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Population Characteristics and Biological Reference Point Estimates for Two Carangid Fishes, *Megalaspis cordyla* and *Scomberoides tol,* in the Northern Arabian Sea Coast of Pakistan

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ABSTRACT

Torpedo trevally, *Megalaspis cordyla* and needle scaled queenfish, *Scomberoides tol* are important fishery resource in the northern Arabian Sea coast of Pakistan. This study on population characteristics and dynamics of both fishes will provide data for developing strategy for its conservation. Fish were sampled from commercial vessels operated in the Pakistan coasts between July 2013 and June 2014. The samples included 293 trevally scad, *M. cordyla*, and 353 needle scaled queenfish, *S. tol*. The sex ratio of *M. cordyla* was female biased with 175 females (59.73%) and 118 males (40.27%), this sex difference was not statistically significant (χ^2=11.088, df=1, P= <0.05). The sex ratio of *S. tol* was also female biased with 222 females (62.9%) and 131 males (37.1%) sampled, but this difference was also not statistically significant (χ^2=23.46, df=1, P= <0.05). von Bertalanffy growth function estimated for *M. cordyla* was L_t= 48.3TL^{cm} [1–e – 0.73(t – 0.148)] and for *S. tol* L_t = 70.3TL^{cm} [1 – e – 0.37 (t – 0.152)]. The natural, fishing and total mortalities were estimated for *M. cordyla* at 1.23, 1.38, 2.62 and for *S. tol* 0.71, 1.86, 2.58. The biological reference points (BRP) F_{opt}, F_{limit} were estimated to determine appropriate management measures for sustainable utilization of these species. Biological reference points estimates and current catch statistics indicates that these stocks have been fished below the level that would support MSY.

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NQ collected fishery data, analyzed and wrote article. SKP designed study and helped in data analysis. SB helped in manuscript writing.

Key words
Needled scale queenfish, torpedo trevally, biological reference point, overharvest, Pakistan

INTRODUCTION

The coast of Pakistan is home to forty two carangid species, which are pelagic schooling fishes, mainly caught close to shore and are widely distributed throughout the Western Indian Ocean and Western Pacific, from Japan to Australia and eastward to Fiji (Bianchi, 1985; Nelson, 2006). The genus *Scomberoides* is the most abundant within the group, with torpedo scad, *Megalaspis cordyla* (Linnaeus, 1758) also important in Pakistan. The needlescaled queenfish, *Scomberoides tol* (Cuvier, 1832) and *M. cordyla* are important food fishes, with market values in 2014 ranging from 0.4 to 1.20 USD/Kg (*M. cordyla*) and 0.5 to 1.50 USD/Kg (*S. tol*), depending on the quality of the fish. Fisheries statistics data recorded an average landing of 5,303 MT of *M. cordyla* from 1999 to 2009 in Pakistan. The data show that *Scomberoides* catch has declined from 17,779 MT in 1999 to 9,072 MT in 2009 (Handbook. MFD, 2009).

In western Indian Ocean, *M. cordyla* capture production decreased from 34,55t in 2004 to 33,28t in 2010, whereas *S. tol* production increased from 184t in 2004 to 262t in 2010. A number of authors have investigated the morphometry, length-weight relationship, population dynamics and biology of carangid species (Sivakami, 1995; Kasim, 1996; Zafar *et al*., 2000; Saker *et al*., 2004; Panda *et al*., 2012; Panhwar *et al*., 2014; Qamar *et al*., 2015). The biological characteristics such as age, growth and mortality of the fish stocks can be estimated with some basic stock assessment tools and are easy to interpretable (Jennings *et al*., 2001). Moreover, these tools enable us to predict stock status and sustainable exploitation of the resource (Hilborn and Walters, 1992). The fish population can undergo various biological changes in response to being fished, which may include changes in total numbers, total biomass, size and age structure and spatial distribution.

