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MORTALITIES ESTIMATE AND EXPLOITATION RATE OF MACROBRACHIUM *VOLLENHOVENII* IN THE LAGOS – LEKKI LAGOON SYSTEM, NIGERIA USING LENGTH FREQUENCY DATA

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Abstract
Mortalities estimate and exploitation rate were carried out for *Macrobrachium vollenhovenii* in the Lagos – Lekki Lagoon System. The mortality estimation was done via the length converted catch curve analysis. Fish stocks are subjected to three forms of mortalities which are total, natural and fishing. The total mortality (Z) was estimated at 2.67 year $^{-1}$ with a 95% Confidence Limit (CL) for Z of 2.54 – 2.79 for *M. vollenhovenii.* The natural mortality M obtained by the Pauly's empirical equation was 1.35 yr $^{-1}$, the fishing mortality F = 1.32 yr $^{-1}$ and an exploitation rate E (F / Z) of 0.49 for *M. vollenhovenii.* The exploitation rate though below the optimum level of 0.5 is however close, thus, for sustainability of this resource, management strategies should ensure that this exploitation rate is not exceeded.

Key words: Mortalities, Exploitation Rate, Lagos-Lekki Lagoon, Nigeria

Introduction
Macrobrachium vollenhovenii is one of the species exploited by the artisanal fisheries in the Lagos-Lekki Lagoon System. *Macrobrachium* species are important ecologically and economically, playing salient role in determining the dynamics and structure of aquatic ecosystem and are valued as food for man. Many workers have studied their ecology, biology and fisheries. Georges (1971) reported on the catch statistics and general biology of *M. vollenhovenii* in St. Paul River, Liberia. Marioghae (1982, 1990) investigated the fishery, distribution and salinity tolerance of *M. macrobrachion* and *M. vollenhovenii* in the Lagos Lagoon. Enin (1995) gave estimates of growth, mortality rates and recruitment patterns of *M. macrobrachion* in the Cross River estuary, while Gabche and Hockey (1995) studied the growth and mortality of *M. vollenhovenii* in Lobe River, Cameroun. Etim and Sankare (1998) reported on the growth, mortality and recruitment of *M. vollenhovenii* in Fahe reservoir, Cote d'Ivore; and Nwosu and Wolfi (2006) studied the population dynamics of *M. vollenhovenii* in the Cross River Estuary.

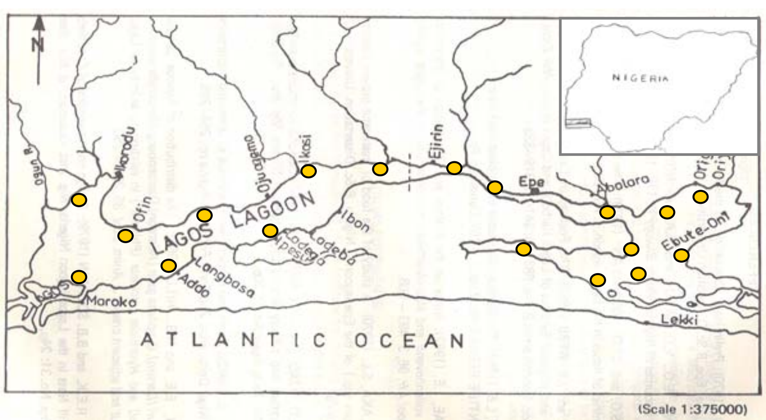
Mortality is one of the fundamental parameters relied upon in the assessment and management of fish stock. Three forms of mortalities occur in fish stocks namely total mortality (Z), natural mortality (M) and fishing mortality (F). Mortalities are very important phenomenon in fish stocks dynamics, either in exploited or unexploited stock. This has thus resulted in development of various methods of estimating mortality. Warner and Cornwell (2005) used acoustic method to estimate the mortality of alewives (*Alosa pseudoharengus*), Gallagher *et al* (2005) used catch curve for the Irish ray fishery and stated that total mortality (Z) estimates were higher for smaller sized species whereas for the larger sized species they were lower. High mortality level is evident of high exploitation. Deval *et al* (2007) used length-based method in estimating the mortality of unexploited stock of *Astacus leptodactylus* (Eschscholtz, 1823) in inland waters of the northern Marmara region, Turkey.

