Population dynamics of the *Metapenaeus monoceros* (Fabricius, 1798) in North-eastern Mediterranean Sea

Manaşırlı M.*

Received: September 2012 Accepted: July 2014

Abstract

Monthly sampling of speckled shrimp was conducted by bottom trawl in the Iskenderun Bay between November 2009 and October 2010. There was a linear relationship between carapace length and total length in males and females (TL = -0.112 + 0.2294*CL; R^2 = 0.8298, n = 327) for males, (TL = -0.3918 + 0.2731 * CL; R^2 = 0.8919, n = 457) for females, and (TL = -0.378 + 0.2684 * CL; R^2=0.8492, n=784) for total individuals. Total length-weight relationships were $W=0.0135*TL^{2.7817}$ for males, $W= 0.0115*TL^{2.8535}$ for females, and $W=0.0109*TL^{2.8108}$ for total individuals. The von Bertalanffy growth constants in length was TL_∞= 162.75mm, K = 1.39 $year^{-1}$, t_0 = -0.0604 year for males; TL_∞= 178.40mm, K = 1.51 $year^{-1}$, t_0 = -0.780 year for females; and TL_∞= 174.14mm, K = 1.47 $year^{-1}$, t_0 = -0.0721 year for total individuals. In this study, the total (Z), natural (M) and fishing (F) mortality coefficient and exploitation rates (E) were determined as 5.39 $year^{-1}$, 2.39 $year^{-1}$, 3.00 $year^{-1}$ and E=0.56 $year^{-1}$, respectively for all of the obtained individuals.

Keywords:*Metapenaeus monoceros*, Iskenderun Bay, Population dynamical, Fisheries.

Fisheries Faculty, Cuk. University, 01330 Balcalı, Turkey

*Corresponding author's email: mozutok@cu.edu.tr

Introduction

Shrimp makes up an important portion of crustacean, commercial fisheries worldwide. Although shrimp aquaculture is common throughout the world, it is still in its infancy in Turkey. Speckled shrimp (*Metapenaeus monoceros* Fabricius, 1798) has been recorded in the eastern Mediterranean, the east coast of Africa, Madagascar, the Red Sea, all coasts of Indian sub-continent, , and Malaysia as far as the Straits of Malacca. Aquaculture of this species is practiced in India, whereas wild stocks are mainly caught from Egypt, Israel, Cyprus and Eastern Mediterranean waters (Rao, 1989; Sukumaran *et al*., 1993; Nandakumar and Srinath, 1999; Yilmaz *et al*., 2009). Although the Aegean and Mediterranean Seas are rich in shrimp diversity, *M. monoceros* is found mainly in the Mediterranean Sea. Kumlu (2001) mentioned this species as a potentially important shrimp for the Turkish aquaculture.

Shrimp comprises one of the most important fisheries in Iskenderun Bay. As a result of favourable environmental conditions as well as fast growth and short life span, shrimp is considered a key fisheries item, and its product efficiency can fluctuate in broad range due to the same factors. Therefore, stock assessments need to be conducted annually. Knowing the growth and mortality rates are essential to assess the status of the exploited stock.

Although the biology and fisheries of this shrimp has been studied in Indian and other Mediterrenean countries (Rao, 1989; Sukumaran *et al*., 1993; Nandakumar and Srinath, 1999; Nandakumar, 2001; Abraham *et al*., 2007), the studies related to Turkish waters are too limited (Kumlu *et al*., 1999; Yilmaz *et al*., 2009; Bayhan and Gökçe, 2010).

Materials and methods

This study was performed in Iskenderun Bay, which is located in north-eastern part of the Mediterranean Sea in Turkey (Fig. 1). Monthly samples of shrimp were collected from November 2009 to October 2010 by a typical, commercial Mediterranean deep trawl net (nominal value of 22 mm cod-end mesh size) from a depth range of 20 to 80 meters.