Although *M. cordyla* and *S. tol* are important in carangid landings in Pakistan, there is little information available on their biology and population dynamics for stock assessment. Gaining an understanding of growth, mortality and population exploitation rates would assist in implementation of management practices for the sustainable use of the resource.

This study aims to establish key population parameters and biological characteristics for *M. cordyla*

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and *S. tol*, two economically important carangids in the north Arabian Sea coast of Pakistan.

MATERIALS AND METHODS

Two hundred and ninety three *M. cordyla* and 353 *S. tol* were sampled from the Pakistani coast by commercial trawlers from July 2013 to June 2014. Total length (TL in cm), fork length (FL in cm), standard length (SL in cm), and total wet weight (TW in g) were collected.

The length-weight relationship was calculated using the equation $W = aL^b$, where W is the total weight, L is the fork length, and *a* and *b* are shape parameters (Ricker, 1975). Length-weight relationship parameters were estimated on the linearized form of the above equation. The sex ratio was calculated for both species based on the histological examination of each gonad. A chi square χ^2 test was applied to determine whether the ratio was significantly different from 1:1.

Growth parameters were estimated from the von Bertalanffy growth equation, $L_t = L_\infty [1 - e - k (t - to)]$, where L_t is the length at time *t*; L_∞ is the asymptotic length; K is the growth coefficient and *t* is the hypothetical time at which length is 0 (von Bertalanffy, 1938; Sparre and Venema, 1992).

Relative condition factor *(Kn)* was estimated with the equation

$$K_n = \frac{W}{\hat{W}}$$

Le Cren (1951), where *w* is observed weight and $\hat{W}$ is the calculated weight from length-weight equation above. Monthly relative conditon factor (*Kn*) was calcualted seperately for males and females of *M. cordyla* and *S. tol* (Fig. 1).

Estimation of natural (*M*), fishing (*F*) and total (*Z*) mortalities were conducted using Pauly's equation (Pauly, 1980a, b) based on length-converted catch curves. Catch curves were obtained by pooling monthly length frequency data using natural logarithm (*ln*) of the number of individuals (*N*) in age groups. Age group abundances, in turn, were plotted against their relative age (*t*) (Pauly, 1983; Moses, 1988) to obtain catch curves. Natural mortality was estimated with the equation $\log_{10}M = 0.0066–0.279 \log_{10} L_\infty + 0.6543 \log_{10} k + 0.4634 \log_{10} T$, where *T* = the average annual sea surface temperature (SST = 26°C) recorded in the coastal water of Pakistan. The fishing mortality (*F*) was obtained by subtracting *M* from *Z* and exploitation ratio (*E*) was obtained from

$$\frac{F}{Z}.$$

Monthly recruitment was estimated to determine entrance of new individuals in the population. The initial exploitation rate (IER) was calculated using Beaverton and Holt's (1957) $U = F (1–\exp(-Z))/Z$. Optimum (F_{opt}) and maximum (F_{limit}) fishing mortality biological reference point were estimated for the target species. The biological reference points (BRP) were estimated using

$$F_{opt} = 0.5\ M \text{ and } F_{limit} = \frac{2}{3} * M.$$

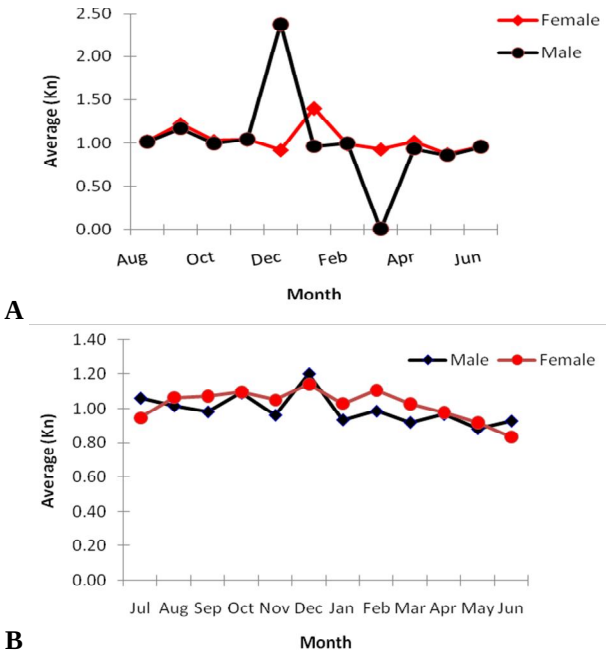

Fig. 1. Relative condition factor estimated for *M. cordyla* (A) *S. tol* (B).

