Journal of Fisheries International 3 (1): 19-26, 2008
ISSN: 1817-3381

Cohort Analysis of *Macrobrachium vollenhovenii* in the Lagos-Lekki Lagoon System, Nigeria

[1]E.A. Falaye and [2]P.O. Abohweyere
[1]Department of Wild Life and Fisheries Management, University of Ibadan, Ibadan, Nigeria
[2]Nigerian Institute for Oceanography and Marine Research, P.M.B. 12729, Wilmot Point Road, Bar-Beach, Victoria Island, Lagos, Nigeria

Abstract: A cohort analysis was carried out on a 24 month length-frequency data of *Macrobrachium vollenhovenii* (African river prawn) from the Lagos-Lekki lagoon system, via modal progression analysis using Bhattacharya's method in FISAT (FAO-ICLARM Stock Assessment Tools) software. A total of 11,033 specimen of *M. vollenhovenii.* was used for the analysis. Three cohorts were decomposed from the composite length frequency sample. The residual of the Gulland and Holt plot, from the length at age derived from the linking of cohort means gave the value of the amplitude of growth oscillation C as 0.40 and the winter point WP as 0.75 or September. The amplitude of seasonal growth oscillation and the winter point derivable from the cohort analysis are of paramount importance in the stock assessment and ultimately management of the resource as they revealed the strength of growth oscillation along with the period of slowest growth which can be inferred as the most susceptible period for the stock. Therefore, resource sustainability require that fishing mortality be minimized in this period (September) in the Lagos-Lekki lagoon system.

Key words: Cohort analysis, *Macrobrachium vollenhovenii*, amplitude of oscillation, winter point, Nigeria

INTRODUCTION

A cohort is a batch of fish all approximately the same age and belonging to the same stock. It is assumed that a cohort consist of average fish only such that all fish of a cohort have the same age at a given time thereby attaining recruitment age at the same time (Beverton and Holt, 1956). The average length of cohort is therefore, used to describe growth. For decades, assessing tropical fish stocks has been hindered by the difficulty of obtaining reliable estimates of growth parameters. The development of length-frequency analysis (Pauly and Morgan, 1987) has represented substantive progress.

The detailed analysis of length-frequency data was besides mark-recapture studies and direct observation of captive fish, the only method available to draw inferences on growth of tropical fishes and indeed the only method that could be applied routinely (Pauly, 1987). Modal Progression Analysis (MPA) involves several length-frequency samples plotted sequencially, where the apparent shift of modes is used to infer growth. In MPA, the first step is the decomposition of composite distributions into their components cohorts to identify means, secondly is identification and linking of means belonging to the same cohorts and thirdly is using the growth increments and size-at-(relative) age data resulting from the linking to estimate growth parameters. The critical issue is the linking of means perceived to belong to the same cohort. The growth parameters estimates are essential tools in the management of exploited fishery resource.

Macrobrachium vollenhovenii is an important resource in coastal lagoon shrimp fishery in Nigeria. This species together with *Macrobrachium macrobrachion* accounted for up to 60% by weight of prawn landings in Lagos lagoon (Marioghae, 1982). However, there is a dearth of information on this species, most of previous research had been on fecundity and food and feeding habit (Ajayi, 1970; Omo-Malaka, 1970) in Lagos and Epe lagoons.

A cohort analysis of the length-frequency data of *Macrobrachium vollenhovenii* was done in other to generate growth parameters that would be used for the management of the stock in the Lagos-Lekki lagoon system.

