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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Biological traits and population dynamic of *Parapenaeus longirostris* (Lucas, 1846) in the Marmara Sea, Turkey

Marmara Denizi'nde *Parapenaeus longirostris* (Lucas, 1846)'in biyolojik özellikleri ve populasyon dinamiği

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Abstract: *Parapenaeus longirostris* is a valuable resource for the crustacean fisheries in the Marmara Sea, therefore, in this study length-weight relationships, growth, mortality, reproduction, recruitment patterns, the probabilities of capture and per recruit analyses were determined. Total 36288 samples were collected by beam trawl between September 2011 and July 2014 in 229 sampling stations. The total length (TL), body weight (g) and carapace length (CL) values ranged between 34 -175 mm, 0.2 - 28.9 g and 8 - 41 mm, respectively. CL-weight relationship equations were calculated for females, males and combined sexes, respectively, $W=0.0023\times CL^{2.5}$, $W=0.0029\times CL^{2.43}$, $W=0.0022\times CL^{2.52}$. The growth parameters were determined as L_∞=199.5 mm, k=0.47, t_0=-0.5 in TL, L_∞=36.8 mm, k=0.37, t_0=-0.69 in CL. L_{25}, L_{50}, and L_{75} values were found to be 15.15 mm, 16.29 mm, 17.44 mm for males and 16.62 mm, 18.07 mm, 19.52 mm for females. The sexual maturity length for females was found 27.3 mm CL and the exploitation rate was found at 0.62 for the whole population.

Keywords: *Parapenaeus longirostris*, length-weight relationship, growth, reproduction, stock assessment, Sea of Marmara

Öz: *Parapenaeus longirostris*, Marmara Denizi'ndeki kabuklu balıkçılık için değerli bir kaynaktır, bu nedenle bu çalışmada uzunluk-ağırlık ilişkileri, büyüme, ölüm, üreme, stoğa katılım modelleri, yakalanma olasılıkları ve stoğa katılım analizleri belirlenmiştir. 229 örnekleme istasyonunda Eylül 2011 ile Temmuz 2014 arasında algarna ile toplam 36288 adet birey toplanmıştır. Toplam uzunluk (TL), vücut ağırlığı (g) ve karapaks uzunluğu (CL) değerleri sırasıyla 34-175 mm, 0,2 – 28,9 g ve 8 - 41 mm arasında değişmiştir. Karapaks boyu-ağırlık ilişkisi denklemleri sırasıyla dişi, erkek ve tüm cinsiyetler için hesaplanmıştır, $W=0.0023\times CL^{2.5}$, $W=0.0029\times CL^{2.43}$, $W=0.0022\times CL^{2.52}$. Büyüme parametreleri toplam boyda L_∞ = 199,5 mm, k = 0,47, t_0 = -0,5, karapaks boyunda L_∞ = 36.8 mm, k = 0.37, t_0 = -0.69 olarak belirlenmiştir. L_{25}, L_{50} ve L_{75} değerleri erkekler için 15,15 mm, 16,29 mm, 17.44 mm ve dişiler için 16,62 mm, 18,07 mm, 19,52 mm olarak bulundu. Dişiler için ilk eşeysel olgunluk boyu 27,3 mm CL ve tüm populasyon için sömürülme oranı 0,62 olarak bulundu.

Anahtar kelimeler: *Parapenaeus longirostris*, boy-ağırlık ilişkisi, büyüme, üreme, stok değerlendirmesi, Marmara Denizi

INTRODUCTION

The crustacean fishery has become an important resource for world-wide sea-food markets where crustaceans with claws, spiny lobsters, crabs and penaeid shrimps present high demand. The Deep water rose shrimp *Parapenaeus longirostris* (Lucas, 1846) has commercially importance in the Mediterranean area especially in Spain, France, Italy, Greece and Tunisia. (Levi et al., 1995; Abello et al., 2002; Deval et al., 2006). The Deep water rose shrimp presents high potential of capture in the marine coasts of Turkey (Zengin et al., 2004; Bayhan et al., 2005; Manaşırlı, 2008) and the 58 % percent of total crustacean production came from the Marmara Sea (TUIK, 2019). However, in recent years the deep water rose shrimp abundance followed a fluctuating. The amount of production is showing a varying trend in the capture volume since 2007 with 2761 t until 2013 with 1620 t, in 2014 2500 t were captured, after that, decreased to 1764 t and increased again in 2018 with 3212 t (TUIK, 2019). Due to the high commercial value of the shrimps, the actual populations are being caught intensively. Nonetheless, the intensity of catching is decreasing rapidly in the Turkish seas as well as in the whole world. Therefore, the sustainability of shrimp stocks needs to be ensured. In this context, it is required to know the biological parameters of P. longirostris to start to clarify the causes in the fluctuation of available populations.