RESULTS

The overall female to male sex ratio for *M. cordyla* was 1:1.7 (59.73% females and 40.27% males). Females showed a higher proportion from October to March (χ^2=11.088, df =1, P = <0.10; Table I). The overall female to male sex ratio for *S. tol* was 1:1.6 (62.9% females and 37.1% males). No statistical differences in monthly sex ratios were observed (χ^2=23.46, df =1, P =< 0.05) (Table I).

Eight size-classes (18.0 to 49.9 cm) were assigned to the sample of *M. cordyla*. The highest number (91) of individuals was observed in the 22.0-25.9 cm size-class and the lowest in the 42.0-45.9 and 46.0-49.0 size-classes with one and two individuals, respectively. The length of first capture was estimated to be 18.94 cm for *M. cordyla* and 15.68 cm for *S. tol* (Table II). All the individuals of *S. tol* were grouped into sixteen size-classes, whereas, 88

percent individuals were recorded in 22.0 to 45.9 cm size (Table II).

Table I.- Monthly sex ratios of *M. cordyla* and *S. tol* sampled from the Northern Arabian Sea along the Pakistan coasts between July 2013 and June 2014.

Months	*M. cordyla*		*S. tol*	
	Total	Proportion of males	Total	Proportion of males
July	-	-	23	0.43
August	32	0.68	21	0.52
September	22	0.69	24	0.25*
October	27	4.4*	36	0.44
November	35	0.52	29	0.24*
December	38	0.19*	71	0.46
January	46	0.53*	16	0.44
February	20	0.43*	16	0.19*
March	13	0*	45	0.38
April	23	1.3	32	0.31*
May	15	0.67	33	0.27*
June	22	2.14	7	0.29*
Total	293		353	

*Significant at 0.10 *P*-value

The length-weight relationship estimated for *M. cordyla* indicated that growth was allometric, with a regression fit of over 0.65 (Table V) and *S. tol*, on the other hand, had isomeric growth, with an R^2 of over 0.95 (Table V).

The highest *Kn* (2.38) was in December for *M. cordyla*, whereas in the remaining months *Kn* was below 0.8. The highest Kn for *S. tol* was also observed in December (1.14) and the lowest in June (0.83).

Estimated value of *K* (the growth coefficient) for *M. cordyla* was 0.77 and for *S. tol* was 0.37 (Table IV).

The M, F, and Z were estimated as 1.23, 1.38 and 2.62 for *M. cordyla* and 0.71, 1.86 and 2.58 *S. tol*, respectively (Table VII, Fig. 2). The F of 1.38 and 1.86 estimated for *M. cordyla* and *S. tol* were substantially greater than an optimum targets of F_{opt}=0.49 and F_{limit}=0.65.

Annual recruitment of *M. cordyla* increased in the Boreal winter (Fig. 3), whereas *S. tol*, peak recruitment occurred in both, boreal fall and winter (Fig. 3).

