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Evaluating the fisheries potential of solar salt works reservoirs at Ungwana Bay, North Coast, Kenya

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Abstract

Artisanal fisheries are important livelihoods for coastal communities in many developing countries, where uncontrolled fishing can easily lead to depleted stocks in nearshore waters. Man-made reservoirs associated with solar salt works along the coast of Ungwana Bay provide alternative fishing grounds for local fishers unable to venture far offshore. We evaluated the fisheries potential of salt works reservoirs through regular catch assessment surveys at Gongoni, Kurawa and Marereni reservoirs between January 2015 and February 2016. Fishing effort and catch data were analyzed for seasonal patterns in catch composition and catch rates. Prawn seine nets were the dominant fishing gear used in the three reservoirs, augmented by traps at Kurawa. A total weight of 4.02 tonnes consisting of 49 finfish and 9 crustacean species was sampled. *Metapeneaus monoceros* was the most abundant species at Gongoni and Marereni, and *Oreochromis mossambicus* dominated at Kurawa. Non-metric multidimensional scaling (nMDS) showed distinct catch composition in all reservoir / season combinations for prawn seines. Highest species diversity occurred at Marereni during northeast monsoon conditions, whereas lowest diversity occurred at Gongoni during the southeast monsoon. Catch composition of prawn seines and traps differed at Kurawa. There was a significant difference in catch rates (kg/fisher.hr-1) between reservoirs, but not between seasons. Fisheries production in reservoirs was therefore affected more by their location and the gear type used, rather than by season.

Keywords: Catch composition, Catch rate, Solar salt works reservoirs, Prawn seines

Introduction

Solar salt works reservoirs are anthropogenic supratidal habitats exploited for sea salt, which becomes progressively concentrated by evaporation (López *et al.*, 2010). These systems are considered the most efficient converters of solar energy into an inorganic commodity (Sedivy, 2009). Along the Ungwana Bay on the north coast of Kenya, there are a total of six salt production companies, namely Krystalline Salt Limited, KEMU Salt Packers Production Limited, Kurawa Industries Limited, Malindi Salt Works, KENSALT Limited, and Mombasa Salt Works Limited (KNCHR, 2006). Solar salt works reservoirs are unique man-made wetlands that feed a network of shallow ponds (salt pans) for salt making. The co-existence of regular and hyper-saline waters in the network of ponds supports important biological systems as well as providing refuge for aquatic life (Davis, 2009). Utilization of these ponds for other activities apart from salt production has been reported in many parts of the world. For example, in India, mariculture has been conducted in the salt works where water reservoirs and salt pans are utilized for prawn culture. According to Rao *et al.*, (1988) this practice not only increased the prawn production and enhanced food security but also increased income levels for both the salt industry owners and the local communities. In Kenya, the culture of brine shrimp (*Artemia franciscana)* has been practiced on a small-scale and non-commercial basis alongside salt production in the salt pans since the 1980s when the species was first introduced into the Kurawa salt works (Kaiser *et al*., 2006). In addition, the salt works reservoirs have created foraging grounds for migratory birds including piscivorous and filter feeding bird species such as flamingoes and pelicans (López *et al*., 2010).

Generally, these man-made reservoirs are not constructed for fisheries production as the main objective. However, in the process of operation, fisheries emerge as a crucial secondary resource with income from these activities often exceeding that of the primary purpose of the reservoirs (Rocha *et al*., 2011). From the time of their establishment, reservoirs of the salt works in Ungwana Bay have been popular fishing grounds for local fishers who lack appropriate crafts to venture into the open sea. High abundance of penaeid prawns and other species such as *Oreochromis mossambicus,* capable of surviving wide salinity ranges, have been reported to contribute significantly to the total landings in Ungwana Bay (KMFRI, 2015). The solar salt works reservoirs are therefore essential fishing grounds for artisanal fishing and the main source of animal protein (Beard *et al.*, 2011) for many low income communities living near these resources. The reservoir fisheries in the solar salt works are however unique, and different from other artisanal fisheries in the bay. Unlike the inshore and open sea where artisanal fishing activity is higher during the dry northeast monsoon (NEM) season and lower during the wet southeast monsoon (SEM) season due to rough sea conditions (McClanahan, 1988), fishing activities in the reservoirs largely depend on the operations of the salt works which run throughout the year, and hence are less affected by the seasons (Munga, 2013). This study describes and characterizes the fisheries of the solar salt works reservoirs through assessment of the seasonal patterns in catch composition and catch rates.

