Aims and scope: The Western Indian Ocean Journal of Marine Science provides an avenue for the wide dissemination of high quality research generated in the Western Indian Ocean (WIO) region, in particular on the sustainable use of coastal and marine resources. This is central to the goal of supporting and promoting sustainable coastal development in the region, as well as contributing to the global base of marine science. The journal publishes original research articles dealing with all aspects of marine science and coastal management. Topics include, but are not limited to: theoretical studies, oceanography, marine biology and ecology, fisheries, recovery and restoration processes, legal and institutional frameworks, and interactions/relationships between humans and the coastal and marine environment. In addition, Western Indian Ocean Journal of Marine Science features state-of-the-art review articles and short communications. The journal will, from time to time, consist of special issues on major events or important thematic issues. Submitted articles are subjected to standard peer-review prior to publication.

Manuscript submissions should be preferably made via the African Journals Online (AJOL) submission platform (http://www.ajol.info/index.php/wiojms/about/submissions). Any queries and further editorial correspondence should be sent by e-mail to the Chief Editor, wiojms@fc.ul.pt. Details concerning the preparation and submission of articles can be found in each issue and at http://www.wiomsa.org/wio-journal-of-marine-science/ and AJOL site.

Disclaimer: Statements in the Journal reflect the views of the authors, and not necessarily those of WIOMSA, the editors or publisher.

Copyright © 2019 – Western Indian Ocean Marine Science Association (WIOMSA)
No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means without permission in writing from the copyright holder.

ISSN 0856-860X
Stock status and some biological aspects of *Lethrinus lentjan* (Lacapede, 1802) from the south coast of Kenya

Nathan Mrombo¹², Chrisestom Mlewa¹, Cosmas Munga³, Julius Manyala⁴

¹ Department of Biological Sciences, Pwani University, PO Box 195 – 80108, Kilifi, Kenya
² Kenya Marine and Fisheries Research Institute, PO Box 81651 – 80100, Mombasa, Kenya
³ Department of Environment and Health Sciences, Marine and Fisheries Programme, Technical University of Mombasa, PO Box 90420 – 80100, Mombasa, Kenya;
⁴ Department of Fisheries and Aquatic Sciences, University of Eldoret, PO Box 1125 – 30100, Eldoret, Kenya

Corresponding author: lenjomrombo@gmail.com

Abstract
The Pinkear Emperor (*Lethrinus lentjan*, Laçepède, 1802) is among the three demersal species dominating fish catches in the artisanal fishery on the Kenyan coast. Available data indicate that total landings of *L. lentjan* have declined over the past decade due to possible over-exploitation. This paper provides a brief account of the stock status of this species and ecological aspects including length-weight relationship, body condition, and reproduction from a total of 575 fish specimens sampled. Sampling was done at Msambweni, Shimon, Majoreni and Vanga fish landing sites on the south coast of Kenya from September 2016 to February 2017. Individual total length (TL, cm) and body weight (BW, g) was measured on site while some specimens were dissected for sex and gonad maturity analysis. Mortality, exploitation rate, length-weight relationship, condition factor, fecundity, and size at maturity (*L₅₀*) were determined. Length frequency analysis indicated that *L. lentjan* was exploited above the optimum level, at *E* = 0.55 (exploitation rate). Growth was allometric with the length exponent (b = 2.95) being significantly <3. Mean fecundity was 89,573 ± 9,841 eggs/female/year. Gonadosomatic index was highest in January (2.08 ± 0.20) suggesting a possible peak spawning period at this time. The study provides a brief scientific overview of *L. lentjan* as a baseline for future in-depth biological studies of this species along the Kenyan coast.

