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Seasonal variation in the length-weight relationship and condition factor of thirty fish species from the Shimoni artisanal fishery, Kenya

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Abstract

Seasonal variation in the length-weight relationship (LWR) and condition factor were assessed for 3 704 fish specimens constituting 30 fish species belonging to 11 families. The fish were sampled from artisanal fisher catches on the south coast of Kenya between March 2014 and March 2015. The regression results for the LWR were 0.57 for *Siganus luridus* and 0.97 for *Lutjanus argentimaculatus* during the northeast monsoon (NEM), and 0.76 for *Scolopsis ghanam* and 0.98 for *Parupeneus macronema* during the southeast monsoon (SEM). The '*b*' values ranged from 1.8 for *Siganus luridus* to 4.3 for *Plectorhinchus gaterinus* during the NEM, and 1.4 for *Plectorhinchus chubbi* to 3.2 for *Parupeneus heptacanthus* during the SEM. The mean '*b*' values for the SEM and NEM seasons were 2.73 and 2.63 respectively and significantly differed from 3 (*t*–test, $P < 0.5$). Mean condition factors of 0.37 (S.E = 0.01) during the NEM, 0.34 (S.E = 0.01) during the SEM for *Hemiramphus far* and 0.56 (S.E = 0.03) during the NEM, and 0.59 (S.E = 0.03) during SEM for *Cheilio inermis* were recorded indicating that these species were feeding poorly, the environment was not conducive, or that high competition for food from other species existed, while the other species had mean condition factors above 1 during the two seasons. The condition factor significantly differed for eleven species during the two seasons ($P < 0.05$).

Keywords: Length–weight, fish species, season

Introduction

Collection of length and weight data from fishery landings is often a routine aspect in fisheries assessments which, when presented as length–weight relationships (LWR), can provide important information that is useful in the determination of biomass, population dynamics and the condition of fished populations (e.g. Duarte *et al*., 1999; Sparre and Venema, 1998; Haimovici and Velasco, 2000).

LWR information can also be used to assess the physiological wellbeing or condition of a fish, as the heavier a fish is at a given length, the better its physiological condition. Such information can also be used as an indicator of the status of an ecosystem in which fish live. Seasonal variations in LWR and condition factor can provide information on when the marine environment is most optimal for the growth and development of fish. In Kenya, LWR studies have been documented for a number of marine species (i.e. Mbaru *et al*., 2010; Aura *et al*., 2011) but there are no studies that have been conducted to assess effects of seasonality on body condition. This assessment was therefore conducted to contribute to filling these information gaps.

Materials and methods

Study area

This study was conducted at Shimoni (south coast Kenya) which is located between 04°39'0"S and 39°23'0"E, adjacent to the Kisite Marine National Park and Mpunguti Marine National Reserve as indicated in Fig. 1. Generally the Kenyan coast is influenced by the movement of the inter–tropical Convergence Zone (ITCZ) creating two distinct seasons; the northeast monsoon (NEM) locally known as 'Kazi kazi', and the southeast monsoon (SEM), locally known as 'Kusi'(McClanahan, 1988). The NEM season prevails from May to September and is characterized by calm and hot weather with wave heights dropping during this time, and the SEM season prevails from November to March and is characterized by windy and cold weather accompanied by rough seas.

Data collection and analysis

Fish samples were obtained from artisanal fisher catches between March 2014 and March 2015. The catches were sorted and identified using identification guides (Lieske and Myers, 2001; Anam and Mostarda, 2012). Total length (TL) of each fish was measured from the snout to the caudal fin nearest to 0.1 cm using a standard fish length measuring board, then weighed to the nearest 0.01g (total weight) using a hand held portable electronic weighing balance.

LWR is expressed by the equation $W = a L^b$ where W and L represent weight and length of fish, 'a' is the initial growth index and 'b' is the equilibrium constant which measures the growth pattern of the fish. The 'b' value remains constant at 3 for ideal fish growth (Wootton, 1990) lesser or greater values indicate either positive allometric growth ($b > 3$) or negative allometric growth ($b < 3$) (Ricker, 1975). LWR of 30 species which had sufficient samples (five individuals or more) were determined by linearly regressing the log-transformed data in scatter plots to obtain the 'a' and 'b' values following the procedure described by Le Cren (1951) as:

$$\text{Log } W = \log a + b \log L$$

Where, W= weight of the fish (g), L is the observed total length (cm), 'a' is the regression intercept and 'b' is the regression slope. Condition factor was calculated using Fulton's Condition Factor (K) (Fulton, 1902) which assumes isometric growth (b = 3) indicating that the shape of the fish does not change with growth, calculated as:

$$\mathrm{K} = \frac{W \times 10^5}{\mathrm{L}^3}$$

Where, W=weight of fish (g), L=Length of fish (cm).

