Environment & Ecology 29 (3) : 1166—1171, 2011
 ISSN 0970-0420

Growth and Mortality of *Pampus argenteus* (Euphrasen) from Kakdwip Estuarine Region of West Bengal, India

JOSHITA O. DEVI, T. S. NAGESH* AND N. A. TALWAR[1]

Department of Fisheries Resources Management, [1]Department of Fishery Engineering
Faculty of Fishery Sciences, West Bengal University of Animal & Fishery Sciences
Panchasayar, Kolkata 700094, India
E-mail : tsnagesh1@rediffmail.com
**Correspondence*

Abstract

Estimates of growth, mortality and exploitation level of *Pampus argenteus* from estuarine region of Kakdwip, West Bengal, India were obtained from sets of length frequency distributions resulting from commercial trawl catches from November 2005 to June 2006. Data analysis was performed using length frequency data analysis (LFDA) version 5.0, a Microsoft package. The von-Bertalanffy growth parameters L_∞, K and t_o ranged from 43.5 to 50 cm, 0.813 to 1.00 per year ; and -0.790 t_o -0.587 years, respectively. The growth performance index (ϕ') ranged from 3.277 to 3.395. The annual mortality coefficients Z, M and F ranged 2.415 to 6.989, 1.25 to 1.54 and 0.875 to 5.459, respectively. The exploitation rate (U) varied between 0.726 and 0.7803, which indicated that the fishery of *P. argenteus* stock is overexploited in the area studied and calls for an urgent need to reduce the current fishing effort for the sustainable yield.

Key words : *Pampus argenteus*, Growth, Mortality, Exploitation level.

West Bengal has a rich diversity of aquatic ecosystems enriched with a diverse group of fauna and flora. West Bengal contributes about three percent of the total marine catch of India. Pomfrets contribute about three to four percent of the total marine production of the state and 18% of the total pomfret production of India. The species comprised of *Pampus argenteus* (50—55%), *Parastromateus niger* (30—35%) and *Pampus chinensis* (8—10%) (1). The silver pomfret, *Pampus argenteus* (2), locally known as "Baul Chandi" belonging to family Stromateidae (Butterfishes) under order Perciformes, is one of the most commercially important and highly valued fishes for domestic consumption due to its scrumptiousness and foreign exchange earnings. It contributes significantly to the commercial fishery of India (3) which is caught in greater abundance in Gujarat and Maharastra on the west coast ; and West Bengal and Orissa on the east coast. The species is exploited by a variety of gears viz., drift gill-nets, dol nets and trawl nets. Despite its commercial and economic importance, the knowledge on its biology and population dynamics is meager in the Indian waters (4). Fish stock assessment plays an important role for appropriate management of fishery as it provides information about population parameters and advises fishery managers for the regulation of mesh size, and optimization of catch and effort (5, 6). The present study was therefore envisaged to understand the growth parameters, growth performance index, mortality coefficients, exploitation level and stock position with an ultimate goal of providing the generated data to evolve a sound management policy for the development of *P. argenteus* fishery along the coast of West Bengal.

(The authors thank Sri Nirmal Das, owner of the trawlers, Prabhat Hati, A. D. F. Marine, South 24 Parganas, Ismile Sarder, Manager of the Shyama Fish Syndicate, Ranjan Das, Manager, Kirtyoneeya Ice Factory, for their co-operation in collection of data during the study period and the Dean, Faculty of Fishery Sciences, WBUAFS for providing the facilities).

Methods

Collection of Data

The length frequency data of unsexed fresh

Table 1. Pooled length-frequency distribution for *P. argenteus* collected from different trawlers off Kakdwip.

Length interval (cm)	Frequency										
	07.11.05	02.12.05	20.12.05	09.01.06	21.01.06	12.02.06	04.03.06	23.03.06	15.04.06	20.05.06	10.06.06
12—15	3	0	0	0	0	0	0	0	1	2	0
15—18	9	7	0	3	0	0	0	0	2	2	1
18—21	13	5	8	14	4	2	3	1	6	14	8
21—24	6	14	7	6	10	5	4	4	8	9	8
24—27	3	8	13	10	11	27	25	7	5	3	8
27—30	5	4	4	6	4	6	10	19	16	5	7
30—33	1	2	0	2	6	0	0	8	3	2	7
33—36	0	0	0	0	0	0	0	1	0	1	0

samples of *Pampus argenteus* were collected at regular intervals from the Sultanpur fish landing center and Nagendra Bazar fish market at Diamond Harbour, South 24 Parganas, West Bengal, India from November 2005 to June 2006. These samples were caught off Kakdwip by four trawlers. A total of 428 fresh samples of *P. argenteus* were collected and the total length (from the tip of the snout to the end of the longest caudal ray) was measured in centimeter for each individual corrected to the nearest 0.1 mm using meter scale. The total length ranged from 12.5 to 33.9 cm. The data collected from different trawlers were pooled and subsequently grouped into the length classes of 3 cm intervals (Table 1), for the estimation of growth parameters.