Gedamke and Hoenig (2006) estimated mortality from mean length data in non-equilibrium situations for goosefish (*Lophius americanus*). Estimation of mortalities relies on the distribution of the lengths, which is determined by the age distribution, mortality rates, and individual variability in growth rates (Wang and Ellis, 2005). They developed a maximum likelihood approach for estimating mortality and stated that separating fishing mortality from natural mortality is possible only when there is substantial contrast in the effort pattern. DeLong *et al* (2001) have reported a method for estimating density-dependent natural mortality from length-frequency data for juvenile winter flounder (*Pseudopleuronectes americanus)* not subjected to fishing mortality. The estimation of natural mortality rates is one of the most difficult and most critical elements of many fishery stock assessments (Hewitt *et al*, 2007). The natural mortality rate is a key determinant of the potential productivity of a fish stock and thus the amount of exploitation a stock can sustain. In general, assuming that natural mortality and harvest mortality are additive, stocks with higher natural mortality rates are more productive and are able to sustain higher rates of exploitation.

Using a length-structured model for red king crab (*Paralithodes camtschaticus*) in Bristol Bay, Alaska, Zheng *et al* (1997a, 1997b) found that stock rebuilding and long-term harvest strategies were highly sensitive to changes in M of 0.2 – 0.3 per year. These and other results indicate that it is desirable to have precise knowledge about M for assessment purposes. Estimates of total and fishing mortality indices are traditionally obtained through the analysis of age composition of catches (Tserpes and Tsimenides, 1996). This study estimated the three forms of mortalities for *M. vollenhovenii* in the Lagos-Lekki Lagoon system using the length converted catch curve, thereby providing scientific information that is required for rational management of this fishery resource.

Materials and Methods

The monthly length-frequency samples of *M. vollenhovenii* analyzed in this study were collected from eighteen (18) stations on the Lagos – Lekki lagoon system, longitude 3°22.5' to 4 ° 13' E and latitude 6°24' to 6° 38'N (Fig. 1) by the artisanal gear. The gear consisted of a conical shaped cane trap of 44 - 47cm in length and a mouth opening of 17 - 19cm in diameter. The sampling period was from April 2002 to May 2004. Total length (TL), from the orbital notch to the tip of the telson, of individual specimen was recorded. These measurements were made to the nearest centimetre (0.5cm), as described by FAO species identification sheets for fishery purposes (FAO, 1981).



Key:
○ = Sampling Site

Fig 1: Study Area (Lagos – Lekki Lagoon System) with Sampling Sites

ELEFAN II in FiSAT (Gayanilo *et al*, 1996; Gayanilo and Pauly, 1997) was used to estimate total mortality (Z) via length-converted catch-curve analysis given estimates of L_∞ (asymptotic length) and K (growth coefficient). Length-converted catch curve (Pauly, 1990; Pauly et al., 1995), where the percentage of samples in length groups are pooled to stimulate a steady-state population, gave mortality coefficient Z of the single negative exponential mortality model.

Computation of Z is from the equation:

$\ln (N_i / \Delta t_i) = a + bt_i$ …………………..1

Here Ni = number of prawns in length class i,

$\Delta t_i = (1 / K) \ln [(L_\infty - L_1) / (L_\infty - L_2)]$ the time needed for the prawns to grow through length class i,

$t_i = - 1 / K \ln [(1 - (L_t / L_\infty)]$ the relative age (computed with $t_0 = 0$) corresponding to the mid length of length class i,

L_1 = lower limits of length class i

L_2 = upper limits of length class i,

b with sign changed gives an estimate of Z.

The instantaneous natural mortality coefficient (M) was computed using the empirical model of Pauly (1980).

$\log M = - 0.006 - 0.27 \log L_\infty + 0.654 \log K + 0.463 \log T$ ……….2

Where T = Mean Temperature

Fishing mortality was calculated from

$F = Z - M$…………………………………………………………3

And the exploitation rate (E) from

$E = F/Z$………………………………………………………………4

i.e. the fraction of total mortality (Z) due to fishing mortality

The L_∞ and K parameters of the von Bertalanffy growth formula used in this study for *M. vollenhovenii* in the Lagos – Lekki Lagoon system were 18.81cm and 0.550 per year respectively, while the mean temperature was 27^{oC}

Results

A total of 11,033 specimens were used and the length frequency with the growth curve supper imposed in the ELEFAN procedure from which subsequent analysis were done for the mortality estimate is shown in figure 2.

