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Species composition, abundance and diversity of beach seine catches at Sakumono landing beach, Ghana

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Abstract
Fisherman at the Sakumono landing beach, Ghana is constantly experiencing high rates of marine litter in their catches which is currently having a negative effect on the composition and abundance of species within the nearshore environment. Given this, the main objective of the study was to assess the diversity and composition of catches from beach seine fishermen in Sakumono landing beach, Ghana. Samples of fish were purchased from beach seine fishermen from the nearshore waters at the Sakumono near Accra (Ghana) from September, 2018 to August, 2019. From the samples, species abundance and composition were assessed. The species diversity indices, including richness, evenness, dominance and diversity indices were calculated using the PAST statistical tool. A total of 28 species belonging to 18 families was recorded. The dominant taxonomic families were: Carangidae and Sciaenidae. The dominant species from the study was *Pteroscion peli* as the most dominant (27%) while *Caranx hippos, Dasyatis margarita, Trachinotus goreensis, Penaeus notialis* and *Sardinella aurita* were the least dominant species (less than 0.1%). The species richness using Margalef index ranged from 1.14 to 2.75. The range for species evenness estimated using Pielou's index was 0.32-0.67. The dominance index was estimated as 0.53-0.71. The range of the Shannon index was less than 3.0 which indicated that the Sakumono nearshore waters of Ghana is moderately polluted.

Keywords: Ghana, beach seine, Sakumono, richness, dominance, evenness

Introduction
Fisheries in Ghana are the foremost vital non-traditional trade product (DoF, 2004) [21]. The fisheries division is assessed to account for approximately 3% of the agricultural gross domestic product (GDP) and utilizes around 10 % of the nation's financially dynamic populace (Amador *et al.*, 2006) [19]. Normal per capita utilization is 25 kg per annum (DoF, 2004) [21]. Ghanaian fisheries contain the artisanal, semi-industrial, and mechanical sub-sectors. The artisanal segment is the foremost imperative and accounts for 70 % to 80 % of the national fisheries generation (Amador *et al.*, 2006) [19]. Beach seine fishing activities is one of the overwhelming marine artisanal gears utilized in Ghana and along the coast of West Africa. Nunoo *et al.* (2006) [3] stated that beach-seine fisheries contribute 12 % to the overall Ghanaian artisanal fisheries generation and has quantitatively portrayed fish collections related to the nearshore environment in Sakumono, Ghana. There are 1074 beach seine units working from 315 landing sea shores along the coastline of Ghana (Akyempon *et al.*, 2014) [19].
However, over the years beach seine fishermen in Ghana have endorsed the use of illegal mesh sized fishing gears for fishing, which has partly resulted in the declined size of some commercial fishes. As result, beach seining is viewed as ruinous and adds to the decrease of the producing capability of little pelagic stocks shared by nations flanking the western Bay of Guinea (Nunoo, 2003; Nunoo *et al.*, 2006) [2, 3]. Despite the negative implications of beach seine activities on the nearshore environment and its corresponding marine resources, limited studies have been undertaken with past literature relating to species composition has been done in other places other than Sakumono, Ghana (e.g. Nunoo and Azumah, 2014, Aggrey-Fynn and Sackey-Mensah, 2015). This study is significant because it will address the implications of the beach seine fishing gears on catch composition and the status of the nearshore environment of Sakumono based on diversity indices.

Methodology

Study Area: The Sakumono area II Lagoon (Figure 1) is a semi open lagoon located on the eastern part of Greater Accra, 3 km west of Tema along the Accra Tema coastal road (Koranteng *et al.*, 1997) [33]. It is located within latitudes (5º 36.5"N and 5º 38" N, and between 1 º 30 "W and 2º 30" W lengths). It has an area of 2,7 km ^{2} (Tumbulto and Bannerman, 1995) [19], and its catchment area covers a total area of 350 km ^{2} although the effective catchment area is 127 km^2 due to the damming of the streams that lead to the lagoon (Tumbulto and Bannerman, 1995) [19]. It is characterized by an average annual rainfall of around 753 mm and temperatures ranging from 24.7 ° C in August to a maximum of 28.1 ° C in March with monthly averages.

Fig 1: Map shows the study area (Source: Mensah, 2013)

Data Collection

Fish samples were purchased randomly from beach seine fishermen within the Sakumono landing beach, once every month from September 2018 to August 2019. The random sampling was done to ensure that all the fishers have an equal chance of being selected. Samples purchased were sorted to the species level using identification keys by Kwei and Ofori-Adu (2005) [26].