Analysis of Data

Growth Parameters. The total length frequency distributions of *P. argenteus* were analyzed using Length Frequency Data Analysis (LFDA) version 5.0, a Microsoft package developed by MRAG Ltd. under Fisheries Management Science Program (FMSP) (7) for establishing growth parameters of the non-seasonal version of the von Bertalanffy growth curve. The von-Bertalanffy growth parameters (L_∞, K and T_o) (8) were estimated using the Shepherd's length composition analysis (SLCA) (9), projection matrix method (PROJMAT) (10) and electronic length frequency analysis (ELEFAN) (11). These growth parameters of *P. argenteus* were used to fit the VBGF equation as

$$L_t = L_\infty [\,1\text{-}e^{-K\,(t\,-\,to)}]$$

Where, L_t = Length (cm) of the fish at age t, L_∞ Asymptotic length (cm) of the fish, K = Catabolic growth co-efficient or curvature parameter (per year), t_o = Age at zero length or initial condition factor (years).

Growth Performance Index. The growth performances index (ϕ') for *P. argenteus* in terms of growth in length was estimated using the index (12), by the following formula

$$\phi' = \log K + \log\ L_\infty$$

where, K = catabolic growth co-efficient or curvature parameter (per year), L_∞ = asymptotic length (cm) of the fish.

The ϕ' values in the present study were estimated separately by using the growth parameters resulted from SLCA, PROJMAT and ELEFAN methods.

Table 2. Growth parameters, annual mortality rates and exploitation level of *P. argeneteus* (n=428).

Methods	Growth parameters				Growth performance index (ϕ')	Annual mortality rates			Exploitation level (U)
	$L\alpha$ (cm)	K (year)	T_0 (years)	Von-Bertalanfyy growth equation		Z	M	F	
SLCA	50.00	0.993	-0.587	$L_t = 50\ [1—e^{-0.993\ (t+0.587)}]$	3.395	6.989	1.53	5.459	0.7803
PROJMAT	43.50	1.000	-0.0736	$L_t = 43.5\ [1—e^{-1(t+0.0736)}]$	3.277	2.145	1.54	0.875	0.3620
ELEFAN	48.86	0.813	-0.790	$L_t = 48.86\ [1—e^{-0.813\ (t\ =\ 0.790)}]$	3.288	4.584	1.25	3.334	0.726

Total Mortality Rate. The annual rate of total mortality (Z) of *P. argenteus* was estimated using the Beverton and Holt's Z equation (13), as given below using the growth parameters resulted from SLCA, PROJMAT and ELEFAN methods.

$$Z = K\left[\frac{L_\infty - \underline{L}_c}{\underline{L}_c - L_c}\right]$$

Where, L_c = Length (cm) at which 50% of the fish entering the gear are retained, $\underline{L}_c$ = Average length (cm) of the entire catch for which all fish of L_c and longer are under full exploitation, L_∞ = Asymptotic length (cm) of the fish, K = Curvature parameter or catabolic growth co-efficient (per year).

Natural Mortality Rate. The annual rate of natural mortality (M) of *P. argenteus* was estimated using the concept (14) by using the curvature parameter (K) obtained from SLCA, PROJMAT and ELEFAN methods ; and the longevity in terms of years (t_{max}) as given below

$$M = \frac{-\ln 0.01}{t_{max}} \text{ and } t_{max} = 3/K$$

Fishing Mortality Rate. The annual rate of fishing mortality (F) of *P. argenteus* was obtained by subtracting annual rate of natural mortality (M) from annual rate of total mortality (Z), i.e.

$$F = Z - M$$

Exploitation Level. The exploitation level (U) of *P. argenteus* was estimated (15, 16).

$$U = F / Z\,(1 - e^{-Z})$$

where, F = Annual rate of fishing mortality, Z = Annual rate of total mortality, e = Base of the natural (or Naperian) logarithms ; e = 2.71828.

Results and Discussion

Stock assessment tools are ways of determining different properties of fish stock, which help to make decisions about different management actions at different stages. Thus, information on stock assessment is imperative in formulating management and conservation policies and in further development of the fishery of a species studied. The estimates of growth parameters, growth performance index, annual mortality rates and exploitation level are given in Table 2.