The relationship between length and weight was evaluated using multiple regression analysis, and the student's t–test was used to confirm whether the LWR was significantly different from 3 and whether the LWR differed between seasons ($\alpha = 0.05$). Analysis of variance (ANOVA) was then used to determine if there was a significant difference in the mean condition factor of the fish between seasons ($P < 0.05$). All statistical analysis was done using Microsoft Excel® and STATISTICA software packages.

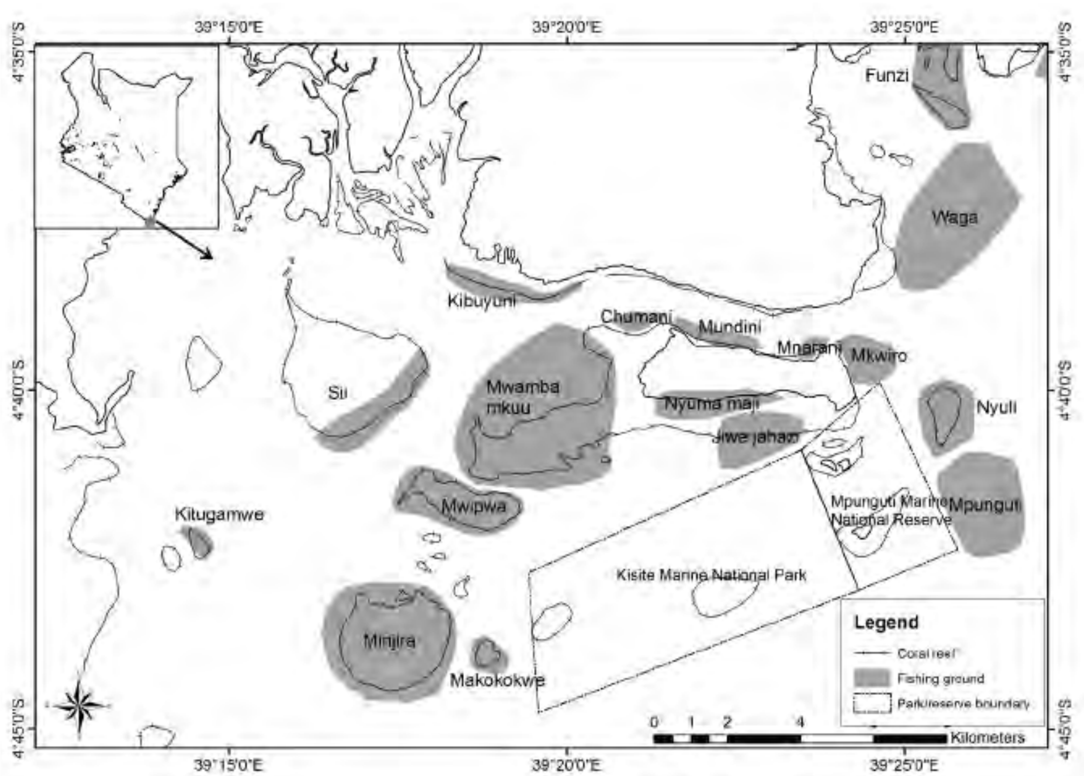

Figure 1. Location of the fishing grounds at Shimoni on the on the south coast of Kenya.

Results

A total of 3 704 fish specimens of 30 species belonging to 11 families were measured, with 2 027 fish sampled during the NEM and 1 677 fish sampled during the SEM, respectively. During the NEM the catch was dominated by the shoemaker spinefoot, *Siganus sutor* (Valenciennes, 1835) accounting for 18.0% (367) of the total catch, and snubnose emperor, *Lethrinus borbonicus* (Valenciennes, 1830) accounting for 12.7% (257) of the total catch. During the SEM the pink ear emperor, *Lethrinus lentjan* (Lacèpede, 1802) and Dory snapper, *Lutjanus fulviflamma* (Forsskål, 1775) dominated the catch accounting for 12.0% (200) and 9.6% (161), respectively (Fig. 2a and 2b).