Keywords: Stock status; length-weight relationship; condition; reproduction; allometric growth; south coast of Kenya

Introduction
Lethrinids are among the most commercially important group of fishes on many tropical coasts (El Gammal, 1988) and are considered a good source of animal protein for the communities of the western Pacific and the Indian Ocean (Carpenter and Allen, 1989). Hicks and McClanahan (2012) reported that *L. lentjan* accounted for 22% of the total catch on the south coast of Kenya and forms one of the top 3 species landed along with *Siganus sutor* (Valenciennes, 1835) and *Leptoscarus viagiensis* (Quoy and Gaimard, 1824). However, as reported for other species, there is a concern that landings of this species along the Kenyan coast have declined over the years (Kaunda-Arara *et al.*, 2003). Moreover, *L. lentjan* is exploited at levels that have led to both recruitment and growth overfishing (Hicks and McClanahan, 2012). These findings are consistent with those of a more recent study that examined decadal trends in Kenyan artisanal fisheries revealing that the decline of catches in the coral reef fisheries have quadrupled since the mid-1980s (Samoilys *et al.*, 2017). Few studies on stock status and biological aspects have been conducted on fish species in Kenya (Nzioka, 1979; Ntiba and Jaccarini, 1990; Kaunda-Arara and Ntiba, 1997; Kulmiye *et al.*, 2003).

http://dx.doi.org/10.4314/wiojms.v18i2.7
2002; Kaunda-Arara et al., 2003) Generally, no comprehensive stock assessment and biological studies of *L. lentjan* have been conducted on the Kenyan coast. This presents a challenge to management efforts, as adequate data and information is not available (Fondo and Sigurðsson, 2004). This study therefore provides a brief overview of biological aspects of *L. lentjan* on the south coast of Kenya as a baseline for in-depth future studies on this important commercial species.

**Materials and Methods**

**Data Collection**

This study was conducted at Vanga, Mkunguni, Shimoni and Majoreni fish landing sites on the south coast of Kenya (Fig. 1). Fish samples were collected in the months of September through to February 2017. Individual fish TL in cm and BW in g were measured and LWR and condition factor determined. Some fish specimens were dissected to determine sex and gonad maturity using macroscopic observation. Determination of gonad maturity followed the guidelines from Ntiba and Jaccarini (1990) and those modified by Kulmiye et al. (2002). The whole ovary of each fish specimen was excised, weighed and preserved in Bouins solution in labelled containers for 48 hours. The gravimetric method of Holden and Raitt (1974) was then used to estimate the total fecundity of each fish specimen.

**Data Analyses**

The LWR by sex was expressed as a logarithmic transformation of the equation:

\[ W = aL^b \] (Pauly, 1983)

where \( W \) is the body weight, \( L \) is the total length, \( 'a' \) is the intercept, and \( 'b' \) is the slope of the regression line. Condition factor was calculated using the formula for relative condition factor:

\[ (Kn) = \frac{W}{\bar{W}} \]

where \( W \) is the weight of an individual fish and \( \bar{W} = aL^n \) is the computed length-specific mean weight from the LWR as described in Le Cren, (1951).

Fishing mortality \( (\dot{F}) \), Exploitation Rate \( (E) \) and growth parameters \( K \) and Asymptotic Length \( L_\infty \) were estimated using Length-Frequency Analysis (LFA) in the
FAO ICLARM Stock Assessment Tool (FiSAT) II package (Gayanilo et al., 2005). ELEFAN 1, a sub-package in FiSat II was used to estimate the von Bertanlanffy growth parameters $K$ and $L_\infty$ as applied by Kaunda-Arara et al. (2003). Gonadosomatic Index (GSI) was calculated using the formula described in Wooton (1990):

$$\text{GSI} = \frac{\text{Gonad Weight}}{(\text{Body Weight} \times 100)}.$$

The fish specimens were sorted according to size classes of 4 cm interval and the number of individuals of each maturity stage recorded according to size class. Gonad maturity stage III and above were considered sexually mature for both males and females. The percentage of mature individuals in each length class was then calculated and cumulated. Delta Graph Win (Ver. 5.6.2) software was then used to determine the length at massive maturity $L_{50}$ by curve fitting the data to the following logistic equation as applied by Obota et al. (2016):

$$L_{50} = \frac{M(TL)}{1+\exp(-a*(x-b))}$$

where 'a' is a constant and 'b' is the $L_{50}$.