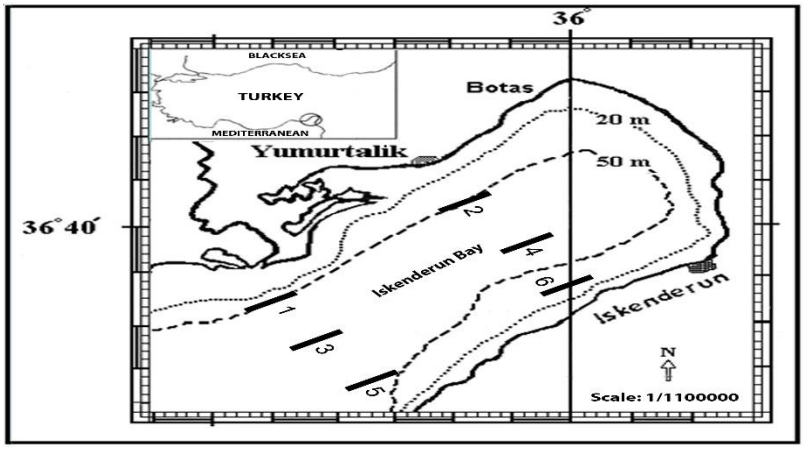

Figure 1:Trawling stations in the Iskenderun Bay.

Samples were collected randomly from each haul as recommended by Holden and Raitt (1974), kept in ice and transported to the laboratory. Then the carapace length (CL, to the nearest 0.1 mm; from the posterior margin of the orbit to the posterior margin of the carapace) as well as the body weight (BW, to the nearest 0.01 g) of these individuals were measured as wet weight in the laboratory. Sex determination was made by viewing the thelycum or petasma in female or male respectively (Fischer *et al*., 1987).

Total length of shrimps (TL) was measured to the nearest 0.1 mm immediately after capture, and monthly length–frequency distributions were used to estimate the growth parameters. Growth in length were analyzed separately for each sex using von Bertalanffy growth function (VBGF), by means of the ELEFAN I routine incorporated in the FISAT software (Mathews *et al*., 1987; Gayanilo *et al*., 1995). An aspect of ELEFAN I which adds considerably to the versatility of the program is that the growth equation used for generating the growth curves is a seasonally oscillating version of the VBGF which has the form;

$$L_t = L_\infty * \left[1 - e^{(-K(t-t_0) - (CK/2\pi)\sin(2\pi(t-t_s)))}\right]$$

where L_t is the length at age t, L_∞parameter is known as asymptotic length, K is growth coefficient, C is a parameter exposing the intensity of the seasonal growth oscillation ($0<C<1$), t_s is the start of a sinusoid growth, and it is a parameter where growth is slowest (WP). The ELEFAN estimates only two of the three growth parameters (L_∞ and K), thus we needed to compute the third parameter (t_o) by the empirical equation of Pauly (1980) for growth fitting:

$$\text{Log}(-t_o) = (-0.3922) - 0.2752 \log L_\infty - 1.038 \log K$$

Natural mortality (M) was calculated using Pauly's formula (Pauly *et al*., 1984):

$$\log M = (-0.0066) - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

Where, $L_\infty$and K are the VBGF parameters and T the mean environmental temperature.

Sea surface temperatures (SST) were measured with a probe of YSI® model (±1°C). (Manasirli *et al*., 2011).

For estimation of total mortality (Z), length-converted catch curves were developed from the length frequencies (Gayanilo *et al*., 1995). The exploitation rate (E) was computed from $E = F / Z$ (Sparre and Venema, 1992), where F is the fishing mortality ($F = Z–M$).

The length-weight relationships were determined according to the equation given by Sparre and Venema (1992), where $W=a*L^b$.

In this equation, W is total weight, a and b are regression constants, and L is total length. Also the carapace length-total length relationships were determined for each sex as

$$Cl = a + b.Tl$$

Where Cl is carapace length, Tl is total length and a and b are parameters (Sparre and Venema, 1992).

Results

The highest SST value measured was 29.07°C in August and the lowest

16.36ºC in February, with a mean of 21.96±4.68ºC.

