J. Agr. Sci. Tech. (2016) Vol. 18: 669-679

Estimation of Growth and Mortality Parameters of Croaker *Atrobucca alcocki* in Pakistani Waters

K. H. Memon[1,2], Q. Liu[1*], M. A. Kalhoro[1, 2], K. Nazir[1], B. Waryani [3], M. S. Chang[1,4], and A. Nabi[4]

ABSTRACT

Five demersal trawl surveys were conducted in the Pakistani waters in October, November 2009 and August, October, November 2010. A total of 819 length-weight and 7,240 length-frequency data of *Atrobucca alcocki* were collected, the length ranged from 10 cm to 45 cm with the dominant length group from 19 to 29 cm. The total weight ranged from 14 to 928 g. The length-weight relationship can be expressed as $W= 0.012*L^{2.925}$ (R^2= 0.972). Using the ELEFAN program in FiSAT computer package, the calculated von Bertalanffy growth function parameters were L_∞ = 47.25cm, K= 0.180 yr^{-1}. Total mortality (Z) was computed using the length-converted catch curve analysis at Z= 1.07 yr^{-1}. Natural mortality was computed as M= 0.494 yr^{-1} at an annual average sea surface temperature of 26°C, hence, the fishing mortality was computed as F=Z-M= 0.576 yr^{-1}. The Exploitation ratios (E) were computed as E_{max} = 0.421, E_{10} =0.355, E_{50} =0.278. Yield per recruit analysis revealed that when t_c was assumed to be 2, F_{max} was calculated at 0.75 and $F_{0.1}$ at 0.6. When t_c was assumed to be 1, F_{max} was calculated at 0.55 and $F_{1.0}$ at 0.45. Current age at first capture was about 1 year and $F_{current}$ was 0.576, therefore, $F_{current}$ was larger than $F_{0.1}$ and F_{max}. When biological reference point was F_{opt} equal to M (0.494), current fishing mortality rate of 0.576 was larger than the target biological reference point.

Keywords: Biological reference points, Bertalanffy growth function, Length-converted catch curve, Natural mortality.

INTRODUCTION

The coast line of Pakistani waters extends 1,100 km from the north west Iranian border (Baluchistan Coast) to the southeast Indian border (Sindh Coast) having an Exclusive Economic Zone (EEZ) of 240,000 km^2, from which Pakistan can explore and exploit their marine resources (Snead, 1967).In Pakistani waters, there are 250 demersal fish species, 50 small pelagic fish species, 15 medium sized pelagic species and 20 large pelagic species, 15 shrimp species and 12 cephalopods (squid, cuttlefish, octopus) and 5 species of lobster.(FID-/CP/PAK/FAO 2009). The Sciaenidae is a large family of Perciformes fishes that comprises at least 270 species that represent approximately 70 genera (Nelson, 2006; Froese and Pauly, 2007). In Pakistani waters, 18 species of the family are reported by Jaleel and Khaliluddin (1972). The members of this family are distributed worldwide and are among the most common fishes in tropical and subtropical marine and brackish waters of Atlantic, Pacific and Indian Oceans (Trewavas, 1977; Chao, 1986), and have secondarily invaded fresh water in both North and South America (Chao, 1978).

[1]College of Fisheries, Ocean University of China, Qingdao 266003, People's Republic of China.
*Corresponding author; e-mail: qunliu@ouc.edu.cn
[2] Department of Marine Fisheries, Fish Harbor West Wharf Karachi, 74000, Pakistan.
[3] Department of Zoology, University of Sindh, Jamshoro, Pakistan.
[4] Department of Microbiology, University of Sindh Jamshoro, Sindh, Pakistan.

However, Sciaenidae are represented in freshwater by only six genera and 28 species, with these being predominantly restricted to the Atlantic drainages of South America (Chao, 1986; Casatti, 2003, Nelson, 2006).

Croaker *Atrobucca alcocki* belongs to family Sciaenidae, commonly known as drums or croakers. The species was first scientifically described by Talwar in 1980. It is a marine benthopelagic fish found in tropical western Indian Ocean: Arabian Sea off Bombay, India and Sindh Pakistan waters, (Sasaki and Kailola, 1988).

The croaker fishery is important in Pakistan because it is a cheap protein source for the poor people of the country. It had the largest catch of the species during the demersal survey of Pakistani waters in 2009 by United Nations Food and Agriculture Organization (FAO, 2009).

In recent years, there is some published work available for the stock assessment of some other species such as: "Growth and Mortality of Brushtooth Lizardfish *Saurida undosquamis* from Pakistani Waters" by Kalhoro *et al*. (2014); Maximum Sustainable Yield Estimates of the Barramundi *Lates calcarifer* Fishery from Northern Arabian Sea by Memon *et al*. (2014); "Estimation of Maximum Sustainable Yield of Bombay Duck *Harpodon nehereus* Fishery in Pakistan Using CEDA and ASPIC Ppackages" by Kalhoro *et al*. (2013) and "Reproductive Pattern and some Biological Features of Anadromous Fish *Tenualosa ilisha* (family *Clupeidae*) from Pakistan" by Panhwar *et al.* (2011). But there is no work available on fish stock assessment of *A. alcocki* from Pakistani waters. Keeping this in view, we attempted to estimate the growth and mortality parameters of the *A. alcocki* using length-frequency data from the Pakistani waters.

