allometric growth. In contrast, isometric growth was observed in the mainland fishing beaches of Domira Bay, and negative allometry was observed in Nkhotakota south and Senga Bay. The graphical representation of the length-weight relationship of the fish from the different fishing strata is shown in Figure 2.

Table 2. Sampling sites, number of examined specimens, total length and weight data (min, max, mean ± standard deviation (SD)) of the studied populations of utaka (*Copadichromis* spp.)

Stratum	N	Total length (cm) min	Total length (cm) max	Body weight (g) min	max	Observed	Calculated
5.1	154	7.0	17.0	4.3	34.8	16.8	18.2
4.2	103	8.0	18.0	5.9	71.7	31.8	26.8
4.1	154	7.0	19.2	7.0	201.0	39.0	32.5
Mbenji	51	8.0	21.7	11.5	228.5	101.3	83.8

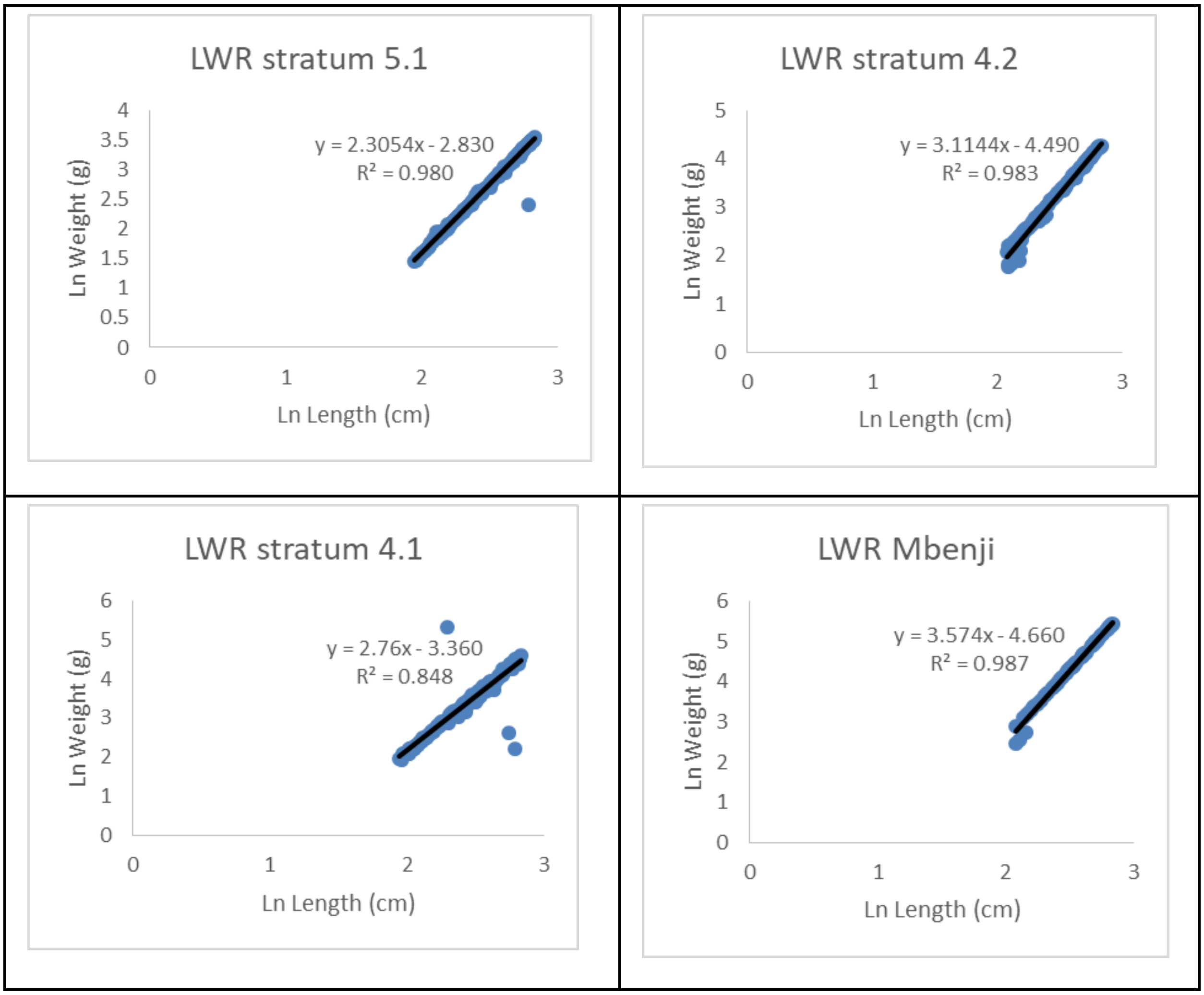

Figure 2. Length-weight relationships (LWRs) of the studied populations of the cichlid fish belonging to the genus *Copadichromis* (utaka) at Mbenji Island and Government-controlled areas (strata 5.1, 4.2, 4.1), Lake Malawi

	Unit					*F*-value	*p*-value
		5.1	4.2	4.1	Mbenji		
L	cm	12.0 ± 3.1	12.2 ± 2.8	11.9 ± 2.8	12.7 ± 2.7	1.135	0.334
W	g	16.8 ± 9.5[a]	31.8 ± 20.8[b]	39.0 ± 28.2[b]	101.3 ± 64.8[c]	108.8	0.000

Table 4. The length-weight exponential equation, length-weight relationship parameters (a, b, and R2), growth pattern, and relative condition factor of the studied populations of utaka (Copadichromis spp.) in the various fishing strata.

	Stratum			
	5.1	4.2	4.1	Mbenji
$W = a\,L^b$	$0.059\ (L)^{2.305}$	$0.111\ (L)^{3.114}$	$0.034\ (L)^{2.761}$	$0.009\ (L)^{3.574}$
R^2	0.980	0.983	0.848	0.987
SE(*b*)	0.026	0.040	0.094	0.058
CI(*b*)	2.253-2.357	3.034-3.194	2.574-2.949	3.457-3.691
p-value (t-test)	0.000	0.160	0.012	0.000
p-value (regression)	0.000	0.000	0.000	0.000
Growth	-ve allometry	Isometry	-ve allometry	+ve allometry
Kn±SD	0.922±0.05	1.186±0.09	1.199±0.75	1.207±0.08