Materials and Methods

Study Area

The Ungwana Bay on the north coast of Kenya provides nursery and feeding grounds for pelagic fishes such as sharks, sailfish, marlin and swordfish while at the same time supporting an important artisanal fishery and a semi-industrial bottom trawl prawn fishery

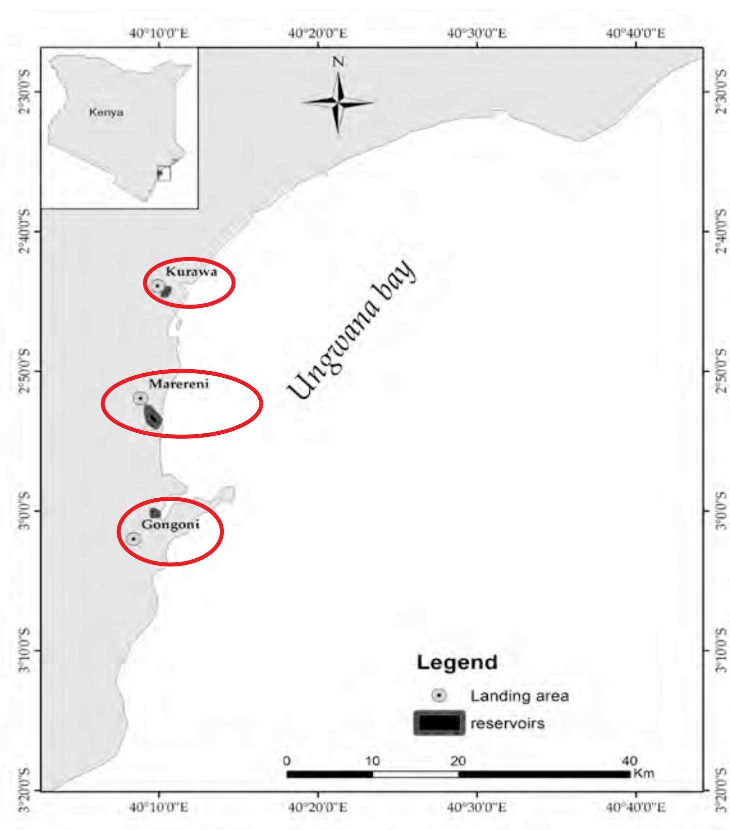

Figure 1. A map showing the Ungwana Bay and the selected solar salt works reservoirs (fish landing sites) on the north coast of Kenya.

(Fig. 1; WWF, 2002; Munga *et al.*, 2014). The Ungwana Bay is part of the larger Malindi-Ungwana Bay complex (2°30'- 3°30'S; 40°- 41°E) extending along a shoreline of about 200 km, and has a total trawlable area of about 11 000 km^2 (Fig. 1; Munga *et al.*, 2014). Artisanal fishing and prawn trawling activities are concentrated around the Tana and Sabaki river estuaries and shallow offshore banks (Kitheka *et al.*, 2005; Kitheka, 2013). Mangrove forests, patchy reefs, islets, sandy shores and tidal flats are the main habitats in the bay. Weather patterns are dominated by large scale pressure systems of the Western Indian Ocean, and the dry NEM season (October to March) and wet SEM season (April to September) (McClanahan, 1988). This study was specifically conducted in selected solar salt works reservoirs along the Gongoni-Kurawa stretch of the Ungwana Bay. The area lies in the semi-arid region of coastal Kenya and experiences hot and dry conditions with heavy rains only in some parts further north (Gordon *et al.*, 2013).

Data Collection

Catch and effort data were collected for 10 months between January 2015 and February 2016 at the three selected reservoirs of Gongoni, Marereni, and Kurawa (Fig. 1). These selected reservoirs represent major fishing grounds for the artisanal fishers in the area. Field sampling was done for five consecutive days every month exclusively targeting fishers of the salt works water reservoirs. These were night fishers who landed their catch early in the morning and day time fishers who landed their catch in the mid-morning and afternoon. Day time fishers were accompanied to the fishing grounds and data on catches, fishing gear, crew size, and fishing duration were recorded. Night fishers were interviewed after landing catches early in the morning.

Total wet weights of catches landed by each fisher or crew were measured using a digital weighing balance (Ashton Meyers® 7767) to the nearest 50g. For larger catches a representative sub-sample of approximately a quarter of the total catch was taken and then sorted into the different categories of fin fish and prawns. Each category was further sorted to species level before recording the number and weight of each species. For smaller catches of up to 1 kg, the entire catch was sorted, individuals counted and weighed by species. Species identification was done using identification keys adopted from the FAO species catalogues and field guides (Lieske & Myers, 2001; Anam & Mostrada, 2012). Species which could not be identified in the field were preserved in 10% formalin and taken to the laboratory for identification.

Data Analysis

Data on weights of catches from fishers for the entire study period were compared across the three reservoirs by season and taxa (fin fish and crustaceans). Catch rate expressed as kg.fisher.$^{-1}$hr^{-1} was calculated as the total weight of catches divided by the total number of fishers sampled, then divided by the active fishing time (hr), and fishing duration, taken as the time when a fisher started fishing until the time the catch was landed (Munga *et al.*, 2014). Data were tested for homoscedasticity of variances using the Levene's test (Levene, 1960) prior to statistical analysis, and assumptions for the parametric ANOVA test accepted at $p > 0.05$. Data that did not meet the ANOVA test assumptions were appropriately transformed. The differences in catch rates across reservoirs and between seasons were analyzed using 2-way ANOVA. A post hoc pair-wise comparison using the Tukey HSD test was used to confirm whether differences indeed existed between variables (Tukey, 1977). These tests were conducted using STATISTICA v7® statistical software.