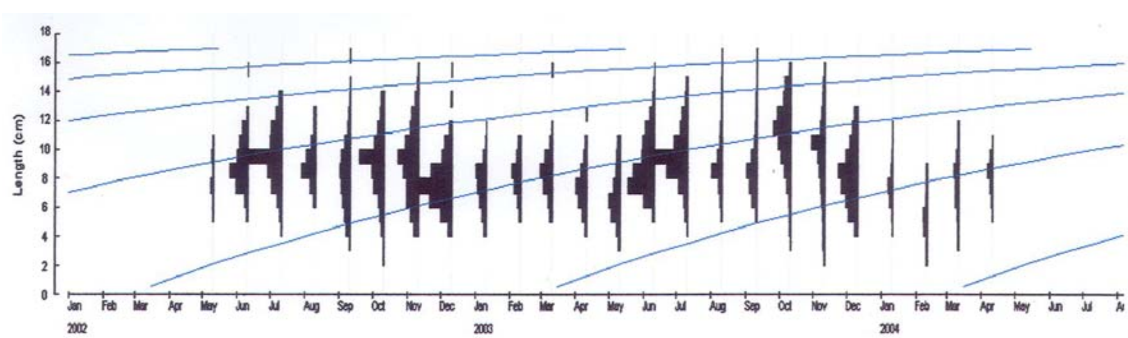


Fig. 2: Length-Frequency for *Macrobrachium vollenhovenii* with growth curve super imposed in Lagos – Lekki Lagoon System.

The total mortality (Z) for *M. vollenhovenii* in the Lagos – Lekki Lagoon system was estimated at 2.67 year $^{-1}$ (Fig. 3) with a 95% Confidence Limit (CL) for Z of 2.54 – 2.79. The point parameters in the catch-curve for the first and last classes are given in Table 1.

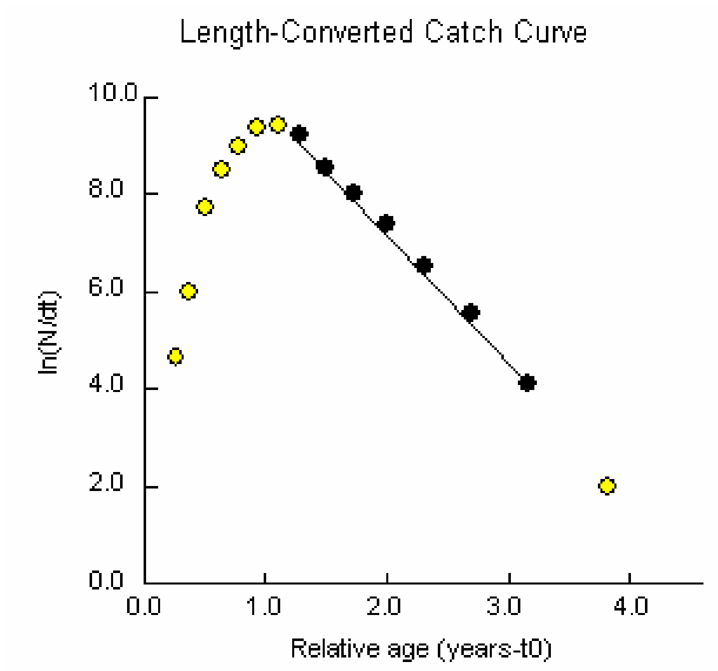


Fig. 3: Length-Converted Catch Curve for *M. vollenhovenii* based on growth parameter L∞ = 18.81 and K = 0.550.
(The slope of right descending arm (black dots) of the curve with sign changed gave an estimate of Z. Estimated Z = 2.67 year $^{-1}$).

Table 1: Point Parameters in Catch Curve for *M. vollenhovenii* in Lagos – Lekki Lagoon System

Parameter	**First**	**Last**
Class No	8	14
Y: In (N/Δt)	9.25	4.12
X: Relative Age	1.28	3.16

The natural mortality M obtained by the Pauly's empirical equation was 1.35 yr $^{-1}$, the fishing mortality F = 1.32 yr $^{-1}$ and an exploitation rate E (F / Z) of 0.49 for *M. vollenhovenii.*