MATERIALS AND METHODS

Monthly length-frequency samples analyzed in this study were collected from 18 stations on the Lagos-Lekki

Corresponding Author: E.A. Falaye, Department of Wild Life and Fisheries Management, University of Ibadan, Ibadan, Nigeria

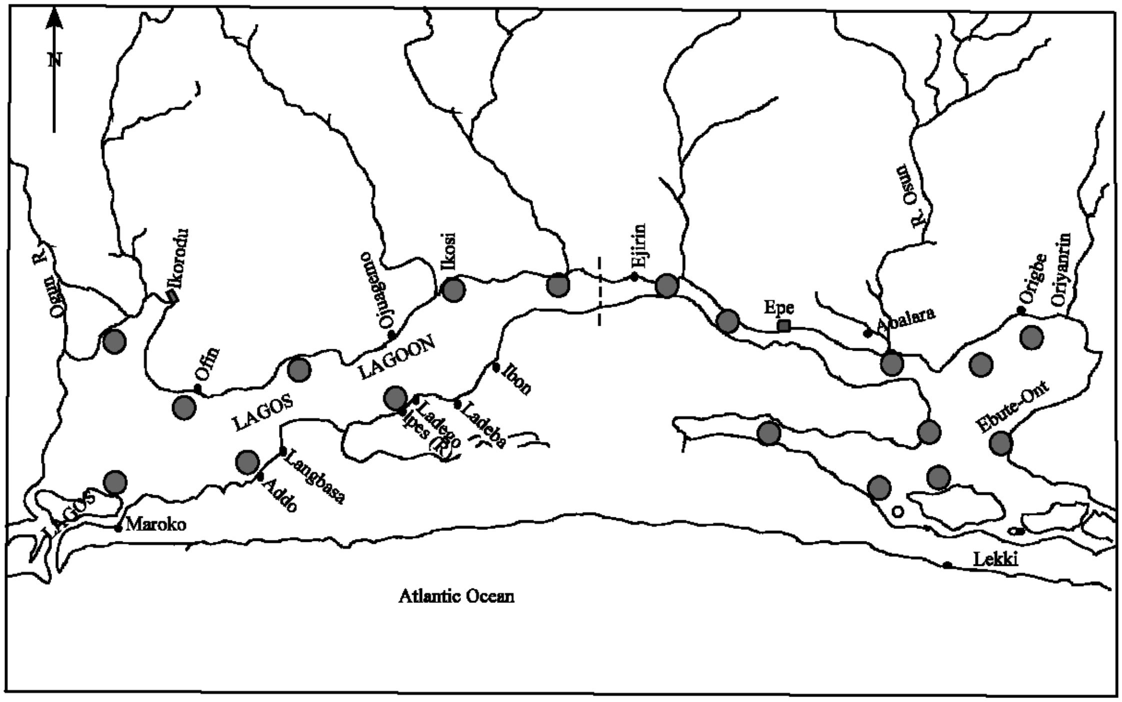

Fig. 1: Study area (Lagos-Lekki Lagoon system) with sampling sites

lagoon system, longitude 3°22.5' to 4°13' E and latitude 6°24' to 6°38'N (Fig. 1) by the artisanal shrimping gear. The gear consists of a conical shaped cane trap of 44- 47 cm in length and a mouth opening of 17-19 cm 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 (cm).

Bhattacharya (1967) method in FiSAT (Gayanilo *et al*., 1996) software was used in the decomposition of composite distribution of the length-frequency data into cohorts. This method splits composite distribution into separate normal distributions, each representing a cohort of shrimp, from the overall distribution in the sample starting from the left side of the total distribution. Once the first normal distribution has been determined it is removed from the total distribution, the same procedure is repeated as long as it is possible to separate normal distributions from the total distribution. Gulland and Holt (1959) Plot also in FiSAT based on preliminary estimates of Von Berthalanffy Growth Formula (VBGF) parameters. $L\infty$ and K was used for growth increments estimation. Also the residual of the plot was used for inference on seasonality of growth.

RESULTS

Monthly length frequency data for 24 months (May 2002-April 2004) of *Macrobrachium vollenhovenii* is presented in Table 1.

The 24 monthly samples were decomposed into cohorts and the number of cohorts per sample ranged from 1 to 3. Samples that had only one cohort represented were three namely samples 9, 10 and 24. Two cohorts sample representation were the highest accounting for 15 of the samples. Six samples (14-19) had three cohorts representation. Figure 2-4 are examples of the decomposed samples.