Length frequency data are particularly important where there is a limited age-structured data available, e.g. in tropical fisheries (Sparre and Venema, 1998). Length and weight data of fish can be used for the estimation of the length and age structures, growth and mortality rates of the fish (Kohler *et al*., 1995), and stock assessment (Garcia *et al*., 1989; Sparre and Venema, 1998; Blackwell *et al*., 2000; Haimovici and Velasco, 2000). The main objective of this study was to estimate the growth and mortality parameters of *A. alcocki* in Pakistani waters. The results can be helpful for fishery managers to manage the fishery of the species in the region at a sustainable level.

MATERIALS AND METHODS

Data Collection

Five demersal trawl surveys were conducted from the waters of Pakistan. *A. alcocki* were caught from 109 stations out of a total of 250 stations in October and November 2009 and in August, October and November, 2010 (Figure 1).

The fishes were identified using taxonomic identification sheets (Fischer and Bianchi, 1984) and field guide (Bianchi, 1985); the length-weight and length frequency data were recorded on board during those surveys.

Data Analysis

The length frequency distribution data were analyzed using computer software package FiSAT II (FAO-ICLARM Stock Assessment Tool) following Gayanilo *et al.* (2003).

Length Weight Relationship

Total of 7,240 lengths and 819 length and weight of *A. alcocki* were measured, 3,248 in October, 3109 in November 2009, 10 in August, 16 in October and 857 in November 2010. The Total Length (TL) after log-transformed was measured to 1cm and weight after log-transformed was measured to 1 g.

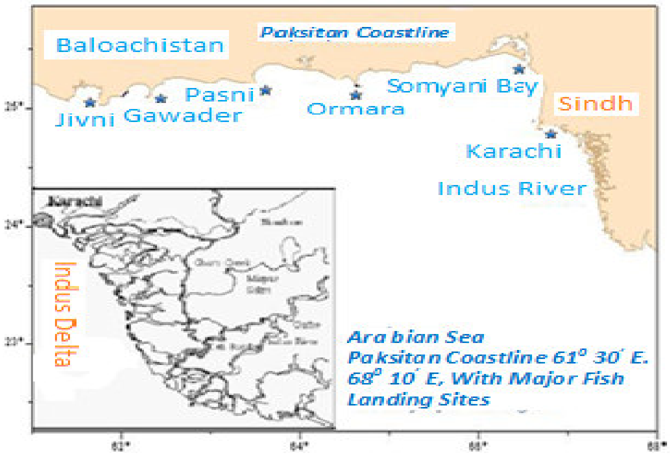

Figure 1. Map showing the Coastline of Pakistani waters with its major landing sites.

To determine the length-weight relationship of the observed Length (L) and Weight (W) for *A. alcocki,* the power function: $W = aL^b$ was used, where W was weight of fish in g, L was length of fish in cm and "*a*" was constant condition factor and "*b*" was slope. The total number of lengths and total number of weights of *A. alcocki* after log-transferred were analyzed to estimate the standard error and standard deviation of L and W for *A. alcocki,* using the SPSS computer software, and t test was done using the SPSS computer software to obtain the p values, .

Growth

Von Bertalanffy Growth Function (VBGF) was used to determine the length with age of *A. alcocki* as the following equation:

$$L_t = L_\infty(1-\exp(-k(t-t_0)))$$

Where, L_t is the length at age t, L_∞ is the length (in cm), k is the growth coefficient (per year) and t_0 is the theoretical age at zero length (Haddon, 2001) which can be calculated using the empirical equation of Pauly (1983) as:

$$\log_{10}(-t_0) = -0.3922 - 0.275\log_{10} L_\infty - 1.038\log_{10} k$$

Mortality

The length-converted catch curve analysis method in computer software package FiSAT II was used to calculate the annual total mortality rate (Z) (Pauly, 1983). The coefficient of natural mortality (M) was estimated by the Pauly's (1980) empirical formula as:

$$\log_{10}(M) = 0.006 - 0.279\log_{10}(L_\infty) + 0.654\log_{10}(k) + 0.6434\log_{10}(T)$$

Where, T is the annual average sea surface temperature of Pakistani water of 26°C (Qasim, 1982). By subtracting (M) from (Z) Fishing mortality (F) is obtained, E is the Exploitation ratio calculated from *F/Z.*

Biological Reference Points

Gulland (1969) described the biological reference points, which were calculated by:

$$F_{opt} = M$$

Beverton-Holt Y/R Analysis

The Beverton-Holt Model was used to calculate the yield per recruit as the following equation:

$$Y_w / R = FW_\infty e^{M(t_c-t_r)} \sum_{n=0}^{3} \frac{Q_n e^{-nk(t_c-t_0)}}{F+M+nk}, (1-e^{-(F+M+nk)(t_\lambda-t_c)})$$

where Y_w/R is yield per recruitment, t_c is mean age at first capture of fish, t_r is recruitment age, t_λ is asymptotic age , Q_n is

[DOR: 20.1001.1.16807073.2016.18.3.9.1]

constant value equal to 1, -3, 3 , -1 when *n* is 0, 1, 2, 3, respectively (Pitcher and Hart, 1982).