Carapace Length (CL) - Total Length (TL) relationship:

Totally 784 specimens were analyzed, among which 457 were females (58.30%) and 327 were males (42.70%). The equations were used separately for carapace length-Total length relationships for each sex and for the total as below:

Males: $CL=-0.112+0.2294*TL$ ($R^2=0.8298$, n=327)

Females: $CL=-0.3918+0.2731*TL$ ($R^2=0.8919$, n=457)

Total: $CL=-0.378+0.2684*TL$ ($R^2=0.8492$, n = 784)

CL-TL relationships are linear relationship for all sexes.

Length and weight distribution

The total length of *M. monoceros* ranged from 4.5 to 15.5 cm, 74.11% of which were within 9.5-13.5 cm (Fig. 2). Total lengths of females ranged from 4.5 to 15.5 cm, with 74.84% being between 9.5 and 14.0 cm. As to males, total length varied between 5.0 and 15.0 cm, with 87.5% being between 9.5 and 13.5 cm.

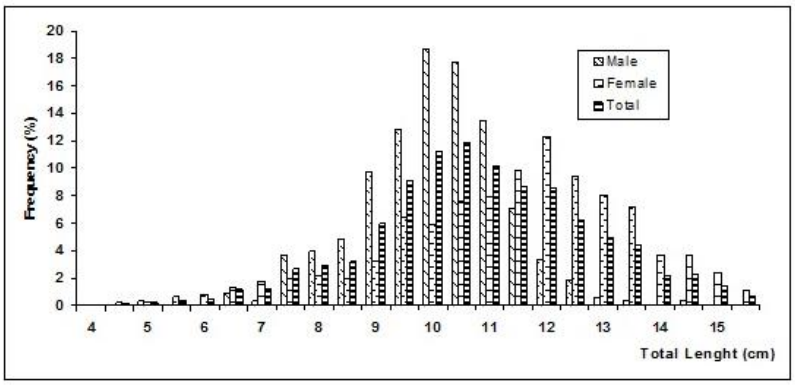

Figure 2: Length frequency of *M. monoceros.*

The total weight of *M. monoceros* ranged from 2 to 32 g, with 58.42% being between 5 and 12 g (Fig.3). The weight of females ranged from 2 to 32 g, with 64.99% being between 6-21 g, whereas the weight of males ranged from 2 to 20 g, with 85.63% being between 5-12 g.

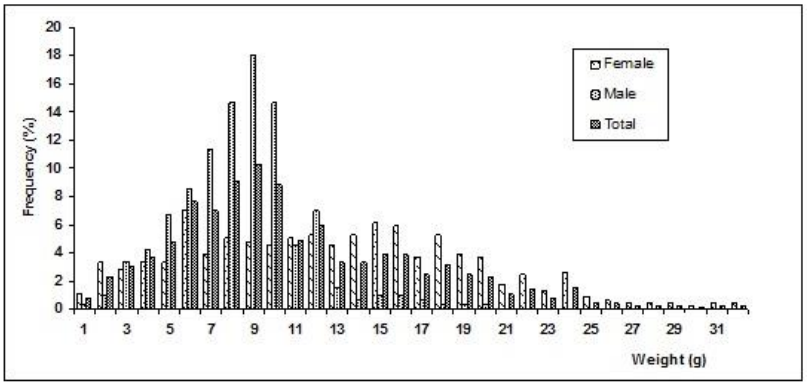

Figure 3: Weight frequency of *M. monoceros.*

The monthly length-frequency distribution and von Bertalanffy's length growth curves for sexes of *M. monoceros* are given in Figs. 4, 6.

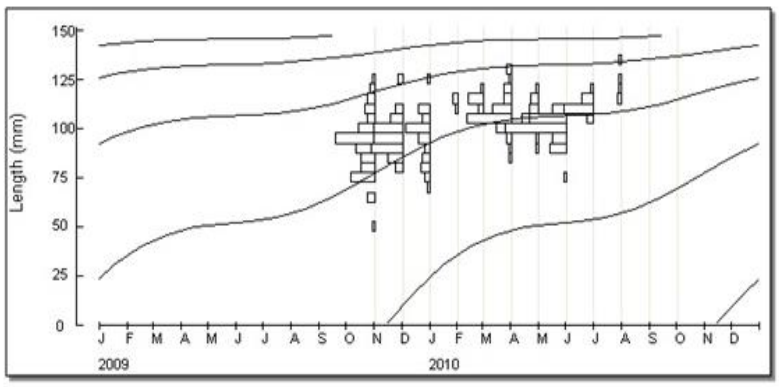

Figure 4: The monthly length-frequency distribution and von Bertalanffy's length growth curves for males of *M. monoceros.*

