Multidisciplinary Journal of TUM 4(2) 2025: 12-35 https://doi.org/10.48039/mjtum.v4i2.96 **Research Article**

Different fishing vessel-gear combinations confirm resource-use overlap in small-scale fisheries of south coast Kenya

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Abstract

Fish consumption globally has increased due to the rise in human population making fisheries resources vulnerable to overexploitation. The open access fisheries in Kenya coupled with the multi-fleet, multi-gear and multi-species nature of the fisheries make its management more difficult. A closer observation into the scenario proves the existence of resource use overlap among different vessel-gear combinations. This study assessed the resource use overlap among different vessel-gear combinations for the multi-gear and multi-fleet small-scale fishery in selected fishing areas in south coast Kenya. We conducted shore-based catch assessment from January 2019 to December 2021covering both the cool south east monsoon (SEM) season and the warm north east monsoon (NEM) season at Mkunguni fish landing site in Msambweni area and Shimoni fish landing site in Shimoni area. The data was analyzed for total fish landings and species composition by vessel-gear combinations, as well as analyzed for resource-use overlap. A total weight of 52.32 tons of fish was recorded over the study period, and this was higher in the NEM season (26.52 tons) than in SEM season (25.32 tons). An overall total of 321 species in 88 fish families were sampled. Mkunguni recorded more species (n = 253) than Shimoni (n = 186) and species richness was significantly higher in Mkunguni than Shimoni ($p = < 0.0001$). The most effective and preferred vessel-gear combinations overall were footfisher-speargun and dhows-handline. Seasonal species diversity also indicated an overlap in resource-use where different vessel-gear combinations landed multiple species with the highest number of species recorded by gears used in combination with canoe being handline (120 ± 8 species) and basket trap (87 ± 6 species). Fishing gears used with dhows being handlines which recorded the highest mean number of species caught (73 ± 4 species) and gillnet (58 ±5 species). The observation made in the presence of similar fish species in different vessel-gear combinations that had been used in different fishing grounds is a clear indication of resource-use overlap in the small-scale fishery.

Key Words: Small-scale fisheries, Vessel-gear combinations, Resource-overlap, South coast Kenya

Introduction

The estimated number of fishing vessels in the world according to FAO (2022) stands at 4.1 million, which has been reducing over the last two decades. However, the number of fleets has been increasing in Africa by about 10 % between the years 2015 and 2020 now comprising 23.5 % of the total fishing vessels globaly (FAO, 2022,; Government of Kenya, 2022). Globally, small-scale fisheries play an integral role in the wellbeing of the dependent communities through employment, food security and nutrition (Mwakaribu et al., 2023). Half the world's fishing effort is represented by the small-scale fishery and makes over one-quarter of the global catch volume and represents over 90 % of employment in capture fisheries (Oliveira et al., 2016; Rousseau et al., 2019). Of the world's total number of boats, 81 % are small-scale vessels of a length of less than 12 m, mostly undecked (FAO, 2022). Asia is leading in number of small-scale vessels followed by America and Africa.

Developing countries of the Western Indian Ocean (WIO) are met with the challenges of

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developing sustainable fisheries resources management. Most of these countries in this region (Mozambique, Tanzania, Kenya, Madagascar and Comoros) lack the capacity to sustainably draw benefits from the fisheries resources or even assess its potential (van der Elst, et al., 2009). Fisheries in this region is mainly small-scale and artisanal in nature which is characterized by simple technology and low-capacity investment (Oliveira et al., 2016) subjected to open access and compounded by multi-species, multi-gear and multi-fleet. The open access nature of the artisanal fisheries in these developing nations has resulted to over exploitation due to increasing effort, use of destructive fishing gears, rapid growing population and low compliance of set management measures (Oliveira et al., 2016; Samoilys et al., 2017). This situation facing the artisanal fisheries is excerbated by the unprecedented climate change impacts (Cinner et al., 2009) further posing more challenges in the sustainable management of the small-scale fishery.

Quality fish catch data has been a great challenge with unreliable capture and remittance platforms which is partly due to the open access, multi-gear and multi-species nature of this fishery (McClanahan, et al 2004; Mwaluma., 2021). This poor quality of catch data has led to management challenges leading to impacts like resource use conflicts, overharvesting and unsustainable fisheries practices (Kamau et al., 2021). Fisheries data is critical, and information derived from such data is useful in formulating management recommendations for sustainable resource use (Kamau et al., 2021). For example, catch data for different fishing gear types have been used to recommend for appropriate gear-based management interventions (Pfeiler et al., 2005; Cinner, 2009; Munga et al., 2014; Kamau et al., 2021). This has led to tremendous campaign on the importance of understanding the effectiveness and role of different vessel-gear combinations and their selectivity in the management of fisheries (Munga et al, 2014). According to Jiddawi (2002) and Aloo et al., (2014), management of artisanal fisheries particularly in the tropics including the WIO region has been challenging due to regulations that allow open access to the multi-species and multi-fleet fishery. Kenya has a total of 36 fishery types as per the WIOFish report of 2017 (Everett, et al., 2017). Out of the 36 fisheries, 31 are active while 5 are inactive or non-operating with most of them operating within the small-scale fisheries sector. These fisheries are; artisanal (26), subsistence (16), small-scale commercial (15), industrial (4), foreign fleet (2), semi-industrial (2), other (2), sport (2), recreational (1), tournament (1) (Everett, et al., 2017). Notably, 11 of these fisheries do not use any technology that aid fishing which limits their exploitation of the resource and the overall catch.

Along the Kenya coast, artisanal fishery directly employs more than 14,000 fishers (Government of Kenya, 2022) and this number has been increasing due to increased demand of fish and fish products. In south coast Kenya, Kwale County has a total of 6,333 fishers in the year 2022 which accounted for 30% of the total fishers' population in coastal Kenya (Government, 2022). Majority of these fishers practice artisanal fishing. Most of the fishing grounds are located within the lagoons, and inshore areas with a few fishers accessing offshore fishing grounds for limited hours due to small and low-technology vessel types and lack of post-harvest fish handling equipment (Fondo, 2004). The lack of capacity to explore offshore fisheries resources has forced most of the fishers in south coast Kenya to employ the use of all fishing gear types within the reef to increase catches thus has resulted to dwindling catches due to over exploitation (McClanahan and Mangi, 2000; Ndarathi et al., 2021). The main fishing gear used are the most affordable gillnets, hand lines, and traps targeting high value reef and sea grass fish species (Ndarathi et al., 2021). This influx of artisanal fishers in nearshore and within the lagoons has a detrimental effect to the critical habitats and is severely eroding key ecological goods and services that coral reefs and sea grass beds provide (MacRae et al., 2001; Kamau et al., 2021).

In an effort to balance the human needs against the ecosystem needs for conservation, some of the measures taken by managers and the local communities have been the establishment of marine protected areas (MPAs), and community conservation areas (CCAs) (Agardy et al., 2011;

Kawaka et al., 2017). If well implemented, these measures can help to buffer the impacts of overfishing and presence of artisanal fishers within the reef in the developing countries like Kenya, but they are however, too small to sustain the broader seascape (Wisz et al., 2008). The Fisheries Management and Development Act of 2016 in Kenya restricts the use of some fishing gear types. Additionally, the fisheries sector in Kenya is undergoing significant transformation through the implementation of the Kenya Marine Fisheries and Socio-Economic Development Project (KEMFSED), which comprises three key components. These include, focus on enhancing the governance and management of priority marine fisheries, aiming to improve management through co-management of nearshore fisheries and infrastructure development at national and county levels, empowering coastal communities and enhancing livelihoods through various support mechanisms, like technical assistance, financial aid, and capacity-building initiatives. For proper management it is important to note that the mode of propulsion of the various fishing vessels used in combination with different gears by the artisanal fishery may have specific impacts on fish catches due to differences in operational efficiencies of different vessel-gear combinations. The landed fish composition depicts a picture of resource use overlap in the artisanal fisheries which may require specific management measures considering the specific level of fishing pressure at fish species level. To better understand the effectiveness of different vessel-gear combinations this study attempts to answer the questions; which vessel-gear combinations show resource-use overlap by landing similar fish species?