Growth Performance Index

Growth performance index (ϕ') of *A. alcocki was* calculated by the equation given by Pauly and Munro (1984): $\phi' = \log_{10} k + 2\log_{10} L_\infty$

RESULTS

Length-weight Relationship

Of the 819 *A. alcocki* collected during 2009-2010, length and weight ranged from10 to 45 cm with the dominant length group ranging from 19 to 29 cm and 14 to 928 g and mean length after log-transformed data was 1.4239 *SD* (±.08788) and *SE* (0.00394) cm and mean weight after log-transformed data was 2.2770 *SD* (±.27948) and *SE* (0.01557) g, respectively (Figure 2).

The length-weight relationship was calculated as $(W = 0.012^* L^{2.925} (R^2 = 0.972)$ (n= 819) (Figure 3) and *P* values were estimated at 0.0000 or < 0.001.

Growth

The *VBGF* parameters were estimated as: L_∞ = 47.25 cm and *K*= 0.180 yr^{-1} (Figure 3). The goodness of fit of model estimation was R_n = 0.350 and t_0= - 0.189.

Mortality

Total mortality (Z) was computed using the length-converted catch curve analysis method as Z= 1.07 yr^{-1} in FiSAT computer software package (Figure 4). Natural mortality was computed as M= 0.494 yr^{-1} at an annual average sea surface temperature of 26°C, hence, the fishing mortality and exploitation ratio for length-converted catch curve method were calculated to be 0.576 and 0.538 yr^{-1}, respectively.

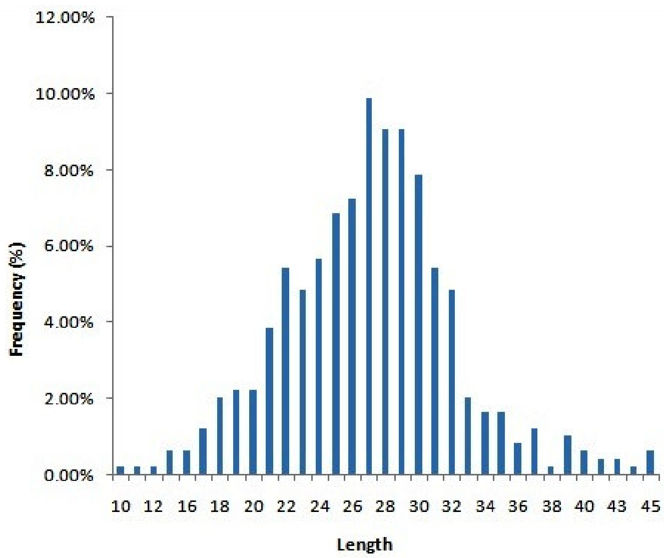

Figure 2. Length frequency distribution of *A. alcocki* in Pakistani waters in 2009-2010.

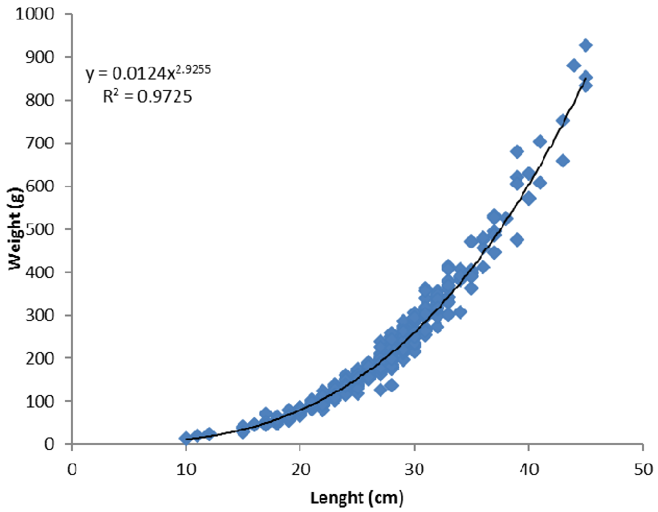

Figure 3. Length weight relationship of *A. alcocki* in Pakistani waters in 2009-2010.

Biological Reference Points

Figure 5 revealed yield per recruit contour map when the maximum age was 12 years. When t_c was assumed to be 2 years, F_{max} was calculated at 0.75 and $F_{0.1}$ at 0.6. When t_c was assumed to be 1year, F_{max} was calculated at 0.55 and $F_{0.1}$ at 0.45. Current age at first capture was about 1 year and $F_{current}$ was 0.576 therefore $F_{current}$ was larger than $F_{0.1}$ and F_{max}. When biological reference point was F_{opt} equal to M (0.494), current fishing mortality rate of 0.576 was larger than the target biological reference point.