Growth Parameters

The study of growth means basically the determination of the body size as a function of age. Therefore, all stock assessment requires age-composition data obtained through counting year rings on the hard parts of the fish. However, such age determination is difficult in tropical areas because of no well-demarcated fluctuations in the seasons. Moreover, *P. argenteus,* being a tropical fish considered difficult to age by means of hard parts such as otolith because the otolith structure is complex and the daily increments are highly irregular making them difficult to observe and interpret (17) or by applying modal progression analysis. In such cases, the length-frequency data analysis has been recommended and in use for the stock assessment studies in tropical waters (18—20). Length based methods for stock assessment on *P. argenteus* was successfully used by several scientists (21, 22). Hence, the LFDA version 5.0, a Microsoft package developed under FMSP (7) was used in the present study using the length frequency distribution. Several models have been used to express growth using simple mathematical equations (23). However, the von-Bertalanffy growth equation is being most commonly used for the marine species as it fits the data from a wide range of species (15). Therefore, in the present study also, the growth parameters (L_∞, K and t_o) obtained from different methods of LFDA were used to fit the VBGF equation.

The non-seasonal growth parameters of *P. argenteus* estimated in the present study did not deviate much from the different methods employed in earlier works indicating the compatibility of the methods used. The L_∞ values of *P. argenteus* were 50 cm (SLCA), 43.5 cm (PROJMAT) and 48.86 cm (ELEFAN). These values did not show much difference when compared to L_∞ values estimated by the other authors for the same species, from different regions.

The L_∞ value of *P. argenteus* varied from 39 cm to 41.8 cm TL in the Bay of Bengal (24) and 36.1 cm FL (=51.1 cm TL) off north coast of Gresik (25). The L_∞ values of *P. argenteus* to be ranged from 50.1 cm to 56.5 cm TL along the different coasts off west coast of India (4) and found to be ranged from 45 cm to 63.9 cm (21, 22). Thus, it appears that the L_∞ value recorded in the present study is within the range of earlier reports. The L_∞ is the mean length that the fish would reach if they were to grow to a old age (16). Since the largest size of the species encountered was 33.9 cm, the estimated L_∞ of 43.5 to 50.0 cm appears to be quite satisfactory.

The curvature parameter (K) determines how fast the fish approaches its L_∞. In general, tropical fishes have high K values than the temperate ones. In the present study, the K values of *P. argenteus* were 0.993 per year (SLCA), 0.813 per year (ELEFAN) and 1.00 per ear (PROJMAT), thus showing the compatibility of the methods used. The K values from the earlier reports fluctuated between as low as 0.2405 per year (26) in Korean water and 1.12 per year (22) in Khoozestan waters along northwest Persian Gulf. The estimated K values (0.2405 to 0.262 per year) off Korean waters were much less then those from the Indian waters (0.53 to 0.7 per year) (4.26, 27).

The initial condition parameter (t_o) is the age the fish would have had zero length if they had always grown to the VBGF equation. The calculated t_o of *P. argenteus* in the present investigation from different methods were -0.790 years (ELEFAN), -0.736 years (PROJMAT) and -0.587 years (SLCA). The t_o values reported from earlier authors varied from -1.1 years in Korean waters (26) to -0.505 years along East Java (25). The results obtained in the present study were within the range of the earlier reports. Age at zero length (t_o) is thought of merely as a scaling factor in the growth curve. Generally, t_o has a small positive or more usually a small negative factor (28). It has been observed that the juveniles with negative t_o values grow more quickly than the predicted growth curves of adults and with positive t_o values, juveniles grow more slowly (28).

The VBGF equations of the species fitted using the values of the growth parameters resulted from SLCA, PROJMAT and ELEFAN methods are represented in Table 2.

Growth Performance Index

The growth performance index (ϕ') explains the overall growth performance of the fish population in terms of growth in length (12). In the present investigation, the ϕ' values for *P. argenteus* obtained from the growth parameters estimated by different methods were consistent (3.277 for PROJMAT, 3.288 for ELEFAN and 3.395 for SLCA). The ϕ' values reported from different regions fluctuated between 2.43 off East China Sea (26) and 3.24 off Persian Gulf (29). The intermediate values have been noticed by other authors (21, 30, 31). Thus, it appears that the ϕ' values obtained from the present study are slightly higher than the earlier reports. This might be associated with the differential fishing intensity or environmental conditions prevailed during the study.