Material and Methods

The Study Area

This study was conducted in south coast Kenya at Mkunguni fish landing site (4° 28' 19.94" S, 39° 29' 30.76" E) in Msambweni fishing area and Shimoni fish landing site (4° 38' 49.92" S, 39° 22' 47.28" E) in Shimoni fishing area (Figure 1). Shimoni is located in Lungalunga Sub-county in Kwale County and in close proximity to the Kisite-Mpunguti marine protected area (MPA). This is also part of the south coast area which falls within the proposed transboundary conservation area between south coast Kenya and north coast of Tanzania. Msambweni on the other hand is close to Gazi Bay which has both mangrove and sea grass ecosystems. Both rivers Mkurumudzi and Kidogoweni drain waters into the bay. The local communities in south coast Kenya have a fishery dependent economy with the main fishing grounds situated in Msambweni and Lungalunga sub-counties. The fishery is mainly small-scale which employs the use of small fishing vessels that are concentrated within the shallow lagoons (Government of Kenya, 2016). The small-scale fishery is also characterized by multi-fleet, multi-gear and multi-species, with the most common gear types being spear guns, seine nets, monofilament nets, gillnets, hand-lines, and trawl lines (McClanahan and Mangi, 2004). The vessels are composed of dugout and outrigger canoes, dhows, and fiberglass boats (Jiddawi and Öhman, 2002), and some fishers do not use any fishing vessels commonly known as the foot-fishers. The study area is rich with a variety of reef and sea grass associated fish species but dominated by the family Siganidae (rabbitfishes), Lethrinidae (emperors), Scaridae (parrotfishes), Lutjanidae (snappers) and Octopodidae (octopus) (County Government of Kwale, 2019; Mwaluma et al., 2021). The annual landings is estimated at 2.5 metric tons annually with higher landings recorded during the warm and calm season of the northeast monsoon (NEM) (Government of Kenya, Frame survey report 2022).

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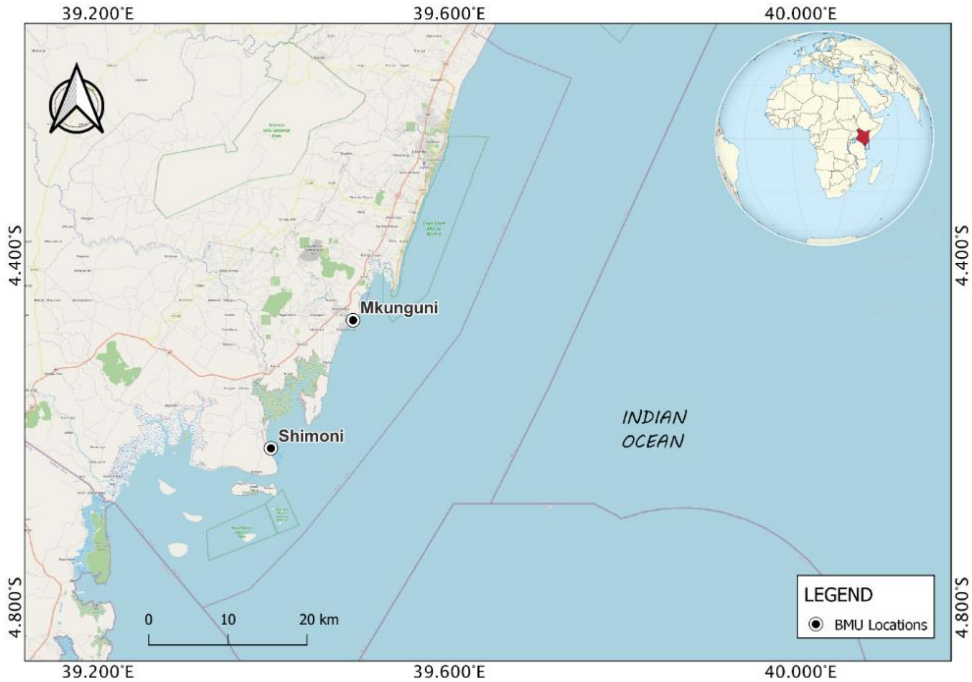

Figure 1. A map of the study showing the sampling sites of Mkunguni and Shimoni of south coast Kenya

Data Collection

Show-based catch assessment

The study used both existing and additional new data on shore-based catch assessment from the fish landing sites of Msambweni and Shimoni in south coast Kenya. Existing monthly catch and effort data from January 2019 to August 2020, showing total landings, species composition, fishing gear and vessel types, and fishing grounds were compiled from the Kwale County Fisheries Department office. Additional new data was collected from September 2020 to December 2021 using similar procedure of shore-based catch assessment. Identification of landed fish was done to the level of species using available fish identification guides (Lieske and Myers, 1996; Smith and Heemstra, 2003; Anam and Mostrada, 2012). Additional data on fishing gear types, fishing vessel types, fishing ground, crew size and fishing duration (hours) were recorded in a designed data sheet.

Data Analysis and Statistical Tests

The overall total monthly fish landings data was analyzed to observe trends in fish landings and relative abundance during the period of the study. ANOVA was used to test for significant differences in species recorded between vessel-gear combinations across the study period at a significant level of $p<0.05$. All parametric tests were performed using STATISTICA statistical software version 7. Species diversity by vessel-gear combinations was analyzed using species richness (S) and Shannon-Weiner diversity Index (H′) as measures of diversity. Species richness (S) was calculated as the total number of species for each vessel-gear combination. Mean species richness was calculated for vessel-gear combinations, fishing area and by season. The following formula was used to calculate H′ according to Pillans et al., (2007):

$$H' = - \Sigma i \; pi \log (pi) \text{ ---------------------------------- (ii)}$$

Where *pi* is the proportional of the total count (or biomass) arising from the ^{ith} species.

Significant differences in Shannon-Wiener diversity index across vessel-gear combinations, between sites and between the seasons was tested using Kruskal-Wallis test even after when the data was transformed and did not meet the conditions for a parametric ANOVA test. Significancy level was set at $p < 0.05$.

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Results

Distribution of Fishing Vessels by Fish Landing Sites

A total of 4 fishing vessel types were considered for analysis. The use of canoes and fiberglass boats was more common in Mkunguni fish landing site in Msambweni than in Shimoni while dhows and foot fishers were more common in Shimoni. Small-scale fishers from both Mkunguni and Shimoni fish landing sites commonly used three fishing vessels: canoes, dhows, fiberglass boat as well as foot fishers who dominated in both fish landing sites. At Mkunguni, fishers using canoes were most dominant (92.4%; n = 4,223) and fishers who used fiberglass boats were the least (4.1%; n = 188). At Shimoni small-scale fishers mostly used dhows (63.3%; n = 1,324) (Figure 2). Although, the overall number of foot fishers was less compared to fishers using vessels, more foot-fishers were recorded at Shimoni (7.2%; n = 72) than at Mkunguni (1.6%; n = 150) (Figure 2).

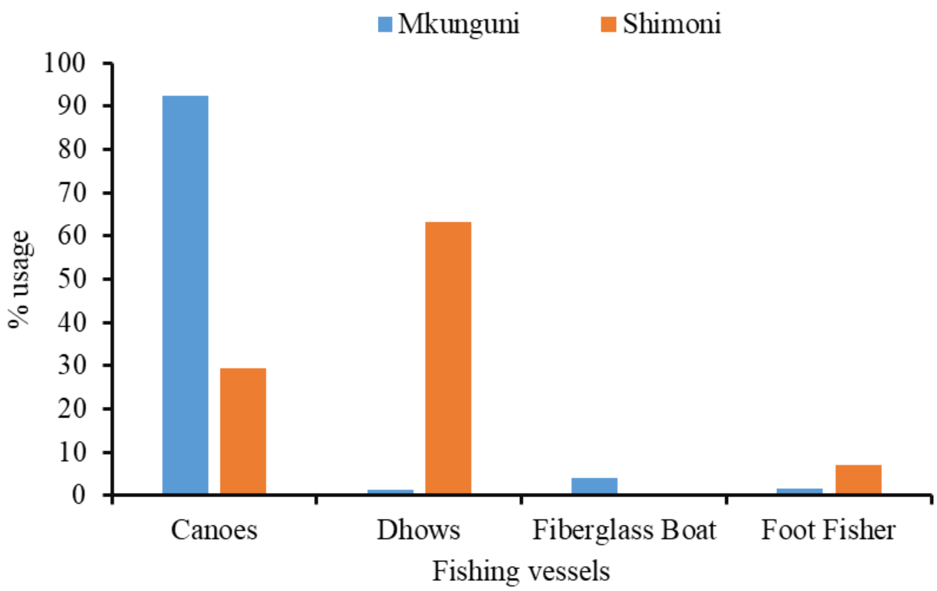

Figure 2. Distribution and use of fishing vessels by small-scale fishers including foot-fishers sampled over the study period at Mkunguni and Shimoni fish landing sites, south coast Kenya

Distribution of Fishing Gear Types by Fish Landing Site

A total of 11 fishing gear types were considered for analysis. Several fishing gear types were recorded at both Mkunguni and Shimoni (Figure 2). The most common gear types at both fish landing sites were basket traps, hand lines, and spear guns. At Mkunguni, the use of basket traps dominated (52.4%; n = 2,395) followed by use of hand lines (32.5%; n = 1,486). At Shimoni, handlines (36.2%; n = 815) and spear guns (20.4%; n = 460) were commonly used. The least used fishing gear types at both fish landing sites were trawling lines, monofilament nets and longlines (0.75%, 0.61% and 0.02%), respectively. Gill nets although not very commonly used compared to other gears were used in both fishing areas at almost equal proportion while hooked sticks and seine nets were exclusively used at Shimoni fish landing site (Figure 3).