DISCUSSION

This study has established key population parameters and biological characteristics of two important carangid stocks exploited in the North Arabian Sea in Pakistan. The overall sex ratios in the population

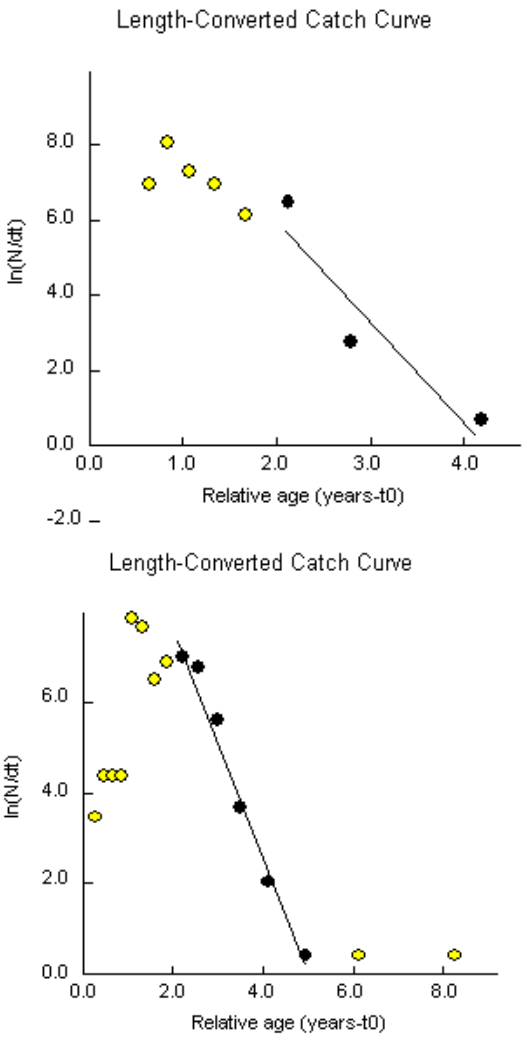

Fig. 2. Length-converted catch curve for *M. cordyla* (A), *S. tol* (B) estimated in the present study. A: L_∞ = 48.3cm and k =0.73 per year; B: L_∞ = 70.35cm and k = 0.37 per year.

of *M. cordyla* and *S. tol* deviated from an expected 1:1 ratio, favoring females, but these differences were not statistically significant. Even though there was no statistically significant difference in the sex ratio for either species, the differences could still be biologically significant. Nevertheless, biased sex ratios may be due to sex-specific migration, differences in growth or mortality rates or sex-specific selectivity of the fishing gear. There were no statistical significant differences in the length-weight relationships between males and females of *M. cordyla* or *S. tol*. Estimated slope (*b*) for males and females of *M. cordyla* showed allometric growth. *M. cordyla* populations assessed from Mumbai (Saker *et al.*,

Table II.- Monthly size-class intervals in the population of *M. cordyla* and *S. tol* sampled from the Northern Arabian Sea along the Pakistan coasts between July 2013 and June 2014.

Month	18.0-21.9	22.0-25.9	26.0-29.9	30.0-33.9	34.0-37.9	38.0-41.9	42.0-45.9	46.0-49.9
M. cordyla								
August	14	3	2	11	0	1	0	1
September	1	0	1	16	0	4	0	0
October	0	11	13	2	0	0	1	0
November	4	16	6	4	4	1	0	0
December	2	21	2	9	4	0	0	0
January	3	16	3	2	5	17	0	0
February	3	13	1	0	0	3	0	0
March	0	5	4	0	2	2	0	0
April	0	0	14	0	3	6	0	0
May	0	0	2	0	4	9	0	0
June	0	6	2	2	3	8	1	0
Total	**27**	**91**	**50**	**46**	**25**	**51**	**2**	**1**
S. tol								
July	0	1	4	3	2	4	7	2
August	0	0	15	2	0	0	4	0
September	0	2	7	5	0	0	5	4
October	0	0	7	3	4	16	6	0
November	0	1	0	8	14	3	3	0
December	16	36	17	0	0	1	0	0
January	1	2	1	1	5	6	0	0
February	0	4	10	1	1	0	0	0
March	0	14	6	1	12	7	2	2
April	0	18	1	0	0	1	3	7
May	0	1	4	1	1	12	13	1
June	0	0	0	0	1	1	3	1
Total	**17**	**79**	**72**	**25**	**40**	**51**	**46**	**17**