Data on catch by species was first standardized as relative percent contribution prior to analysis, for prawn seines that were recorded in all the three reservoirs, and for prawn seines and traps that were both recorded only in Kurawa reservoir. The multivariate non-Metric Multidimensional Scaling (nMDS) technique was then used to visualize catch composition with season combination for the prawn seines across all the reservoirs. The same technique was used for Kurawa reservoir to visualize composition of prawn seine and trap catches with season combination. The 1-way Analysis of Similarity (ANOSIM) test was used to statistically determine if catch compositions were significantly different. Further, 1-way SIMPER analysis was used to identify which species contributed to the dissimilarity. All these tests were conducted using PRIMER v.6 statistical software (Clark & Warwick, 2001).

The number of individuals by species was used to determine the relative abundance (%). The relative abundance was calculated as:

$$\text{Relative Abundance (\%)} = \frac{\text{Number of individuals per species per site}}{\text{Total number of individual of all species per site}} \times 100$$

Species diversity was analyzed using rarefaction curves. The rarefaction technique standardizes non-uniform sampling and sample sizes, hence it is suitable for comparing diversity of data among different sample sizes (Sanders, 1968). The rarefaction

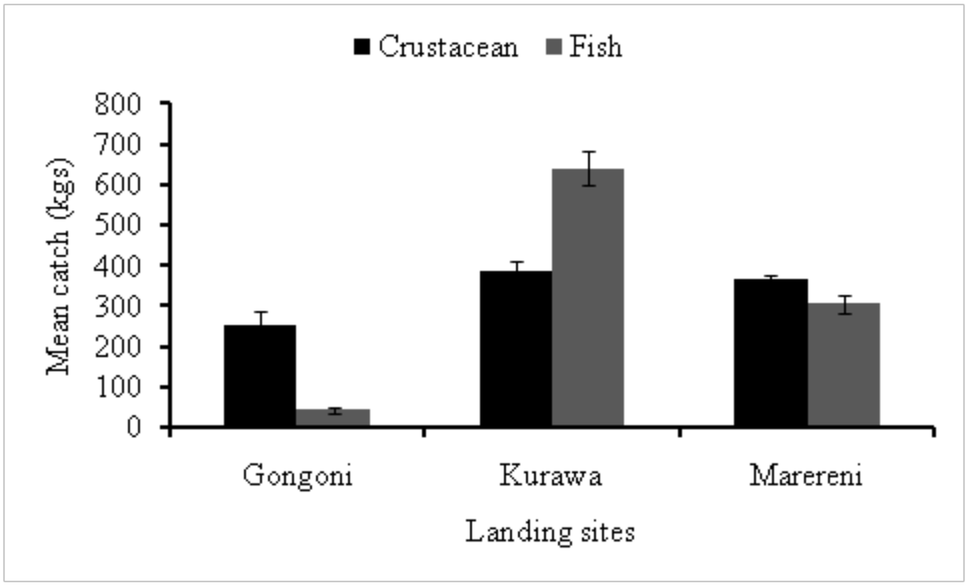

Figure 2. Catch by category (Mean± SE) from the reservoirs of the solar salt works sampled during the study period.

curves analyzed the expected number of species sampled in a given sample size across the reservoirs with season combination.

Results

Total catches sampled from the reservoirs

Two major taxa, finfish and crustaceans (mainly the family Penaeidae) made up the composition of the reservoir catches sampled from both prawn seines and traps. An overall total catch of 4 022.04 kg was recorded during the entire study period with higher catches of prawns (2 046.87 kg, 50.9%) than finfish (1 975.17 kg, 49.1%). The highest total catch was recorded for the northernmost Kurawa reservoir (2 050.6 kg) followed by Marereni (1 338.4kg) and the southmost Gongoni reservoir (633.13 kg). Based on catch category, more crustaceans were recorded in Gongoni and Marereni while more finfish were recorded in Kurawa (Fig. 2). Results of 2-way ANOVA indicated a significant difference in total weight of catches across the reservoirs and between seasons (df = 2; f = 12.033; p = 0.000 and df = 1; f = 13.045; p = 0.001, respectively).