The optimum exploitation ratios were computed as E_{max}=0.421, E_{10}= 0.355 and E_{50}= 0.278. The Beverton-Holt relative yield per recruit computed using the knife-edge method is shown in Figure 6.

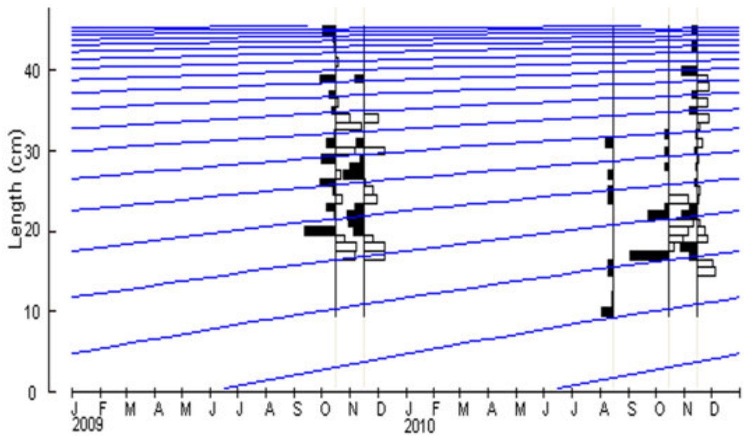

Figure 4. Length frequency distribution data and growth curves estimated using ELEFAN method for *A. alcocki* in Pakistani waters in 2009-2010.

[DOR: 20.1001.1.16807073.2016.18.3.9.1]

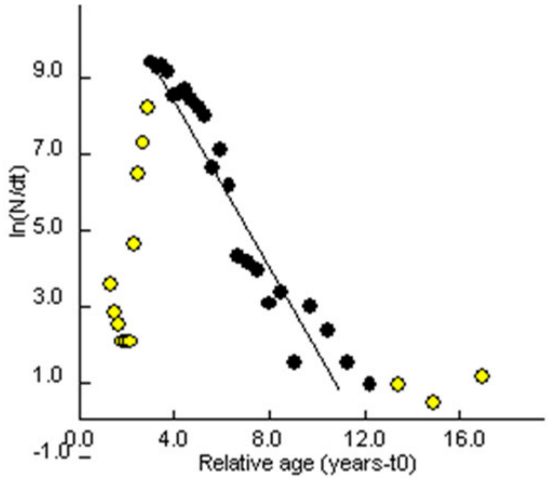

Figure 5. Length converted catch curve analysis of *A. alcocki* in Pakistani waters in 2009-2010.

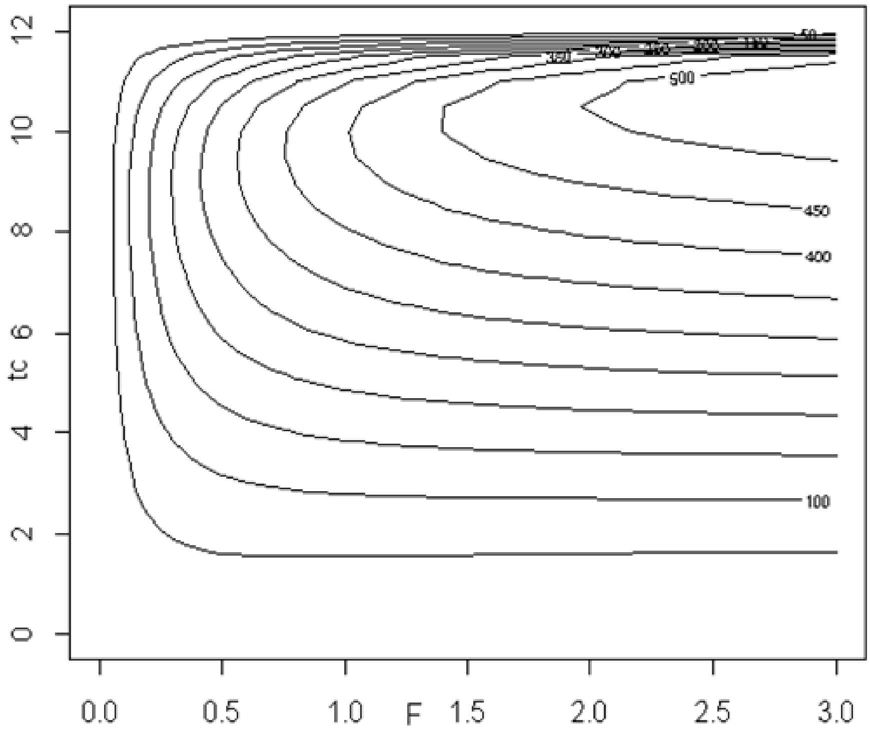

Figure 6. Contour map of yield per recruit for *A. alcocki* in Pakistani waters in 2009-2010.

[DOR: 20.1001.1.16807073.2016.18.3.9.1]

Growth Performance Index

For the *A. alcocki*, the growth performance index (ϕ') was computed as 2.604 in Pakistani waters.