The decomposition results (cohorts mean lengths) are in Table 2 and these plotted, form growth increments representing the progression through time of the mean length of the cohort as shown in Fig. 5a, while Fig. 5b shows the linking of these different cohorts that forms incremental data for use in the Gulland and Holt Plot. Three cohorts were identified in Fig. 5b.

The Gulland and Holt plot estimated growth parameters from growth increments based on the VBGF, in which growth rate declined linearly with increase in length, reaching zero at $L\infty$. The $L\infty$ and K are preliminary estimates and these were 18.81cm and 0.175, respectively. Also the residuals of the plot were used for inference on

Table 1: Length-frequency data of *M. vollenhovenii* from Lagos-Lekki lagoon system (May 2002-April 2004)

	2002								2003												2004			
ML	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
2.5						4													5			3		
3.5					10	8							12					1	8			7	2	
4.5			7		39	20	42	32	19			12	30		5			14		27	3	26	7	
5.5	6	11	16		53	36	66	96	38	12	7	38	77	10	25	8	6	7	20	82	7	30	12	4
6.5	9	27	35	21	64	45	98	193	53	28	30	74	98	96	31	18	44	12	26	104	27	14	21	8
7.5	25	102	84	53	74	85	102	284	78	57	70	92	54	232	75	28	63	29	34	143	39	9	23	26
8.5	7	153	121	122	92	103	130	180	86	77	98	50	37	185	178	87	90	55	47	168	14	4	37	44
9.5	14	94	306	87	76	212	174	82	26	35	61	23	26	111	325	41	48	80	60	99	8		15	23
10.5	5	72	100	41	47	81	116	64	10	19	18	12	19	102	117	21	25	103	111	67	3		2	3
11.5		50	90	22	23	52	73	25	4		5			83	64	14	15	148	38	51	1		1	
12.5		15	49	26	14	35	58					6		37	49	12	10	110	22	36				
13.5			23		8	23	35	7						15	26	9	7	62	19					
14.5					5		12							6	16	7	5	47	13					
15.5		2					7	2			2			3		4	2	9	3					
16.6					3											2	1							
Total	66	526	831	372	508	704	913	965	314	228	301	307	353	880	911	251	316	668	419	777	102	93	120	108

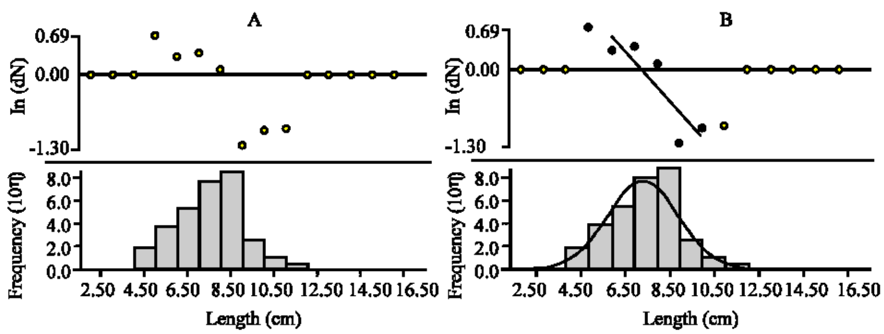

Fig. 2: One cohort Bhattacharya's Decomposition of Composite Distribution of *M. vollenhovenii* for Sample 9. (A) The upper part of the figure is the log-plots of the slopes between successive frequencies while the lower part is the resulting distribution. (B) Upper part of figure shows the first and last data points that identified a group, lower part of figure shows the decomposed distribution into it's composite cohort