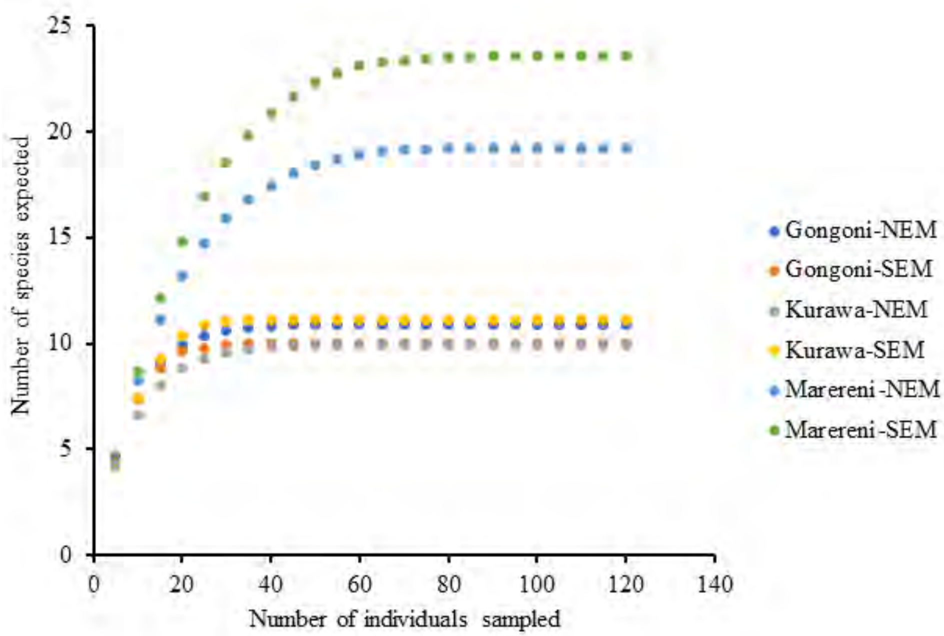

Figure 3. Rarefaction curves indicating the expected number of species caught with increase in sample size by site with season combination for the prawn seine net.

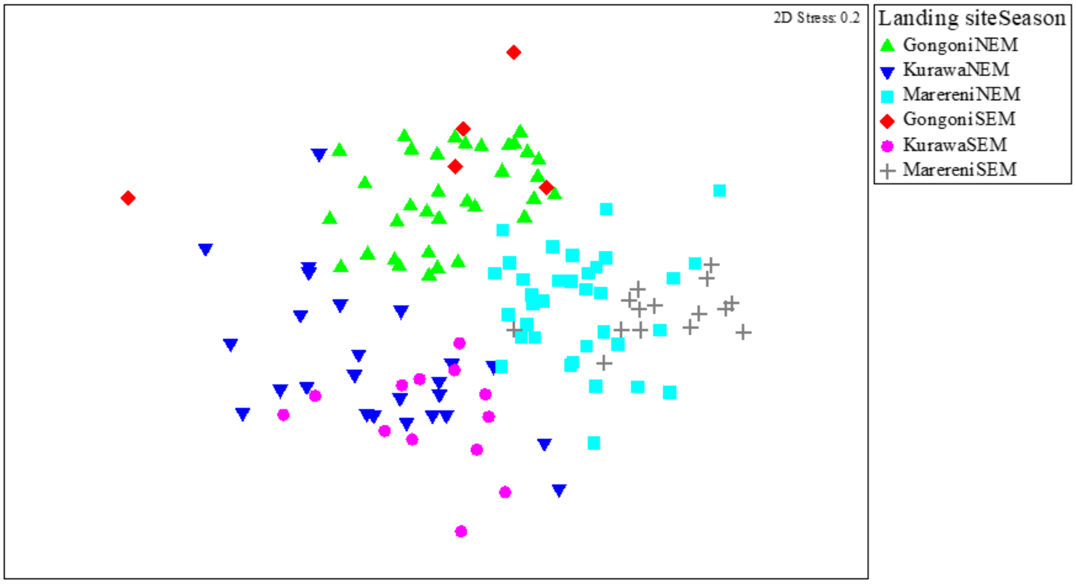

Figure 4. Non Metric MDS showing distinct separation of catches from standardized data by reservoir with season combination in Ungwana Bay, Kenya.

However, the same test indicated no significant difference in catches across reservoirs with season interaction (df = 2; f = 0.468; p = 0.626).

Species diversity of catches and relative abundance

A total of 58 species belonging to 38 families were sampled. These constituted 9 species in 3 families of crustaceans and 49 species of finfish in 35 families. Among the crustaceans, the family Penaeidae was the most speciose with 6 species, while Carangidae for the finfish had the most species (4). Higher total number of species (54) were recorded during the NEM, as compared to the SEM (48). Spatially, Marereni recorded the highest number of species (29 ± 2), followed by Kurawa (17 ± 2), while Gongoni had the lowest number of species (15 ± 1). Further analysis using rarefaction curves confirmed highest species diversity for Marereni samples compared to Gongoni and Kurawa, which recorded lowest, but similar, species diversity (Fig. 3). In most cases, higher species diversity was associated with the SEM season across the reservoirs (Fig. 3).