Methods

Species abundance

This indicates how rare or common a species is relative to other species in a defined location. This was expressed in percentage, using the expression below:

$$\frac{\text{Number of individuals of species}}{\text{Total number of individuals}} * 100$$

Species Richness

This is the number of different species represented in an ecological community**.** Margalef index was to determine the species richness with the following expression;

$$\frac{(S-1)}{\ln N} \text{ (Margalef, 1967)}$$

Where s is the number of different species represented in the sample and N is the total number of individual organisms in your sample

Species evenness

This refers to how close in numbers each species in an environment is. Pielou's evenness index was used to calculate the evenness of the fish species in the sample following expression;

$$\frac{H'}{H'max} \text{ (Pielou, 1969)}$$

Where H' is the number derived from Shannon diversity index and H'max is the maximum possible value of H' (if every species was equally likely).

Simpson Dominance index

Simpson dominance index is the measure of diversity which takes into account the number of species present as well as the relative abundance of each species. This was estimated using the formula below:

$$\frac{1 - \Sigma\, n(n-1)}{N(N-1)} \text{ ... (Ogbeibu, 2005)}$$

The value of 1 - *D* ranges between 0 and 1. With this index, 1 represents an infinite diversity and 0, no diversity.

Shannon Werner index

The idea behind this index is that the diversity of a community is similar to the amount of information in a code or message. It is calculated in the following way:

$$-\Sigma\left[\left(\frac{ni}{N}\right) \times \ln\left(\frac{ni}{N}\right)\right] \text{ (Shannon and Weaver, 1963) [9]}$$

Where, pi is the proportion of individuals found in species i. For a well-sampled community, we can estimate this proportion as $p_i = n_i/N$, where n_i is the number of individuals in species i and N is the total number of individuals in the community.

Data Analysis

Descriptive statistics such the mean, medium and range were estimated using the length frequency distribution data. Frequency statistics was applied in showing the number of species obtained in each sampling area in relation to other species. The Microsoft Excel Tool was used in estimating the descriptive statistic of the recorded length data of the species which involved the mean, medium and range. The species diversity indices were done using the PAST V4.0 software. Data obtained was presented in tables and charts for easy understanding.

Results

Catch Composition

Table 1 shows the types of fish species obtained during the study period. From the Table 1, the highest number of species (18) was obtained during the October, 2018 study period whereas the lowest number of species (8) was recorded during the September, 2018 study period.

Table 1: Composition of species from beach seine fishing activities at Sakumono landing beach

Species	Sep-2018	Oct-2018	Nov-2018	Dec-2018	Jan-2019	Feb-2019	Mar-2019	Apr-2019	May-2019	Jun-2019	Jul-2019	Aug-2019
Brachydeuterus auritus	-	+	+	+	+	+	+	+	+	+	+	+
Caranx crysos	-	+	-	+	-	+	-	+	+	-	+	-
Caranx hippos	-	-	-	-	-	+	+	-	-	-	-	-
Chloroscombrus chrysurus	-	+	+	+	+	+	+	+	+	+	+	+
Cynoglossus senegalensis	-	+	-	-	-	-	-	+	+	-	-	-
Dasyatis margarita	-	-	-	-	-	-	+	-	-	-	-	-
Drepane africana	-	-	-	+	-	-	-	+	+	+	+	-
Elops lacerta	-	+	-	-	-	-	-	-	-	-	-	-
Engraulis encrasicolus	-	-	-	-	-	-	-	-	-	-	-	+
Ethmalosa fimbriata	-	-	-	+	-	-	-	-	-	-	-	-
Galeoides decadactylus	-	+	-	+	+	+	+	+	+	-	+	-
Ilisha africana	+	+	+	+	+	-	-	-	+	+	+	-
Parapenaeus longirostris	+	+	+	-	-	-	+	-	-	-	-	-
Penaeus notialis	-	-	-	-	-	-	-	+	-	-	-	-
Pentanemus quinquarius	+	-	-	+	+	-	-	-	-	+	-	+
Portunus validus	-	+	-	-	-	+	-	-	-	-	-	-
Pseudotolithus senegalensis	+	+	-	+	+	-	+	+	+	+	+	+
Pseudotolithus typus	+	+	-	-	-	-	+	+	-	-	+	+
Pteroscion peli	+	+	+	+	+	+	+	+	-	+	+	+
Sardinella aurita	-	-	-	-	+	-	-	-	-	-	+	-
Sardinella maderensis	-	+	+	-	-	+	+	+	+	+	+	-
Selene dorsalis	+	+	+	+	+	-	+	+	+	+	+	+
Sepia officinalis	-	-	-	+	-	+	-	-	-	-	+	-
Sphyraena sphyraena	-	+	+	-	+	+	+	+	+	-	-	+
Trachinotus goreensis	-	-	+	-	-	-	-	-	-	-	-	-
Trachinotus ovatus	-	+	+	+	-	+	+	+	-	-	-	+
Trichiurus lepturus	+	-	+	-	-	+	-	+	+	-	+	+
Umbrina canariensis	-	-	-	+	-	-	-	-	-	+	-	-
Total	8	18	11	14	10	10	13	17	14	10	14	11