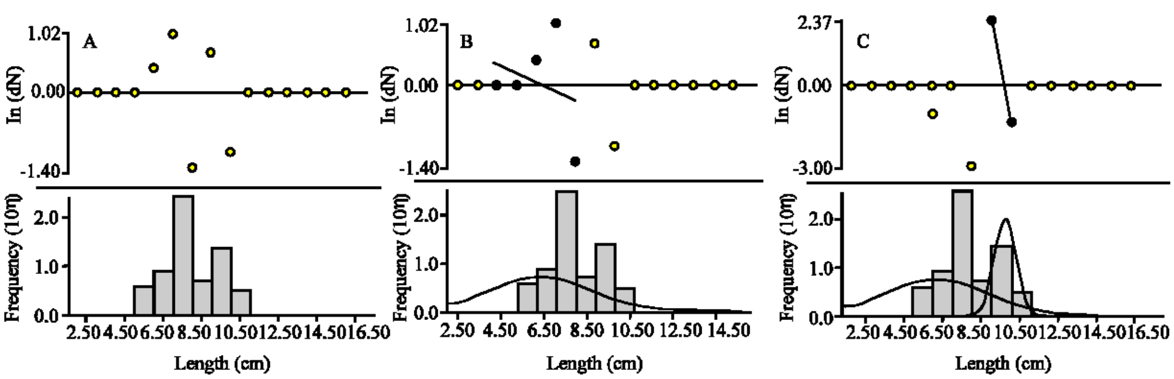

Fig. 3: Two cohorts Bhattacharya's Decomposition of Composite Distribution of *M. vollenhovenii* for Sample 1. (A) The upper part of the figure is the log-plots of the slopes between successive frequencies while the lower part is the resulting distribution. (B) Upper part of figure shows the first and last data points that identified a group, lower part of figure shows the decomposed distribution into it's composite cohorts and (C) Upper part of figure shows the first and last data points of the second cohort identified, lower part of figure shows the decomposed distribution into it's composite cohorts