In this study, the Marmara Sea was selected as a principal area of analysis; there were chosen 229 sampling points to record detailed information about length-weight relationship, sex ratio, reproduction period, gonadosomatic index, condition factor, first maturity length, mean length of ages, growth parameters, mortality rates, probability of capture, recruitment pattern, relative R/Y and B/R analysis of *P. longirostris*. In the

Marmara Sea there are only a few studies dealing with distribution and biological aspects about *P. longirostris* with few sampling points (Baran and Öztürk, 1990; Zengin et al., 2004; Yazıcı, 2004; Bayhan et al., 2005; Erten, 2009).

On the other hand, in the Mediterranean region several studies have been conducted to study the length-weight relationship (Levi et al., 1995; Garcia-Rodriguez et al., 2009), the reproduction system (Spedicato et al., 1996; Guijarro and Massuti, 2006; Mori et al., 2000; Ben Meriem et al., 2001), the age and growth parameters (Ardizzone et al., 1990; Abello et al., 2002; Ragonese et al., 2002; Kapiris et al., 2013; Garcia-Rodriguez et al., 2009; Guijarro et al., 2009) in *P. longirostris* . Therefore, in this study we also compare the biological structure of *P. longirostris* on the Mediterranean coasts with the Marmara Sea (length distribution, age, growth parameters and reproduction time) to reveal the stock structure.

To our knowledge there are not previous records about the recruitment pattern, probability of capture, yield-per-recruit (Y/R) and biomass-per-recruit (B/R) analysis of P. longirostris in the Sea of Marmara. Therefore, our study becomes in the first detailed work about the length-weight relationship, age, growth and reproduction of P. longirostris in the Marmara Sea.

MATERIAL AND METHODS

Sampling and data collection

The sampling collection was done in the Marmara Sea, Turkey. Monthly samples of *P. longirostris* were collected in 229 stations from September 2011 to July 2014 (Figure 1). Specimens were caught using a beam trawl with a cod-end mesh size of 32 mm, between 50 and 200 m depth. In total, 36288 specimens were measured. The carapace length (CL) was recorded with caliper to the nearest 1 mm taken from the posterior part of the left orbit to the center of the posterior edge of the carapace; total length (TL) was measured with a ruler to the nearest 1 cm from the tip or the rostrum to the end of the telson; body weight (g) was recorded using a digital balance to the nearest 0.01 g.

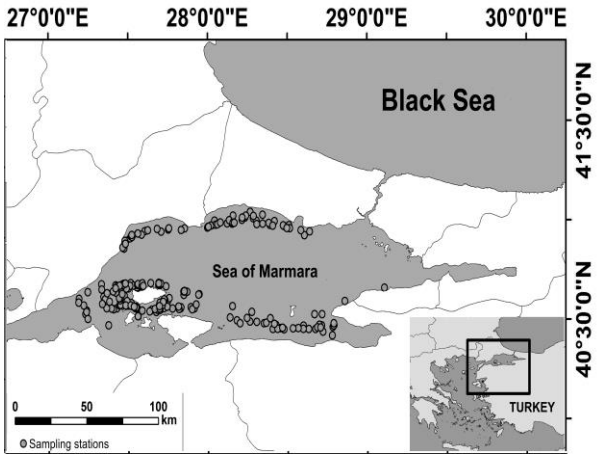

Figure 1. Sampling stations in the Sea of Marmara

Calculation of biological parameters

Length-weight relationships were calculated considering the allometric equation: $W=a\times L^b$, where L is the total length, W is the total weight and a and b are the equation parameters (Sparre et al., 1989). The growth type was defined by using Student's t-test by the equation according to Sokal and Rohlf (1987). Differences between sexes were analyzed with ANCOVA using SPSS16 package program.

