Resource evaluation, stock, growth and mortality of the Bombay duck (*Harpodon nehereus* Hamilton, 1822) fishery in the coastal waters of Pakistan

M T Kalhoro[a], M Yongtong*[,a], M A Kalhoro[b], S B H Shah[c], A M Memon[d], M Moshin[e] & M A Dahri[a]

[a]College of Fisheries, Fisheries Economics and Management, Ocean University of China, Qingdao – 266 003, China
[b]Faculty of Marine Science, Lasbela University of Agriculture, Water, and Marine Sciences, Uthal Balochistan – 90150, Pakistan
[c]College of Economics, Ocean University of China, Qingdao – 266 003, China
[d]Department of Fisheries Hyderabad, Government of Sindh – 71000, Pakistan
[e]College of International Finance and Trade, Zhejiang Yuexiu University of Foreign Languages, Shaoxing – 312 000, China

*[E-mail: ytmu@ouc.edu.cn]

Bombay duck, *Harpodon nehereus* (Hamilton, 1822), harvested mainly by dol nets, has been a prolific fishery in the northern Arabian Sea. Monthly length composition data for *H. nehereus*, landed at the Karachi Fish Harbor (KFH) from July 2014 to June 2015 was used to determine growth, mortality and stock evaluation. Total 2252 specimen with an average of 19.171 ± 2.659 cm TL (14 to 28 cm total length), an average of 45.254 ± 23.113 g of 9 to 174 g (total body weight) analyzed. The data used in FiSAT-II applying ELEFAN-I package for estimating population dynamics. The estimated the growth parameters of von Bertalanffy $L\infty = 29.40$ cm, $K = 0.610$ year^{-1} and $t_0 = -0.359$ year^{-1} with a phi $\varphi' = 2.722$. The length-weight relationship was $W = 0.001L^{3.477}$ ($R^2 = 0.918$) and $b > 3$ is described as positive allometric growth. Total mortality was calculated at $Z = 1.800$ year^{-1}, natural mortality estimated at $M = 1.276$ year^{-1} at 27 °C in addition, fishing mortality rate was 0.524 year^{-1} is not much higher than the safe level ($F_{opt} = 0.638$ year^{-1}) and a little below edge ($Fl_{imit} = 0.850$ year^{-1}) biological reference points. Due to mortality and exploitation rate ($E = 0.291 < 0.50$), the population stock and reserves were underutilized.

[**Keywords**: Arabian Sea, Growth, *Harpodon nehereus*, Mortality, Pakistan]

Introduction

Fisheries play a significant role in state financial system which provides employment and food to the common people. Recently fish catch is decreasing due to anthropogenic activities and illegal, unreported, and unregulated (IUU) fishing nets[1]. Pakistan coast is about 1120 km and divided into two parts including Sindh 348 km and Baluchistan 772 km (Fig. 1). Baluchistan coast is sharp, irregular between 12-32 km, bottom is generally rocky and also found few islands like Charna and Astole Island. Astola Island is declared as marine protected area due to special habitat and rich in biodiversity. Sindh coast has sandy and muddy bottom and the area extended 40 - 120 trawling ground and rich in mangroves and fisheries resources due to Indus River[1] (Fig. 1). *Harpodon nehereus* (Hamilton, 1822) Synodontidae family and commonly called as Bombay duck and is harvested mainly by Dol nets (stationary bag nets), has been a prolific fishery in the northern region of Arabian Sea, and key fishery resources of Pakistan. *H. nehereus* found at offshore deep waters on sandy and muddy bottom but also found at mouth of river during monsoon season[2]. Indus river freshwater creates suitable atmosphere for nursery for finfish, shellfish and other marine life[3]. Mostly fishery management is depending on estimating population dynamics, for example the length-weight relationships (LWR), growth and mortality, and exploitation parameters[4]. Different research work on different parameters has been conducted from Indian waters[5]. Some biological aspects and stock analysis have been studied from different area[6,7]. There are different studies on fish stock assessment have been conducted on different fish species. Like stock assessment of *Nemipterus* spp.[8,9], *Portunus* spp.[10,11], Lizardfishes[12-15], Indian scad, loligo and Indian oil sardine[16-19] from Pakistani waters. Results shows that stock of single fishery from Pakistani waters are over-exploitation state and suggests few management steps to maintain fish stock at a sustainable state.