**Statistical Analyses**

The differences in mean $K_n$ and GSI between sexes and between months sampled were tested using the non-parametric Kruskal-Wallis test. Post hoc pair-wise comparison was used to confirm the actual differences between variables. These tests were conducted using the statistical software STATISTICA version 7. The relationship between fecundity and TL of females was analyzed using regression, and the same analysis was conducted for the relationship between BW and fecundity. The Analysis of Co-Variance (ANCOVA) test was used to test whether there was any significant difference between the slopes of the regression of the LWR for the males and the females. Data were subsequently pooled to give one regression equation for both male and female specimens. The slopes were then tested for significant difference from 3.0 using a one sample t-test as described in Townend (2013). Chi-square test of goodness was used to test whether the sex ratio of the population conformed to the ideal sex ratio of 1:1. These tests were conducted using MINITAB statistical software version 17. Significance level for all tests was assigned at $p < 0.05$.

**Results and Discussion**

A total of 575 fish specimens were sampled from September 2016 to February 2017. Results of some population parameters of this species derived from the length frequency are presented in Table 1. The growth coefficient $K$ of 0.25/yr obtained in this study suggests that the growth of *L. lentjan* in Kenyan waters is much slower than that recorded in the waters of Tanzania (1.00/yr) (Benno, 1992) and Yemen (0.48/yr) (Aldonov and Druzhinin, 1979). Enberg et al. (2008) attributed differences in the rate of growth to differences in environmental parameters such as temperature, seasonality and ecological parameters, particularly population density and anti-predatory behavior. As these parameters were not investigated in the present study, it is possible that any or a combination of these could explain the observed differences. According to Gulland (1971), the exploitation rate ($E$) indicates the level of exploitation of a stock; lightly exploited ($E < 0.5$) and strongly exploited ($E > 0.5$), based on the assumption that fish are optimally exploited when $F = M$ or $E = 0.5$. Therefore, the $E$ value of 0.55 determined in this study indicates that the exploitation rate for the *L. lentjan* stock on the south coast of Kenya is slightly higher than this. However, it is noted that Hicks and McClanahan (2012) reported much higher exploitation values of $F = 4.29$ and $E = 0.82$ for *L. lentjan* in Kenyan waters, which may be related to the fact that samples in their study were largely collected within the lagoon and inshore fishing grounds.

| Parameter                  | Value |
|----------------------------|-------|
| Asymptotic length ($L_\infty$) | 55.00 |
| Curvature of growth ($K$)      | 0.25  |
| Total mortality ($Z$)           | 1.32  |
| Natural mortality ($M$)         | 0.60  |
| Fishing mortality ($F$)         | 0.72  |
| Exploitation rate ($E$)         | 0.55  |

Table 1. Estimated growth, mortality and exploitation parameters for *Lethrinus lentjan* on the south coast of Kenya.
Mixed sex data was used to determine the LWR (Fig. 2) described by the equation \( \log W = 2.95 \log TL - 1.78 \) (\( n = 413, r^2 = 0.98, p < 0.05 \)). The \( b \) value for mixed sex in this study was 2.95 while that for males (\( n = 154 \)) and females (\( n = 259 \)) was 2.92 and 2.97, respectively. These \( b \) values were significantly less than 3 (\( t = -50.81, p < 0.05 \)) indicating negative allometric growth; that is, the fish became slimmer as length increased (Riedel et al., 2007). Letourneur et al. (1998) also reported \( b \) values of less than 3 for this species in the coral reefs and lagoons of New Caledonia. However, Mbaru et al. (2010), reported a \( b \) value of 3.183 for \( L. lentjan \) on the Kenyan coast for samples collected throughout the year. Samples in the present study were only collected during the North East Monsoon (NEM) season. According to Biswas (1993) and Armin et al. (2005) \( b \) values for the same species may vary due to geographical differences, seasonal variations in environmental parameters such as temperature, salinity, nutrition, gonadal development and physiological state at the time of sampling. These factors are likely to explain the observed differences.