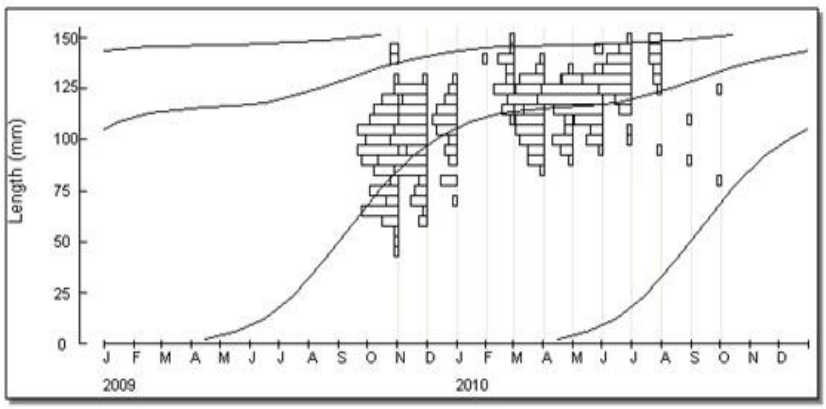

Figure 5: The monthly length-frequency distribution and von Bertalanffy's length growth curves for females of *M. monoceros.*

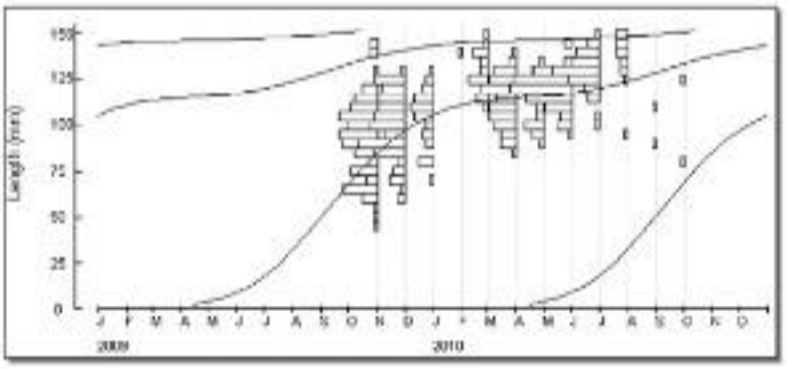

Figure 6: Monthly the length-frequency distribution and von Bertalanffy's length growth curves for total of *M. monoceros*

Table 1: Von Bertalanffy growth constants for sexes.

Sexes	von Bertalanffy Growth Constants					
	TL_∞ (mm)	K (yıl^{-1})	C	WP	t_0 (yıl)	Rn
Males	162.75	1.39	0.80	0.40	-0.0604	0.269
Females	178.40	1.51	0.85	0.29	-0.0780	0.320
Combined	174.14	1.47	0.85	0.30	-0.0721	0.370

The asymptotic lengths for females were higher than that of males (Table 1). Moreover, the lengths for age increasing in males were less than those for females Fig. 7.

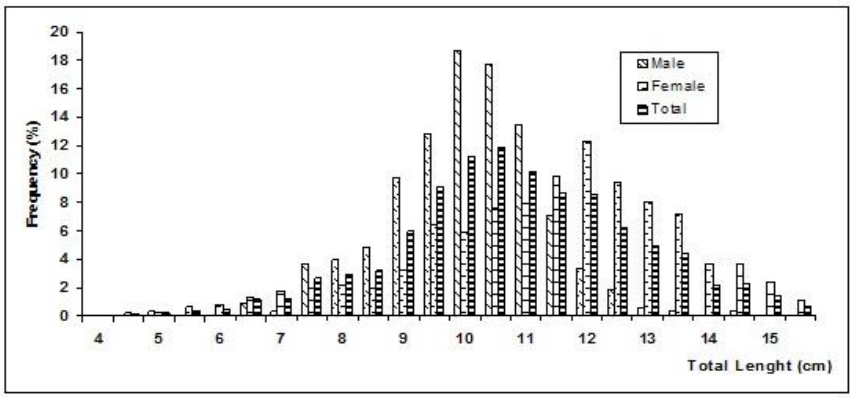

Figure 7: The length growths curves modelled for sexes.