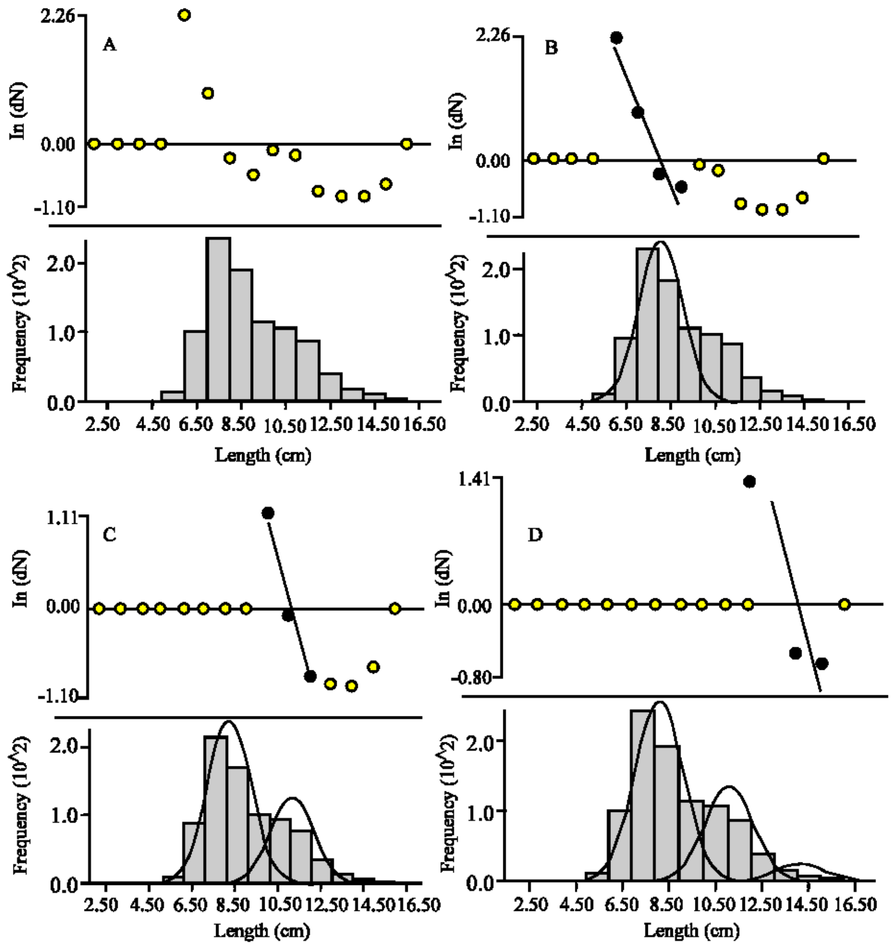

Fig. 4: Three cohorts Bhattacharya's Decomposition of Composite Distribution of *M. vollenhovenii* for Sample 14. (A) The upper part of the figure is the log-plots of the slopes between successive frequencies while the lower part is the resulting distribution. (B) Upper part of figure shows the first and last data points that identified a group, lower part of figure shows the decomposed distribution into it's composite cohorts. (C) Upper part of figure shows the first and last data points of second cohort identified, lower part of figure shows the decomposed distribution into it's composite cohorts and (D) Upper part of figure shows the first and last data points of third cohort identified, lower part of figure shows the decomposed distribution into it's composite cohorts

Table 2: Bhattacharya decomposition result for *M. vollenhovenii*

Observation	Month	Years	Mean	Standard deviation
1	5	2002	6.20	2.56000
2	5	2002	9.65	0.52000
3	6	2002	8.56	1.40000
4	6	2002	11.23	0.85000
5	7	2002	8.98	1.36000
6	7	2002	12.26	1.16000
7	8	2002	8.77	1.27000
8	8	2002	12.29	0.63000
9	9	2002	7.95	2.08000
10	9	2002	13.53	0.99000
11	10	2002	8.84	1.53000
12	10	2002	13.66	0.69000
13	11	2002	9.20	1.89000
14	11	2002	13.10	0.98000
15	12	2002	7.36	1.32000
16	12	2002	11.44	0.97000
17	1	2003	7.36	1.55000

Table 2: Continued

Observation	Month	Years	Mean	Standard deviation
18	2	2003	8.21	1.50000
19	3	2003	8.32	1.19000
20	3	2003	11.33	0.69000
21	4	2003	7.12	1.32000
22	4	2003	11.67	1.67000
23	5	2003	6.25	1.14000
24	5	2003	9.22	1.76000
25	6	2003	8.14	1.03000
26	6	2003	11.09	1.02000
27	6	2003	14.09	0.99000
28	7	2003	6.15	0.85000
29	7	2003	9.19	1.00000
30	7	2003	12.02	1.77000
31	8	2003	8.89	1.05000
32	8	2003	12.29	1.44000
33	8	2003	15.41	0.93000
34	9	2003	8.16	1.13000
35	9	2003	11.49	0.88000
36	9	2003	14.16	1.32000
37	10	2003	5.26	0.89000
38	10	2003	11.28	2.08000
39	10	2003	16.00	0.88000
40	11	2003	9.57	1.62000
41	11	2003	13.32	1.19000
42	11	2003	16.00	1.12000
43	12	2003	7.77	1.73000
44	12	2003	11.95	1.06000
45	1	2004	7.08	1.23000
46	1	2004	10.08	1.06000
47	2	2004	5.22	0.98000
48	2	2004	7.81	0.58000
49	3	2004	7.42	1.28000
50	3	2004	12.00	0.96000
51	4	2004	8.27	0.96000