Parameters *a* and *b* represent the intercept and slope of the log-transformed equation: $ln(W) = ln(a) + a\ ln(L)$. L: total length; W: body weight; SE: standard error; CL: confidence limits of *b*; R^2: coefficient of determination; *p*-value (regression): significance of the regression line at $\alpha < 0.05$; *p*-value (t-test): significance of the *t*-test at $\alpha < 0.05$ to verify if *b* is significantly different from the consensus *b* = 3. The growth behaviour was deduced based on the value of *b*; *Kn*: mean relative condition factor and its standard deviation (SD).

Discussion

A total of 462 specimens of utaka (*Copadichromis* spp.) were measured and weighed for the present study. Total length and body weight ranged from 12.0 – 12.7 cm and 16.8 – 101.3 g respectively. The fish did not differ significantly ($p = 0.334$) between strata in terms of total length, but they differed significantly ($p < 0.001$) in terms of body weight. These biometrics denote that changes in length were not accompanied by equal changes in body weight, resulting in different growth behaviour and values of the slope 'b' in different strata. The calculated 'b' values ranged from 2.305 to 3.575, which are consistent with the findings of Froese (2018). The value of 'b' was significantly lower than the consensus 3 in Nkhotakota south ($p = 0.000$) and Senga Bay ($p = 0.012$), depicting negative allometric growth which implies increased numbers of small-sized fish, suggesting overfishing for larger fish (Hossain *et al*., 2012). In contrast, the 'b' value at Mbenji Island was significantly higher than the consensus 3 ($p = 0.000$), indicating positive allometric growth associated with a greater change in weight per unit change in length (stoutness). This is a typical growth behaviour in areas with optimal growing conditions where large fish are numerous and are not overfished (Nazek *et al*., 2018). There was isometric growth in Domira Bay as 'b' values were not significantly different ($p = 0.160$) from the consensus 3. An equal change in weight in isometric growth behaviour balances the change in length, commonly observed in areas of intermediate fishing intensity (Froese, 2018). This might suggest that Domira Bay is receiving a spillover of healthy fish stocks (adult export and juvenile subsidies) from the vicinity of the nearby community conserved area at Mbenji Island (Lorenzo *et al*., 2020).