Length-Weight Relationships

The equation used to calculate the length weight relationship parameters for sexes is given in Table 2.

Table 2: The length-weight relationship parameters for sexes.

Sexes	N	Length-Weight Relationships Parameters		
		a	b	R^2
Male	327	0.0135	2.7817	0.9041
Female	457	0.006	2.8535	0.9685
Combined	784	0.0065	2.8108	0.9565

The parameter b was less than 3, and as a result of the t-test, estimated "b" values seem to be significantly different from 3 (Table 2), which means negative algometry in growth. Length-weight relationship for males, females and combined sexes of *M. monoceros* is an exponential relationship (Fig. 8).

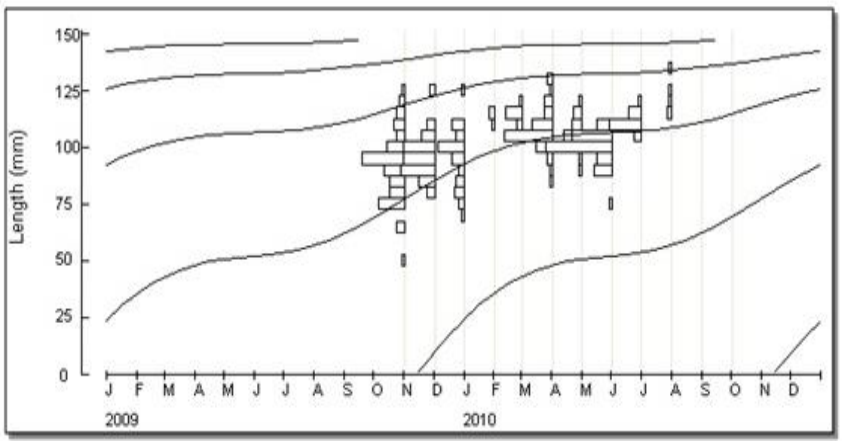

Figure 8: Length-weight relationships for combined sex.

The modelled age-weight curves are shown in Fig. 9. The weight increase in females were substantially more than males. This trend in growth continued until a gradual decrease was observed.

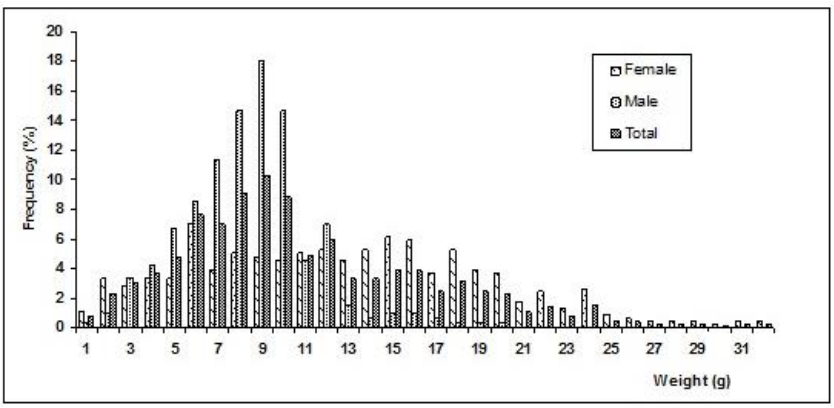

Figure 9: The weight growth curves modelled for males and females.

Mortality and exploiting rates:

The total mortality rates (Z), the natural mortality rates (M) and the fishing mortality rates (F) are given in Table 3 as totally and for both sexes separately.

Table 3: The total (Z), Natural (M), the fishing mortality rates (F), the exploitation rates (E) for each sex and their total.