DISCUSSION

Length-weight Relationship

The length-weight relationship parameters provide the knowledge of growth condition of fish (Tesch, 1971; Wooton, 1998). This relationship can also be helpful to assess the feeding rate, gonad maturity and metamorphosis of fish (Le Cren, 1951). According to Tesch (1968), condition factors can be useful to compare the condition, fatness, or well-being of fish. If the value of *b* is 3, it shows that growth of fish is an isometric and fish will maintain a specific shape throughout the life (Wooton, 1990). If the *b* values are less than 3, it means that the growth of fish is negative allometric, and if the *b* values are greater than 3, it means that the growth of fish is positive allometric (Gayanilo and Pauly, 1997). Froese (2006) explained that values of *b*= 3 shows that the small fish specimens have the same form and probably have the same condition as large fish specimens. Beverton and Holt (1957) reported that the *b* values going away from 3 are rare in adult fishes. In this study, the values of *b* for the *A. alcocki* were 2.925 (Table 1) which is close to the ideal *b* values of 3, however, the estimated p values of 0.0000 or < 0.001 shows that b values were significantly smaller than 3, which indicates that the species have a negative allometric growth. Pauly and Gayanilo (1997) stated that *b* value ranged between 2.5 to 3.5, which indicate that the results of our study are in the range of those values. Small differences may be due to the sample collection time, area of sampling, vessels, and fullness of stomach, maturity of gonads, health differences, and also some other factors related to fish ecology such as sex, age of fish, season, habitat, temperature, availability of food, and conditions for spawning (Ricker, 1973; Baganel and Tesch, 1978) may have an influence on the growth of the fish.

Kashifa *et al.* (2008) estimated the length-weight relationship based on 72 specimens of *A. alcocki* from Pakistani waters .The estimated values of length-weight parameters were, *a*= 0.0167 and *b*= 2.788 and R^2= 0.951. In our study, the estimated length-weight relationship parameters of *a*= 0.012, *b*= 2.925 and R^2= 0.972 were compared with those of estimated length-weight relationship parameters by Kashifa *et al*. (2008) from Pakistani waters. The obtained results of length-weight relationship parameters in our study were about the same as in the estimated results of previous study conducted by Kashifa *et al.* (2008).

Growth Parameters

Parameters of *VBGF* of asymptotic length (L_∞) and growth coefficient (K) for the *A. alcocki* are shown in Table 1. In this study, the calculated values of *K* (0.18 yr^{-1}) show that the species has a low growth rate. There is a very close relationship between growth rate (K) and L_∞. Beverton and Holt (1956) stated that natural mortality coefficient (M) was directly proportional to the growth coefficient (K) of a fish and inversely proportional to the asymptotic length (L_∞) and the life span. In simple words, fishes with higher growth coefficient have higher natural mortality and shorter life span; hence, those with larger L_∞ and lower growth coefficient have lower natural mortality and longer life span. This relationship is often affected by different factors such as temperature, or availability

Table 1. Summary of calculated parameters of *A. alcocki* in Pakistan waters.[a]

b	L_∞	K	ϕ'	t_0	Z	M	F
2.925	47.25	0.18	2.604	-0.189	1.07	0.494	0.576

[a] *b*= Slope of length-weight relationship; L_∞ = Asymptotic length; *K*= Growth coefficient; ϕ' = Growth performance index; t_0= Theoretical age at zero length; *Z*= Total mortality; *M*= Natural mortality, *F*= Fishing mortality.

of food. Food in a sufficient amount is a source for a fish to grow up towards maximum size, but rate of growth may not increase (Torcu-Koc, 2004).

Different methods and different data may be used to produce the different results. For the calculated VBGF growth coefficient, a non-parametric method is used in this research, which is usually used for the analysis of length frequency of fish that is fundamentally *ad hoc* and is not dependent on calculating the cohort distribution parameters directly. Hence, this does not draws a strong assumption regarding the distribution of sizes in the cohorts. Lengths of the model of every cohort are fixed to lie upon a curve described by growth models such as Von Bertalanffy growth model, thus, it makes a strong assumption about growth (Pitcher, 2002).

Mortality

The calculated results for *Z, M, and F* of *A. alcocki* from Pakistani waters are shown in Table 1. The mortality parameters show the death rate of the fish population, the rate of total mortality, natural mortality, and fishing mortality may not stay at a constant level and may vary from time to time (Gayanilo *et al.* 2003; Sparre and Venema, 1998). Even small variations in growth parameters can affect the calculated mortality rates (Tserpes and Tsimendis, 2001). Optimum Exploitation ratio (E) showing overfishing or not for a fish population is roughly 0.5 (Gulland, 1971). The calculated exploitation ratio for the species of 0.536 yr^{-1} is larger than 0.5, which shows that the stock of this species in the region may be under the pressure and not in a safe condition. When biological reference point was F_{opt} equal to *M* (0.494), current fishing mortality rate of 0.576 was larger than the target biological reference point, which again indicates that the stock of the *A. alcocki* may not be at a sustainable level.