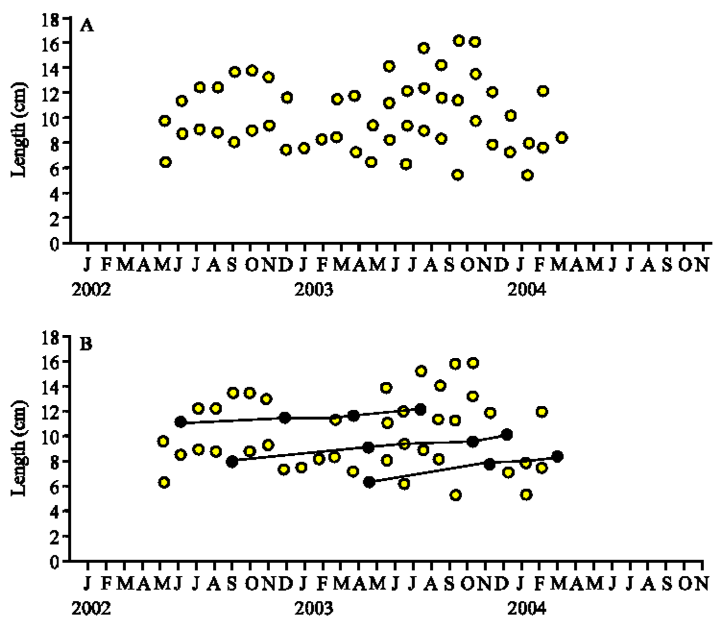

Fig. 5: (A) Mean lengths of cohorts plotted against sampling dates for *M. vollenhovenii*.(B). Mean lengths of different cohorts linked over time representing the growth of the cohorts for *M. vollenhovenii*

seasonality of growth. The seasonal growth oscillation or amplitude of growth oscillation (C) estimated was <0.40 while the Winter Point (WP) was 0.75 or September.

DISCUSSION

Length-frequency data.is a source for obtaining basic information required to assess and manage exploited fish and other aquatic invertebrate stock (Caddy, 1986; Pauly, 1987; Pauly and Morgan, 1987; Rosenberg and Beddington, 1988; Barry and Tegner, 1989). It is the most suitable in the tropics and most importantly for shrimps as it not dependent on calcareous structure that does not survive the periodic shedding of the exoskeleton. MPA infers growth from apparent shift of the modes or means in the time series of length frequency samples. The number of cohorts decomped from each length frequency composite sample of *M. vollenhovenii* in the Lagos-Lekki lagoon attested to the fact that shrimps are short lived organisms. Out of the 24 sampled decomposed two cohorts sample representation were the highest being 15, followed by 6 for three cohorts samples. The one cohort representation samples were the lowest with only three samples.

Three cohorts were identified by the linking of means over time for *M. vollenhovenii* (Fig 5b). This is also in agreement with the fact that shrimps are known to be short lived organisms, for *Macrobrachium* species estimates of longevity vary from 0.9 (Gabche and Hockey, 1995), 1.7 (Enin, 1995), 2 (Gray, 1991a, b) to 3 years (Etim and Sankare, 1998). The Gulland and Holt plot showed that growth rate declined linearly as length increased reaching zero at L∞ (Fig. 6). The residual of the Gulland and Holt plot, from the length at age derived from the linking of mean gave the value of the amplitude of growth oscillation (C). Aquatic animals are well known to exhibit the phenomenon of seasonal growth especially in the temperate region, in the tropics however, growth variation is usually linked to the seasonal pattern of rainfall. Pauly and Ingles (1981) and Pauly (1982, 1985, 1989) showed that virtually all natural fish stocks, including those in tropical waters, display seasonally oscillating growth.

The VBGF has a component that quantifies the seasonality of growth and it's advantageous because it deals with length-growth oscillation and so avoids the problem of shrinkage which occurs in weight growths. C in the VBGF is the empirical constant that indicates the amplitude of growth oscillation, while the other constant Winter Point (WP) indicates the time of year when growth is slowest. The estimated C was 0.40 for *M. vollenhovenii*,

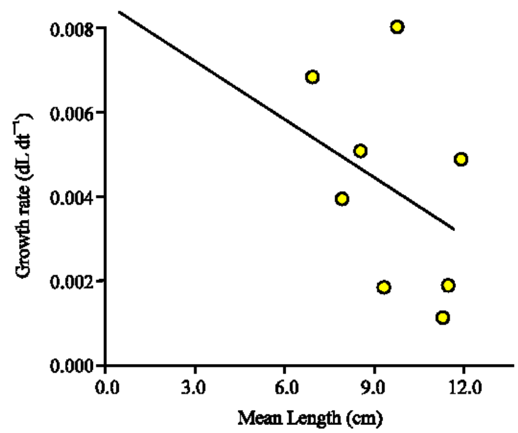

Fig. 6: Plot of growth rate against mean length, which declines linearly as length increases reaching zero at L∞ for *M. vollenhovenii*