During the NEM season, *Metapeneaus monoceros* was the most abundant prawn species (13.8%) followed

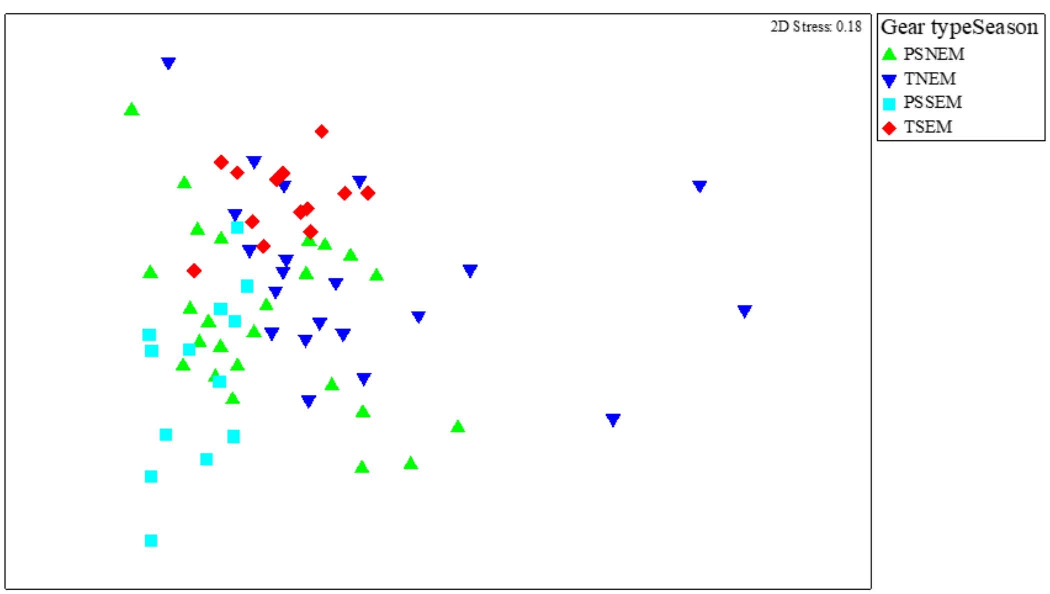

Figure 5. Non Metric MDS showing distinct separation of catches from prawn seines and traps with season combination from standardized data for Kurawa reservoir in Ungwana Bay, Kenya.

Table 1. Species composition and relative abundance (%) by reservoir and season (NEM = Northeast Monsoon; SEM = Southeast Monsoon; bold numbers = most abundant; - = not recorded).

Family	Species	Gongoni		Kurawa		Marereni	
		NEM	SEM	NEM	SEM	NEM	SEM
Penaeidae	*Fenneropenaeus indicus*	**12.9**	**11.4**	**13.9**	**15.5**	8.3	6.4
	Metapenaeus monoceros	**13.8**	**11.4**	12.2	10.7	8.7	**6.7**
	Metapenaeus stebbingi	7.9	11.4	3.8	7.6	6.1	4.0
	Penaeus japonicus	0.3	-	3.3	1.7	3.9	2.5
	Penaeus monodon	**8.5**	-	**12.3**	10.7	6.7	**6.9**
	Penaeus semisulcatus	0.9	10.2	-	6.0	-	1.1
Palaemonidae	*Macrobrachium rude*	-	1.1	2.0	6.0	2.8	5.1
	Nematopalaemon tenuipes	-	-	-	-	0.1	0.4
Carangidae	*Carangoides ferdau*	4.9	**10.2**	0.2	0.2	2.2	2.9
	Carangoides malabaricus	-	-	0.1	-	-	-
	Caranx heberi	1.8	3.4	-	0.2	-	-
	Caranxs pecioza	-	-	0.6	-	-	-
Lutjanidae	*Lutjanus bohar*	-	-	-	-	-	0.6
	Lutjanus ehrenbergii	-	1.1	-	-	-	-
	Lutjanus fulviflamma	0.4	-	0.2	-	1.7	3.5
Lethrinidae	*Lethrinus lentjan*	-	-	0.6	-	0.1	-
	Lethrinus mahsena	-	-	0.4	-	0.4	1.0
	Lethrinus nudus	-	-	0.2	-	-	-
Terapontidae	*Terapon jarbua*	1.0	2.3	4.1	2.1	5.7	5.3
	Terapon puta	0.3	-	0.1	0.5	0.1	-
Engraulidae	*Thryssa malabaricus*	-	-	-	-	1.6	-
	Thryssa vitrirostris	2.0	-	-	-	-	-
Haemulidae	*Diagramma pictum*	-	-	-	-	0.1	0.6
	Plectorhinchus gaterinus	-	-	0.7	-	0.7	1.8
	Plectorhinchus gibbosus	-	-	-	-	0.1	-
Clupeidae	*Amblygaster sp.*	-	-	-	-	0.2	-
	Spratellomorpha bianalis	-	-	0.1	-	-	-
Gobiidae	*Glossogobius giuris*	-	-	-	-	1.1	-
	Gobies sp	11.8	**10.2**	6.6	4.8	7.0	6.5
Alpheidae	*Alpheus sp.*	-	-	0.4	-	1.2	1.5
Ambassidae	*Ambassis natalensis*	5.4	6.8	1.0	1.4	4.5	5.2
Anguillidae	*Anguilla anguilla*	-	-	0.1	-	0.3	0.8
Ariidae	*Arius africanus*	-	-	-	-	0.1	0.4
Atherinidae	*Atherinomorus lacunosus*	-	-	1.2	-	0.1	-
Chanidae	*Chanos chanos*	-	1.1	8.2	5.0	3.6	2.4