Biological Reference Points

The biological reference points have been calculated as $0.494\, year^{-1}$ as in Patterson (1992). The analysis of yield per recruit (Figure 6) shows that when t_c was 1, $F_{\max}$ was 0.55 and $F_{0.1}$ was 0.45. Current age at first capture is about 1 year and $F_{current}$ was 0.576; which shows that the rate of current fishing mortality is larger than the biological reference point (F_{opt} 0.494). Hence, it is suggested that the fishing efforts in Pakistani waters for the species is not in a safe condition and fishery may not be sustainable. Since in the present study the available data is limited, it is a little difficult to compare the parameters of life history with those of other studies, i.e. in which different biological and ecological factors are involved in this process. As the life history parameters of *A. alcocki* can be affected by spatial and temporal differences, in this regard, our study may raise some concerns from the fishery science related community.

CONCLUSIONS

The present study reveals that stock of *A. alcocki* may not be in a sustainable condition. Even though the difference between biological reference point and fishing mortality is small, it would be better for the well-being of fishery that the fishery managers take necessary actions, particularly in the spawning season, in order to protect the stock of *A. alcocki* in Pakistani waters for the coming generations.

ACKNOWLEDGEMENTS

Authors are grateful to the Ministry of Ports and Shipping, Government of Pakistan and Director General, Marine Fisheries Department, Karachi. The first author is thankful to Chinese Scholarship Council

(CSC) for funding his PhD. degree. This work is supported by the special research fund of Ocean University of China (201022001).

REFERENCES

1. Baganel, T. B. and Tesch, F. W. 1978. Age and Growth. In: "*Methods for Assessment of Fish Production in Fresh Waters*", (Ed.): Baganel, T. B.. Blackwell Scientific Publications, Oxford, PP. 101-136.
2. Beverton, R. J. H. and Holt, S. J. 1956. A Review of Method for Estimating Mortality Rates in Exploited Fish Population, with Special Reference to Source of Bias in Catch Sampling. *Rapp. P. V. Reun. CIEM*, **140:** 67-83.
3. Beverton, R. J. H. and Holt, S. J. 1957. *On the Dynamics of Exploited Fish Populations.* Fishery Investigations Series II**,** Fisheries and Food, Ministry of Agriculture, London, 533 PP.
4. Bianchi, G. 1985. *Field Guide to the Commercial Marine and Brackish-Water Species of Pakistan.* FAO Species Identification Sheets for Fishery Purpose, Prepared with the Support of Pak/77/033 and FAO (FIRM) Regular Programmed, Rome, FAO, 200 PP.
5. Blackwell, B. G., Brown, M. L. and Willis, D. W. 2000. Relative Weight (W_r) Status and Current Use in Fisheries Assessment and Management. *Rev. Fish. Sci.*, **8(1):** 1-44.
6. Casatti, L. 2003. Family Sciaenidae (Drums or Croakers). In: "*Check List of the Freshwater Fishes of South and Central America*", (Eds.): Reis, R. E., Kullander, S. O. and Ferraris Jr., C. J.. EDIPUCRS, Porto Alegre, PP. 599-602.
7. Chao, N. L. 1978. A Basis for Classifying Western Atlantic Sciaenidae (Teleostie: Perciformes). NOAA Technical Report Circular, 415 PP.
8. Chao, N. L. 1986. A Synopsis on Zoogeography of the Sciaenidae. In: "*Indo-Pacific Fish Biology*", (Eds): Uyeno, T., Arai, R., Taniuchi, T. and Matsuura, K.. *Proceedings of the Second International Conference on Indo-Pacific Fishes,* The Ichthyologica Society of Japan, Tokyo, PP. 570-589.
9. FAO. 2009. Demersal Survey Report from Pakistani Waters from 29 October-6 November. 9 PP.
10. Fischer, W. and Bianchi G. 1984. *Western Indian Ocean (Fishing Area 51)*: *FAO Species Identification Sheets for Fishery Purpose.* Prepared and Printed with The Support of the Danish International Development Agency (DANIDA), FAO, Rome, PP. 1-6.
11. Froese R., 2006. Cube Law, Condition Factor and Weight-length Relationship, History, Meta-analysis and Recommendations**.** *J. Appl. Ichthyol.*, **22:** 241-253.
12. Froese, R. and Pauly, D. 2007. *Fish Base.* Version (01/2007), World Wide Web Electronic Publication, www.fishbase.org
13. Garcia, C. B., Buarte, J. O., Sandoval, N., Von-Schiller, D. and Najavas, P.1989. Length Weight Relationship of Demersal Fishes from the Gulf of Salmanea, Colombia. *Fish Byte*, **21:** 30-32
14. Gayanilo, F. C., Sparre, P. and Pauly, D. 1994. *The FAO–ICLARM Stock Assessment Tools (FISAT) User's Guide.* FAO Computerized Information Series 6, 186 PP.
15. Gayanilo Jr., F. C. and Pauly, D. 1997. *FAO-ICLARM Stock Assessment Tools (FiSAT).* Reference Manual Comparative Information Series (Fish), No. 8, Rome, 262 PP.
16. Gayanilo, F. C., Sparre, P. and Pauly, D. 2003. *FAO ICLARM Stock Assessment Tool (FiSAT-II).* User's Guide FAO Computerized Information Series (Fisheries), No. 8, FAO, Rome, 266 PP.
17. Gulland, J. A. 1969. *Manual of Methods of Fish Stock Assessment. Part I. Fish Population Analysis*. Fishery Resources and Exploitation Division, FAO, Rome, 154 PP.
18. Gulland, J. A. 1971. *The Fish Resources of the Oceans West By Fleet*. Surrey News (Books), Ltd. FAO, 255 PP.
19. Haddon, M. 2001. Growth of Individuals. In: "*Modeling and Quantitative Methods in Fisheries*". Chapman and Hall, CRC Press, Washington DC, USA, PP. 197-246
20. Haddon, M. 2011. *Modeling and Quantitative Methods in Fisheries*. Chapman and Hall, CRC Press, London, 449 PP.
21. Haimovici, M. and Velasco, G. 2000. Length Weight Relationship of Marine Fishes from Southern Brazil, Naga. *ICLARM,* **23:** 19-23.