The \( K_n \) for females ranged from 0.62 - 1.40 with a mean of \( 1.00 \pm 0.01 \), while that of males ranged between 0.34 and 2.16 with a mean of \( 1.03 \pm 0.01 \). Results of the Kruskal-Wallis test indicated significant differences in mean \( K_n \) between months for males (\( df = 5, H = 15.91, p \)

![Figure 2. Length-weight relationship based on pooled data for Lethrinus lentjan sampled on the south coast of Kenya during the study period.](image)

![Figure 3. Percentage proportion of mature Lethrinus lentjan in relation to their Total Length sampled on the south coast of Kenya over the study period. Arrows indicate value of \( L_{50} \).](image)
< 0.05) and females (df = 5, H = 14.84, p < 0.05). This is indicative that both males and females were in a good physiological state. The variation in Kn for both males and females during the study may be due to several factors such as differences in maturity stages, type of food consumed, the extent of muscular development and amount of fat reserve (Barnham and Baxter, 2003).

The mean TL of L. lentjan was 21.54 ± 0.26 cm and the average weight was 180.74 ± 7.26 g. The smallest specimen measured 12.20 cm and weighed 25.30 g, whereas the largest individual measured 52.0 cm and weighed 1,913.0 g. Length at 50% maturity (L₅₀) for male and female L. lentjan was 25.8 cm and 26.2 cm, respectively (Fig. 3). A total of 54 males out of 154 (35%) and 85 females out of 259 (32.82%) had attained this length. This was different from other studies on L. lentjan where, for example, Toor (1964) reported an L₅₀ of 30 cm and 28.7 cm standard length (SL) for males and females, respectively in Indian Ocean waters, while Grandcourt et al. (2011) reported an L₅₀ of 24.6 cm and 27.7 cm fork length (FL) for males and females, respectively in the southern Arabian Gulf. These differences could be related to fishing pressure on this species in various areas as suggested by Lappalainen et al. (2016) who noted that L₅₀ is a potential indicator of fishing pressure in fish stocks. However, environmental factors such as food availability may also have an effect (Reznick, 1993). The smallest female with ovaries in a mature condition (Stage III and IV) measured 21.6 cm and weighed 160.4 g, while the smallest male in a mature condition (Stage IV) measured 18.7 cm and weighed 93.5 g.

Only 35% of the male and 32% of the female specimens in this sample had attained the L₅₀ (25.80 cm and 26.2 cm, respectively) indicating that the majority of the fish were caught before attaining maturity. This suggests growth overfishing characterized by small immature fish in the catch (Amponsah et al., 2016). This is probably due to the use of beach seines within lagoons in some fishing grounds at Majoreni, one of the sampling sites in this study. The beach seines used by fishers at Majoreni are less than 2-inch mesh size, with a ‘kakaban’ code end which limits the escape of juveniles. Fishing in Majoreni and Vanga mostly occurs in mangrove swamps and shallow inshore fishing grounds which are critical habitats for juveniles (Carpenter and Allen, 1989; Kimirei et al., 2011). On the other hand, fishers in Shimoni and Mkunguni usually exploited deeper waters outside the reef, and therefore landed bigger sized fish compared to Majoreni and Vanga.

The mean GSI for females was higher (0.97 ± 0.08) than for males (0.21 ± 0.22). Differences were highly

![Figure 4](image-url)  
**Figure 4.** Mean ± SE gonadosomatic index of *Lethrinus lentjan* on the south coast of Kenya over the study period.
significant \((H = 37.91, \text{df} = 1, p < 0.05)\). Differences also existed in the mean monthly GSI for combined sexes \((H = 70.12, \text{df} = 5, p < 0.05)\). An increasing trend was observed from September peaking in January, and a decline in February. January had the highest GSI, with a mean of \(2.08 \pm 0.20\) (Fig. 4), and February had the lowest mean GSI of \(0.22 \pm 0.08\). Monthly variations in GSI provide a reasonable indicator of reproductive seasonality of fish with spawning time often identified from changes in the GSI (Arruda et al., 1993). This is based on the assumption that gonad weight increases during times of spawning due to the swelling and ripening of oocytes (Taylor and McIlwan, 2012). This explains the steady increase in GSI for the species in this study from September peaking in January, and a sudden decline in February. Females sampled in January had the highest GSI suggesting that they had ripe oocytes and were ready to spawn. This compares well with the January-February peak spawning reported for the species in east African reefs by Nzioka (1979) and Currey et al. (2009) in the Australian Great Barrier Reef. In other studies, \(L. \text{lentjan}\) has been reported to spawn almost throughout the year with two main peaks (Mobiha, 1991). Since sampling did not cover the entire year in the present study, this could not be confirmed from the data collected. However, the occurrence of individuals in different gonadal maturity stages in all monthly samples over the study period suggests that \(L. \text{lentjan}\) is a multiple spawner. Similar results were reported by Currey et al. (2009) for this species.