Chirocentridae	*Chirocentrus nudus*	0.1	-	-	-	0.7	1.0
Belonidae	*Crocodilus crocodilus*	-	-	-	-	-	0.7
Cynoglossidae	*Cynoglossus durbanensis*	-	-	-	-	0.1	0.4
Serranidae	*Epinephelus malabaricus*	-	-	-	-	0.4	1.0
Gerrenidae	*Gerres oyena*	1.5	-	-	3.3	2.7	5.0
Gonodactylidae	*Gonodactylus smithii*	-	-	-	-	0.4	-
Hemiramphidae	*Hemiramphus far*	8.3	4.5	2.2	1.2	5.5	3.2
Sciaenidae	*Johnius dissumieri*	1.0	3.4	-	1.0	-	-
Leiognathidae	*Leiognathus equulus*	0.6	-	0.2	-	1.9	1.9
Scaridae	*Leptroscarus vaigiensis*	-	-	-	-	0.1	0.2
Mugilidae	*Liza macrolepis*	0.1	-	-	3.3	0.3	2.3
Megalopidae	*Megalops saura*	-	-	0.2	-	0.5	0.7
Monodactylidae	*Monodactylus argenteus*	2.0	2.3	0.5	0.2	2.1	4.2
Mugilidae	*Mugil cephalus*	0.9	-	-	-	-	0.5
Cichlidae	*Oreochromis mossambicus*	4.1	4.5	**18.2**	**14.0**	6.0	1.3
Sciaenidae	*Otolithes ruber*	-	1.1	-	-	-	-
Mullidae	*Parupeneus indicus*	-	-	-	-	-	0.1
Pristigasteridae	*Pellona ditchela*	1.6	-	-	0.2	0.8	1.1
Ephippidae	*Platax orbicularis*	-	-	-	-	0.2	0.1
Portunidae	*Scylla serrata*	3.6	3.4	2.7	2.4	3.3	4.4
Siganidae	*Siganus sutor*	0.1	-	-	-	0.3	-
Sillaginidae	*Sillago sihama*	0.5	-	2.3	1.9	2.0	3.5
Sphyraenidae	*Sphyraena barracuda*	0.4	-	0.1	-	1.8	2.7

by *Fenneropeneaus indicus* and *Penaeus monodon* (12.9% and 8.5%, respectively) for Gongoni. The finfish species *Oreochromis mossambicus* was the most abundant (18.2%) for Kurawa, followed by the prawns *F. indicus* (13.9%) and *P. monodon* (12.3%). *M. monoceros* was also the most abundant species (8.7%) for Marereni followed by *F. indicus* (8.3%) (Table 1). During the SEM season, *F. indicus*, *M. monoceros* and *M. stebbingi* were the most abundant species, each at 11.4% for Gongoni, followed by *P. semisulcatus* (10.2%), and the finfish *Gobies* sp. and *Carangoides ferdau* at 10.2% each. For Kurawa, *F. indicus* was the most abundant (15.5%) followed by *O. mossambicus* (14.0%) and *M. monoceros* and *P. monodon* at 10.7% each. *P. monodon* was the most abundant (6.9%) followed by *M. monoceros* (6.7%) and *F. indicus* (6.4%) for Marereni.

The non-Metric Multidimensional Scaling (nMDS) plots showed distinct composition of prawn seine catches across the reservoirs, and to some extent distinct between the seasons (Fig. 4). Results of 1-way ANOSIM indicated a significant difference in the composition of samples with season combination ($R = 0.675$; $p = 0.001$). Pair-wise comparison tests confirmed these differences ($p < 0.05$ in all cases). The average seasonal dissimilarities within reservoirs were: 49.1% for Gongoni, 41.0% for Marereni, and 47.3% for Kurawa. Higher average dissimilarities across reservoirs in the NEM season ranged between 48.9% to 53.6%, and between 57.6% and 63.0% for the SEM season. Much higher average dissimilarities across reservoirs and between seasons ranged between 52.3% and 63.8%. One-way SIMPER analysis indicated the differences across reservoirs was attributed to more abundant *O. mossambicus* for Kurawa reservoir than for Gongoni and Marereni reservoirs. The seasonal difference in composition for Gongoni was attributed to more abundant *M. stebbingi* and *P. semisulcatus* in the SEM, and more abundant *P. monodon* in the NEM. For Kurawa, seasonal difference was attributed to more abundant *M. stebbingi* and *P. semisulcatus* in the SEM than in the NEM. In Marereni, more abundant *O. mossambicus* and *P. semisulcatus* in the