22. Jaleel, S. A. and Khaliluddin, M.1972. *A Check List of Marine Fishes of West Pakistan.* Department of Marine Fisheries, Karachi, 16 PP.
23. Muhsan Ali, K., Liu, Q., Hussain Memon, Kh., Chang, M. S. and Jatt, A. N. 2013, Estimation of Maximum Sustainable Yield of Bombay Duck *Harpodon nehereus* Fishery in Pakistan Using CEDA and ASPIC Packages, *Pak. J. Zoo.*, **45(6):** 1757-1764.
24. Muhsan Ali, K., Liu, Q., Baradi, W., Sher Khan, P. and Hussain Memon, Kh. 2014, Growth and Mortality of Brushtooth Lizard Fish *Saurida undosquamis*, from Pakistani Waters, *Pak. J. Zool.*, **46(1):** 139-151.
25. Kohler, N., Casey, J. and Turner, P. 1995. Length-weight Relationship for 13 Species of Sharks from Western North Atlantic. *Fish. Bull.*, **93:** 412-414.
26. Le-Cren, E. D. 1951. The Length-weight Relationship and Seasonal Cycle in Gonad Weight and Condition Factor in the Perch (*Perca fluviatilis*). *J. Anim. Ecol.,* 20: 201-219.
27. Memon, Kh. H., Qun L., Muhsan A. K., Nabi, A., Zhang K., 2014. Maximum Sustainable Yield Estimates of Barramundi *Lates calcarifer* Fishery from Pakistani Waters. *Ind. J. Geo-Mar. Sci*, (Accepted, Unpublished).
28. Nelson, J. S. 2006. *Fisheries of the World.* 4th Edition, John Wiley, New Jersey.
29. Panhwar, S. K., Ghazala, S., Zarien, A., 2011. Reproductive Pattern and Some Biological Features of Anadromous Fish *Tenualosa ilisha* (Family *Clupeidae*) from Pakistan. *Ind. J. Geo. Mar-Sci.*, **40(5):** 687-696.
30. Patterson, K. 1992. Fisheries for Small Pelagic Species: An Empirical Approach to Management Targets. *Rev. Fish Biol. Fish.*, **2(4):** 321-338.
31. Pauly, D. 1980. On the Relationships between Natural Mortality, Growth Parameters and Mean Environmental Temperature in 175 Fish Stocks. *J. Cons. CIEM*, **39(3):** 175-192.
32. Pauly, D. 1983. *Some Simple Methods for Assessment of Tropical Fish Stocks*. Fisheries Technical Paper, 234, FAO, 52 PP.
33. Pauly, D. and Munro, J. I. 1984. Once More on the Comparison of Growth in Fish and Invertebrates. *Fish Byte*, **2:** 21-23.
34. Pauly, D. and Gayanilo Jr., F. C. 1997. A Bee: An Alternative Approach to Estimating the Parameters of a Length-weight Relationship from Length Frequency Samples and Their Bulk Weight. Research Report NAGA, ICLARM, Manila, Philippines.
35. Pitcher, T. J. and Hart, P. J. B. 1982. *Fishery Ecology.* Corm Helm, London, PP. 250-292.
36. Pitcher, T. J. 2002. A Bumpy Old Road: Size-base Methods in Fisheries Assessment. 2. In: "*Hand book of Fish Biology and Fisheries*", (Eds.): Hart, P. J. B. and Reynolds, J. D.. Blackwell Publishing, Oxford, PP. 189-210
37. Qasim, S. Z. 1982. Oceanography of the Pakistani Waters. *Deep Sea Res*., **29(9a):** 1041-1068.
38. Ricker, W. E. 1973. Linear Regression in Fisheries Research. *J. Fish. Res. Board Can.,* **30:** 409-434
39. Sasaki, K. and Kailola, P. J.1988. Three New Indo-Australian Species of the Sciaenid Genus *Atrobucca* with a Re-evaluation of Generic Limit, Japan. *J. Ichthyol.*, **35(3):** 261-277.
40. Snead, R. E. 1967. Recent Morphological changes along the coast of West Pakistan. *Ann. Ass. Amer. Geog.*, **57 (3)**: 550-565.
41. Sparre, P. and Venema, S. C. 1998. *Introduction to the Tropical Fish Stock Assessment*. Manual Fisheries Technical Report, 306, FAO, 407 PP.
42. Talwar, P. K. 1980. A New Species of *Atrobucca* (Pisces: Sciaenidae) from the Arabian Sea. *Bull. Zoological Surv. India*, **3(1-2):** 23-26.
43. Tesch, F. W. 1968. Age and Growth. In: *Methods for Assessment of Fish Production in Fresh Waters*", Blackwell Scientific Publications, Oxford, PP. 93-123.
44. Tesch , F. W. 1971. Age and Growth. In: "*Methods for Assessment of Fish Population in Fresh Waters*", (Ed.): Ricker, W. E.. Blackwell Scientific Publications, Oxford, UK, PP. 98-103.
45. Torcu–Koc, H., Turker-Cakir, D. and Dulcic, J. 2004. Age, Growth and Mortality of the Comber *Serranus cabrilla* (Serranidae) in the Edmerit Bay. *Cybium*, **28(1):** 19-25.
46. Trewavas, E. 1977. The Sciaenid Fishes of Indo-West Pacific. *Trans. Royal Soc. London*, **33:** 253-541.