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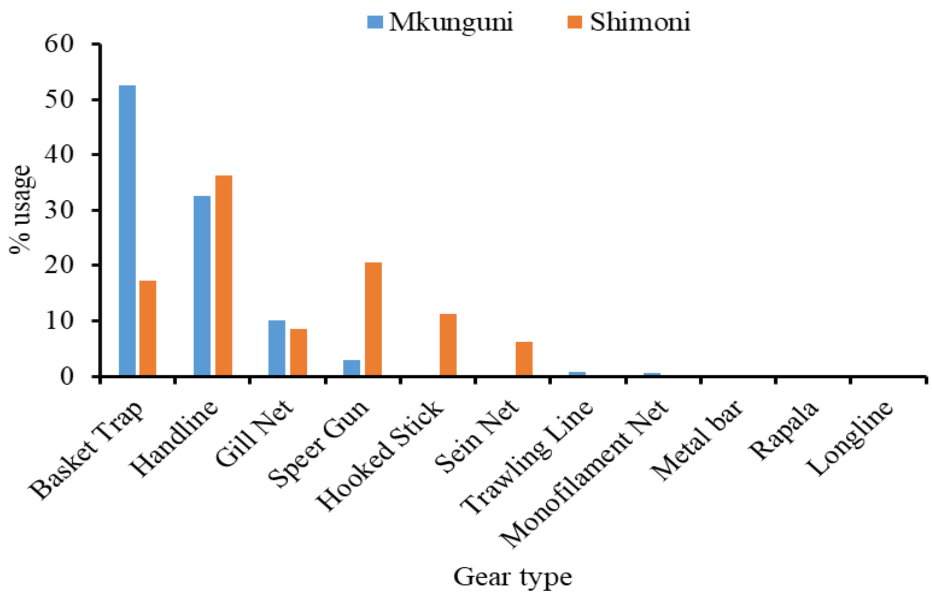

Figure 3. Distribution and use of fishing gear types used by small-scale fishers at Mkunguni and Shimoni fish landing sites in south coast Kenya

Seasonality in Fish Landings by Landing Site and Fishing Ground

A total of 52.32 tons of fish were landed over the study period. The NEM season experienced higher fish landings (26.52 tons) than the SEM season (25.32 tons) (Figure 4). Shimoni recorded higher fish landings (38.54 tons) than Mkunguni (13.78 tons) over the study period. Seasonal differences in fish landings were also observed in Shimoni and Mkunguni. In Shimoni, slightly higher fish landings was recorded in the SEM season (19.99 tons) than in NEM season (18.55 tons). Also higher fish landing in NEM (7.97 tons) than SEM (5.8 tons) was recorded in Mkunguni fish landing site over the same period. Simillarly, on average there was higher fish landings in Shimoni (6.18 ± 0.91 tons in SEM and 6.07 ± 0.11 tons in NEM) than Mkunguni fish landing site (1.94 ± 0.03 tons in SEM and 2.66 ± 0.17 tons in NEM).

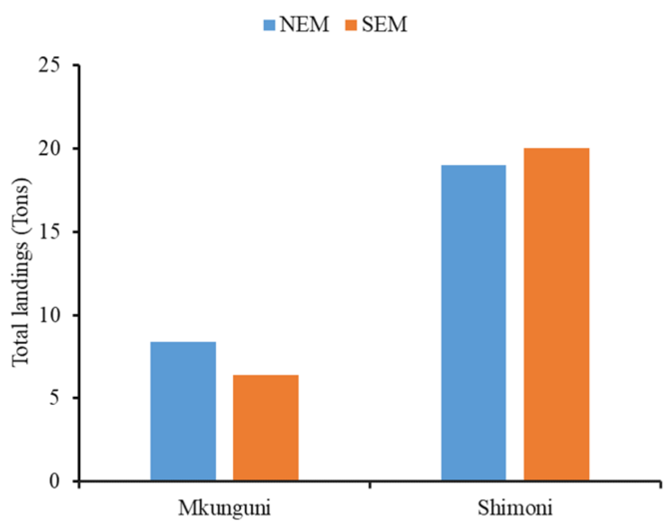

Figure 4. Overall total fish landings recorded in Msambweni and Shimoni fish landing sites over the study period

During the study, 24 fishing grounds were recorded (Figure 5). Mpunguti was the most productive fishing ground (18.08 tons) closely

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followed by Nyuli fishing ground (7.60 tons). Both fishing grounds were situated outside Msambweni and Shimoni fishing areas where the fish landing data was collected. Most of the fishing grounds each recorded less than 2 tons of fish landings over the study period.

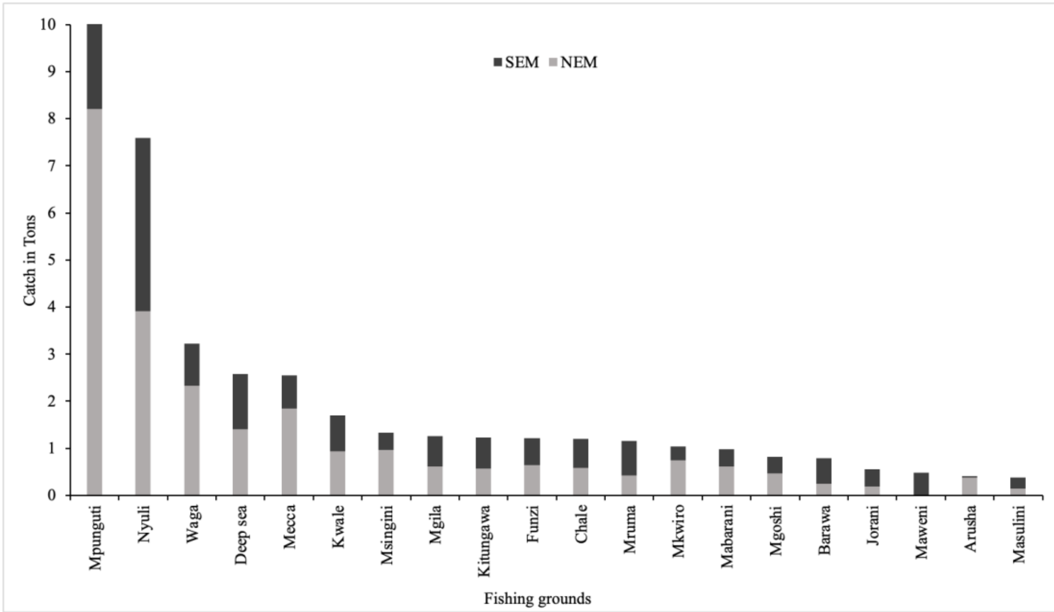

Figure 5. Overall seasonal total fish landings by fishing ground recorded over the study period

Total Fish Landings by Fishing Gear and Fishing Ground

Over the study period, 13 fishing gear types were recorded that were used by the small-scale fishers in the 24 fishing grounds. Five most common fishing gear types were handline, basket trap, hooked stick, spear gun and gill net distributed over a total of 13 fishing grounds (Figure 4.5). The remaining 11 fishing grounds accounted for only 12.2% of the total fish landings from these main fishing gear types.

Trends in Fish Landings

The overall fish landings showed an increasing trend throughout the study period (Figure 6). There was a difference in seasonal trends of fish landings where an increasing trend over the study period was observed for fish landings associated with NEM season and a decreased trend in fish landings associated with the SEM season. More results indicate that there was monthly variation in fish landings at both landing sites with a monthly mean of 1,148.3 ± 84.8 kg for Mkunguni and 3,064.1 ± 154.4 kg for Shimoni. Shimoni landing site recorded the lowest landings over the months of May and June coinciding with the SEM season while at Mkunguni landing site lowest catch landings were between May and September also coinciding with the SEM season (Figure 6).