Fecundity ranged between 90 to 380,364 eggs with a mean of \(89,573 \pm 9,841\) eggs/female/year. The females ranged from a TL of 20.6 to 52.0 cm and 124.4 g to 1,913.0 g in individual BW. This differs from the findings of Toor (1964) who reported that the fecundity for \(L. \text{lentjan}\) in Indian Ocean waters ranged between 12,146 – 77,922 eggs. This variation could be due to several environmental factors such as temperature, sunlight, and weather (Jonsson and Jonsson, 1999). Simple linear regression of fecundity and TL, and fecundity and BW showed a weak significant positive relationship, even after log transformation (i.e. \(\log F = 6.24 \log TL - 4.43\) \((n = 94, r^2 = 32.50, p < 0.05)\) and \(\log F = 2.00 \log BW - 0.378\) \((n = 94, r^2 = 32.70, p < 0.05)\). A total of 413 individuals were sexed; 154 males \((37.29\%)\) and 259 females \((62.71\%)\). There were more females than males (Table 2), and females also dominated throughout the length classes with a female:male sex ratio of 1:0.59, which was significantly different from the expected 1:1 (Chi square test, \(\chi^2 = 26.70, \text{df} = 1, p < 0.05\)). The frequency of occurrence of males and females in the various size classes all showed no significant difference \((p < 0.05 \text{ in all cases})\) in sex ratio, except in size classes 20.00 – 23.99 and 24.00 – 27.99 cm. Results indicate that males attained smaller sizes than females, with the largest male being in the 36.00 - 39.9 cm size class while the largest female was in the 48.00 - 52.99 size class.

This study established that \(L. \text{lentjan}\) in the waters of the south Kenyan coast had a relatively slow growth

Table 2. Sex ratio of various size classes of \(L. \text{lentjan}\) sampled on the south coast of Kenya over the study period.

| Size class | No. of males | No. of females | Sex ratio | Chi-square value | P-value |
|------------|--------------|----------------|------------|------------------|---------|
| 12         | 15           | 23             | 1:0.65     | 1.68             | 0.19    |
| 16         | 46           | 67             | 1:0.69     | 3.90             | 0.05    |
| 20         | 24           | 48             | 1:0.5      | 8.00             | 0.01    |
| 24         | 30           | 67             | 1:0.45     | 14.11            | 0.00    |
| 28         | 24           | 35             | 1:0.66     | 2.05             | 0.15    |
| 32         | 14           | 13             | 1:1.08     | 0.04             | 0.85    |
| 36         | 1            | 4              | 1:0.25     | 1.80             | 0.18    |
| 40         | 0            | 0              | -          | -                | -       |
| 44         | 0            | 1              | -          | -                | -       |
| 48         | 0            | 1              | -          | -                | -       |
| Total      | 154          | 259            | 0.59:1     | 29.70            | 0.00    |
rate compared to other regions. The stock was also being exploited above the optimal rate, and this, coupled with the fact that the species is a slow grower, can easily lead to overexploitation. Growth overfishing was also apparent catches made up of over 60% immature individuals. Higher GSI values in January suggest peak spawning at this time, however, the occurrence of individuals in various gonadal maturity stages in monthly samples is indicative of multiple spawning. There is a need to enforce fishing regulations such as restriction on mesh size and destructive fishing gears such as beach seines commonly used in some parts of the Kenyan coast. This will prevent the capture of juvenile fishes and instead allow them to recruit into the fishery. Mesh size and gear type restrictions will also avoid damage to critical habitats such as sea grasses and corals that are important for fish survival. In addition, there is a need for research on gear selectivity to enable recommendation of suitable mesh sizes. There is also need for longer term studies on reproduction of this species covering the whole year and to cover other parts of the Kenyan coast to establish whether the species is a multiple spawner.