Maximum sustainable yield study was conducted from Pakistani waters[15] but there was no work reported on length-weight and population dynamic parameters of Bombay duck fishery from Pakistani waters. The length-weight and length frequency
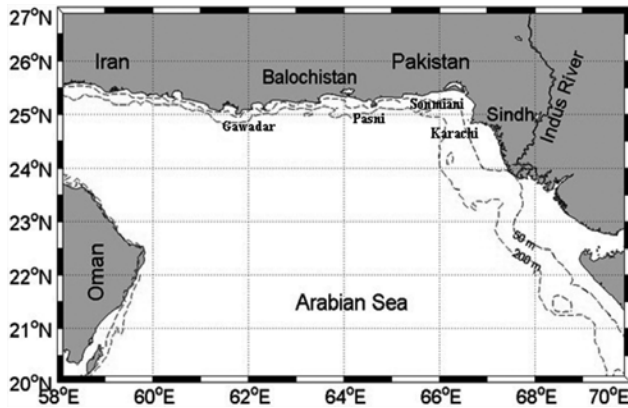
Fig. 1 — Pakistan coastline: showing fish harbors along Pakistan coast

distribution of Bombay duck were used from Pakistan for growth and mortality parameters using FISAT-II software. Present findings may be used for biological as well as fishery management particularly for this species.

Materials and Methods

Samples were collected on weekly bases during July 2014 to June 2015 from Karachi fish landing site. Fish samples brought to biological lab for further analysis and measurement. Total length and weight were analyzed in centimeters (cm) and grams (g), respectively.

Length weight relationship

Power function: $W = aL^b$ was used to determine the length-weight parameter of species. Total of 2252 pairs of length-weight relationship were measured as length (L) and weight (W) for *H. nehereus*. *W* is weight (g), *L* is length (TL) of fish in cm and *a* is constant condition factor and slope *b*.

Growth parameters

Von Bertalanffy growth function (VGBF) used to estimate length with age of *H. nehereus* using:

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

Where L_t was length at age *t*, L_∞ was asymptotic average maximum length, *K* was growth rate and t_0 was the hypothetical age at zero[20] calculated by empirical equation[21]:

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

Biological reference points

Biological reference points were calculated as: $F_{opt} = M$ following Gulland[22].

Mortality rate

The length-converted catch curve method was used to analyze total mortality $(Z)^{[21]}$, applying growth parameters (L_∞ and *K*).

Natural mortality was estimated following Pauly's formula as:

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

Where, L_∞ in cm and *K* is growth curve. T is sea surface temperature of Pakistani water at 27 °C. By subtract (M) from (Z) fishing mortality (F) was obtained, exploitation rate (E) was calculated from F/Z.

Virtual population analysis (VPA)

VPA for the *H. nehereus* was determined by using population parameter values into FiSAT software.

Growth performance index (phi)

phi, ϕ of *H. nehereus* was determined following Pauly and Munro[23] as:

$$\phi' = \log_{10} k + 2 \log_{10} L_\infty$$

Results

Length-weight relationship

Total 2252 pairs of length-weight pairs of *H. nehereus* were collected during July 2014 to June 2015, length and weight ranges from 14 to 28 cm and 15 to 151 g, respectively. The dominant length variety was 16 to 21 cm (Fig. 2). The average length and weight were 19.171 ± 2.659 cm TL (14 to 28 cm total length) an average of 45.254 ± 23.113 g of 9 to 174 g (total body weight) were examined. Relationship of length and weight was found at $W = 0.001L^{3.477}$ ($R^2 = 0.918$; Fig. 3).

Growth parameters

Length frequency data were analyzed using software FiSAT-II using the ELEFAN-I package for estimating population dynamics. The growth parameters of von Bertalanffy $L\infty = 29.4$ cm, K = 0.610 year^{-1} (Rn = 0.306) and t_0 = -0.359 year^{-1} (Fig. 4).

Biological reference points

Biological reference points was F_{opt} = 0.638 year^{-1}, which is less than exploitation rate and optimum fishing range.