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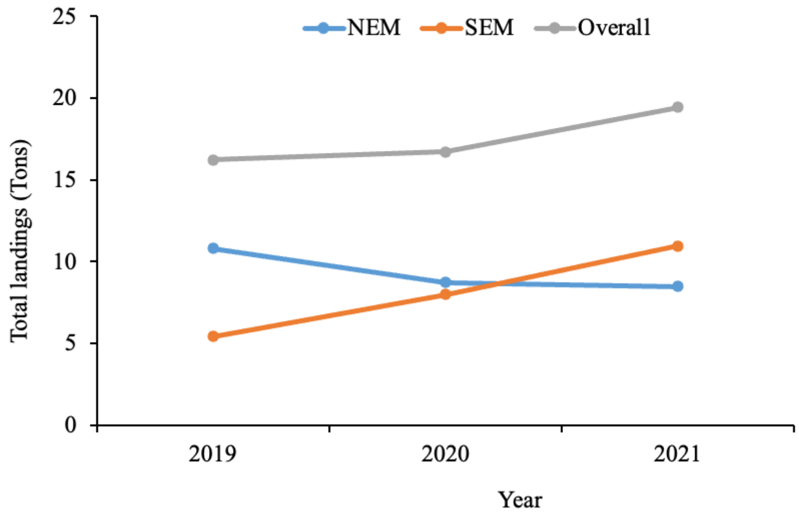

Figure 6. Annual and seasonal trends in fish landings over the study period for combined Mkunguni and Shimoni fish landings

Annual Total Fish Catches by Vessel-Gear Combinations

Based on total fish landings, the most common vessels used were canoes and dhows while the most common fishing gear types were basket traps, handline, gill nets, spear guns and hooked sticks. In general, the highest total fish landings was recorded by canoe-basket trap (5.37 tons) followed by canoe-handline (4.87 tons) and dhow-hand line (4.04 tons) (Figure 7). Lowest total fish landings was recorded by dhows used with basket traps (1.44 tons), dhow-hooked stick (1.39 tons) and dhow-spear gun (2.04 tons). Increasing trend from 2019 to 2021 in fish landings was observed for canoe-handline (1.40 – 1.97 tons), dhow-basket trap (0.27 – 0.90 tons) and dhows-spear gun (0.43 – 1.01 tons) over the study period.

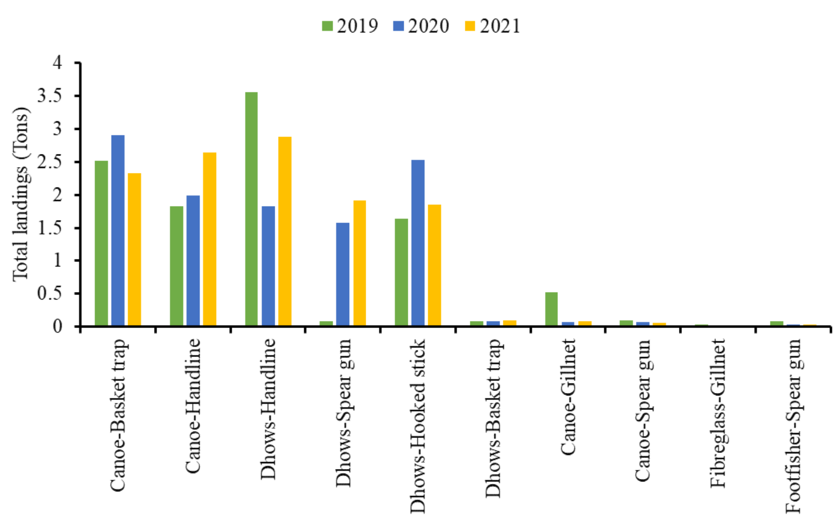

Figure 7. Annual total fish landings by most common vessel-gear combinations over the study period

Composition of Sampled Fish Catches over the Study Period

Fish sampling identified 321 fish species belonging to 88 fish families recorded (Annex 1) in the study area during the study period from a total of 10,310 individuals specimens with a total weight of 52.32 tons. In Mkunguni 253 species

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were recorded from a total of 5,848 specimens and in Shimoni 186 species were recorded from a total of 4,462 specimens (Figure 8).

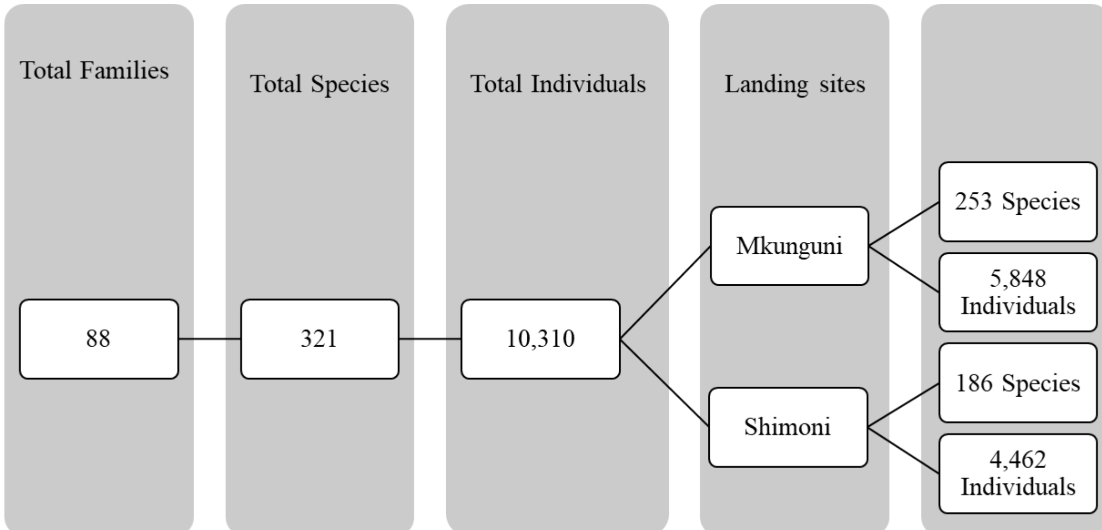

Figure 8. Summary of catch composition sampled at Mkunguni and Shimoni fish landing sites during the period of the study period

Species richness varied greatly for, the different fishing grounds accessed during the study period depicting a picture of how different ecological conditions influenced the existence of fish species. The highest species richness was observed in fishing grounds around the Kisite Mpunguti marine protected area, Mpunguti and Waga mostly accessed by fishers from Shimoni landing site. These were followed by fishing grounds within the Gazi bay laying behind Chale Island and in close proximity to the mangrove ecosystems, Nyuli and Kwale (Figure 9).

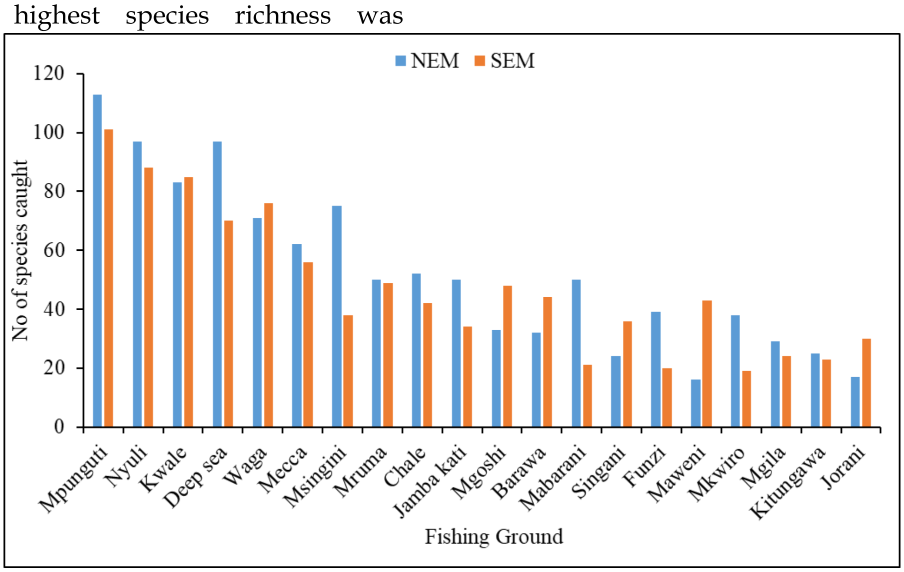

Figure 9. Number of fish species caught in the top twenty fishing grounds accessed over the study period

The species *Siganus sutor* (17%) and *Lethrinus mahsena* (8%) were the most abundant in this study. *Octopus vulgaris*, and Octopodidae was the third most abundant at 5.5% of the total landings. The lowest of the top 20 most abundant species were *Sphyraena barracuda* (1%), a pelagic fish species and *Uroteuthis duvaucelii* (1%) commonly known as squid belonging to the family Loliginidae. (Figure 10).