Figure 2 shows the overall relative abundance of species recorded from beach seine fishing gear from September, 2018 to August, 2019. From Figure 2, twenty-eight (28) species were obtained with *Pteroscion peli* as the most dominate (27%) and *Caranx hippos, Dasyatis margarita, Trachinotus goreensis, Penaeus notialis and Sardinella aurita* as the least dominant species (less than 0.1%).

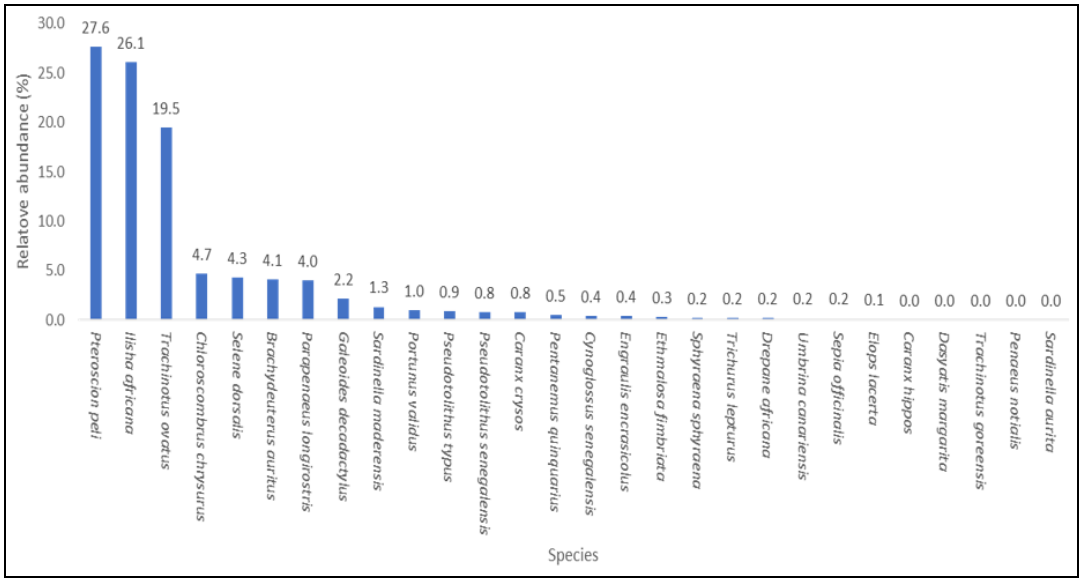

Fig 2: Percentage of species abundance

Catch composition by family

Table 2 shows the types of fish species obtained during the study period. Overall, eighteen (18) fish family was documented during the study period (September, 2018 to Aug, 2019). These were Pomadasyidae, Portunidae, Caranigidae, Cynoglossidae, Dasyatidae, Drepanidae, Elopisdae, Clupadae, Polyrenidae, Palinundae, Penaedae, Scianeidae, Sepiidae, Sphyranidae and Trichunidae. The lowest number of family was recorded in August 2019 (i.e. 3 families) and the highest was recorded in April and October 2018 (i.e. 10 families) as shown in Table 2.