Table III.- Parameters of regression coefficient (CI-confidence intervals, a-intercept, b-slope) estimated for *M. cordyla* and *Scomberoides tol.*

	a	*b*	CI of *a*	CI of *b*	Standard error of *b*	R^2
Megalaspis cordyla						
♀(175)	-2.814	2.499	-1.7	2.23-2.75	0.131	0.675
♂(118)	-3.846	2.822	-1.28	2.62-3.01	0.09	0.875
Scomberoides tol						
♀ (222)	-4.654	3	-0.4	2.904-3.023	0.03	0.978
♀ (131)	-4.542	2.9	-0.67	2.824-3.028	0.051	0.961

Table IV.- Population parameters estimated for *M. cordyla* and *S. tol.*

Species name	Parameters								
	L_∞	K	M	F	Z	t_0	U	E	Lc
M. cordyla	48.3	0.73	1.239	1.381	2.62	-0.148	0.49	0.53	18.942
S. tol	70.35	0.37	0.715	1.865	2.58	-0.152	0.67	0.72	15.689

2004) showed similar results, whereas for *M. cordyla* assessed from India and Bangladesh growth was isometric (Panda *et al*., 2011; Zafar *et al*., 2000).

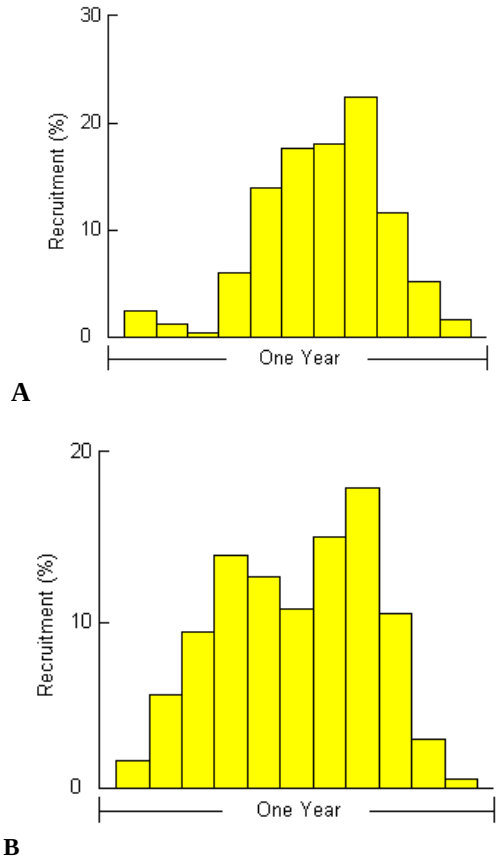

Fig. 3. Percentage recruitment calculated round the year in the population of *M. cordyla* (A) and S. *tol* (B) in this study.

In general, short lived fish species reach their asymptotic lengths in the first few years of life and are characterized by a high value of K (the growth coefficient). In the present study asymptotic length (L_∞) of *M. cordyla* was similar to the range provided by (Reuben *et al*., 1992), but smaller than that provided by (Jaiswar *et al*., 1994; Kasim, 1996) and higher than (; Zafar *et al*., 2000; Panda *et al*., 2012; Jadhav and Mohite, 2013). This difference may be due to the ecological characteristics such as habitat, fish adaptive life pattern and location that directly affect the growth rate. Moreover, sampling methods and population size also influencing the growth parameters (Adam, 1980).