Annual Mortality Rates

The annual rate of total mortality (Z) denotes the rate of reduction of fishes from the population due to death. This comprised of two components viz. natural mortality (M) due to natural causes and fishing mortality (F) caused by the fishing operation. The annual Z values of *P. argenteus* computed in the present investigation were 6.989 (SLCA), 2.415 (PROJMAT) and 4.584 (ELEFAN). The annual Z estimates using catch curve methods were 1.5, 1.62 and 2.4 (22, 32, 33). Annual Z values ranged between 3.165 and 5.4 along different regions off west coast of India (4). The annual Z values were found to vary from 2.6 to 5.36 off Khoozesthan Province (22).

The computed annual M values in the present investigation were 1.53 (SLCA), 1.54 (PROJMAT) and 1.25 (ELEFAN). The annual M estimates varied from 0.52 to 1.05 (32) and 1.4 to 1.6 (22). The lowest value of M = 0.45 per year has been recorded off Korean waters (34).

The computed annual F values in the present investigation were 5.459 (SLCA) 0.875 (PROJMAT) and 3.334 (ELEFAN). From earlier reports, the annul F estimates were found to be fluctuated between 0.45 off Korean waters (34) and as high as 4.2 off Maharashtra in the Indian waters (4). The value obtained from PROJMAT method was not found to be realistic considering the fishing intensity prevailed as observed during the investigation.

Exploitation Rate

The rates of exploitation (U) were found to range between 0.726 (ELEFAN) and 0.7803 (SLCA) in the present study area. The exploitation level (0.362) for PROJMAT was not found to be realistic considering the natural mortality rate obtained during the present study and the fishing intensity existed in the study area. The estimated U values ranged from 0.5 to 0.779 along the different regions off west coast of India (4). Based on their observations, they concluded that *P. argenteus* stock off Karnataka, Maharashtra and Gujarat were heavily fished. The yield is optimized when F=M ; therefore, when U is more than 0.5, the stock is said to be overfished (35). Thus, from the present study, it is evident that the fishery of *P. argenteus* stock is over fished in the area studied and hence, there is an urgent need to reduce the current effort for the sustainable yield.

References

1. Srinath M. and N. G. K. Pillai. 2006. Marine Fisheries of India : An Approach to Responsible Fisheries Management. *Fishing Chimes* 26 : 23—28.
2. Euphrasen B. A. 1788. Beskrifning pa zine fiskar. *Vetensk. Aka. Nya. Handl. Stockholm* 9 : 51—55.
3. Pati S. 1980. Food and feeding habits of silver pomfret *Pampus argenteus* (Euphrasen) from Bay of Bengal with a note on its significance in fishery. *Ind. J. Fish*. 27 : 244—257.
4. Khan M. Z., M. Kumaran, A. A. Jayaprakash, K. S. Scariah, V. M. Deshmukh and M. H. Dhulkhed. 1992. Stock assessment of pomfret off west coast of India. *Ind. J. Fish.* 39 : 249—259.
5. Anderson L. G. 1977. *The economics of fishery management*. The John Hopkins Univ. Press, New York, USA.
6. Pearse P. H. 1980. *Regulation of fishing effort.* FAO Fish. Tech. Pap. 197 : 82 pp.
7. Kirkwood G. P., R. Aukland and S. J. Zara. 2001. *Length frequency distribution Analysis (LFDA).* Version-5.0. MARG Ltd., London, UK.
8. Von-Bertalanffy L. 1957. Qualitative laws in metabolism and growth. *Qual. Rev. Biol*. 32 : 217—231.
9. Shepherd J., G. Morgan, J. A. Gulland and C. P. Mathews. 1987. Methods of analysis and assessment. Report of working group III. Length-based methods in fisheries research. D. Pauly and G. R. Morgan (eds). *ICLARM Conf. Proc.* 13 : 352—362.
10. Basson M., A. A. Rosenberg and J. R. Beddington. 1988. The accuracy and reliability of two new methods for estimating growth parameters from length frequency data. *J. Cons. Int. Explor. Mer.* 44 : 277—285.
11. Pauly D. 1987. A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic vertebrates. p. 7-34. *In* D. Pauly and G. R. Morgan (eds). Length-based methods in fisheries research. *ICLARM, Conf. Proc.* 13 : 468.
12. Pauly D. and J. L. Munro. 1984. Once more on growth comparisons in fish and invertebrates. *Fishbyte* 2 : 21.
13. Beverton R. J. H.and S. J. Holt. 1956. A review of methods for estimating mortality rates in fish populations, with special reference to sources of bias in catch sampling. *Rapp. P-v. Reun. CIEM.* 17A : 1—153.
14. Alagaraja K. 1984. Simple method for estimation of parameters for assessing exploiteds fish stocks. *Ind. J. Fish.* 31 : 115.
15. Beverton R. J. H. and S. J. Holt. 1957. On the dynamics of exploited fish populations. *Fish. Investig. London.* 2 : 533.
16. Ricker W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd. Canada* 119 : 203—233.
17. Brothers E. and C. P. Mathews. 1987. Application of otolith microstructural studies to the age determination of some commercially valuable fish of the Arabian Gulf. *Kuwait Bull. Mar. Sci.* 9 : 127—157.
18. Pauly D. and D. David. 1981. ELEFAN-1 a basic program for the objective extraction of growth parameters from Length-frequency data. *Rep. Mar. Res.* 28 : 205—211.
19. Gayanilo F. C. Jr. and D. Pauly. 1996. *The FAO-ICLARM stock assessment tools (FiSAT) user's guide.* FAO Comput. Infor. Ser. (Fish.). No. 8. FAO. Rome.
20. Hoggarth D.D., S. Abeyasekera, R. Arthur, J. R. Beddington, R. W. Burn. A. S. Halls, G. P. Kirkwood. M. Mc. Allister P. Medley, C. C. Mees, G. B. Parkes, G. M. Pilling, R. C. Wakeford and R. L. Welcomme. 2005. *Stock assessment for fishery management—A framework guide to the use of the FMSP fish stock assessment tools.* FAO Fish. Tech. Paper. No. 487. Rome. FAO. 2005. 259 pp.
21. Morgan G. R. 1985. Stock assessment of the pomfret (*Pampus argenteus*) in Kuwait. *J. Cons. Int. Explor. Mer.* 42 : 3—10.
22. Parsamanesh A., M. Shalbaf and N. Najafpour. 1998. On the status of *Pampus argenteus* in Khoozestan waters (North-west Persian Gulf). I. R. Iran. *Ind. J. Anim. Sci.* 68 : 407—409.
23. Allen K. R. 1971. Related between production and biomass. *J. Fish. Res. Bd. of Canada* 28 : 1573—1581.
24. Dwiponggo A., T. Hariati, S. Banon, M. L. Palomares and D. Pauly. 1986. *Growth, mortality and recruitment of commercially important fishes and penaeid shrimps in Indonesian waters.* ICLARM Tech. Rep. Fishbase (1995), 17, 91.
25. Herianti I., M. D. M. Pawarti and Subani. 1986. Study on growth and some biological parameters of Gresik, East Java. *J. Mar. Fish. Res.* 36 : 95—101.
26. Lee D. W., Y. M. Kim and B. Q. Hong. 1992. Age