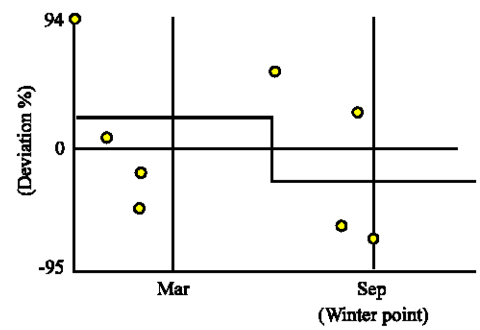

Fig. 7: Residuals, re-expressed in percentage and plotted against the midrange of time for *M. vollenhovenii*

in the Lagos-Lekki lagoon system, though strong is not high when compared to what was obtained in other part of Nigeria. Enin (1995) estimation for *M. macrobrachion* was 0.5 while Nwosu and Wolfi estimate for *M. vollenhovenii* was 0.95 both from the Cross River estuary. Etim and Sankare (2006) estimate for *M. vollenhovenii* from Fahe Reservoir in Cote d'Ivoire was also high giving a value of 0.92 (Fig. 7).

Pauly (1982, 1987) demonstrated a direct relationship between the value of C and difference between the highest and lowest mean monthly temperature to which fish or shrimps are exposed to during one year (ΔT), suggesting that growth oscillation is mainly due to temperature changes. The mean annual temperature of 10°C corresponds to a C value of 1 in Pauly's model. The mean annual temperature difference in Lagos and its environment was 2°C during the study period, thus, this could account for the low values of C estimated for *M. vollenhovenii* in this study. The amplitude of oscillation observed for *M. vollenhovenii* indicates that growth does strongly decrease in September for *M. vollenhovenii* as the Winter Point (WP) estimated was 0.75. Marioghae (1982) reported that the reproductive activity of *Macrobrachium* species peaks from July to October, the WP for *M. vollenhovenii* (September) falls within this period. Inyang (1984) observed that spawning in *M. felicinum* in the lower Niger River takes place mainly during the rainy flood period (July-October). The slow growth occurring in this period may be due to the reproductive activities whereby ingested energy may mainly be diverted to reproductive growth. In the Cross River, *Macrobrachium* winter point also falls within the period according to Enin (1995) that estimated 0.5 or July for *M. macrobrachion*, Nwosu and Wolfi (2006) with an estimate of 0.6 or July for male and 0.45 or June for female *M. vollenhovenii*.

CONCLUSION

The amplitude of seasonal growth oscillation and the winter point derivable from the cohort analysis are of paramount importance in the stock assessment and ultimately management of *M. vollenhovenii*.resource of the Lagos-Lekki lagoon system. These parameters reveal the strength of growth oscillation along with the period of slowest growth which can be inferred as the most susceptible period for the stock. Therefore resource sustainability require that fishing mortality be minimized in this period (September).

REFERENCES

Ajayi, T.O., 1970. Preliminary observations on the fecundity of prawns of the genus Macrobrachium at Epe. B.Sc. Dissertation, University of Ife, Nigeria.

Beverton, R.J.H. and S.J. Holt, 1956. A review of methods for estimation of mortality rates in exploited fish population with special reference to sources of bias in catch sampling. Rapp. P v. Reun. Cons. Int. Explor. Mer., 140: 67-83.

Bhattacharya, C.G., 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics, 23: 115-135.

Caddy, J.F., 1986. Size frequency analysis in stock assessment, some perspectives, approaches and problems. In: Proceedings of the 37th Annual Meeting of the Gulf of Caribbean Fisheries Institute, Miami, Florida, pp: 212-238.

Enin, U.I., 1995. First estimates of growth, mortality and recruitment parameters of Macrobrachium macrobrachion Herklots 1851. In the Cross River Estuary, Nigeria. Dana, 11: 29-38.