Acknowledgements
The authors are immensely grateful to the Kenya Coastal Development Project (KCDP) for fully funding this study, and the Kenya Marine and Fisheries Research Institute (KMFRI) for providing laboratory space and facilities for analysis of samples. Hearty thanks go to Mr Sammy Kadhengi and Ms Fatma Moyo who assisted during the field work and laboratory analysis of samples.

References
Aldonov VK, Druzhinin AD (1979) Some data on scavengers (Family Lethrinidae) from the Gulf of Aden region. Journal of Ichthyology 18: 527-535
Amponsah SKK, Ofori-Danson PK, Nunoo FKE (2016) Study of the population parameters of the bigeye grunt, Brachydeuterus auritus (Valenciennes, 1831) in Ghanaian coastal waters and its implications for management. International Journal of Fisheries and Aquatic Studies 4 (6): 413-419
Armin P, Ivan J, Mate A (2005) Weight-length relationships for II chondrichthyan species in the eastern Adriatic Sea. International Journal of Ichthyology 29(1): 93-96
Arruda LM, Azevedo JN, Neto AI (1993) Abundance, age-structure and growth, and reproduction of gobies (Pisces; Gobiidae) in the Ria de Aveiro Lagoon (Portugal). Estuarine, Coastal and Shelf Science 37(5): 509-523
Barnham CA, Baxter AF (2003) Condition factor, K, for salmonid fish. Department of Primary Industries. State of Victoria. 3 pp
Benno BL (1992) Some features of beach seine fishery along the Dar es Salaam coast, Tanzania. MSc Thesis, University of Kuopio. 68 pp
Biswas SP (1993) Manual of methods in fish biology, South Asian Publishers, New Delhi. 157 pp
Carpenter KE, Allen GR (1989) FAO Species Catalogue. Vol. 9. Emperor fishes and large-eye breams of the world (family Lethrinidae). An annotated and illustrated catalogue of lethrinid species known to date. FAO Fisheries Synopsis 125(9). 118 pp
Currey LM, Williams AJ, Simpendorfer CA, Ballagh AC, Penny AL (2009) Comparative biology of key inter-reefal lethrinid species on the Great Barrier Reef. Reef and Rainforest Research Centre Ltd., Cairns. 29 pp
El-Gammal, FI (1988) On the growth and demographic structure of Lethrinus variegatus Cuv. and Val. (1830) from the Red Sea. Bulletin of the National Institute Oceanography and Fisheries, Egypt 14: 1-12
Enberg K, Dunlop E S, Jørgensen C (2008) Fish growth. Encyclopedia of Ecology 2: 1564-1572
Fondo EN, Sigurðsson Ï (2004) Assessment of the Kenyan marine fisheries from selected fishing areas. United Nations University fisheries training program, Final Training Report. Reykjavik, Iceland. 55 pp
Gayanilo FC, Sparre P, Pauly D (2005) FAO-ICLARM Stock assessment tools II: User’s guide (Vol. 8). FAO, Rome.
Grandcourt E, Al Abdessalaam TZ, Francis F, Al Shamsi A (2011) Demographic parameters and status assessments of Lutjanus ehrenbergii, Lethrinus lentjan, Plecosthinchus sordidus and Rhabdosargus sarba in the southern Arabian Gulf. Journal of Applied Ichthyology 27(5): 1203-1211
Gulland JA (1971) The fish resources of the ocean. Fishing News (Books), Ltd., for FAO. 255. Revised edition of FAO Fisheries Technical Paper 97. 425 pp
Hicks CC, McClanahan TR (2012) Assessing gear modifications needed to optimize yields in a heavily exploited multi-species seagrass and coral reef fishery. PLoS ONE 7(5) [doi:10.1371/journal.pone.0036022]
Holden MJ, Raitt DFS (1974) Manual of fisheries science. Part 2-Methods of resource investigation and their application. FAO Fisheries Technical Papers. FAO, Rome.
Jonsson N, Jonsson B (1999) Trade-off between egg mass and egg number in brown trout. Journal of Fish Biology 55: 767-783
Kaunda-Arara B, Ntiba M J (1997) The reproductive biology of *Lutjanus fulviflamma* (Forsskål, 1775) (Pisces: Lutjanidae) in Kenyan inshore marine waters. Hydrobiologia 333(1): 153-160