Mortality rate

Total mortality (Z) calculated on basis of length converted catch curve and was found at Z = 1.800 year^{-1} (95 % CI = 1.65-1.95; Fig. 5). The black dots data selected for total mortality in which black dots
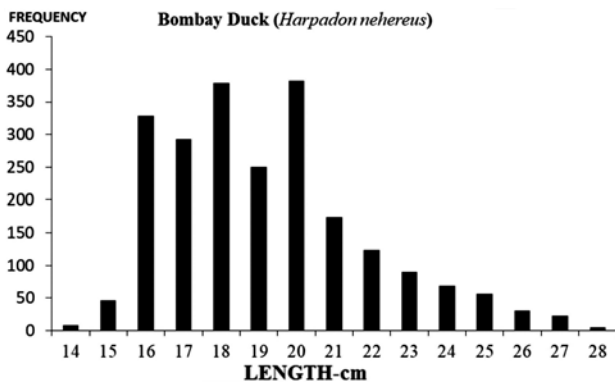

Fig. 2 — Length data of *H. nehereus* during 2014-2015 ranges from 14 to 28 cm (both sexes), where dominant length was from 16 to 21 cm
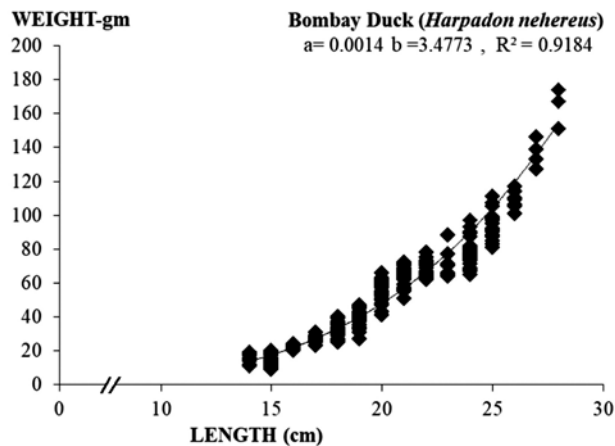

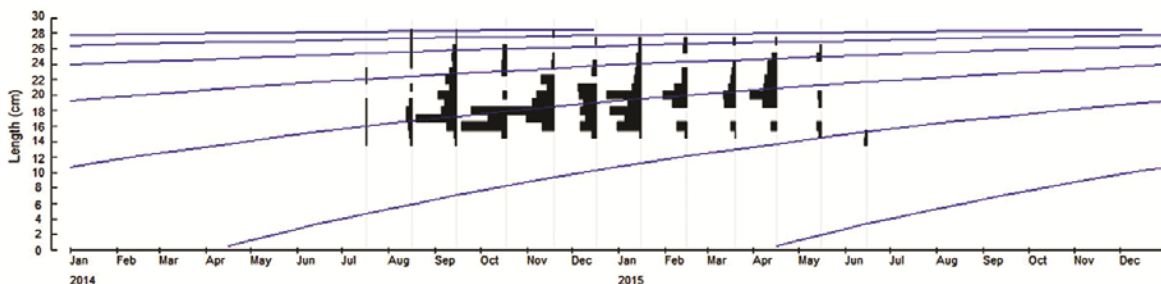Fig. 3 — LWR of *H. nehereus* from Pakistani waters during 2014-2015

representing the larger size of fishes while yellow dots showing smaller fish species. The larger size fish species were selected to estimate the total mortality. The natural mortality estimated using growth rate and average sea surface temperature (SST) at 27 ºC was M = 1.276 year^{-1}. Fishing mortality (F) and exploitation rate (E) was estimated at 0.524, 0.291 year^{-1}, respectively (Fig. 6) from Pakistani waters.

Virtual population analysis

The VPA shows that most of the fish catch pressure was on the fish size from 20 to 28 cm (Fig. 7).

Growth performance index

Phi (ϕ) of *H. nehereus* was computed as 2.604 in Pakistani waters.

Discussion

Length-weight relationship

Relation of length and weight data provide the basic information about growth state of fish[24]. This relationship can also be helpful to know fish feeding rate, maturity and metamorphosis[25]. This relation compares the fatness and wellbeing condition of fish[24]. Slope *b* equals to 3 describe isometric growth[23]. The values less than 3 means negative allometric and values greater than 3 means positive allometric growth[26]. The values equal to 3 means small fish and large fishes have same form of condition[27]. Beverton & Holt[28] reported that *b* values going away from 3 are unusual in larger fishes.