Etim, L. and Y. Sankare, 1998. Growth and mortality, recruitment and yield of the freshwater shrimps Macrobrachium vollenhovenii Herklot, 1857 (Crustacea, Palaemonidae) in Fahe Reservoir, Cote d'Ivoire, West Africa. Fish. Res., 38: 211-223.

Gabche, C.E. and H.U.P. Hockey, 1995. Growth and mortality of the gaint African prawn *Macrobrachium* vollenhovenii (Herklots: Crustacea: Palaemonidae) in Lobe River, Cameroun: A preliminary evaluation. J. Shellfish. Res., 14: 185-190.

Gayanilo, Jr. F.C.P., P. Sparre. and D. Pauly, 1996. FAO-ICLARM Stock Assessment Tools (FiSAT). Rome, pp: 126 (+3 diskettes).

Gray, C.A., 1991a. Temporal variability in the demography of palaemonid prawn *Macrobrachium* intermedium in two seagrasses. Mar. Ecol. Progr. Ser., 75: 227-237.

Gray, C.A., 1991b. Demographic pattern of the palaemonid prawn *Macrobrachium* intermedium in South Eastern Australia: Spatial heterogeneity and the effect of species on seagrasses. Mar. Ecol. Progr. Ser., 75: 239-249.

Gulland, J.A. and S.J. Holt, 1959. Estimation of growth parameters for data at unequal time intervals. J. Cons. CIEM, 25: 47-49.

Inyang, N.M., 1984. On the biology of *Macrobrachium* felicium Holthius in the lower Niger River of South eastern Nigeria (Crustacea: Palaemonidae). Rev. Zool. Afr., 98: 440-449.

Marioghae, I.E., 1982. Notes on the biology and distribution of *Macrobrachium* macrobrachion in the Lagos lagoon (Crustacea, Decapoda, Palaemonidae). Rev. Zool. Afr., 96: 493-508.

Nwosu, F.M. and M. Wolfi, 2006. Population Dynamics of Giant African River Prawn *Macrobrachium* vollenhovenii Herklots 1857 (Crustacea, Palaemonidae) in the Cross River Estuary, Nigeria. West Afr. J. Applied Ecol. (WAJAE)-ISSN: 0855-4307 Vol. 9.

Omo-Malaka, S.L., 1970. A study of the food of freshwater prawn (*Macrobrachium* sp.) of Epe lagoon, Nigeria. B.Sc Dissertation, University of Ife, Nigeria.

Pauly, D., 1982. Studying Single-Species Dynamics in a Tropical Multispecies Context. In: Theory and Management of Tropical Fisheries. Pauly, D. and G.I. Murphy (Eds.). ICLARM Conf. Proc., 9: 33-70.

Pauly, D., 1985. On improving operation and use of the ELEFAN Part. I. avoiding drift of K toward low values. ICLARM Fishbyte, 3: 13-14.

Pauly, D. and J. Ingles, 1981. Aspects of the Growth And Natural Mortality Of Exploited Coral Reef Fishes. In: Proceeding of the 4th International Coral Reef Sym., Manila, Philippines, Gomez E., C.E. Birkeland, R.W. Buddemeyer, R.E. Johannes, J.A. Marsh Jr. and R.T. Tsuda (Eds.)., 1: 89-98.

Pauly, D., 1987. A Review Of The ELEFAN System For Analysis Of Length-Frequency Data In Fish And Aquatic Invertebrates. In: Length-Based Methods in Fisheries Research. Pauly, D. and G.G. Morgan (Eds.). ICLARM Conf. Proc., 13: 7-34.

Pauly, D. and G.R. Morgan, 1987. Length-based methods in fisheries research. ICLARM Conf. Proc., 13: 468.

Pauly, D., 1989. Food consumption by temperate fish populations: Some generalizations. J. Fish. Biol., 35 (Suppl. A): 11- 20.

Rosenberg, A.A. and J.R. Beddington, 1988. Length-based Methods Of Fish Stock Assessment. In: Fish Population Dynamics. Gulland, J.A. (Ed.). 2nd Edn., pp: 83-103.