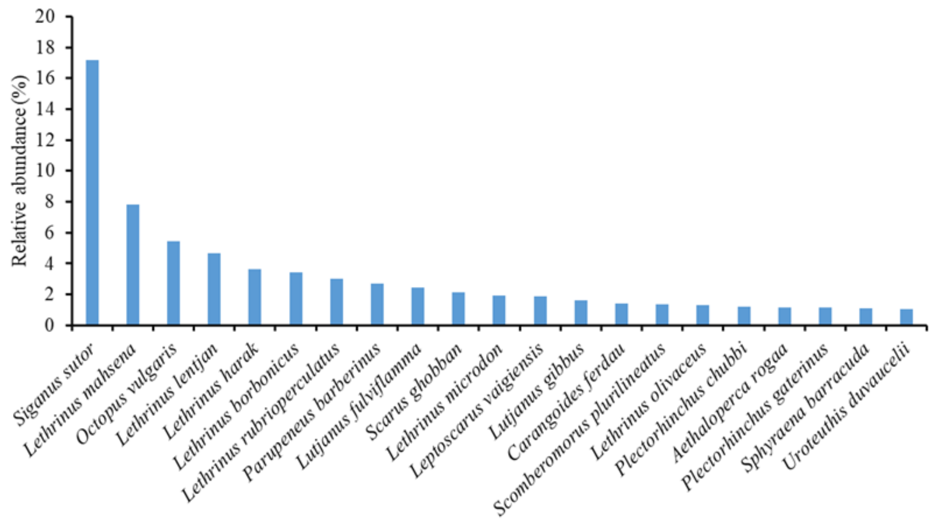

Figure 10. Top twenty most abundant fish species sampled in Mkunguni and Shimoni over the study period

Species Diversity by Vessel-Gear Combinations

The mean number of species sampled across the years slightly differed over the study period. There was a slightly increase in the number of fish species recorded across the year 2019 (48 ±12 species) 2020 (49b ± 8 species) and 2021 (49 ± 9 species) (Figure 11). The mean number of fish species across years sampled slightly differed. Slightly higher numbers of species were recorded in years 2021 and 2020. Results of 1-way ANOVA test however, indicated no significant difference in mean number of fish species sampled across the years (df = 2; f = 0.007; p = 0.993).

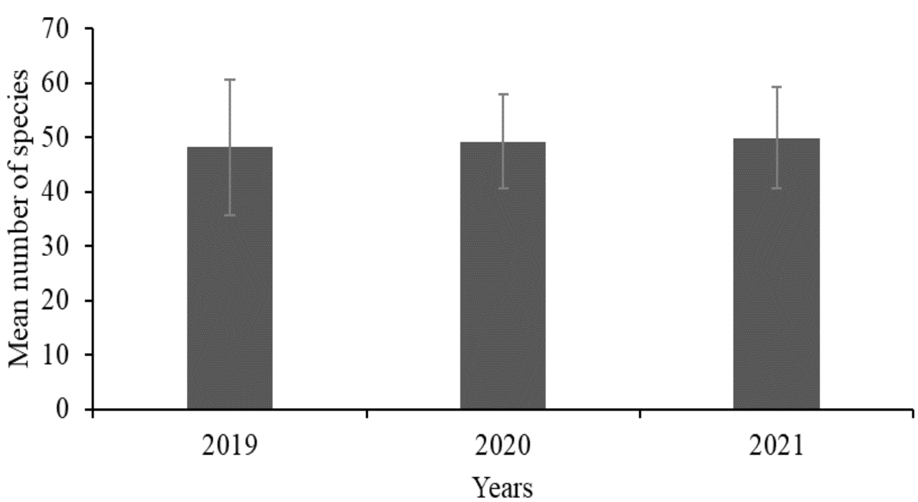

Figure 11. Annual mean number ± SE of species sampled in Mkunguni and Shimoni over the study period

The highest average number of species were recorded by gears used with canoes. These were: handline (120 ± 8 species) and basket trap (87 ± 6 species) while in gears used with dhows, handlines recorded the highest mean number of species caught (73 ± 4 species) and gillnet (58 ±5. Least number of species landed were recorded by fiberglass used with gillnet (12 ± 5 species) and

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dhows with hooked sticks (17 ± 1 species) (Figure 12).

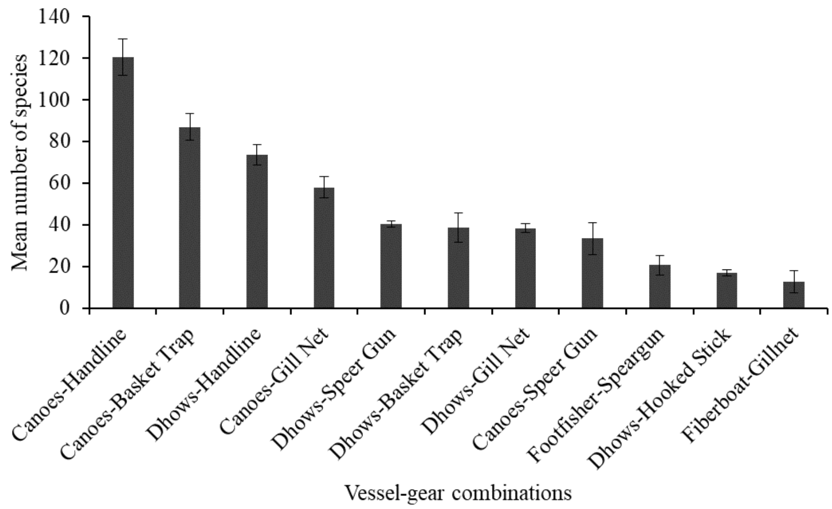

Figure 12. Mean number ± SE of species by vessel-gear combinations sampled Mkunguni and Shimoni over the study period

Consequently, based on the excel results on species presence test by vessel gear combination conducted for the most abundant species, there was a higher similarity in the species present in catches from different vessel gear combination. The highest number of individuals sampled was in canoe basket trap in *Siganus sutor* and *Lethrinnus mahsena* (Figure 13).

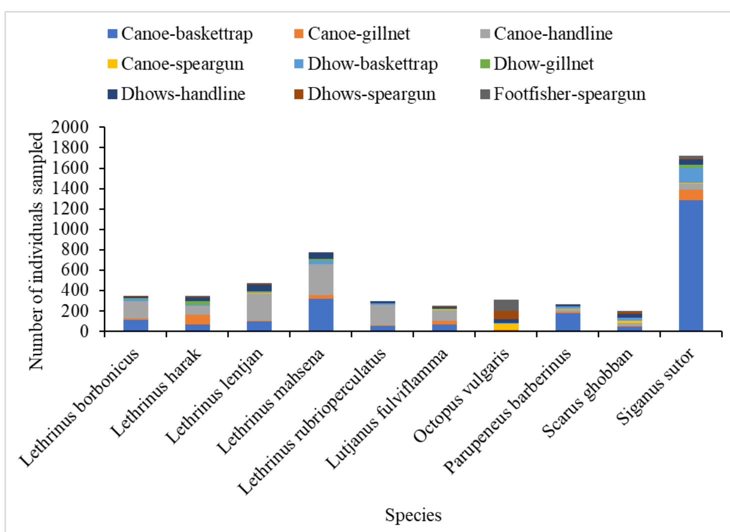

Figure 13. Number of individuals for selected species by vessel gear combination for most abundant species

Discussion

The significance of fishing in south coast Kenya was displayed by the overall fish catch results obtained over the study period. These results also affirm that coastal waters of south coast Kenya are biodiverse owing to various ecosystems including mangroves, sea grass beds and coral reefs. These ecosystems support the 321 species in 88 families recorded over the study period. Additionally, these results display the importance of fish as source of food and animal protein for the coastal communities, coming out as a major contributor (Mwakaribu et al., 2023). The two landing sites of Shimoni and Mkunguni in south coast Kenya are among the 24 fish landing sites with over 4,000 fishers accounting for 30% of the total fisher population along the Kenya coast (Government of Kenya, 2022). It was found out that fishing grounds used by fishers at Mkunguni fish landing site landed more fish species than those used by fisher's landing at Shimoni. This disparity in diversity of fish species landed could be attributed to differences in fishing methods and bottom habitats associated with an area. In Mkunguni, most fishers target demersal fish species in coral reef and seagrass dominated fishing grounds compared to pelagic fish species in Shimoni mostly using large nets in relatively offshore fishing grounds. Similar observations of differences in total fish weight landed between fish landing sites were recorded. This correlates previous studies that identified fishing grounds related to Mkunguni landing site to be substantially productive (Okemwa et al., 2009).

Diversity of fish species in south coast Kenya is characterized by dominance of emperors (Lethrinidae), and rabbitfishes (Siganidae), snappers (Lutjanidae), sweetlips (Haemulidae), parrotfishes (Scaridae), surgeonfishes (Acanthuridae) and goatfishes (Mullidae). These were the most caught fish families over the study period which compliments conclusions by Maina, (2013). Additionally, based on the results of Shannon-Weiner diversity index, the vessel-gear combinations that landed most catch also recorded highest fish diversity. This indicates the effectiveness of these gears which further extends to the vessels they are used with (Mung et al., 2014). The observed statistical differences in fish diversity between the different vessel-gear combinations is further an indication of catch efficiency based on choice of vessel and gears. The artisanal nature of the Kenya coastal and marine fishery demands maximizing on catch which could explain the prevalence of several vessel-gear combinations which change seasonally with differing species diversity (Mwaluma et al., 2021).