Table 2: Composition of species based on family from beach seine catches at the Sakumono landing beach

Family	Sep-2018	Oct-2018	Nov-2018	Dec-2018	Jan-2019	Feb-2019	Mar-2019	Apr-2019	May-2019	Jun-2019	Jul-2019	Aug-2019
Pomadasyidae	-	+	+	+	+	+	+	+	+	+	-	-
Portunidae	-	+	-	-	-	+	-	-	-	-	-	-
Caranigidae	+	+	+	+	+	+	+	+	+	+	+	+
Cynoglossidae	-	+	-	-	-	-	-	+	+	-	-	-
Dasyatidae	-	-	-	-	-	-	+	-	-	-	-	-
Drepanidae	-	-	-	+	-	-	-	+	+	+	+	-
Elopisdae	-	+	-	-	-	-	-	-	-	-	-	-
Clupeidae	+	+	+	+	+	+	+	+	+	+	+	-
Polynemidae	+	+	-	+	+	-	+	+	+	+	+	-
Palinundae	-	-	-	-	-	-	-	-	-	-	-	-
Penaedae	+	+	+	-	-	-	+	+	-	-	-	-
Sciaenidae	+	+	+	+	+	+	+	+	+	+	+	+
Sepiidae	-	-	-	+	-	+	-	-	-	-	-	-
Sphyranidae	-	+	+	-	+	+	+	+	+	-	-	+
Trichunidae	+		+	-	-	-	+	+	+	-	+	-
Total	6	10	7	7	6	7	9	10	9	6	6	3

Abundance by species family

Figure 3 shows the overall relative abundance of species recorded from beach seine fishing gear from September, 2018 to August, 2019. From Figure 3, the most encountered fish family was Carangidae (19%), followed by Sciaenidae which accounted for (15%). About thirteen (13) families recorded percentages less than 10% of the total number of families. The least families recorded four (4%), namely; Haemulidae, Cynoglossidae, Dasyatidae, Drepaneidae, Elopidae, Engraulidae, Polynemidae, Pristigasteridae, Penaeidae, Portunidae, Trichiuridae, Sphyraenidae and Sepiidae as shown in Figure 3.

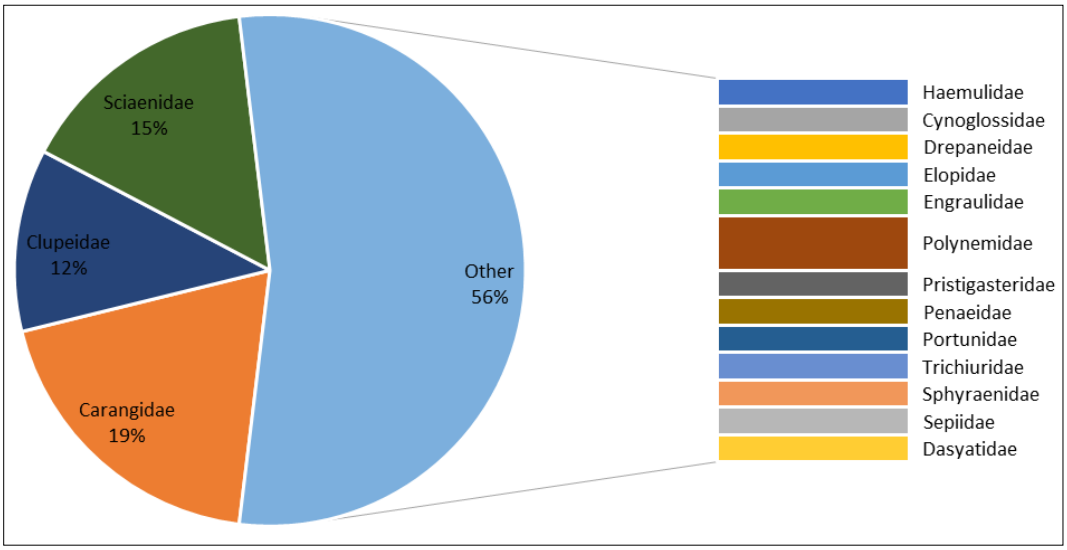

Fig 3: Percentage abundance of species family

Species diversity indices

Table 3 shows the diversity indices for the species obtained the sampling period at the Sakumono landing beach. From Table 3, the number of species ranged from eight (8) in September 2018 and February (2019) to eighteen (18) species in April. The minimum number of species was recorded in September (2018) and February (2019) while the highest number of species (i.e. 18 species) was recorded in October (2018). The number of individuals ranged from fifty-three (53) to fifteen thousand and seventy-eight (15078). The minimum number of individuals was recorded in February (2018) while the highest number of individuals was recorded in October (i.e. 15078 individuals). The Simpsons index for dominance ranged from 0.53 to 0.79. The minimum index of dominance was recorded in June (2019) while the highest index of dominance was recorded in November (2018). The Shannon index ranged from 1.18 to 1.81. The minimum index was recorded in January (2019) while the highest index was recorded in October (2018). The index of Evenness index ranged from 0.32 to 0.67. The minimum index was recorded

in July (2019) while the highest index was recorded in May (2019). The Margalef index ranged from 1.14 to 2.75. The minimum index was recorded in September (2018) while the highest index was recorded in April (2019).