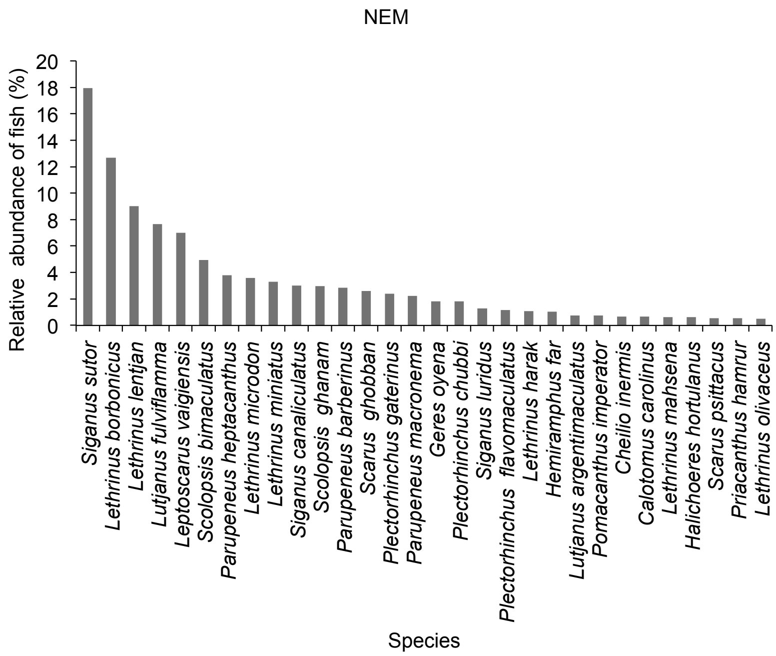

Figure 2(a). Sample size of the species analysed for the NEM season.

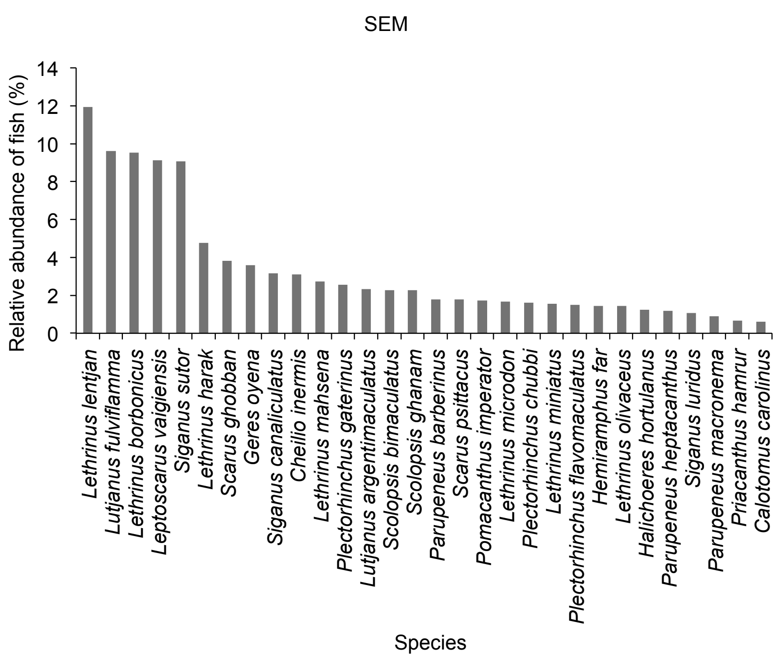

Figure 2(b). Sample size of the species analysed for the SEM season.

Length–weight relationship

A summary of the LWR for the 30 fish species is shown in Table 1a and 1b for both the NEM and SEM seasons, respectively. LWR were highly significant for all 30 species assessed with the coefficient of determination, *r*, ranging between 0.57 for dusky spinefoot, *Siganus luridus* (Rüppell, 1829) and 0.97 for mangrove jack, *Lutjanus argentimaculatus* (Forsskål, 1775) during the NEM season (Table 1a), and 0.76 for Arabian monocle bream, *Scolopsis ghanam* (Forsskål, 1775) and 0.98 for long-barbel goatfish, *Parupeneus macronema* (Lacèpede, 1801) during the SEM season (Table 1b). The '*b*' values ranged from 1.8 for *S. luridus* to 4.3 for black-spotted rubberlip, *Plectorhinchus gaterinus* (Forsskål, 1775) during the NEM and 1.4 for dusky rubberlip, *Plectorhinchus chubii* (Regan, 1919) to 3.2 for cinnabar goatfish, *Parupeneus heptacanthus* (Lacèpede, 1802) during the SEM. During the NEM a mean '*b*' value of 2.66 was recorded. During this season the thumbprint emperor, *Lethrinus harak* (Forssåkal, 1975), longface emperor, *Lethrinus olivaceus* (Valencienes, 1830), black-barred halfbeak, *Hemiramphus far* (Forssåkal, 1775) and emperor angelfish, *Pomacanthus imperator* (Bloch, 1787) had isometric growth (b = 3), while cigar wrasse, *Cheilio inermis*, common silver-biddy, *Geres oyena*, blackspotted rubberlip, *Plectorinchus gaterinus* (Forsskål, 1775), checkerboard wrasse, *Halichoeres hortulanus* (Lacèpede, 1801) had positive allometry (b > 3), and the rest of the