In this study, *M. cordyla* and *S. tol* both exhibited moderate growth rates. However, *M. cordyla* grows faster than *S. tol*. Wheras, slow growth also reported for *S. commersonnianus* from Karachi coast (Panhwar, 2014). It is, therefore, proposed that fishing pressure must be reduce to recover stocks of slow growing *S. tol* that requires longer time to attain viable size. The growth coefficient K value is greater than reported earlier (Sreenivasan, 1978; Zafar *et al*., 2000; Panda *et al*., 2012; Jadhav and Mohite, 2013). It is assumed that it might be due to temperature and availability of sufficient food for *M. cordyla* in the Northern Arabian Sea coast. *M. cordyla* is a short lived fast growing species, and its length at first captured was lower than that for *S. tol* (Panda *et al*., 2012; Zafar *et al*., 2000). The fishing mortality estimated here was higher than previously reported (Jaiswar *et al*., 2000; Panda *et al*., 2012). The difference in growth, mortalities and distribution of different stocks may affect the length of species. High mortalities of small size classes have great impact on the recruitment. In general, fish may be subjected to death due to predation (Otobo, 1993), cessation (King, 1991) and through environmental causes (Chapman and van Wall, 1978). The total, fishing and natural mortality estimates were greater than previously found (Jaiswar *et al*., 2000; Panda *et al*., 2012). Fishing mortality rate of 0.71 and 1.3 in both species was substantially greater than the targets/ biological reference points F_{opt}, and F_{limit} and optimum level (Gulland, 1971).

Management action should aim to reduce catch and effort to achieve sustainability, which could be achieved through a revision of mesh size regulations and a substantial reduction in fishing effort and undersize catching should be discouraged (Panhwar and liu, 2013). These results are important for fisheries management authorities, as they allow managers to plan stock recovery for meeting management objectives. The data presented here indicates that these two resources have been exploited beyond the management target level, and that management action is required.

CONCLUSION

This study showed that *M. cordyla* and *S. tol* are under high fishing pressure, which could be reversed by reducing fishing effort. The information gathered here provides evidence of severe stock depletion and that these stocks are likely being fished at biological unsustainable levels.

REFERENCES

Adam, P., 1980. Life history pattern in marine fishes and their consequences for fisheries management. *Fish. Bull.*, **78:**1-12.

Beverton, R.J.H. and Holt, S.J., 1957. *On the dynamics of exploited fish populations.* Fishery Investigations Series II. Ministry of Agriculture, Fisheries and Food, London. 533 pp.

Bianchi, 1985. *Species identification sheets for fishery purpose "field guide to the commercial marine and brackish-water species of Pakistan.* Marine Resources Service, Fisheries resources and Environment Division, Fisheries Department, PAK/77/033 and FAO (FIRM) Regular Programme.

Chapman, D.W. and Van Well, P., 1978. Growth and mortality of *Stolothrissa tangenicae. Trans. Am. Fish. Soc*., **2107:** 26-35

Gulland, 1971.The fish resource of the ocean. West Byfleet, Survey, Fishing News (Books), Ltd. for FAO, Fisheries Technical paper, **97**:425.

Handbook, MFD., 2009. *Fisheries statistics of Pakistan*, compiled by Marine Fisheries Department Karachi.

Hilborn, R. and Walter, C. J., 1992. *Quantitative fisheries stock assessment, choices, dynamics and uncertainty*. Chapman and Hall, New York, London.

Jadhav, T.D. and Mohite, S.A., 2013. Length frequency analysis of torpedo trevally, *Megalaspis cordyla* along Ratnagiri coast, Maharashtra, India. *Indian J. Sci*., **2**:109-111.

Jaiswar, A.K., Biradar, R.S. and Gulati, D. K. 1994. Stock dynamics of horse mackerel, *Megalaspis cordyla* (Linnaeus) along north-west coast of India. *J. Indian Fish. Assoc*., **24**: 115-119.

Jennings, S., Kaiser, M.J. and Reynolds, J.D., 2001. *Marine fisheries ecology*. Blackwell Science Ltd. ISBN.0-632-05098

Kasim, H. M., 1996. Carangid fishery of Veraval coast with notes on the biology and population dynamics of *Megalaspis cordyla* (Linneaus). *4th Indian Fish. Form. Proc.*, **24-28**: 377-380.

King, R.P.L., 1991. Some aspects of the reproductive strategy of *Ilisha Africana* (Bloch, 1795) (Teleost, Clupeidae) in Qua Iboe estuary, Nigeria. *Cymbium*, **15:** 239-251.

Le Cren, E. D., 1951. The length–weight relationship and seasonal cycle in gonad weight and condition in the perch *Perca fluviatilis. J. Anim. Ecol*., **20**: 201–219.