	Mortality and Exploitation Rates (year^{-1})			
Sexes	**Z**	**M**	**F**	**E**
Male	5.34(3.91-8.12)	2.335	3.86	0.74
Female	5.11 (4.73-7.14)	2.264	2.85	0.56
Total	5.39(4.2-8..83)	2.390	3.00	0.56

As seen in Table 3, the mortality rate of the males were higher than that of the females. Table 5 reveals that all exploitation rates were more than 0.5 year^{-1}; consequently, the optimum value could not be attained in either of the sexes or in their total. The (E) value closest to optimum was found to be 0.56, in the females. As a result, it can be said that the males of this species were subject to overfishing in the Iskenderun Bay.

Discussion

von Bertalanffy growth constants were achieved both via ELEFAN, which was used in this study, and through other researchers as well. The maximum length of this species, or in other words, its asymptotic length (TL $_\infty$) for males and females, were reported as 19-22.50 cm for the coast of Karwar (George *et al*., 1988); 20.84-21.62 cm (Lalitha Devi, 1987) and 17.84 -20.73 cm (Rao and Krishnamoorthy, 1990) for the Kakinada; 18 -21 cm (Sukuraman *et al*., 1993), and 17.84 -20.73 cm (FAO, 2011) for the Indian coastal waters. Thesevalues were 17– 20.40 cm for the Cochin (Nandakumar and Srinath, 1999), 18 cm for both sexes in Bangladesh (Mustafa, 2003), but 18 - 19.40 cm for males and females in Bangladesh by FAO, 2011. However, in the current study, the asymptotic length was 16.28 cm for the males, 17.84 cm for the females and 17.41 cm for the total specimens. Our results were different to those reported by Lalitha Devi (1987), George *et al*. (1988), Sukuraman *et al*. (1993), Nandakumar and Srinath (1999), and FAO (2011), whose results for female individuals for Indian Coasts were higher than ours.

In our study, the total length, for males and females of *M. monoceros* individuals, were 90.11-106.08 mm respectively in 6 months, 130.31-148.28 mm TL in twelve months, and 153.47-170.66 mm in eighteen months in the Iskenderun Bay. These values were similar to those reported by Rao and Krishnamoothy (1990) for Kakinda coast, and Sukumaran *et al*. (1993) for the Indian coasts.

Winter Point (WP) is calculated 0.40 for males, 0.29 for females and 0.30 for combined sexes of *M. monoceros.* These values correspond to the lowest temperature of the year measured in February and March (16.3-16.7^{o}C). The environmental conditions affect the growth pattern of all living organisms. In theory, growth slows at low temperatures, and increases in higher and optimum temperatures (Dall *et al*., 1990). In our study the growth pattern of *M. monoceros* in the Iskenderun Bay also complied with the seasonal temperature changes, showing a fast growth in summer and declining in cold season.

The length-weight parameters are given in Table 4 for the *M. monoceros* from various regions.

Table 4: The length-weight achieved from various regions.

Sexes	a	b	R^2	Area	Author
M	0.0000	2.4940		Zambezi Deltas	FAO 2011
F	0.0002	2.6670			
M+F	0.0199	2.7600		Indian	
M+F	0.0199	2.7603			
M+F	0.01989	2.7603		Indian	Sukumaran *et al*., 1993
M	0.706675	2.9521	-	Indian	Rao, 1989
F	0.737566	3.1509	-		
M+F	0.311754	2.9700	0.915	Antalya Bay	Yilmaz *et al*., 2009

As is seen in Table 4, b value reported by various researchers varies from 2.4940 to 3.1509, but only that of Rao (1989) is over 3 for females and total individuals, which exhibits a positive allometric growth. On the other hand, b values achieved in this or other studies were under 3, exhibiting a negative allometric growth trend for both sexes (Table 2).

Our results indicated that *M. monoceros* from Iskenderun Bay were smaller in both length and weight compared to the other regions and males were smaller than females (Figs. 7 and 9). This pattern was consistent with other results obtained by various studies (Dall *et al*., 1990). This result is also consistent with this finding that the growth pattern of crustaceans, even the offspring of the same parents living in the same environment, may show heterogeneous tendency (Lee and Wickins, 2008).