The observation made in the presence of similar and multiple fish species in different vessel-gear combinations that had been used in different fishing grounds is a clear indication of resource use overlap. The vessel-gear combination that recorded the highest Species diversity were; canoe-handline, canoe-basket trap, dhows-handline, dhows-gillnet, dhows-spear-gun and dhows-basket trap. Species that occupy different trophic levels interact in various ways at different stages of their life span either during feeding, spawning or even migrations. Thus, fisheries managers should put this into consideration when coming up with management policies that target certain fish species. This study assessed the various fishing gear and vessel types used and their effectiveness. The findings showed that fishery is further identified as mainly artisanal characterized by multi-species, multi-fleet and multi-gear (Munga et al., 2014). The most common fishing vessels were canoes, dhows and fiberglass boats which are easy to acquire and guarantee considerable yield (Samoilys et al., 2016). Additionally, the most common used fishing gear included basket traps, handlines, gill nets, spear guns and hooked sticks. This affirmed the Kenya coast fishery as multi-species landings, multiple gears, propulsion and craft combinations posing a challenge in management (Samoilys et al., 2016; Ndarathi et al., 2021). However, the choice of fishing vessels and gears was found to differ between fisher's landing at Shimoni and Mkunguni based on frequency of use and total catch landed. In Mkunguni landing site, most fishers used canoes and fiberglass boat while in Shimoni they used dhows and canoes as well as considerable number of foot fishers. On the other hand, the fishing gears used were found to be common in both landing sites. Therefore, this renders the catch results comparable within the two landing sites in relation to vessel-gear combination (Ndarathi et al., 2021).

The annual fish landings observed showed an increasing trend from 2019 to 2021 but with a small drop in 2020 owed to the impacts of COVID19 pandemic containment measures (Aura et al., 2020). The Kenya coast is influenced by two seasons, the warm and calm NEM season from November to March and the cool and rough SEM season from April to Sept (Ochiewo et al., 2021). The NEM season is characterized by dry season which allows fishers to access fishing grounds easily while the SEM season is characterized by rainy season where most fishing

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grounds are inaccessible due to storms (Ochiewo et al., 2021). From this present study, several conclusions can be drawn resource-use overlap across these combinations. This three year-long study of Kenya coastal fishery, points out that the two landing sites of Shimoni and Mkunguni share several similarities in fishing methods and vessels used. However, there are obvious differences in fish landings due to difference in types and target species and even the use of different vessel gear combinations. Larger nets and basket traps are commonly used in Shimoni as compared to Mkunguni, which contributes more to higher and diverse catches in Shimoni than Mkunguni. The higher diversity on fish species occurrence in different vessel gear combinations used from these two landing sites affirms our hypothesis that there exist a resource use overlap as evidently shown by these results and findings. Based on the findings of this study, the following recommendations are made: There is need for an in-depth analysis of fishing activities to explore other season influenced factors that affect species composition. Fisheries managers to consider identified overlaps when formulating management policies targeting specific fish species, recognizing the complexity of the ecosystem and fishing practices. There is need for enhanced understanding of resource use dynamics across fishing practices as basis for sustainable management practices in the region. Finaly, further investigations to ascertain the choice of vessel and gear as an indicator of resource use overlap per fishing sites.

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Annex 1. List of species sampled in Mkungui and Shimoni of south coast Kenya over the study period

S/ No.	Species	Family	No. Sampled	Relative Abundance (%)
1.	*Siganus sutor*	Siganidae	1766	17.47
2.	*Lethrinus mahsena*	Lethrinidae	803	7.94
3.	*Octopus vulgaris*	Octopodidae	549	5.43
4.	*Lethrinus lentjan*	Lethrinidae	480	4.75
5.	*Lethrinus harak*	Lethrinidae	371	3.67
6.	*Lethrinus borbonicus*	Lethrinidae	354	3.50
7.	*Lethrinus rubrioperculatus*	Lethrinidae	308	3.05
8.	*Parupeneus barberinus*	Mullidae	276	2.73
9.	*Lutjanus fulviflamma*	Lutjanidae	252	2.49
10.	*Scarus ghobban*	Scaridae	218	2.16
11.	*Lethrinus microdon*	Lethrinidae	198	1.96
12.	*Leptoscarus vaigiensis*	Scaridae	195	1.93
13.	*Lutjanus gibbus*	Lutjanidae	167	1.65
14.	*Carangoides ferdau*	Carangidae	147	1.45
15.	*Scomberomorus plurilineatus*	Scombridae	140	1.38
16.	*Lethrinus olivaceus*	Lethrinidae	137	1.36
17.	*Plectorhinchus chubbi*	Haemulidae	127	1.26
18.	*Plectorhinchus gaterinus*	Haemulidae	119	1.18
19.	*Aethaloperca rogaa*	Serranidae	117	1.16
20.	*Sphyraena barracuda*	Sphyraenidae	112	1.11
21.	*Uroteuthis duvaucelii*	Loliginidae	105	1.04
22.	*Lethrinus obsoletus*	Lethrinidae	102	1.01
23.	*Lutjanus argentimaculatus*	Lutjanidae	101	1.00
24.	*Pangasius macronema*	Pangasiidae	99	0.98
25.	*Platycephalus indicus*	Platycephalidae	97	0.96
26.	*Parupeneus cyclostomus*	Mullidae	77	0.76
27.	*Calotomus carolinus*	Scaridae	69	0.68
28.	*Thunnus albacares*	Scombridae	67	0.66
29.	*Lethrinus variegatus*	Lethrinidae	65	0.64
30.	*Aprion virescens*	Lutjanidae	62	0.61
31.	*Scarus sordidus*	Scaridae	62	0.61
32.	*Chelio inermis*	Labridae	61	0.60
33.	*Silurus bimaculatus*	Siluridae	59	0.58
34.	*Plectorhinchus flavomaculatus*	Haemulidae	57	0.56
35.	*Gymnocranius grandoculis*	Siganidae	55	0.54

36.	*Gerras oyena*	Gerreidae	54	0.53
37.	*Parupeneus forsskali*	Mullidae	53	0.52
38.	*Panulirus longipes*	Palinuridae	53	0.52
39.	*Lethrinus nebulosus*	Lethrinidae	52	0.51
40.	*Cheilinus trilobatus*	Labridae	45	0.45
41.	*Mulloidichthys vanicolensis*	Mullidae	43	0.43
42.	*Parupaneus heptacanthus*	Mullidae	43	0.43
43.	*Gymnocranius elongatus*	Lethrinidae	38	0.38
44.	*Euthynnus affinis*	Scombridae	38	0.38
45.	*Taeniura lymma*	Dasyatidae	37	0.37
46.	*Rastrelliger kanagurta*	Scombridae	36	0.36
47.	*Diagramma pictum*	Haemulidae	35	0.35
48.	*Scarus psittacus*	Scaridae	31	0.31
49.	*Acanthurus dussumieri*	Acanthuridae	30	0.30
50.	*Scolopsis ghanam*	Nemipteridae	30	0.30
51.	*Coryphaena hippurus*	Salmonidae	30	0.30
52.	*Cheilinus chlorourus*	Labridae	27	0.27
53.	*Lethrinus croscineus*	Lethrinidae	27	0.27
54.	*chlorurus carolinus*	Scaridae	27	0.27
55.	*Scarus rubroviolaceus*	Scaridae	26	0.26
56.	*Siganus canaliculatus*	Siganidae	26	0.26
57.	*Cheilinus fasciatus*	Labridae	25	0.25
58.	*Lethrinus xanthochilus*	Lethrinidae	24	0.24
59.	*Katsuwonus pelamis*	Scombridae	24	0.24
60.	*Lutjanus bohar*	Lutjanidae	23	0.23
61.	*Cephalopholis argus*	Serranidae	23	0.23
62.	*Caranx heberi*	Carangidae	22	0.22
63.	*Caranx ignobilis*	Carangidae	22	0.22
64.	*Lutjanus kasmira*	Lutjanidae	22	0.22
65.	*Parupeneus indicus*	Mullidae	22	0.22
66.	*Siganus luridus*	Siganidae	21	0.21
67.	*Argonauta hians*	Argonautidae	19	0.19
68.	*Pterocaesio digramma*	Caesionidae	19	0.19
69.	*Scolopsis bimaculata*	Nemipteridae	19	0.19
70.	*Scomberomorus commerson*	Scombridae	19	0.19
71.	*Tylosurus acus melanotus*	Belonidae	18	0.18
72.	*Lutjanus bengalensis*	Lutjanidae	18	0.18
73.	*Parupeneus rubescen*	Mullidae	18	0.18