The condition factor Kn values ranged from 0.923 to 1.208, with Mbenji Island recording the highest Kn. The condition factor reflects interactions between biotic and abiotic factors in the physiological condition of fishes (Lizama *et al*., 2002). The health status, condition or well-being of the fish stocks is considered good when Kn >1, while the fish has poor condition compared to an average fish with the same length when Kn < 1 (Nazek *et al*., 2018).

Water quality plays a substantial role in influencing fish production and the health status of fish stocks (Tumwesigye *et al*., 2022). Therefore, any study aimed at understanding the spatial or temporal dynamics of fish productivity in an aquatic ecosystem will invariably have an aspect of water quality assessment. The present study evaluated the spatial variations in the health of fish stocks of the genus *Copadichromis* (utaka) and hypothesised an association between such variations to differences in water quality at Mbenji Island and the adjacent mainland fishing strata of Nkhotakota south, Domira Bay and Senga Bay in Lake Malawi. The utaka are zooplankton-feeding cichlids that are both ecologically significant and commercially important as food fish (Turner *et al*., 2022). As zooplankton biomass depends on phytoplankton for food, which is influenced by the level of nutrients, particularly soluble reactive phosphorus (SRP), the link between water quality and utaka production becomes visible. The results on water quality, including the absence of discernible thermal stratification during the period of this study, were consistent with previous studies in Lake Malawi, e.g. Eccles (1974); Bootsma and Hecky (1993); Guildford *et al*. (1999) and Macuiane *et al*. (2016). All water quality parameters investigated in this study, including SRP and phytoplankton biomass, did not differ significantly between the various fishing strata ($p > 0.05$), negating the likelihood of association between possible variations in the health status of fish stocks and their environment.

The Mbenji Island traditional fisheries management scheme under Senior Chief Makanjira has established strict fishing rules since the 1950s. A four-month closed season from December to April is enforced yearly, where all forms of fishing are not allowed. Based on indigenous knowledge of the breeding pattern of fish, this rule is intended to provide an opportunity for all fish species at Mbenji Island to breed and grow while allowing those fishers who also engage in agriculture the necessary time to tend to their farms as the season also coincides with the farming period. The extended closed season allows the fish to grow to more extensive sizes than in other fishing strata. Two committees (main- and sub-committee) authorised by Chief Makanjira strictly enforce the closed season. The main committee patrols the beaches of the mainland to ensure no fisherman leaves for Mbenji during closed season and no unauthorized gear is taken to the island when the fishery opens. This committee consists of traditional leaders led by Senior Group Village Headman Nyangulu. The sub-committee, consisting of youthful community members, keeps vigilance on the Island itself to ensure no one fishes in its waters during the closed season and everyone complies with the fishing rules during the open season.

When the fishery opens, several rules are in place at Mbenji. Under-meshed and destructive fishing gears and methods (such as beach seines lined with mosquito nets, monofilament gillnets, and light attraction for night-time Chilimira fishing) are not allowed to operate. This allows the maintenance of large-sized fish populations in the fishery and prevents ghost fishing by lost gear or their fragments. Killing wildlife or cutting down trees is not allowed, as this is believed to undermine the sanctity of places where ancestral spirits are believed to reside. This keeps both the aquatic and terrestrial ecosystems healthy. Anyone breaking the rules is heavily fined and banned from fishing for a period. The money collected from the fines is used to finance the enforcement activities and the closing and opening ceremonies of the Mbenji fishery. The strict enforcement regime practised by the communities ensures high compliance with fishing rules and helps to maintain the health of the fish stocks and their ecosystem. Thus, while the fisheries in Lake Malawi have generally declined due to climate crisis, overfishing and poor management, the fisheries at Mbenji Island have remained healthy (Sato and Pemba, 2022).