Present study of *b* values for *H. nehereus* was 3.477 (R^2 = 0.918), which shows the allometric growth of this from Pakistani waters. Gayanilo *et al.*[26] confirmed the slope *b* values ranged between 2.5 to 3.5, and current study results are in the range of those values. R^2 (R^2 = 0.918) or goodness of fit values from present study shows that the sample size of this study

Fig. 4 — Length distribution data and growth rate using ELEFAN method *for H. nehereus* during 2014-2015 (L∞ = 29.4 cm, K = 0.610 year^{-1})

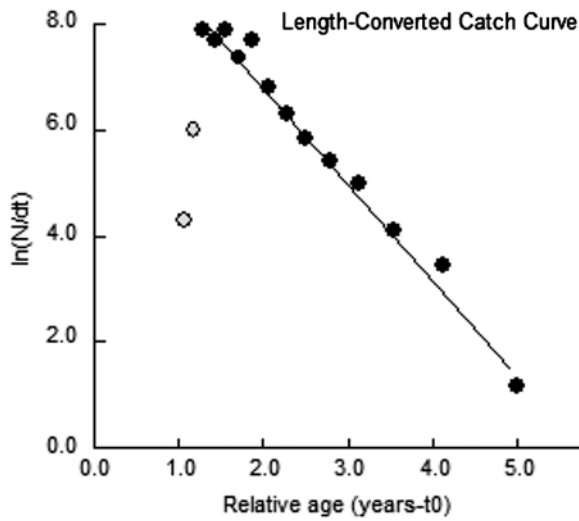Fig. 5 — Length converted catch curve method for estimating total mortality which is at Z = 1.800 year^{-1}

Table 1 — Comparison of LWR results with earlier findings from different regions

Reference	Region	*a*	*b*	r^2
Amrullah Taqwa *et al.*[31]	Indonesia	0.005	3.00	0.93
Sarker *et al.*[33]	Bay of Bangal	0.003199	3.00	-
Tasnuba Hasin[41]	Chittagong Bangladesh	0.02019	2.404	0.834
Asbar Laga *et al.*[39]	Tarakan Island, Indonesia	0.01	2.7	0.826
Shingadia[42]	Coastal waters of Mumbai	.006	2.9	0.89
Behera *et al.*[43]	West Bengal	0.000001	3.341	0.930
Ghosh *et al.*[6]	Saurashtra coast India	-2.271	3.024	0.93
Balli *et al.*[38]	Mumbai waters, India	-3.1362	3.606	0.9309
Amin[32]	Neritic water of Bangladesh	0.00243	3.051	0.99
Present study	Pakistan Arabian Sea	0.001	3.477	0.918

However, the values of length-weight relationship of *H. nehereus* are compared with previous studies from different areas (Table 1). The obtained exponential values of slope *b* from this study are similar to the previous studies. Differences in values may be because of different areas and different water quality and food availability and growth of fish conditions like age, sex and maturation[29].

Growth parameters

The VBGF method commonly used to estimate the growth parameters which are based on using length frequency data which depend on size of fish[30,31].

Estimated growth rate values were compared with previous studies from different regions (Table 2). Values from India was L∞ = 42.5 and K = 0.761 year^{-1} and L∞ = 35.39 cm and 0.86 year^{-1} [ref. 6], from Bangladesh L∞ = 24.48 cm and K=1.50 and L∞=45.05 and K=1.30 year^{-1}[refs. 32,33], from Taiwan L∞ = 62.24, K = 0.143 year^{-1}[ref. 34]. The obtained result from present study (L∞ = 29.4 cm, K = 0.610 year^{-1}). The Rn shows the goodness of growth model in present study the values (Rn = 0.306) shows the model is suitable for to estimate the growth parameters. Generally, fishes having high K have high natural mortality (M) and shorter life span. It clearly shows that the L∞ values from India and Taiwan are higher than the present study but those from Bangladesh are lower. Generally, related values are showing in Table 2 which shows the difference in values some are close or similar with the present study and some values are higher than present study.
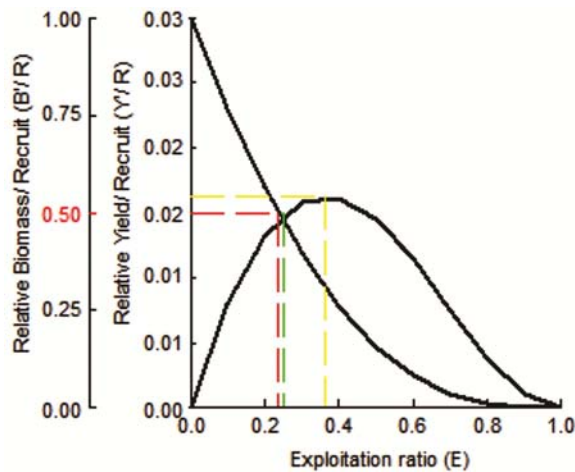