Table 3: Species diversity indices from beach seine catches at the Sakumono landing beach

Diversity indices	Mean	SE Mean	StDev	Minimum	Maximum
Dominance	0.70	0.02	0.08	0.53	0.87
Shannon-Weiner	1.57	0.08	0.29	1.18	2.23
Evenness	0.41	0.03	0.11	0.32	0.67
Richness	1.91	0.14	0.49	1.14	2.75

Table 4: Seasonal variation of species diversity indices from beach seine at the Sakumono landing beach

Indices	Season	Mean	SE Mean	StDev	Minimum	Maximum
Simpson	Dry	0.71	0.02	0.04	0.63	0.74
	Wet	0.69	0.05	0.11	0.53	0.87
Shannon	Dry	1.53	0.08	0.20	1.18	1.74
	Wet	1.60	0.15	0.37	1.21	2.23
Evenness	Dry	0.41	0.04	0.10	0.33	0.59
	Wet	0.42	0.06	0.14	0.32	0.67
Margalef	Dry	1.95	0.22	0.54	1.39	2.75
	Wet	1.88	0.20	0.49	1.14	2.49

Discussion

Species composition and abundance

For the current study, twenty-eight (28) species were recorded from the beach seine catches at the Sakumono landing site, Ghana. Studies by Nunoo and Azumah (2015) [24] revealed sixty-seven (67) species. Nunoo *et al*. (2006) [3] works also document sixty-three (63) species from the nearshore waters of Sakumono. Aggrey-Fynn and Sackey Mensah (2012) [1] recorded a total of 56 species with Winneba, Saltpond and Cape Coast recording 28, 34 and 31 species respectively. There were about forty-three (43) species recorded by Anetekhai *et al.* (2018) [28] from Badagry, Lagos State, South West, Nigeria'. Furthermore, Karama *et al.* (2017) works in Lamu, north coast, Kenya' reported a total of ninety-eight (98) species. From the comparison with other studies, it was observed that the number of species recorded from the current study was lower than reported from other works. The reasons for the variation in species could be as a result of the following factors, such as environmental factors, time of sampling, sampling duration, depth and type of beach seine fishing gear, biological activities of fish species, geographical location, the possibility of tear of fishing gears and the intensity of fishing activities. Nunoo *et al*. (2006) [3] reported that the duration of sampling influences the abundance of species caught. For instance, Ashong (unpublished data) found 23 fish species during a five-month study at Sakumono, and Azumah (1986) recorded 32 fish species in OLA Duakor, Cape Coast, Ghana, during a 12-month study. Nunoo *et al.* (2006) [3] stated that species abundance and occurrence in the nearshore fish community at the Sakumono is high from November to January and low from May to July. Lefkaditou *et al*. (1998) [29] stated the seasonal changes in fish assemblages is reliant on changes in environmental factors. For example, it has been suggested that tidal level and duration of solar radiation are important predictors of the fish community structure in the nearshore waters of Sakumono (Modde and Ross, 1981) [30]. Also, Lasiak (1984) [31] pointed out that differences in sampling technique, length and mesh size of gears used affect the abundance of species encountered. Another reason to explain the differences is that the constantly changing population of the fish assemblages at the shore zone as a result of the changes of the geology of the shore zone (Warlef and Merriman, 1944). In terms of numerical abundance of species, it was observed that few species numerically dominated the catch, namely; *Pteroscion peli*, *Ilisha africana*, and *Trichurus ovatus* in order of decreasing contribution took up 27.6 %, 26.1 % and 19.5 % of the catch respectively. In contrast to expectations, Nunoo *et al*. (2006) [3] observed that *P. notialis*, *C. chrysurus* and *S. dorsalis* were in high abundance in the Tsokome coastal area of Ghana. This shows that the dominant species from the current study are more abundant in the Sakumono coastal area of Ghana, possibly due to favorable environmental conditions. However, the existence of *I. africana* as the second dominant fish species was favorable with findings by Aggrey-Fynn and Mensah (2012) [1] where *I. africana* was the second highest (14.7 %). This observation shows that *I. africana* is not only localized at the eastern coast of Ghana but also at the Western coastal of Ghana as well due to conducive coastal conditions at both areas.