Table 1 (a). Number of specimens (N), Total length (Mean ± S.E and range), Length-weight relationship (LWR), regression and growth parameters of the fish species sampled during the NEM (A-, A+ and I represent negative, positive and isometric growth, respectively)

Species		Total weight (kg)		Total length (cm)		LWR parameters			
	N	Mean ± S.E	Range	Mean ± S.E	Range	a(x10^{-5})	Slope 'b'	R	Growth
Siganus sutor	364	0.23 ± 0.01	0.02 - 0.86	26.0 ± 0.3	12.9 - 44.0	2.5	2.8	0.93	*A-*
Lethrinus borbonicus	257	0.10 ± 0.00	0.01 - 0.36	17.5 ± 0.2	10.6 - 27.7	3.4	2.7	0.91	*A-*
Lethrinus lentjan	183	0.19 ± 0.01	0.03 - 0.74	22.5 ± 0.4	10.6 - 40.0	3.6	2.7	0.94	*A-*
Lutjanus fulviflamma	155	0.11 ± 0.00	0.01 - 0.23	19.3 ± 0.2	15.0 - 28.7	21.6	2.1	0.71	*A-*
Leptoscarus vaigiensis	142	0.21 ± 0.01	0.08 - 0.51	23.1 ± 0.3	16.2 - 38.0	12.9	2.3	0.83	*A-*
Scolopsis bimaculatus	100	0.11 ± 0.00	0.03 - 0.26	18.6 ± 0.3	13.1 - 26.0	10.4	2.3	0.83	*A-*
Parupeneus heptacanthus	77	0.19 ± 0.02	0.06 - 0.75	22.8 ± 0.6	14.0 - 38.5	2.6	2.8	0.96	*A-*
Lethrinus microdon	73	0.17 ± 0.03	0.02 - 1.13	21.2 ± 1.0	12.2 - 50.2	3.8	2.6	0.95	*A-*
Lethrinus miniatus	67	0.49 ± 0.05	0.05 - 1.93	29.8 ± 1.2	13.9 - 49.7	5.4	2.6	0.83	*A-*
Siganus canaliculatus	61	0.18 ± 0.01	0.07 - 0.45	23.7 ± 0.5	16.8 - 33.6	6.5	2.5	0.93	*A-*
Scolopsis ghanam	60	0.08 ± 0.00	0.03 - 0.14	16.8 ± 0.2	12.5 - 22.6	2.2	2.9	0.88	*A-*
Parupeneus barberinus	58	0.13 ± 0.02	0.03 - 0.53	20.4 ± 0.8	11.8 - 36.9	3.5	2.7	0.95	*A-*
Scarus ghobban	53	0.48 ± 0.09	0.07 - 3.65	28.4 ± 1.2	15.5 - 64.6	6.3	2.6	0.92	*A-*
Plectorhinchus gaterinus	49	0.31 ± 0.02	0.05 - 0.60	21.7 ± 0.3	16.0 - 26.5	0.0	4.3	0.66	*A+*
Parupeneus macronema	45	0.08 ± 0.01	0.04 - 0.26	17.4 ± 0.7	13.0 - 27.5	4.6	2.6	0.88	*A-*
Plectorhinchus chubbi	37	0.07 ± 0.15	0.03 - 4.10	33.4 ± 2.4	13.5 - 73.9	2.8	2.8	0.94	*A-*
Geres oyena	37	0.20 ± 0.01	0.09 - 0.35	24.0 ± 0.5	18.3 - 29.5	0.6	3.3	0.88	*A+*
Siganus luridus	26	0.08 ± 0.00	0.04 - 0.13	17.7 ± 0.3	15.0 - 20.8	40.5	1.8	0.57	*A-*
Plectorhinchus flavomaculatus	24	0.36 ± 0.09	0.08 - 1.72	25.3 ± 2.0	15.8 - 50.0	5.6	2.6	0.95	*A-*
Lethrinus harak	22	0.28 ± 0.03	0.12 - 0.72	27.0 ± 0.7	23.2 - 36.8	1.2	3.0	0.96	*I*
Hemiramphus far	21	0.18 ± 0.01	0.09 - 0.27	36.3 ± 0.8	27.9 - 42.2	0.4	3.0	0.95	*I*
Lehtrinus mahsena	13	0.52 ± 0.12	0.17 - 1.82	29.3 ± 2.1	21.7 - 48.2	3.9	2.7	0.96	*A-*
Lutjanus argentimaculatus	15	0.54 ± 0.21	0.17 - 3.33	29.6 ± 3.0	21.0 - 65.0	3.6	2.7	0.97	*A-*
Pomacanthus imperator	15	1.23 ± 0.14	0.08 - 1.83	32.8 ± 1.8	15.5 - 38.8	1.7	3.0	0.96	*I*
Scarus rubroviolaceus	15	0.49 ± 0.14	0.11 - 1.86	28.3 ± 2.7	17.8 - 51.1	9.2	2.5	0.95	*A-*
Cheilio inermis	14	0.16 ± 0.03	0.04 - 0.43	29.1 ± 1.5	20.8 - 40.5	0.2	3.3	0.95	*A+*
Calotomus carolinus	14	0.31 ± 0.04	0.16 - 0.69	25.0 ± 1.1	19.6 - 33.7	5.3	2.7	0.96	*A-*
Lethrinus olivaceus	10	0.50 ± 0.08	0.13 - 0.96	34.0 ± 2.3	21.7 - 43.0	3.0	2.7	0.93	*I*
Priacanthus harmrur	11	0.27 ± 0.03	0.14 - 0.43	27.1 ± 1.5	21.0 - 34.0	37.2	2.0	0.76	*A-*
Halichoeres hortulanus	13	0.14 ± 0.01	0.07 - 0.22	21.0 ± 0.5	17.9 - 24.0	0.4	3.4	0.88	*A+*