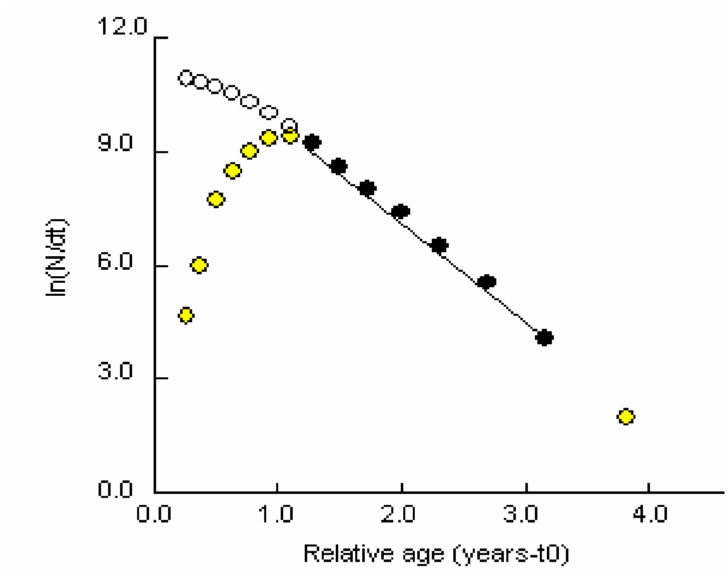


Fig. 4: Length-converted catch curve with extrapolated data points for *M. vollenhovenii* in Lagos – Lekki Lagoon System (Z = 2.67; M {at 27.0^{oC}}= 1.35; F = 1.32; E = 0.49)

Figure 4 shows the length-converted catch curve with extrapolated data points and the left ascending points used in the calculation of the probability of capture of each size class. It also gave the estimates of M as 1.35 year $^{-1}$, F as 1.32 year $^{-1}$ and E as 0.49 year $^{-1}$ respectively.

Discussion

Prawns are short lived animals and as short lived animals high mortality rates are usually imperative. The instantaneous total mortality estimated in the Lagos – Lekki lagoon system was 2.67 year $^{-1}$ with a confidence limit of 2.54 – 2.79 for *M. vollenhovenii.* This value fall within the range of 2.46 and 7.07 year $^{-1}$ estimated by Pauly *et al*.(1984), for several stocks and species of penaeid shrimps. The estimated Z value in this work for *M. vollenhovenii* is close to the value (3.69 year $^{-1}$) obtained for this same species in Fahe Reservoir in Cote d'Ivoire by Etim and Sankare (1998), 3.41 year $^{-1}$ by Gabche and Hockey (1995) in Lobe River, Cameroun and male (3.93 year $^{-1}$) of the species but far from the female (6.85 year $^{-1}$) in the Cross River by Nwosu and Wolfi (2006). The natural mortality (M) obtained by the Pauly's empirical formula and at mean temperature of 27^{0C} was 1.35 year $^{-1}$ while the fishing mortality (F) was 1.32 year $^{-1}$. The natural mortality estimated in this study of 1.35 year $^{-1}$ is within the range of 0.77 – 3.12 estimated for penaeid shrimps by Pauly *et al*. (1984). Garcia (1985) contrasted recent estimates of natural mortality (1.2 - 5.4 year $^{-1}$) with those obtained in the 1960s (up to 26.4 year $^{-1}$) for adult penaeid shrimp. He considered that the earlier values are clearly unrealistic, and showed that estimates based on extensive analyses in the Gulf of Mexico, Ivory Coast, Madagascar and Australia result in mean value of 2.4 per year. The fishing mortality of 1.32 year $^{-1}$ for *M. vollenhovenii* in this study compares well with estimates (0.55 – 4.68 year $^{-1}$) by Pauly *et al*. (1984), as well as with values of 4.72 year $^{-1}$ by Mathews *et al*. (1987) and up to 8.99 year $^{-1}$ by Sumiono (1988).

Gobert (1997) used length frequency data to evaluate the total mortality of several stocks of the same species where growth parameters were poorly known. He reported that the estimate of total mortality (Z) obtained via the length converted catch curve is highly sensitive to input parameters

K and L∞ , the ratio of Z estimates obtained for different stocks with the same combination of parameters is almost independent of these inputs when the fit of the linear regression is good. This therefore provided the possibility of qualitatively comparing several stocks in situations of scarce biological knowledge.

The exploitation rate (E) at this estimated fishing mortality for *M. vollenhovenii* was 0.49. Based on the assumption that in an optimally exploited stock, natural mortalities should be equal to fishing mortality and both values or E be equal to 0.5 (Gulland, 1971), the *Macrobrachium* stock of the Lagos – Lekki lagoon system is not over fished though *M. vollenhovenii* is close to optimum exploitation. In case of *M. vollenhovenii* from the Cross River estuary, only the female with an E value of 0.67 is experiencing over fishing while the male E value of 0.44 shows that it has not attained optimal exploitation level (Nwosu and Wolfi, 2006). In the Fahe Reservoir, the exploitation (0.47) is not at optimal level (Etim and Sankare, 1998) and is close to what we have in the Lagos – Lekki lagoon system, however, it's exploitation (0.07) in the Lobe River is very low (Gabche and Hockey, 1995).

Conclusion

The exploitation rate of 0.49 derived from the mortality estimates for this species in the Lagos – Lekki Lagoon system, though below the optimum of 0.50, is however very close. Thus, for sustainability of this resource, management strategies should ensure that this exploitation rate is not exceeded.

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