Species diversity

Species diversity has two basic components: richness, or number of species in a given area, and evenness, or how relative abundance or biomass is distributed among species (Wilsey and Stirling, 2007). Shannon-Weiner Index assumes that individuals are randomly sampled from an independent large population and all the species are represented in the sample. Shannon diversity is very widely used index for comparing diversity between various habitats (Clarke and Warwick, 2001) [16]. The mean SWI recorded during the study was 1.57 with the highest in the wet season (1.60) and the lowest in the dry season (1.56) (Table 2). According to Odum (1971), diversity tends to be higher in communities in stable environments than disturbed conditions. As per the species diversity scale of Wilhm & Dorris (1968) (H > 3 = clean water, H = 1-3 = moderately polluted, H < 1 = heavily polluted) nearshore waters of Sakumono are moderately polluted. Higher value of SRI represents the highest number of species, lower abundance and lower aquatic pollution (Padmanabha & Belagali 2007). The number of species in a local assemblage is an intuitive and natural index of community structure, and patterns of species richness have been measured at both small (e.g. Blake and Loiselle, 2000)

[23] and large (e.g. Rahbek and Graves, 2001) [18] spatial scales. The mean SRI recorded during the study was 1.91 with the highest in the wet season (1.88) and the lowest in the dry season (1.95) (Table 2). As per the diversity index (D) scale of Staub *et al.* (1970) (D < 1 = heavily polluted, D = 1-2 = moderately polluted, D > 2-3 = lightly polluted, D > 3-4.5 = slightly polluted), the species richness index has been successful to explain convincingly about the pollution levels in these lakes. According to this scale, the nearshore waters of Sakumono landing each is moderately polluted. Simpson Dominance Index value ranges from 0 to 1, if the Index value close to 1 means there is dominance of certain species in the waters (Pratiwi *et al*. 2020). The mean SDI recorded during the study was 0.70 with the highest in the dry season (0.71) and the lowest in the wet season (0.69) (Table 2). The dominance of a species refers to its relative importance in its habitat which determines the degree of influence of the species on the ecosystem (Kinyanjui *et al.*, 2014) [17]. The dominance index for the study was closer to 1, which indicates the dominance of certain species. An increase in the SDI indicates increase in pollution load (Padmanabha & Belagali 2007). Some species are known to intolerant due to increased pollution and disappeared, but few species have increased tolerance for adverse conditions (Myslinski & Ginsberg 1977, Mohammad 1980). This evenness is an important component of diversity indices and expresses evenly distribution of the individuals among different species (Bibi and Ali, 2013) [22]. The mean SEI recorded during the study was 0.41 with the highest in the wet season (0.42) and the lowest in the dry season (1.56) (Table 2). (Table 2). As per the diversity index (D) scale of Wilha (1975) (E < 1 = heavily polluted, E = 1-3 = medium polluted, E > 3 = clean waters), the species richness index has been successful to explain convincingly about the pollution levels in aquatic environment. According to this scale, the nearshore waters of Sakumono landing each is heavily polluted.

Conclusion

Overall, twenty-eight species were obtained with *Pteroscion peli* as the most dominate (27%) and *Caranx hippos*, *Dasyatis margarita*, *Trachinotus goreensis*, *Penaeus notialis* and *Sardinella aurita* as the least dominant species (less than 0.1%). In all, sixteen (16) fish family was documented during the study period (September, 2018 to August, 2019) with the dominant family being Carangidae (19%). Based on the findings from the species diversity indices, the nearshore waters of Sakumono where beach seining is the predominant fishing activity is moderately polluted. This implies that species may not be able to thrive in such environment leading reduced species composition and abundance with severe repercussions on the economic welfare of fishing households who depend on the nearshore environment for livelihood. It is therefore recommended that conservation and preservation measures be put in place to curtail the deteriorating nature of the nearshore waters of the Sakumono landing beach. Alternative sources of livelihood, as sources of income should be identified and presented to beach seine fishermen to reduce their dependence on the sea since the ability of the nearshore to support fish species is presently depreciating.

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