Our results for mortality and exploitation rates showed great differences compared to the previous studies, and this differences seemed statistically significant (p<0.05) (Table 5).

Based on the Exploitation Rates (E) values for both male and females all of the previous studies on *M. monoceros* seemed to be under pressure of overfishing except Rao (1994). Considering that, the maximum level of production was obtained when the exploitation or the utilization rate was E=0.5 or in other words, when F=M,

which indicate either inadequate or over exploitation of the stocks (Sparre and Venema 1992). Therefore it is suggested that the existing exploitation rate should be decreased by 12% in order to achieve and maintain a sustainable yield from the Iskenderun Bay.

Table 5: The calculated Total Mortality (Z), Native Mortality (M), Fisheries Mortality (F), Exploitation Rates (E) for *M. monoceros* for different areas.

Sexes	Z	M	F	E	Area	Author
M	3.16	0.47	2.69	0.85	Kanvar	George *et al*., 1988
F	1.06	0.45	0.61	0.60		
M	7.98	1.81	6.17	0.66	Kakinada	Lalitha Devi, 1987
F	5.49	1.84	3.65	0.77		
M	4.36	2.42	1.94	0.60	Kakinada	Rao and Krishnamoorthy, 1990
F	3.66	2.32	1.44	0.55		
M	8.05	1.80	6.25	0.78	Visakhapatnam	
F	6.33	1.80	4.53	0.72		
M	4.28	1.80	2.48	0.58	Veraval	Sukumaran *et al*., 1993
F	4.17	1.80	2.37	0.57		
M	5.85	1.80	4.05	0.69	Bombay	
F	4.68	1.80	2.88	0.62		
M	4.36	2.42	1.94	0.45	Kakinada	Rao, 1994
F	3.66	2.22	1.44	0.40		
M	5.34	2.335	3.86	0.74	Iskenderun	
F	5.11	2.264	2.85	0.56	Bay	This study
M+F	5.39	2.390	3.00	0.56		

References

Abraham, J., Manisseri, M.K. and Sanil, N.K., 2007. Spermatogenesis and spermatozoa ultrastructure in *Metepenaeus monoceros* (Fabricius, 1798). *Indian Journal Fish,* 54(**1**), 1-9.

Bayhan, Y.K. and Gökçe, G., 2010. Shrimp fishery in northeast Mediterranean Sea andtechnical specifications of the shrimp nets. *Journal of Fisheries Sciencesicem*, 4(**2**), 129-125

Dall, W., Hill, B.J., Rothlisberg, C. and Staples, D.J., 1990. Advances in marine biology, Volume 27: the biology of the Penaeidae (J.H.S., Blaxter, A.J., Southward, Eds.*)*. Academic Press Limited 24/28 Oval Road London NW1 7DX, 488P.

FAO, 2011. http://www.sealifebase.org hptt://www.fao.org./

Fischer, W.M., Bauchotet L. and Schneider, M., 1987. Re'dacteurs:. Fishes FAO d'identification des espe'ces pour les besoins de la pe'che. (Re'vision 1). Mediterrane Et Mer Noire. Zone De Peche 37. Rome, FAO, pp. 189-292.

Gayanilo, F.C., Sparre, J.R. and Pauly, D., 1995. The FAO-ICLARM stok assessment tools (FISAT) User's Guide. FAO Computerized Information Series

(Fisheries) No: 8. Rome, FAO, 126P.

George, M.J., Alagaraja, K., Sukumaran, K.K., Nandakumar, G., Ramammurthy, S. and Telang, K.Y., 1988. The present status of shrimp trawling and its impact on shrimp stocks of Karnataka Coast. Proc. Sem. Problems and Prospects of Marine Fishing and Fish Processing in Karnataka, College of Fisheries, Mangalore, pp. 1-14.

Holden, M.J. and Raitt, D.F.S., 1974. Eds. Manual of fisheries science. Part 2 - Methods of recource investigation and their application. FAOFish. 214P.

Kumlu, M., 2001. Bivalve and crustacean farming (in Turkish). Cukurova University, Fisheries Faculty, Book No: 6**,** 338P.