and growth of silver pomfret (*Pampus argenteus*) in Korean waters. *Bull. Nat. Fish. Res. Dev. Agen. (Korea)* 46 : 91—96.

27. Haedrich R. L. 1984. Stromateidae. *In* W. Fischer and G. Bianchi (eds). *FAO species identification sheets for fishery purposes.* Western Indian Ocean (Fishing Area 51). Vol. 4. FAO, Rome. Pag. Var.
28. King M. 1996. *Fisheries biology.* Assessment and Management Publishers. 117 pp.
29. Parsamanesh A. 2001. A comparison of *Pampus argenteus* stock parameters in east and west Asia. *Ind. J. Fish.* 48 : 63—70.
30. Herianti I., H. Wahyuono and W. Subani. 1986b. The estimation of growth parameters of silver pomfret (*Pampus argenteus*) in north coast of Gresik, East Java. *J. Mar. Fish. Res.* 37 : 23—30.
31. Kang Y. J., D. W. Lee, B. Q. Hong and Y. S. Kim. 1989. Studies on the biology of pomfrets, *Pampus* spp. in the Korean waters. 3. Age and growth of Korean Pomfret, *Pampus echinogaster*. *Bull. Korean Fish. Soc.* 22 : 294—305.
32. Al-Hossaini M. 1994. *Finfish and shrimp fisheries management, Food 4.* Kuwait Inst. Sci. Res., Rep. No. 4367, Kuwait.
33. Gulland J. A. 1971. *The fish resources of the ocean*. West Byfleet, Survey, Fishing News (Books), Ltd., for FAO, 225p. Revised edition. FAO Fish. Tech. Pap. No. 17, 425 p.
34. Kim Y. M. and D. W. Lee. 1992. Stock assessment of silver pomfret, *Pampus argenteus* (Euphrasen) in Korean water. *Bull. Nat. Fish. Res. Dev. Agen. (Korea)* 64 : 41—51.
35. Lee J. U., M. Samuel, F. Y. Al-Yamani and P. S. Joseph. 1990. *Fin fisheries management project phase IV*. Kuwait Inst. Sci. Res., Report No. 3484, Kuwait.