Moses, B.S., 1988. Growth, biomass, mortality, production and potential yield of the West African clam, *Egeria radiate* (Lamarck) (Lamellibranchia, Donacidae) in the Cross River system, Nigeria. *Hydrobiologia*, **196**: 1-15.

Nelson, J.S., 2006. *Fishes of the world*. John Wiley & Sons, New York.

Otobo, A. J. T., 1993. *The ecology and fishery of the pygmy Herring,* Sierrathensa loenensis *(Thysvan Den Audenaerde, 1969) in the Num River and Taylor Creek of the Niger Delta.* Ph.D. thesis, University of Port Harcourt, pp. 298.

Panda, D., Chakraborty, S. K., Jaiswar, A. K., Sharma, A. P., Jha, B. C., Sawant, B. T., Bhagabati, S. K. and Kumar, T., 2012. Fishery and population dynamics of two species of carangids, *Decapterus russelli* (Ruppell, 1830) and Megalaspis cordyla (Linnaeus, 1758) from Mumbai waters. *Indian J. Fish.*, **59**: 53-60.

Panhwar, S.K., Qamar, N. and Jahangir, S., 2014. Fishery and stock estimates of Talang queenfish, *Scomberoides commersonnianus* (Fam: Carangidae) from the Arabian Sea coast of Pakistan. *Pakistan J. agric. Sci*., **51**: 1111-1116.

Panhwar, S.K., Liu Qun., 2013. Population statistics of the migratory hilsa shad *Tenualosa ilisha* in Pakistan, *J. of Applied Ichthyology*, **29**:1091-1096.

Panhwar, S. K., Qamar, N., Jahangir, S. 2014. Fishery and stock estimates of Talang queenfish, *Scomberoides commersonnianus* (Fam: Carangidae) from the Arabian sea coast of Pakistan. *Pakistan Journal of Agriculture Sciences*, **51**: 1111-1116.

Pauly, D. 1980a. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, **39**: 175-192.

Pauly, D. 1980b. A selection of simple methods for assessment of tropical fish stocks. FAO. *Fisheries Circulation*, **729**: 1-54.

Pauly, D., 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap*., **234**. 52.

Qamar, N., Panhwar, S.K. and Jahangir, S., 2015. Seasonal variation in diet composition of torpedo trevally, *Megalaspis cordyla* (Linneaus, 1758) depending upon its size and sex. *Pakistan J. Zool*., **47**: 1171-1179.

Reuben, S., Kasim, H. M., Sivakami, S., Radhakrishnan, N. P. N., Kurup, K. N., Sivadas, M., Noble, A., Somasekharan, N. K.V. and Raje, S.G., 1992. Fishery, biology and stock assessment of carangid resources from the Indian seas. *Indian J. Fish*., **39**: 195 – 234.

Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board. Can.*, **191**: 1-382.

Saker, Y., Jaiswar, A.K., Chakraborty, S. K. and Swamy, R. P., 2004. Morphometry and length-weight relationship of *Megalaspis cordyla* (Linneaus, 1758) from Mumbai coast. *Indian J. Fish*., **51**: 481-486.

Sivakami, S., 1995. Fishery and biology of the Carangid fish *Megalaspis cordyla* of Cochin. *J. mar. biol. Assoc. India*, **37**: 237-248.

Sparre, P. and Venema, S. C., 1998. *Introduction to the tropical fish stock assessment*. Manual. FAO Fisheries technical report 306/ Rev.2 Rome 407 pp.

von Bertalanffy, L., 1938. A quantitative theory of organic growth (Inquiries on growth laws. II). *Hum. Biol*., **10**: 181-213.

Zafar, M., Mustafa, M.G. and Haque, M.A., 2000. Population dynamics of Megalaspis cordyla (Linneaus, 1758) from north-eastern part of the Bay of Bengal, Bangladesh. *Indian J. Fish*., **47**: 163-168.