species had negative allometry (b < 3). During the SEM *L. fulviflamma* and *S. luridus* had a mean 'b' value of 3.0 indicating isometric growth while *P. heptacanthus* had a 'b' value of 3.2 indicating positive allometry, and the rest of the species had negative allometry. The mean 'b' value of the fish species was low for the two seasons as most had negative allometry, hence did not obey the cubic law (Wootton, 1990). Student's t–test indicated that the mean 'b' values for NEM (b = 1.4–3.2; mean = 2.63; SD = 0.332) and SEM (b = 1.8–4.3; mean = 2.73; SD = 0.469) differed significantly from 3 (t = – 5.809, P = 0.000: NEM; and t = – 3.187, P = 0.003: SEM) indicating that the cubic law does not apply to most of the fish species in this analysis.

Condition factor (K)

The results indicate that the condition factor for all fish species was above 1 except for *H. far* and *C. inermis* which had condition factors of less than 1 during the two seasons. *H. far* had the lowest condition factor of 0.34, S.E = 0.01 during the SEM and 0.37, S.E = 0.01 during the NEM, while *P. imperator* had the highest condition factor of 3.14, S.E = 0.12 during the SEM, and 3.11, S.E = 0.05 during the NEM. However, there was a significant difference between the weights of the fish sampled during the NEM and SEM, and the mean condition factor of eleven fish species differed significantly between the two seasons (P < 0.05) (Table 2).

Table 1 (b). Number of specimens (N), Total length (Mean ± S.E and range), Length-weight relationship (LWR), regression and growth parameters of the fish species sampled during the SEM (A-, A+ and I represent negative, positive and isometric growth, respectively).