[DOR: 20.1001.1.16807073.2016.18.3.9.1]

47. Tserpes, G. and Tsimendis, N. 2001. Age, Growth and Mortality of *Serranus cabrilla* (Linnaeus, 1785) on the Cretan Shelf. *Fish Res.,* **51:** 27-34.
48. Wooton, R. J. 1990. *Ecology of Teleost Fishes.* 1st Edition, ISBN-3, 9780412317200, Chapman and Hall, London, 404 PP.
49. Wooton, R. J. 1998. *Ecology of Teleost Fishes.* 2nd Edition, ISBN-13, 9780412642005, Kluwer Academic Publishers, Dordrecht, Netherland, 392 PP.

برآورد پارامتر های رشد و میرندگی ماهیان شوریده *Atrobucca alcocki* در آب های پاکستان

ک. ه. ممون، ک. لیو، م. ا. کالهورو، ک. نظیر، ب. واریانی، م. س. چانگ، و ا. نبی

چکیده

این پژوهش، در پنج نوبت بررسی ماهیان روکفزی با استفاده از تورکیسه ای در آب های پاکستان در اکتبر و نوامبر ۲۰۰۹ و ماه های اوت، اکتبر و نوامبر ۲۰۱۰ انجام شد. در مجموع، ۸۱۹ داده طول-وزن و ۷۲۴۰ داده ازطول-بسآمد (length-frequency) ماهیان شوریده جمع آوری شد که درآن ها طول ماهیان در محدوده ۱۰ تا ۴۵ سانتی متری بود که بیشترشان در گروه طولی ۱۹ تا ۲۹ سانتی متری بودند. وزن کل هر ماهی بین ۱۴ تا ۹۲۸ گرم بود. رابطه طول-وزن به صورت فرمول $W=0.012*L^{2.925}$ ($R^2=0.972$) قابل بیان بود. با استفاده از برنامه ELEFAN در بسته کامپیوتری FiSAT، پارامترهای تابع رشد von Bertalanffy محاسبه شد ومقدار L_∞برابر 47.25cm و $K= 0.180\ yr^{-1}$ به دست آمد. میرندگی کل (Z) با استفاده از تجزیه تحلیل طول تبدیل شده منحنی صید(length-converted catch curve analysis) برابر $Z=1.07\ yr^{-1}$ محاسبه شد. با میانگین سالانه گرمای سطح دریا برابر ۲۶ درجه سانتی گراد، میرندگی طبیعی درحد $M=0.494\ yr^{-1}$محاسبه شد واز این قرار میرندگی صید از این قرار بود: $F=Z-M= 0.576\ yr^{-1}$. نیز، برخه بهره برداری (E) به این صورت محاسبه شد: $E_{max}=0.421$، $E_{10}=0.355$، و $E_{50}=0.278$. تحلیل محصول در هر recruit آشکار ساخت که زمانی که t_c برابر ۲ فرض شود، F_{max} برابر ۰/۷۵ و $F_{0.1}$ *برابر* ۰/۶۰ خواهد بود. با فرض $t_c=1$، *مقدار* F_{max} =۰/۵۵ و$F_{0.1}=0/45$ محاسبه شد. سن ماهیان در صید اول تقریبا برابر یک سال و$F_{current}$= ۰/۵۷۶ بود بنا بر این، $F_{current}$ بزرگتر از $F_{0.1}$ و F_{max} بود. هنگامی که نقطه مرجع بیولوژیکی F_{opt} *برابر*M (۰/۴۹۴) فرض شد، نرخ میرندگی جاری *(۰/۵۷۶)* از نقطه مرجع بیولوژیکی مورد هدف بیشتر شد.