Kumlu, M., Avsar, D., Basusta, N. and Eroldogan, T., 1999. Some Biological Aspects of Penaeid Shrimps Inhabiting Yumurtalık Bight in Iskenderun Bay (North-Eastern Mediterranean). *Turkish Journal of Zoology*, 23, 53-61.

Lalita Devi, S., 1987. Growth and Population Dynamics of the three Peneaid Prawns in the Trawling Grounds off Kakinada. *Indian Journal Fish.*, 34 (**3**), 245-263.

Lee, D.O'C. and Wickins, J.F., 2008. Crustacean farming: Ranching and culture, Second edition. John Wiley & Sons, 464P.

Manasirli, M., Avsar, D. and Yeldan, H., 2011. Babadıllimanı Koyu'ndaki (Silifke-Mersin) Derinsu Pembe Karidesi (*Parapenaeus longirostris* Lucas,1846)'nin Büyüme, Ölüm Oranları ve Stoktan Yararlanma Düzeylerinin Belirlenmesi. *Ekoloji Dergisi*, 20(**79**), 38-44.

Mathews, C.P., Al-Hossaini, M., Abdul Ghaffar, A.R. and Al-Shousani, M., 1987. Assessment of short-lived stocks with special reference to Kuwait's shrimp fisheries: A contrast of the result obtained from traditional and recent size-based Techniques. In "length-based methods in fisheries research" (D. Pauly and G.R., Morgan, eds.), ICLARM Conference Proceedings, 13, 147-166.

Mustafa, M. G., 2003. Trophic model of the coastal ecosystem in the waters of Bangladesh, Bay of Bengal. p. 263-280. In: Silvestre, G., L. Garces, I. Stobutzki, M. Ahmed, R.A. Valmonte-Santos, C. Luna, L. Lachica-Aliño, P. Munro, V. Christensen and D. Pauly (Eds.) Assessment, management and future directions of coastal fisheries in Asian Countries. World Fish Center Conference Proceedings. Paper URL.

Nandakumar, G., 2001. Reproductive biology of the speckled shrimp *Metapenaes monoceros* (Fabricius*). Indian Journal Fish*, 48(**1**), 1-8.

Nandakumar, G. and Srinath, M., 1999. Stock assessment of *Metapenaes monoceros* (Fabricus) from Cochin Waters, Kerala. *Indian Journal of Fish*, 46(**3**), 221-226.

Pauly, D., 1980. On the Interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, 39(**2**), 175-792.

Pauly, D., Ingles, J. and Neal, R., 1984. Application to shrimp stocks of objective methods for the estimation of growth, mortality and recruitment-related parameters from legth-frequency date (ELEFAN I and II). Penaeid shrimps-Their biology and management. Fishing News Books Ltd. 308P.

Rao, G.S., 1989. Studies on the reproductive biological of the brown prawn *Metapenaes monoceros* (Fabricius, 1989) along the Kakinada Coast. *Indian Journal Fish,* 36(**2**), 107-123.

Rao, G.S. and Krishnamoorth, B., 1990. Age and growth of *Metapenaes monoceros* along the Kakinada Coast. *Journal of the Marine Biological Association of India*, 32, 154-161.

Rao, G.S., 1994. Mortality rates and stock assessment of *Metapenaes monoceros* along the Kakinada Coast. *Journal of the Marine Biological Association of India*,36,1-18.

Sparre, P. and Venema, S.C., 1992. Introduction to tropical fish stock assessment. Part 1. Manual, FAO Fisheries Technical Paper No. 306. Rev.1. Rome, FAO, 376P.

Sukumaran, K.K., Deshmukh, V.D., Rao, G.S., Alagaraja, K. and Sathianandan, T.V., 1993. Stock assessment of the penaeid prawn *Metapenaes monoceros* Fabricus along the Indian Coast. *Indian Journal of Fish,* 40(**1,2**), 20-34.

Yilmaz, S., Ozvarol, A.B. and Ozvarol, Y., 2009. Fisheries and shrimp economy, some biological properties of the shrimp *Metapenaes monoceros* (Fabricus, 1789) in the Gulf of Antalya (Turkey). *Journal of Animal and Veterinary Advances*, 12, 2530-2536.