Fig. 6 — Exploitation rate of *H. neherus* was estimated and found at 0.291 year^{-1} showing in red line
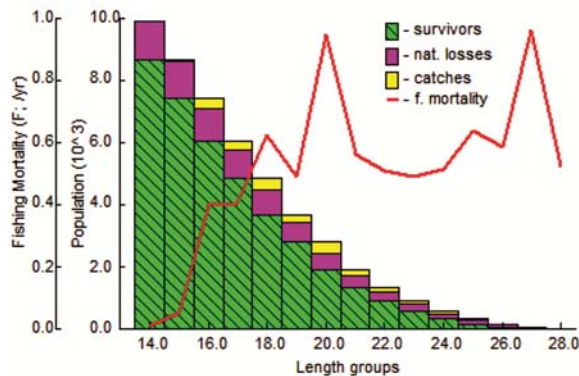

Fig. 7 — The VPA of *H. nehereus* from during 2014-2015

is reliable and samples collected from different fish landing sites represent the size class of this species from Pakistani waters.

Table 2 — Comparison of reported growth parameters values of *H. nehreus* with present study from Pakistani waters

Reference	Research area	K	L∞	ϕ
Amrullah et al.[31]	Indonesia	0.93		-
Sarker et al.[33]	Bay of Bangal	1.30	45.05	2.58
Hasin[41]	Chittagong Bangladesh	0.978	25.4	-
Asbar et al.[39]	Tarakan Island waters, Indonesia	0.51	27.878	0.80
Hitesh et al.[42]	Coastal waters of Mumbai	0.936	22.8	-
Behera et al.[43]	West Bengal	0.930	26.9	3.30
Ghosh et al.[6]	Saurashtra coast India	0.86	35.39	3.25
Balli et al.[38]	Mumbai waters, India	1.225	25.5	-
Amin[32]	Neritic waters of Bangladesh	1.50	24.48	3.50
Mustafa et al.[44]	Kutubdia channel of Bangladesh	1.5	24.48	3.27
He et al.[45]	Min River Estuary, East China Sea	0.94	26.9	3.27
Liao & Lin[34]	Taiwan	1.30	45.05	-
Present study	Pakistan Arabian Sea	0.610	29.4	2.604

K = growth curve, L∞ = Length infinity, ϕ = growth performance index

Small differences may be due the different sizes of samples. The growth performance index values are similar to the present study. The growth of fish can also be affected by the temperature, which affects the physiological process, food, transformation, metabolism and excretion of fish[35].

Mortality rate

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[36]. Even small variations in growth parameters can affect the calculated mortality rates[37]. The length converted catch curve was used to estimate the total mortality, and Pauly empirical formula used to calculate the natural mortality. The estimated mortality rate values from present study (Z = 1.80, M = 1.276, F = 0.524 and E = 0.291 year^{-1}) is compared to previous studies from different parts of the world. The mortality rate values from India (M = 1.52, F = 1.73, Z = 3.25 and E = 0.53)[6], M = 1.30, F = 3.03 and Z = 4.339, from Bangladesh was M = 2.46, F = 3.27, Z = 5.73 and E = 0.57[ref. 38]; M = 1.86, F = 2.58, Z = 4.44 and E = 0.58241[ref. 33], from Indonesia the mortality values were M = 0.51, F = 2.05, Z = 2.56 and E = 0.80[ref. 39].