Species		Total weight (kg)		Total length (cm)		LWR parameters			
	(N)	Mean ± S.E	Range	Mean ± S.E	Range	a(x 10^{-5})	slope 'b'	R	Growth
Siganus sutor	152	0.16 ± 0.11	0.04-0.52	21.8 ± 12.20	12.2 - 35.9	4.2	2.6	0.96	*A-*
Lethrinus borbonicus	160	0.08 ± 0.04	0.02-0.24	15.8 ± 0.22	10.1 - 25	8.7	2.4	0.88	*A-*
Lethrinus lentjan	200	0.15 ± 0.13	0.03-0.64	20 ± 0.41	11 - 34.2	3.4	2.7	0.95	*A-*
Lutjanus fulviflamma	161	0.11 ± 0.04	0.02-0.30	18.6 ± 0.18	12.5 - 27.5	1.7	3.0	0.70	*I*
Leptoscarus vaigiensis	153	0.22 ± 0.09	0.07-0.54	22.8 ± 0.26	16.6 - 31.8	6.6	2.6	0.90	*A-*
Scolopsis bimaculatus	38	0.13 ± 0.03	0.07-0.23	20.6 ± 0.38	16.5 -26	3.6	2.7	0.95	*A-*
parupeneus heptacanthus	20	0.17 ± 0.07	0.04-0.28	22.7 ± 0.71	16.2 - 27	0.7	3.2	0.95	*A+*
Lethrinus microdon	28	0.23 ± 0.19	0.04-0.80	25.5 ± 1.45	14.4 - 42.9	4.8	2.6	0.95	*A-*
Lethrinus miniatus	26	0.08 ± 0.05	0.03 - 0.26	16.1 ± 0.57	11.4 - 25.6	5.5	2.6	0.90	*A-*
Siganus canaliculatus	53	0.21 ± 0.14	0.03 - 0.48	23.7 ± 0.82	11.9 - 33.5	1.9	2.9	0.97	*A-*
Scolopsis ghanam	38	0.08 ± 0.02	0.04 - 0.13	16.8 ± 0.28	12.0 - 21.0	22.8	2.1	0.76	*A-*
Parupeneus barberinus	30	0.12 ± 0.09	0.03 - 0.40	19.6 ± 0.84	13.3 - 32.4	5.5	2.5	0.92	*A-*
Scarus ghobban	64	0.28 ± 0.33	0.08 - 2.55	23.8 ± 0.76	16.0 - 53.9	2.4	2.9	0.92	*A-*
Plectorhinchus gaterinus	43	0.21 ± 0.13	0.05 - 0.65	22.5 ± 0.70	13.4 - 38.2	2.6	2.9	0.96	*A-*
Parupeneus macronema	15	0.13 ± 0.12	0.03 - 0.47	20.1 ± 1.51	13.0 - 35.2	1.9	2.9	0.98	*A-*
Geres oyena	60	0.04 ± 0.02	0.02 - 0.10	11.7 ± 0.44	8.8 - 20.0	137.0	1.4	0.88	*A-*
Plectorhinchus chubbi	27	0.45 ± 0.64	0.04 - 3.22	28.7 ± 1.92	16.8 - 60.9	4.7	2.6	0.90	*A-*
Siganus luridus	18	0.07 ± 0.02	0.04 - 0.14	16.5 ± 0.38	14.3 - 20.0	1.5	3.0	0.88	*I*
Plectorhinchus flavomaculatus	25	0.34 ± 0.25	0.13 - 1.01	26.7 ± 1.22	18.1 - 40.4	7.2	2.5	0.94	*A-*
Lethrinus harak	80	0.23 ± 0.13	0.05 - 0.72	23.9 ± 0.54	13.7 - 36.0	3.5	2.7	0.93	*A-*
Hemiramphus far	24	0.21 ± 0.06	0.09 - 0.35	39.1 ± 0.81	28.0 - 49.5	0.9	2.7	0.89	*A-*
Lutjanus gibbus	5	0.23 ± 0.22	0.08 - 0.62	23.6 ± 3.04	17.5 - 35.1	1.8	2.9	0.98	*A-*
Lutjanus argentimaculatus	39	0.65 ± 0.71	0.12 - 3.30	33.8 ± 1.64	19.6 - 64.6	4.7	2.6	0.95	*A-*
Pomacanthus imperator	29	1.40 ± 0.36	0.58 - 2.10	35.4 ± 0.64	26.0 - 39.6	10.7	2.7	0.93	*A-*
Scarus rubroviolaceus	6	0.21 ± 0.20	0.10 - 0.62	21.8 ± 2.63	17.9 - 34.8	4.6	2.7	1.00	*A-*
Cheilio inermis	52	0.13 ± 0.06	0.04 - 0.33	27.7 ± 0.60	18.5 - 36.4	3.2	2.7	0.86	*A-*
Calotomus carolinus	10	0.31 ± 0.23	0.11 - 0.90	24.3 ± 1.70	17.6 - 36.9	1.5	2.7	0.97	*A-*
Lethrinus olivaceus	24	0.45 ± 0.46	0.07 - 1.44	30.8 ± 2.14	17.3 - 51.0	1.6	2.9	0.95	*A-*
Priacanthus harmrur	11	0.24 ± 0.11	0.06 - 0.40	25.6 ± 1.96	12.0 - 36.5	50.4	1.9	0.87	*A-*
Halichoeres hortulanus	21	0.13 ± 0.05	0.05 - 0.24	20.9 ± 0.72	14.9 - 28.7	5.7	2.5	0.93	*A-*

Table 2. Mean seasonal condition factor (K) ± standard error (S.E), range and ANOVA values for the 30 species sampled during the survey period. (Use of * indicates significant difference in the mean seasonal condition factor at p < 0.05).