Kaunda-Arara B, Rose GA, Muchiri MS, Kaka R (2003) Long-term trends in coral reef fish yields and exploitation rates of commercial species from coastal Kenya. Western Indian Ocean Journal of Marine Science 2(2): 105-116

Kimirei IA, Nagelkerken I, Griffioen B, Wagner C, Mgaya YD (2011) Ontogenetic habitat use by mangrove/seagrass-associated coral reef fishes shows flexibility in time and space. Estuarine, Coastal and Shelf Science 92: 47-58

Kulmiye AJ, Ntiba MJ, Kisia SM (2002) Some aspects of the reproductive biology of the thumbprint emperor, *Lethrinus harak* (Forsskal, 1775), in Kenya coastal waters. Western Indian Ocean Journal of Marine Science 1(2): 135-144

Lappalainen A, Saks L, Šuštar M, Heikinheimo O, Jürgens K, Kokkonen E, Vetemaa M (2016) Length at maturity as a potential indicator of fishing pressure effects on coastal pikeperch (*Sander lucioperca*) stocks in the northern Baltic Sea. Fisheries Research 174: 47-57

Le Cren ED (1951) The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology 20: 201-209

Letourneur Y, Kulbicki M, Labrosse P (1998) Length-weight relationship of fishes from coral reefs and lagoons of New Caledonia: an update. Naga, the ICLARM Quarterly 21(4): 39-46

Mbaru EK, Mlew CM, Kimani EN (2010) Length–weight relationship of 39 selected reef fishes in the Kenyan coastal artisanal fishery. Fisheries Research 106(3): 567-569

Mobiha A (1991) The reproductive biology of eight reef fish species from the Tigak Islands of Papua New Guinea. Science in New Guinea 17(3): 133-142

Ntiba MJ, Jaccarini V (1990) Gonad maturation and spawning times of *Siganus sutor* off the Kenya coast: evidence for definite spawning seasons in a tropical fish. Journal of Fish Biology 37(2): 315-325

Nzioka RM (1979) Observations on the spawning seasons of East African reef fishes. Journal of Fish Biology 14(4): 329-342

Obota CO, Fulanda BM, Okemwa GM, Kimani EN (2016) Reproductive biology and body condition of exploited populations of Emperor Angelfish, *Pomacanthus imperator* (Bloch, 1787) along the Kenyan Coast. Western Indian Ocean Journal of Marine Science 15(2): 19-30

Reznick DN (1993) Norms of reaction in fishes. In: The exploitation of evolving resources. Springer, Berlin, Heidelberg. pp 72-90

Riedel R, Caskey LM, Hurlbert SH (2007) Length-weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds. Lake and Reservoir Management 23(5): 528-535

Samoilys MA, Osuka K, Maina GW, Obura DO (2017). Artisanal fisheries on Kenya’s coral reefs: Decadal trends reveal management needs. Fisheries Research 186: 177-191

Taylor BM, McIlwan JL (2012). Reproductive biology of *Lethrinus harak* on Guam. University of Guam Marine Laboratory Technical Report no. 40. 34 pp

Toor HS (1964) Biology and fishery of the pig-face bream, *Lethrinus lentjan* Lacepede II. Maturation and spawning. Indian Journal of Fisheries 11(2). 581-596

Townend J (2013) Practical statistics for environmental and biological scientists. John Wiley & Sons. 288 pp

Wootton RJ (1990). Ecology of teleost fishes. Chapman and Hall. Upper Saddle River, New Jersey, USA. 404 pp