The values of total mortality Z were calculated by using the length converted catch curve supposing that mortality is consistent with age and that collected samples were illustrative of the age groups considered. The mortality values from previous studies are higher than the present study which may be due to difference in sample size or fishing methods used in different areas., It may also be assumed that the commercial values of this species is higher than Pakistan. Gulland[22] and Patterson[40] described that if the exploitation rate (E) values should be lower than 0.4 year^{-1} than it may be considered at sustainable state. According to the present study the exploitation rate (E = 0.291) shows that the stock of this species is in sustainable state or underutilized. According to present finding it may also be suggested that fishing efforts could be utilized to catch this species to give less stress on other fish species in the Pakistani waters.

Conclusion

Present study is conducted using length-weight and length frequency distribution data from Pakistani waters. The length-weight and growth parameter values are similar to previous studies from different areas of the world. The little difference maybe because of some environmental factors effacing and availability of food may be an effect on the growth of this fish. It is also found that the mortality parameter values and exploitation rate from other area is higher than the present study which clearly defines that the fishing efforts for this particular fishery are very low. The probable reason for the same maybe because the commercial importance of this fishery is very low for the export as well as for the local consumption.

The fishery managers need to set the fishing season, individual fisheries catch in a particular season to catch specific fishes. According to previous studies from Pakistani waters shows that the stock is over-exploited which means the fishermen need to catch such kind of species which is underutilized and export to different countries and local consumption which created their economic value of this fishery in Pakistan.

Conflict of Interest

The authors declare that they have no competing or conflicts of interest to influence the work reported in this paper.

Author Contributions

MTK and MY: Conceptualization, Formal analysis, Funding acquisition, Investigation, Resources, Software, Supervision, Roles/Writing - original draft; MAK, SBH, AMM, MM and MAD: Writing - review & editing.

References

1 FAO, Fishery and Aquaculture Country Profiles, Pakistan (2009), Country Profile Fact Sheets, In: *FAO Fisheries and Aquaculture Department [online]* (Rome), 2009, pp. 1-18. http://www.fao.org/fishery/ , Accessed 5 June 2018.

2 Frimodt C, Multilingual illustrated guide to the world's commercial warm water fish, (Fishing News Books, Osney Mead, Oxford, England), 1995, pp. 215.

3 Ahmed M, Abbas G, Abundance of finfish and shellfish juveniles in the tidal creeks of Bhanbhore, Sindh (Pakistan), *Pak J Zool*, 31 (1999) 129-140.

4 Jellyman P G, Booker D J, Crow S K, Bonnett M L & Jellyman D J, Does one size fit all? An evaluation of length–weight relationships for New Zealand's freshwater fish species, *N Z J Mar Freshw Res*, 47 (4) (2013) 450–468.

5 Kalhoro M A, Liu Q, Memon K H, Chang M S & Jatt A N, Estimation of maximum sustainable yield of Bombay duck, *Harpodon nehereus* fishery in Pakistan using the CEDA and ASPIC packages, *Pak J Zool*, 45 (6) (2013) 1757-1764.

6 Ghosh S N G K P & Dhokia H K, Fishery and population dynamics of *Harpadon nehereus* (Ham.) off the Saurashtra coast, *Indian J Fish*, 1 (56) (2009) 13-19.

7 Putri R E, Samiaji J & Nurrachmi I, The pattern of growth and maturity index of Lomek fish (*Harpodon nehereus*) in Dumai waters, Riau, (Library of Riau University, Indonesia), 2013, pp. 53.

8 Kalhoro M A, Tang D, Ye H J, Morozov E, Liu Q, *et al.*, Population dynamics of Randall's threadfin bream *Nemipterus randalli* from Pakistani waters, Northern Arabian Sea, *Indian J Geo-Mar Sci*, 46 (03) (2017) 551-561.

9 Kalhoro M A, Liu Q, Memon K H, Chang M S & Zhang K, Population dynamics of Japanese threadfin bream *Nemipterus japonicus* from Pakistani waters, *Acta Oceanol Sin*, 10 (33) (2014) 49-57.