Species	Condition Factor (*K*) for NEM		Condition Factor (*K*) for SEM		
	Mean ±S.E	Range	Mean ±S.E	Range	ANOVA
*Siganus sutor**	1.2 ± 0.01	0.19 - 2.70	1.39 ± 0.02	0.90 - 2.40	*F* = 70.15, *p* = 0.00
*Lethrinus borbonicus**	1.68 ± 0.03	0.17 - 7.17	1.84 ± 0.04	0.76 - 4.25	*F* = 10.20, *p* = 0.00
*Lethrinus lentjan**	1.46 ± 0.02	0.52 - 2.52	1.60 ± 0.02	1.01 - 4.00	*F* = 23.29, *p* = 0.00
*Lutjanus fulviflamma**	1.50 ± 0.03	0.17- 2.85	1.63 ± 0.03	0.57 - 3.42	*F* = 9.48, *p* = 0.00
Leptoscarus vaigiensis	1.65 ± 0.04	0.59 - 5.63	1.72 ± 0.02	0.66 - 2.68	*F* = 2.35, *p* = 0.13
*Scolopsis bimaculatus**	1.61 ± 0.04	0.58 - 4.00	1.44 ± 0.02	1.16 - 1.69	*F* = 5.31, *p* = 0.02
Parupeneus heptacanthus	1.41 ± 0.03	0.68 - 2.62	1.37 ± 0.48	0.71 - 1.69	*F* = 0.38, *p* = 0.54
Lethrinus microdon	1.37 ± 0.08	0.06 - 6.52	1.18 ± 0.05	0.80 - 1.93	*F* = 2.05, *p* = 0.16
*Lethrinus miniatus**	1.55 ± 0.04	0.13 - 2.70	1.88 ± 0.12	1.09 - 4.41	*F* = 10.76, *p* = 0.00
Siganus canaliculatus	1.29 ± 0.03	0.89 - 2.04	1.36 ± 0.03	0.78 - 1.85	*F*=2.97, *p* = 0.09
Scolopsis ghanam	1.59 ± 0.04	1.00 - 2.56	1.66 ± 0.66	0.69 - 3.19	*F* = 0.99, *p* = 0.32
Parupeneus barberinus	1.32 ± 0.04	1.00 - 3.15	1.49 ± 0.09	0.87- 2.99	*F* = 3.93, *p* = 0.05
Scarus ghobban	1.74 ± 0.08	1.31 - 4.86	1.73 ± 0.02	1.31 - 2.11	*F* = 0.01, *p* = 0.93
*Plectorhinchus gaterinus**	2.82 ± 0.16	1.22 - 4.52	1.70 ± 0.04	0.84 - 2.26	*F* = 38.48, *p* = 0.00
Parupeneus macronema	1.46 ± 0.05	1.09 - 2.81	1.38 ± 0.08	0.61 - 1.89	*F* = 0.76, *p* = 0.39
Plectorhinchus chubbi	1.29 ± 0.06	0.14 - 2.12	1.43 ± 0.08	0.13 - 2.78	*F* = 2.01, *p* = 0.16
*Geres oyena**	1.36 ± 0.04	0.75 - 2.35	2.98 ± 0.17	0.96 - 5.78	*F* = 56.67, *p* = 0.00
Siganus luridus	1.51 ± 0.07	0.93 - 2.37	1.47 ± 0.05	1.08 - 1.81	*F* = 0.18, *p* = 0.68
Plectorhinchus flavomaculatus	1.75 ± 0.18	0.89 - 4.83	1.61 ± 0.07	1.12 - 2.53	*F* = 0.54, *p* = 0.47
*Lethrinus harak**	1.37 ± 0.03	0.94 - 1.80	1.54 ± 0.04	0.89 - 3.29	*F* = 5.66, *p* = 0.02
*Hemiramphus far**	0.37 ± 0.01	0.29 - 0.45	0.34 ± 0.01	0.20 - 0.43	*F* = 5.49, *p* = 0.02
Lethrinus mahsena	1.84 ± 0.20	1.50 - 4.26	1.66 ± 0.05	0.84 - 2.96	*F* = 1.70, *p* = 0.20
Lutjanus argentimaculatus	1.50 ± 0.10	1.20 - 2.82	1.40 ± 0.04	0.68 - 1.73	*F* = 1.62, *p* = 0.21
Pomacanthus imperator	3.14 ± 0.12	2.15 - 3.87	3.11 ± 0.05	2.47 - 3.78	*F* = 0.11, *p* = 0.74
*Scarus psittacus**	1.57 ± 0.07	1.05 - 1.80	1.96 ± 0.07	1.35 - 3.02	*F* = 11.43, *p* = 0.00
Cheilio inermis	0.56 ± 0.03	0.39 - 0.87	0.59 ± 0.03	0.25 -1.84	*F* = 0.25, *p* = 0.62
Calotomus carolinus	1.90 ± 0.07	1.42 - 2.26	1.96 ± 0.10	1.50 - 2.44	*F* = 0.30, *p* = 0.59
Priacanthus harmrur	1.35 ± 0.11	0.95 - 2.30	1.48 ± 0.19	0.82 - 3.18	*F* = 0.35, *p* = 0.56
Halichoeres hortulanus	1.45± 0.07	1.18 - 2.20	1.38 ± 0.05	0.93 - 1.69	*F* = 0.74, *p*= 0.40
Lethrinus olivaceus	1.16 ± 0.04	1.03 - 1.33	1.16 ± 0.02	1.01 - 1.35	*F* = 0.00, *p* = 0.99