The fisheries management regime at Mbenji can be thought of as ecosystem-based. While the government -controlled fishing areas only focus on protecting the tilapia species belonging to Chambo stocks, the Mbenji fishery practices a holistic fisheries management style by considering the entire ecosystem of the species being managed. By banning all fishing gears during closed season and extending the closed season to four months, the Mbenji fishery protects not only utaka species but all other fish species. The Mbenji fishery management scheme recognizes that besides fishing as a variable that affects species there are other elements such as interactions with other species, environmental changes, pollution and other stresses on habitat and water quality that need to be taken into account for effective resource management. The prohibition of cutting down trees, killing wildlife, gambling, ghost fishing, alcohol, under-meshed gears, and fishing with light attraction devices helps to preserve the entire ecosystem and its dependent species at Mbenji Island.

The situation is different in the government-controlled fishing areas, including those where co-management arrangements are in place through Beach Village Committees (BVCs). The closed fishing season is short, lasting only for two months, from 1st November to 31st December, the duration thought to be the peak breeding time for the tilapia cichlids locally known as Chambo, a fish of high economic value. The only fishing gear prohibited during this closed season is the beach seine net, believed to have the potential to destroy tilapia breeding nests on the bottom of shallow waters where the fish breed. The closed season is poorly enforced, with increased rule-breaking cases (Hara *et al*., 2002). The emphasis on the protection of the single stocks of Chambo is based on the Western legacy of the British colonial government, which focused on conserving those fish stocks that were perceived to be of the highest economic and nutritional value (McCracken, 1987; Chirwa, 1996; Lowe-McConnell, 2000). While target-resource-oriented management (TROM) appears attractive in the temperate marine fisheries conservation models, the interdependence of the tropical multi-species fisheries may require ecosystem-based approaches for effective and sustainable management. Stopping the operation of a single gear does not insulate the protected species from attack by other fishing gears operating on other fish stocks in the ecosystem. The ecosystem-based approach, visible at Mbanji Island, addresses all environmental, ecological, and anthropogenic impacts (including fisheries) on an ecosystem and considers the interconnectedness and interdependence of various ecosystem components (Curtin and Prellezo, 2010).

Conclusion and Lessons Learned

The health status of Copadichromis (utaka) fish stocks, as indicated by the growth behaviour and relative condition factor, differs between Mbenji Island and the neighbouring government-controlled fishing strata, with those from Mbenji Island having the highest health status. As the water quality conditions were not different between Mbenji Island and the neighbouring fishing strata, the differences in growth behaviour and condition factor of utaka fish stocks could not be attributed to environmental conditions but to the type of management scheme in place. The Mbenji Island traditional fisheries management scheme implements an annual closed season that runs for four months from December to April, giving enough time for fish to breed and grow to larger sizes before fishers catch them. The closed season at Mbenji Island is one of a total ban, where all fishing gear are not allowed to operate during the period.

The traditional fisheries management scheme also implements a strict gear restriction regime in which small-meshed nets cannot operate during the open fishing season. The comparative health of utaka fish stocks in Mbenji and the surrounding waters demonstrates the sustainability of the fisheries in the traditional fisheries management scheme. The Mbenji fishery management scheme shows that a longer closed season and associated regulations paired with strong local institutions with established enforcement powers and community buy-in may provide better prospects for sustainable fisheries. A longer closed season associated with total ban on fishing gears has the potential to provide enough time for many species to breed and grow for the effective conservation of fish. Both the closed and open fishing seasons require strict enforcement for the management measures to achieve their intentions. Where the fishing communities demonstrate the capacity and interest to manage their own fisheries resources, the government needs to provide support rather than drive the management agenda.

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Statement of No-Conflict of Interest

The authors declare no conflict of interest in the paper.

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