10 Afzaal Z, Kalhoro M A, Buzdar M A, Nadeem A, Saeed F, *et al.*, Stock Assessment of Blue Swimming Crab *Portunus pelagicus* (Linnaeus, 1758) from Pakistani Waters (Northern, Arabian Sea), *Pak J Zool*, 48 (5) (2016) 1531-1541.

11 Kalhoro M A, Tang D, Ye H J, Evgeny M, Wang S, *et al.*, Fishery appraisal of *Portunus* spp. (Family Portunidae) using different surplus production models from Pakistani waters, northern Arabian sea, *Pak J Zool*, 50 (1) (2018) 135-141.

12 Kalhoro M A, Liu Q, Memon K H, Waryani B & Soomro S H, Maximum sustainable yield of Greater lizardfish *Saurida tumbil* fishery in Pakistan using CEDA and ASPIC packages, *Acta Oceanol Sin*, 2 (34) (2015) 68-73.

13 Kalhoro M A, Liu Q, Valinassab T, Waryani B, Abbasi A R, *et al.*, Population dynamics of Greater Lizardfish, *Saurida tumbil* from Pakistani waters, *Pak J Zool*, 4 (47) (2015) 921- 931.

14 Kalhoro M A, Liu Q, Waryani B, Panhwar S K & Memon K H, Growth and mortality of Brushtooth lizardfish *Saurida undosquamis* from Pakistani waters, *Pak J Zool*, 1 (46) (2014): 139- 151.

15 Kalhoro M A, Liu Q, Memon K H, Chang M S & Jatt A N, Estimation of maximum sustainable yield of Bombay duck, *Harpodon nehereus* fishery in Pakistan using the CEDA and ASPIC packages, *Pak J Zool*, 6 (45) (2013) 1757-1764.

16 Kalhoro M T, Yongtong M, Kalhoro M A, Mahmood M A, Hussain S S B, *et al.*, Stock assessment of Indian Scad, *Decapterus russelli* in Pakistani marine waters and its impact on the national economy, *Fish Aqua J*, 2 (8) (2017) 1-10.

17 Soomro S H, Liu Q, Kalhoro M A, Memon A M, Syed B S, *et al.*, Maximum sustainable yield estimates of Indian Squid *Urotheuthis* (*Photoligo*) *duvaucelli* (D' Orbigny, 1835) from Pakistani waters using ASPIC and CEDA software, *Lasbela Uni J Sci Tech*, 1 (4) (2015) 1-9.

18 Soomro S H, Liu Q, Kalhoro M A, Memon K H, Zhang K, *et al.*, Growth and mortality parameters of Indian squid *Urotheuthis* (*Photoligo*) *duvaucelli* (D' Orbigny, 1835) from Pakistani waters (Arabia Sea) based on length frequency data, *Indian J Geo-Mar Sci*, 44 (10) (2015) 1598-1603.

19 Nadeem A, Kalhoro M A, Buzdar M A, Tariq S, Shafi M, *et al.*, Growth, mortality and exploitation rate of *Sardinella longiceps* (Valenciennes, 1847) from Pakistani waters based on length frequency distribution data, *Indian J Geo-Mar Sci*, 46 (08) (2017)1693 -1703.

20 Haddon M, *Modelling and Quantitative Methods in Fisheries*, (Chapman & Hall/ CRC, London), 2010, pp. 465.

21 Pauly D, *Some simple methods for the assessment of tropical fish stocks*, (Food and Agriculture Org) 1983, pp. 52.

22 Gulland J A, *Manual of methods for fish assessment - part 1, fish population analysis*, 1969. http://www.fao.org/docrep/x5685e/x5685e00.htm. Accessed 5 June 2018

23 Pauly D & Munro J L, Once more on the comparison of growth in fish and invertebrates, *Fishbyte*, 2 (1) (1984) 1-21.

24 Laska M S & Wootton J T, Theoretical concepts and empirical approaches to measuring interaction strength, *Ecology*, 79 (2) (1998) 461-476.

25 Le C E, The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (*Percaflu viatilis*), *J Anim Ecol*, 20 (2) (1951) 201–219.

26 Gayanilo J F C, Sparre P & Pauly P, *FiSAT*: FAO-ICLARM stock assessment tools, User's manual, Computerized Information Series: Fisheries (FAO, Rome), 1996, pp. 126.