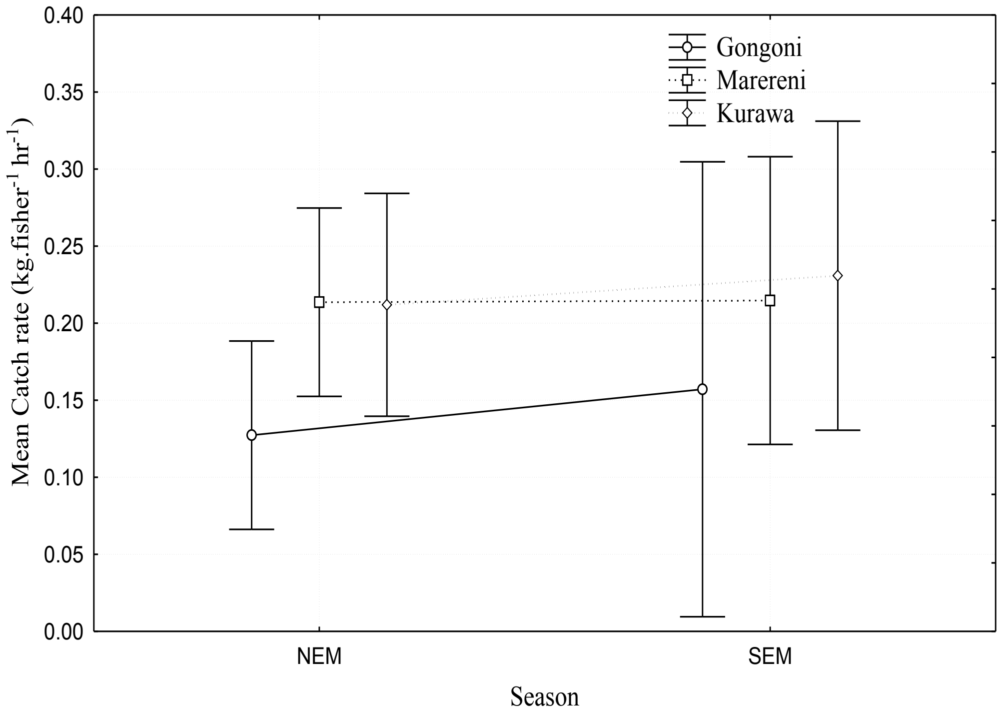

Figure 6. Seasonal mean catch rates (kg.fisher-1hr-1± SE) by reservoir recorded during the study period.

NEM than the SEM attributed to the seasonal difference in species composition.

The nMDS for catch composition from prawn seines and traps for Kurawa reservoir showed distinct composition between gear type and to some extent with season (Fig. 5). Results of 1-way ANOSIM indicated a significant difference in the composition of catches between the gear types with season combination ($R = 0.221$; $p = 0.001$). Pair-wise comparison tests confirmed all catch compositions between gear types with season combination differed significantly ($p < 0.05$), but no significant seasonal difference in catch composition of trap samples within the reservoir was apparent ($p > 0.05$). The dissimilarity between prawn seine samples and trap samples in the NEM was 49.30%. This dissimilarity was attributed to more abundant *O. mossambicus* in trap samples than prawn seine samples. The dissimilarity between the two gears during SEM was 49.25%, mainly attributed to more abundant individuals of *P. monodon, Macrobrachium rude* and *M. stebbingi* during this season.

Catch rates

The catch rates were calculated and compared across reservoirs and between seasons. In all the reservoirs, higher catch rates were recorded during the SEM season (Fig. 6). Overall, the highest catch rate was recorded for Kurawa during the SEM season (0.23 ± 0.053 kg.fisher.$^{-1}$hr^{-1}) and the lowest was recorded for Gongoni in the NEM season (0.12 ± 0.007 kg.fisher.$^{-1}$hr^{-1}; Fig. 6). Results of 2-way ANOVA indicated no significant difference in catch rate between seasons and also across the reservoirs ($df = 1$; $f = 0.182$; $p = 0.670$ and $df = 2$; $f = 1.382$; $p = 0.255$, respectively). The same test showed no significant difference in catch rate with season and reservoir interaction ($df = 2$; $f = 0.004$; $p = 0.952$).