Discussion

The coefficient of determination, *r*, of the fish species was high during the two seasons indicating a proportional increase in weight and length. This is in agreement with a study done for other species by Oribhabor *et al*. (2011) in the Niger Delta mangrove creek. The significant differences of the average '*b*' values from 3 estimated during the two studied seasons follow the findings of Muto *et al*. (2000). The mean '*b*' values of 2.63 during the NEM and 2.73 during the SEM reported for this study does not deviate from the value of 2.8 reported by Abdurahiman *et al*. (2004) showing that the results are genuine. Allometry could be an indication of large sized fish changing their body form to be more elongated (King, 1996) or that small sized fish were in better nutritional condition during sampling (Froese, 2006).

The estimated '*b*' values for the two seasons revealed that most species exhibited negative allometric growth showing that the length of fish increased more than their weight (Wootton, 1990) and the fish became slender as they increased in length (Pauly, 1984), hence not conforming to the cubic law (Wootton, 1990). The negative allometric growth estimates agree with the findings for *Carlarius heudelotii* in the gulf of Guinea (Ndome *et al*., 2012) and those for *Sparus auratus*, *Diplodus annularis* and *Pagellus erythrinus* (Cherif *et al*., 2008). Letourneur (1998), in his study at Rèunion Island, found a positive allometric result (b = 3.381) for *P. macronema*. However, this study recorded negative allometric results (2.6 during the NEM and 2.9 during the SEM) for *P. macronema*.

This study recorded positive allometric results for *P. gaterinus*, *Geres oyena* and *C. inermis* during the NEM, and *P. heptacanthus* and *S. luridus* during the SEM, indicating the species became heavier as they grew longer (Thakur and Das, 1974). Cherif *et al.* (2008) recorded similar results for *Mullus barbatus*, *Merluccius merluccius* and *Scomber scombrus.* Isometric growth was observed for *L. harak*, *H. far*, *and P. imperator* during the NEM, and *L. fulviflamma* during the SEM, respectively. This shows that the weight of these species does not increase faster than the cube of their lengths, hence they follow Le Cren's cubic law. These results also indicate that small sized fish had the same form and were in the same condition as large sized fish (Froese, 2006). Further, the environment was conducive for these species during the two seasons. During this study isometric results were recorded for *L. harak*, *P. imperator*, *H. far* (NEM) and *L. fulviflamma* (SEM). Similar results have been recorded for *Lithognathus mormyrus*, *Boops boops*, *Spicaramaena*, *Trachurus trachurus* and *Trachurus mediterranus* in the Gulf of Tunis (Cherif *et al*., 2008). The isometric result for *P. imperator* also conforms to that recorded in FishBase (Froese and Pauly, 2016).

According to Fulton (1902) a standard condition factor of 1.6 implies excellent condition, 1.4 - good and well-proportioned fish, 1.2 - fair condition, 1 - a long and thin fish in poor condition, and 0.8 - extremely poor condition. From this study *H. far* (mean = 0.37, S.E = 0.01 NEM; mean = 0.34, S.E = 0.01 SEM) and *C. inermis* (mean = 0.56, S.E = 0.03 NEM; and mean = 0.59, S.E = 0.03 SEM) had a mean condition factor of less than 1 indicating that the health of these species in the marine environment is challenged. The other species had a mean condition factor above 1 indicating that the fish species were doing well in the marine environment during the NEM and SEM seasons. However, there was a significant difference in the mean condition factor for 11 species during the two seasons ($P < 0.05$) which could be attributed to variations in body weight of the fish during the two study seasons. The low condition factor values for *S. sutor*, *L. borbonicus*, *L. lentjan*, *L. fulviflamma*, *G. oyena*, *Lethrinus miniatus* and *Lethrinus harak* during the NEM could be attributed to stress related factors such as inadequate food and competition for resources. The use of total weight instead of eviscerated weight may have introduced important bias in the analyses as variations in gonads and gut contents in different seasons may greatly confound the results obtained. Therefore, we recommend that future studies consider evisceration of the fish samples before conducting length weight analyses for comparisons.

Conclusion

This study provides information on the seasonal variation in length–weight relationship and condition factor for species usually encountered in Kenya artisanal fisheries. These results are useful in providing data for stock assessment and estimation of weights for the marine artisanal fisheries in Kenya. The findings from this study are also useful for comparison with the results of other studies undertaken during different seasons and at different localities.

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