27 Froese R, Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations, *J Appl Ichthyol*, 22 (4) (2006) 241–253.

28 Beverton R & Holt S, A review of the lifespans and mortality rates of fish in nature, and their relation to growth and other physiological characteristics, In: *Ciba Foundation Colloquia on Ageing - The Lifespan of Animals*, edited by W Gew & M O'Conner (John Wiley & Sons, Chichester), 1959, pp. 142–180.

29 Bagenal T B, *Age and growth, Methods for assessment of fish production in fresh waters*, 1978, pp.101-136.

30 Pitcher T J, A Bumpy Old Road: Size-Based Methods in Fisheries Assessment, *Handbook of Fish Biology and Fisheries*, 2002, pp. 189-210.

31 Amrullah T, Comparison of Length-Weight Relationship of Bombay Duck (*Harpadon nehereus*) between Juata and Amal, *Int J Curr Res Biosci Plant Biol*, 5 (8) (2018) 11-14.

32 Nurul-Amin S M, Studies on Age and Growth, VPA Analysis and Relative Condition Factor of *Harpodon nehereus* (Ham-Buch) from the Neritic Water of Bangladesh, *Online J Biol Sci*, 1 (4) (2001) 192-194.

33 Sarker, Population Dynamics of Bombay Duck *Harpodon nehereus* (Hamilton, 1822) Of The Bay Of Bengal Along Bangladesh Coast, *Bangladesh J Zool*, 45 (2) (2017) 101-110.

34 Liao Y Y & Lin Y T, Age and Growth of the Bombay-duck (*Harpadon microchir*) in the Waters off Southwestern Taiwan, *J Fish Soc Taiwan*, 37 (2) (2010) 121-134.

35 Otterson G, Kim S, Hue G, Polovina J J & Stenseth N C, Major pathways by which climate may force marine fish populations, *J Mar Syst*, 79 (3) (2010) 343-360.

36 Gayanilo F C, Sparre P & Pauly P, *FiSATII: FAO-ICLARM stock assessment tools II*, user's manual, (FAO, Rome), 2005, pp. 168.

37 Tserpes G & Tsimenidis N, Age, growth and mortality of *Serranus cabrilla* (Linnaeus, 1785) on the Cretan shelf, *Fish Res*, 51 (2001) 27-34.

38 Balli J J, Chakraborty S K & Jaiswar A K, Biology of Bombay duck, *Harpodon nehereus* (Ham., 1822),

from Mumbai waters, India, *Indian J Fish*, 9 (33) (2006) 1-10.

39 Asbar L, Growth and Exploitation Rate of the Bombay duck (*Harpodon nehereus* Hamilton, 1822) (Fish: Synodontidae) in Tarakan Island Waters, Indonesia. *IJSBAR*, 22 (1) (2015) 341-353.

40 Patterson K, Fisheries for small pelagic species: An empirical approach to management targets, *Rev Fish Biol Fisher*, 2 (4) (1992) 321-338.

41 Tasnuba H, Length-weight relationship and condition factor of Bombay duck *Harpadon nehereus* from landings of fishery ghat, Chittagong, *Res Agric Livest Fish*, 3 (2) (2016) 355-360.

42 Hitesh U S, Biometric & Fecundity Studies of *Harpodon nehereus* (Ham-Buch) From Coastal Waters of Mumbai, *Rev Res*, 1 (3) (2014) 1-8.

43 Behera S, Biswas B K, Kumar S & Gogoi R, Length-weight relationship and condition factors of Bombay duck, *Harpadon nehereus* from estuarine region of Kakdwip West Bengal, *J Bio Inno*, 4 (2) (2015) 59-66.

44 Mustafa M G, Zafar M, Matin A K M A & Amin S M N, Population dynamics of *Harpodon nehereus* (Ham.-Buch.) from the Kutubdia channel of Bangladesh, *Bangladesh J Fish Res*, 2 (1) (1998) 83-90.

45 He X, Li J, Shen C, Shi Y, Feng C, *et al.*, Length-Weight Relationship and Population Dynamics of Bombay Duck (*Harpadon nehereus*) in the Min River Estuary, East China Sea, *Thalassas: Int J Mar Sci*, 35 (1) (2019) 253-261.