Discussion

Higher prawn catches from the reservoirs were associated with the dry NEM season. This is contrary to the situation in Ungwana Bay and all the East African prawn fisheries, where higher catches are associated with the wet SEM season (Teikwa & Mgaya, 2003; Mwatha, 2005; Munga *et al*., 2012). Ndoro *et al*. (2014) associated higher prawn catches during the SEM season in Ungwana Bay with the increase in productivity as a result of increased river discharge. During the rainy season, juvenile prawns migrate from the brackish water estuaries to more saline water offshore to complete their life cycle (Staples & Vance, 1986). This seasonal migration between inshore and offshore waters influences the availability of prawns to fishers and could be a possible reason for their low catches from the reservoirs during the SEM season. In addition, low prawn catches during the SEM season in this study may also be attributed to low sampling frequency during the rainy season. Further, it was observed that in some instances, the salt works shifted from a daily regime of pumping water to the reservoirs, to a weekly basis, as a strategy to counter the effects of precipitation on the salt pans, which together with low evaporation, resulted in low salt production. This clearly limited the supply of prawns and fin fish into the reservoirs and may have contributed to the low catches recorded during the SEM season.

The non-Metric Multidimensional Scaling (nMDS) plots clearly indicated that the catch compositions were distinct across the reservoirs with season combination. As much as the reservoirs experienced similar conditions in terms of the salt works operations, their differences in proximity to the inshore fishery and to the point of river discharge might have an effect on their environmental parameters, which in turn could influence the composition and abundance of the available species. Mangi *et al.* (2007) noted that variations in catches and compositions across sites in the artisanal fishery could be as a result of factors such as differences in habitat structure, time of fishing, duration and gear type. Differences in catch composition due to gear type has been well captured in Kurawa catches where both prawn seines and traps were encountered. Other authors further suggested that the variations in catch composition give an insight to the selective nature of a gear and how it is operated, and also the available fish communities in a given area (Fauconnet *et al.*, 2015). Dall *et al.* (1990) observed that habitat choice, especially for penaeid prawns, is species dependent, thus some species were more abundant in some habitats than others.

A relatively high diversity of species exist in the reservoirs with a total of 58 species recorded in this study. However, despite the high diversity, only few species dominate the catches from the reservoirs. Similar findings have also been reported in other tropical coastal artisanal fisheries (Gell & Whitington, 2002; Mbaru, 2013). The diversity of species recorded from the reservoirs were similar to those reported in the adjacent inshore fishery in the Bay, suggesting that there is a link between the reservoirs and inshore fishing grounds. For example, *M. monoceros*, *F. indicus,* and *P. monodon* reported in this study, have also been reported in other studies in the Bay (Munga *et al.*, 2013; Ndoro *et al.*, 2014; KMFRI, 2015). Among the penaeid prawns recorded in the present study, *M. monoceros* and *F. indicus* dominated at the landing sites during the NEM and SEM seasons. Studies done elsewhere in the Western Indian Ocean (WIO) region, for example by Subramaniam, (1980) in Tanzania, Gammelsød, (1992) on Sofala Bank in Mozambique, Munga *et al.*, (2013) and Ndoro *et al.*, (2014) in Ungwana Bay, recorded highest abundances of *F. indicus* followed by *M. monoceros*. Macia (2004), Forbes & Demetriades (2005), and de Freitas (2011), suggested that juveniles of *M. monoceros* and *F. indicus* prefer turbid waters to escape from predators. These observations are consistent with Subramaniam, (1980) who reported that *F. indicus* prefer muddy and mangrove habitats. Therefore, the location of the reservoirs adjacent to mangrove creeks and their proximity to the mouth of the Sabaki River (Kitheka, 2013) creates an environment which favors high abundances in the reservoirs.

Catch rates varied across the reservoirs but these did not differ significantly between the seasons. Although fishing effort in terms of fishing duration (hrs) was similar to that reported in other studies on artisanal fisheries (Ochiewo, 2004; Hoorweg *et al.*, 2008), generally relatively low catch rates were recorded. Consistently, other studies by Mbaru (2013) and KMFRI (2015) in the Ungwana Bay artisanal fishery have reported relatively low catch rates ranging between 0.5 and 1.0 $kg.fisher^{-1}hr^{-1}$ which is close to what is reported in this study. Sobrino *et al.* (2003) associated low catch rates with exploitation of juvenile fishes and prawns. This could be the cause of the low catch rates in this study considering that the taxon, especially the penaeid prawns, caught from the reservoirs were all juveniles. Based on the suggestion by Mbaru *et al.* (2011), catch rate is necessary to determine the Maximum Sustainable Yield (MSY) and Potential Yield of a fishery. This is in addition to the use of biological indices such as size and condition factor of the species. Therefore, the low catch rates in this study could suggest that the reservoirs may not be able to sustain the present artisanal fishery. However, it is noted that this study was carried out over a relatively short period of time and longer term studies will be required to ascertain this.

In conclusion, the dynamics of fishing activities and fisheries production in the reservoirs was influenced mostly by factors such as the location of reservoirs, the effect of seasons to some extent, as well as gear type, as shown for Kurawa reservoir. It is also evident that the salt works reservoirs have some potential for supporting artisanal fishing in the area with significant catches landed throughout the year. It is however, recommended that longer term studies be conducted to generate more information necessary for formulation of guidelines for the sustainable management of the reservoir fisheries in the area.

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