74.	*Tylosurus crocodilus*	Belonidae	17	0.17
75.	*Plectorhinchus schotaf*	Haemulidae	17	0.17
76.	*Epinephelus malabaricus*	Serranidae	17	0.17
77.	*Stellate sturgeon*	Sturgeon	17	0.17
78.	*Myripristis kuntee*	Holocentridae	16	0.16
79.	*Epinephelus fasciatus*	Serranidae	16	0.16
80.	*Trachinocephalus myops*	Synodontidae	16	0.16
81.	*Acanthurus mata*	Acanthuridae	15	0.15
82.	*Myripristis murdjan*	Holocentridae	15	0.15
83.	*Paracaesio xanthura*	Lutjanidae	15	0.15
84.	*Upeneus tragula*	Mullidae	15	0.15
85.	*Siganus stellatus*	Siganidae	15	0.15
86.	*Pomacanthus imperator*	Pomacanthidae	14	0.14
87.	*Johnius amblycephalus*	Sciaenidae	14	0.14
88.	*Arius africanus*	Ariidae	13	0.13
89.	*Arius africanus*	Ariidae	13	0.13
90.	*Carangoides orthogrammus*	Carangidae	13	0.13
91.	*Siganus argenteus*	Siganidae	13	0.13
92.	*Sphyraena putnamae*	Sphyraenidae	13	0.13
93.	*Rhynchobatus djiddensis*	Rhynobatidae	12	0.12
94.	*Epinephelus areolatus*	Serranidae	12	0.12
95.	*Epinephelus fuscoguttatus*	Serranidae	12	0.12
96.	*Pterocaesio tile*	Caesionidae	11	0.11
97.	*Epinephelus tukula*	Serranidae	11	0.11
98.	*Synodus variegatus*	Synodontidae	11	0.11
99.	*Leporinus bimaculatus*	Anostomidae	10	0.10
100.	*Hemiramphus far*	Hemiramphidae	10	0.10
101.	*Otocinclus Affinis*	Loricariidae	10	0.10
102.	*Rachycentron canadum*	Rachycentridae	9	0.09
103.	*Coryphaena equiselis*	Salmonidae	9	0.09
104.	*Epinephelus coloides*	Serranidae	9	0.09
105.	*Acanthurus triostegus*	Acanthuridae	8	0.08
106.	*Naso brevirostris*	Acanthuridae	8	0.08
107.	*Albula vulpes*	Albulidae	8	0.08
108.	*Crocodilus crocodilus*	Belonidae	8	0.08
109.	*Himantura uarnak*	Dasyatidae	8	0.08
110.	*Neotrygun kuhlii*	Dasyatidae	8	0.08
111.	*Gerres filamentosus*	Gerreidae	8	0.08

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112.	*Istiophorus platypterus*	Istiophoridae	8	0.08
113.	*Etelis coruscans*	Lutjanidae	8	0.08
114.	*Monodactylus argenteus*	Monodactylidae	8	0.08
115.	*Hipposcarus harid*	Scaridae	8	0.08
116.	*Carcharhinus limbatus*	Carcharhinidae	7	0.07
117.	*Himantura gerrardi*	Dasyatidae	7	0.07
118.	*Myripristis berndti*	Holocentridae	7	0.07
119.	*Iniistius pavo*	Labridae	7	0.07
120.	*Aphareus furca*	Lutjanidae	7	0.07
121.	*Lutjanus lutjanus*	Lutjanidae	7	0.07
122.	*Cantherhines pardalis*	Monacanthidae	7	0.07
123.	*Epinepherus longispirus*	Serranidae	7	0.07
124.	*Alectes ciliaris*	Carangidae	6	0.06
125.	*Carangoides malabaricus*	Carangidae	6	0.06
126.	*Taeniura melanospilos*	Dasyatidae	6	0.06
127.	*Lutjanus rivulatus*	Lutjanidae	6	0.06
128.	*Parupeneus pleurostigma*	Mullidae	6	0.06
129.	*Apolemichthys trimaculatus*	Pomacanthidae	6	0.06
130.	*Coregonus nigripinnis*	Salmonidae	6	0.06
131.	*Calotomus spinidens*	Scaridae	6	0.06
132.	*Cephalopholis miniata*	Serranidae	6	0.06
133.	*Chonerhinos africanus*	Tetraodontidae	6	0.06
134.	*Acanthurus leucosternon*	Acanthuridae	5	0.05
135.	*Naso hexacanthus*	Acanthuridae	5	0.05
136.	*Arius madagascariensis*	Ariidae	5	0.05
137.	*Arius madagascariensis*	Ariidae	5	0.05
138.	*Pseudobalistes fuscus*	Balistidae	5	0.05
139.	*Naucrates ductor*	Carangidae	5	0.05
140.	*Hyporhamphus dussumieri*	Hemiramphidae	5	0.05
141.	*Tetrapturus angustirostris*	Istiophoridae	5	0.05
142.	*Chlorurus capistratoides*	Scaridae	5	0.05
143.	*caranax melampygus*	Carangidae	4	0.04
144.	*Carangoides fulvoguttatus*	Carangidae	4	0.04
145.	*Caranx lugubris*	Carangidae	4	0.04
146.	*Cycleptus elongatus*	Catostomidae	4	0.04
147.	*Chanos chanos*	Chanidae	4	0.04
148.	*Pomadasys argenteus*	Haemulidae	4	0.04
149.	*Sargocentron diadema*	Holocentridae	4	0.04

150.	*Carcharodon carcharias*	Lamnidae	4	0.04
151.	*Monotaxis grandoculis*	Lethrinidae	4	0.04
152.	*Parupaneus macronema*	Mullidae	4	0.04
153.	*Tridentiger trigonocephalus*	Oxudercidae	4	0.04
154.	*Paralichthys olivaceus*	Paralichthyidae	4	0.04
155.	*Pimelodus ornatus*	Pimelodidae	4	0.04
156.	*Plectropomus pessuliferus*	Serranidae	4	0.04
157.	*Polysteganus coeruleopunctatus*	Sparidae	4	0.04
158.	*Synodus synodus*	Synodontidae	4	0.04
159.	*Naso taeniourus*	Acanthuridae	3	0.03
160.	*Leporinus elongatus*	Anostomidae	3	0.03
161.	*Carangoides chrysophrys*	Carangidae	3	0.03
162.	*Carangoides coeruleopinnatus*	Carangidae	3	0.03
163.	*Carangoides dinema*	Carangidae	3	0.03
164.	*Carangoides oblongus*	Carangidae	3	0.03
165.	*Caranx sexfascietus*	Carangidae	3	0.03
166.	*Pastinachus sephen*	Dasyatidae	3	0.03
167.	*Kyphosus vaigiensis*	Kyphosidae	3	0.03
168.	*Coris formosa*	Labridae	3	0.03
169.	*Halichoeres zeylonicus*	Labridae	3	0.03
170.	*Oxycheilinus bimaculatus*	Labridae	3	0.03
171.	*Thalassoma trilobatum*	Labridae	3	0.03
172.	*Xyrichtys pavo*	Labridae	3	0.03
173.	*Leptoscopus macropygus*	Leptoscopidae	3	0.03
174.	*Gymnothorax flavimarginatus*	Muraenidae	3	0.03
175.	*Gymnothorax monochrous.*	Muraenidae	3	0.03
176.	*Nemipterus japonicus*	Nemipteridae	3	0.03
177.	*Scolopsis ciliata*	Nemipteridae	3	0.03
178.	*Pempheris vanicolensis*	Pempheridae	3	0.03
179.	*Thysanophrys chiltonae*	Platycephalidae	3	0.03
180.	*Scarus caudofasciatus*	Scaridae	3	0.03
181.	*Acanthocybium solandri*	Scombridae	3	0.03
182.	*Auxis rochei*	Scombridae	3	0.03
183.	*Auxis thazard*	Scombridae	3	0.03
184.	*Epinephelus macrospilos*	Serranidae	3	0.03
185.	*Epinephelus melanostigma*	Serranidae	3	0.03
186.	*Epinephelus quoyanus*	Serranidae	3	0.03
187.	*Naso annulatus*	Acanthuridae	2	0.02

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188.	*Naso bipuntatus*	Acanthuridae	2	0.02
189.	*Paracanthurus hepatus*	Acanthuridae	2	0.02
190.	*Pachypanchax playfairii*	Aplocheilidae	2	0.02
191.	*Dipterygonotus balteatus*	Caesionidae	2	0.02
192.	*Caranx chrysophrys*	Carangidae	2	0.02
193.	*Caranx tille*	Carangidae	2	0.02
194.	*Coryphaena equiselis*	Coryphaenidae	2	0.02
195.	*Caroturria spinederius*	Doradidae	2	0.02
196.	*Platax orbicularis*	Ephippidae	2	0.02
197.	*Plectorhinchus gibbosus*	Haemulidae	2	0.02
198.	*Hyporhamphus limbatus*	Hemiramphidae	2	0.02
199.	*Australopithecus africanus*	Hominidae	2	0.02
200.	*Uknown kitumbo*	Kitumbo	2	0.02
201.	*Khyphosus cinerascens*	Kyphosidae	2	0.02
202.	*Anampses caeruleopunctatus*	Labridae	2	0.02
203.	*Bodianus bilinuliatus*	Labridae	2	0.02
204.	*Epibulus insidiator*	Labridae	2	0.02
205.	*Halichoeres hortulanus*	Labridae	2	0.02
206.	*Hologymnosus doliatus*	Labridae	2	0.02
207.	*Oxycheilinus celebicus*	Labridae	2	0.02
208.	*Oxycheillinus digrammus*	Labridae	2	0.02
209.	*Lethrinus conchyliatus*	Lethrinidae	2	0.02
210.	*Lethrinus sordidus*	Lethrinidae	2	0.02
211.	*Aphareus rutilans*	Lutjanidae	2	0.02
212.	*Etelis carbunculus*	Lutjanidae	2	0.02
213.	*Lentjan argenu maculatus*	Lutjanidae	2	0.02
214.	*Lutjanus monostigma*	Lutjanidae	2	0.02
215.	*Lutjanus rufolineatus*	Lutjanidae	2	0.02
216.	*Lutjanus sebae*	Lutjanidae	2	0.02
217.	*Macolor niger*	Lutjanidae	2	0.02
218.	*Coelorinchus mycterismus*	Macrouridae	2	0.02
219.	*Gymnothorax pictus*	Muraenidae	2	0.02
220.	*Hemipterus zysron*	Nemipteridae	2	0.02
221.	*Lamnostoma orientalis*	Ophichthidae	2	0.02
222.	*Centropyge aurantia*	Pomacanthidae	2	0.02
223.	*Pardachirus marmoratus*	Samaridae	2	0.02
224.	*Chlorurus Sordidus*	Scaridae	2	0.02
225.	*Scarlus frenatus*	Scaridae	2	0.02

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226.	*scarus corolinus*	Scaridae	2	0.02
227.	*Scolopsis ghanam*	Sciaenidae	2	0.02
228.	*Grammatorcynus bilineatus*	Scombridae	2	0.02
229.	*Sarda orientalis*	Scombridae	2	0.02
230.	*Lutjanus russellii*	Scorpaenidae	2	0.02
231.	*Epinephelus flavocaeruleus*	Serranidae	2	0.02
232.	*Variola louti*	Serranidae	2	0.02
233.	*Metynnis argenteus*	Serrasalmidae	2	0.02
234.	*Acanthurus nigricauda*	Acanthuridae	1	0.01
235.	*Acanthurus nigrofuscus*	Acanthuridae	1	0.01
236.	*Naso branchycentrun*	Acanthuridae	1	0.01
237.	*Naso tuberosus*	Acanthuridae	1	0.01
238.	*Naso unicornis*	Acanthuridae	1	0.01
239.	*lbula vulpes*	Albulidae	1	0.01
240.	*Apogon dovii*	Apogonidae	1	0.01
241.	*Plicofollis dussumieri*	Ariidae	1	0.01
242.	*Plicofollis polystaphylodon*	Ariidae	1	0.01
243.	*Ariomma indica*	Ariommatidae	1	0.01
244.	*Plicofollis dussumieri*	Ariidae	1	0.01
245.	*Plicofollis polystaphylodon*	Ariidae	1	0.01
246.	*Ariomma indica*	Ariommatidae	1	0.01
247.	*Melichthys indicus*	Balistidae	1	0.01
248.	*Melichthys niger*	Balistidae	1	0.01
249.	*Odonus niger*	Balistidae	1	0.01
250.	*Ablennes acus melanotus*	Belonidae	1	0.01
251.	*Ablennes hians*	Belonidae	1	0.01
252.	*Lipophrys pavo*	Blenniidae	1	0.01
253.	*Pterocaesio chrysozona*	Caesionidae	1	0.01
254.	*Caranx melampygus*	Carangidae	1	0.01
255.	*Caranx papuensis*	Carangidae	1	0.01
256.	*Trachinotus falcatus*	Carangidae	1	0.01
257.	*Carcharhinus longimanus*	Carcharhinidae	1	0.01
258.	*Carcharhinus melanopterus*	Carcharhinidae	1	0.01
259.	*Butterflyfish*	Chaetodontidae	1	0.01
260.	*Chaetodon auriga*	Chaetodontidae	1	0.01
261.	*Chaetodon trifasciatus*	Chaetodontidae	1	0.01
262.	*Chaetodon melannotus*	Chaetodontidae	1	0.01
263.	*Chirocentrus dorab*	Chirocentridae	1	0.01

264.	*Lutjanus cyanopterus*	Cyaneidae	1	0.01
265.	*Drepanane longimana*	Drepaneidae	1	0.01
266.	*Anchoa tricolor*	Engraulidae	1	0.01
267.	*Sarus harid*	Frogfish	1	0.01
268.	*Cryptocentrus octofasciatus*	Gobiidae	1	0.01
269.	*Plectorhinchus albovittatus*	Haemulidae	1	0.01
270.	*Pomadasys multimaculatus*	Haemulidae	1	0.01
271.	*Hologymnosus doliatus*	Holocentridae	1	0.01
272.	*Myripristis jacobus*	Holocentridae	1	0.01
273.	*Sargocentron coruscum*	Holocentridae	1	0.01
274.	*Sargocentron praslim*	Holocentridae	1	0.01
275.	*Sargocentron violaceum*	Holocentridae	1	0.01
276.	*Sargocentron xantherythrum*	Holocentridae	1	0.01
277.	*Holothuria scabra*	Holothuriidae	1	0.01
278.	*Makaira indica*	Istiophoridae	1	0.01
279.	*Choerodon robustus*	Labridae	1	0.01
280.	*Coris caudimacula*	Labridae	1	0.01
281.	*Cossyphus oxycephalus*	Labridae	1	0.01
282.	*Novaculichthys taeniourus*	Labridae	1	0.01
283.	*Oxycheilinus mentalis*	Labridae	1	0.01
284.	*Stethojulis strigiventer*	Labridae	1	0.01
285.	*Thalassoma hebraicum*	Labridae	1	0.01
286.	*Thalassoma pavo*	Labridae	1	0.01
287.	*Invinus lentjan*	Lethrinidae	1	0.01
288.	*Lethrinus erythracanthus*	Lethrinidae	1	0.01
289.	*Sepioteuthis lessoniana*	Loliginidae	1	0.01
290.	*Aphareus miniata*	Lutjanidae	1	0.01
291.	*Lethrinus harak*	Lutjanidae	1	0.01
292.	*Lutjanus ehrenbergii*	Lutjanidae	1	0.01
293.	*Cantherhines dumerilii*	Monacanthidae	1	0.01
294.	*Crenimugil crenilabis*	Mugilidae	1	0.01
295.	*Valamugil engeli*	Mugilidae	1	0.01
296.	*Mulloidichthys flavolineatus*	Mullidae	1	0.01
297.	*Parupeneus multifasciatus*	Mullidae	1	0.01
298.	*Gymnothorax griseus*	Muraenidae	1	0.01
299.	*Aetobatus narinari*	Myliobatidae	1	0.01
300.	*Panulirus ornatus*	Palinuridae	1	0.01
301.	*Thysanophrys arenicola*	Platycephalidae	1	0.01

302.	*Polysteganus coeruleopunctatus*	Polynemidae	1	0.01
303.	*Centropyge acanthops*	Pomacanthidae	1	0.01
304.	*Centropyge flammeus*	Pomacanthidae	1	0.01
305.	*Heliotrygon rosai*	Potamotrygonidae	1	0.01
306.	*Cottunculus nudus*	Psychrolutidae	1	0.01
307.	*Calotomus carolinus*	Scaridae	1	0.01
308.	*Chloneius sordidus*	Scaridae	1	0.01
309.	*Chlorurus perspicillatus*	Scaridae	1	0.01
310.	*Scarus nebrioperculatus*	Scaridae	1	0.01
311.	*Scarus niger*	Scaridae	1	0.01
312.	*Scarus tricolor*	Scaridae	1	0.01
313.	*Scatophagus tetracanthus*	Scatophagidae	1	0.01
314.	*Thunnus tonggol*	Scombridae	1	0.01
315.	*Dendrochirus barber*	Scorpaenidae	1	0.01
316.	*Sepia trygonina*	Sepiidae	1	0.01
317.	*Cephalopholis nigripinnis*	Serranidae	1	0.01
318.	*Cephalopholis spiloperae*	Serranidae	1	0.01
319.	*Cephalopholis leopardus*	Serranidae	1	0.01
320.	*Epinephelus lanceolatus*	Serranidae	1	0.01
321.	*Epinephelus longispinis*	Serranidae	1	0.01