The sex-ratio was calculated and compared to the 1:1 proportion using the chi-square ($\chi 2$) goodness fit test. Maturity stages were determined using the sexual classification scale of ICES (2009). Five stages were observed. Stage I: immature, stage II: maturing, stage III: mature, stage IV: spawning and stage V: post-spawning. The spawning period was determined through monthly observations of the macroscopic development stages, the condition factor and the gonadosomatic index (GSI). The GSI was calculated as follow: GSI=Gonad weight/Bodyweight)x100. The condition factor (KF) was calculated in base of Htun-Han (1978)'s formula:

KF =(TW-GW)/CL3*100

TW=total weight(g), GW=gonad weight(g), CL=Carapace length(mm)

The length at which 50% of specimens were sexually mature (L_{50}) or length at first maturity was estimated for reproductively active specimens (Stages 3-5) per mm size-class, by fitting a logistic function using the Newton algorithm (Microsoft Excel solver routine) which is defined as: P(1)=1/1+e–(a+b1) where P(1) was the proportion of mature specimens at length 1, and a and b the parameters of the logistic equation (Piñeiro and Saínza, 2003).

Von Bertalanffy growth parameters were calculated $L_t=L_\infty(1-e^{-k(t-t_0)})$, where the L_t is the size at age t, L_∞ is the maximum theoretical size, k is the growth factor, t_0 is the age at which the size is 0. Growth parameters (L_∞ and k), and age analyses were performed on the monthly length distributions for the period 2011-2014 and each sex separately by using the ELEFAN I routine, Bhattacharyya's method (Bhattacharyya, 1967) using the FISAT II automatic calculation program (Gayanilo et al., 2002), t_0 was computed by the equation of Pauly (1984): $Log(-t_0)=(-0,3932)–0,2752*logL_\infty-1,038*logk$.

For the sake of comparison, the index of overall growth performance Φ, proposed by Pauly & Munro (1984), was calculated as $\Phi=\log K+2\log L_\infty$. The natural mortality (N) was obtained using Pauly's empirical formula (Pauly, 1984):

$LnM =-0.0152–0.279\times lnL_\infty+0.6543\times lnK+0.463\times ln\ T$

The total mortality (Z) was found using the length converted catch equation (Pauly, 1984). The fishing mortality (F) was calculated by the subtraction of the estimates of M from Z.

F=Z-M. The exploitation rate was calculated as follows: E=F/Z

Recruitment patterns were found from the estimated growth parameters by reflecting the length-frequency data in ELEFAN I The probabilities of capture (Lc_{50}) was estimated from the gear selection curve generated from the length converted catch curve. The relative yield per recruit (Y/R) and relative biomass per recruit (B/R) were computed from the ogive selection using the procedure in the FISAT II program (Gayanilo et al., 2002).

RESULTS

Length-weight relationships (LWRs)

The CL for females ranged from 7 to 41 mm (n=15904) and for males ranged from 9 to 35 mm (n=20384). The mean CL was 24.07 mm (± 4.34) for females, 20.66 mm (± 2.66) for males and 22.58 mm (± 4.07) for the combined sexes (Figure 2).

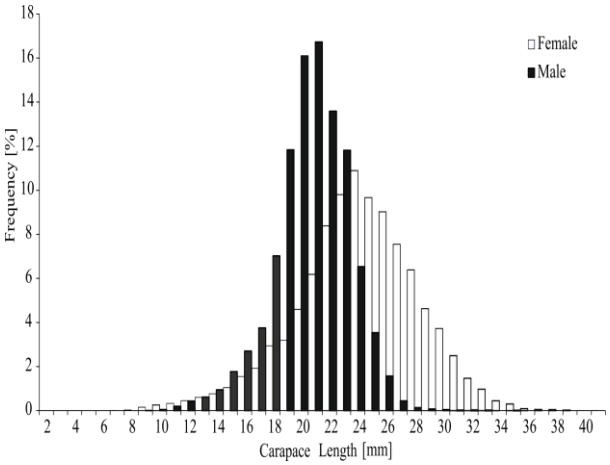

Figure 2. Length frequency distribution of *P. longirostris* in the Sea of Marmara

The CL and weight values were determined yearly and seasonally, the values did not present statistical differences between seasons and years ($p > 0.05$). CL-weight relationships were separately estimated for females, males and combined. The length-weight relationship equation for female, male and sexes combined was calculated as $W=0.0023*CL^{2.5}$, $W=0.0029*CL^{2.43}$, $W=0.0022*CL^{2.52}$, respectively. The results for the CL-weight relationships according to the sex indicates a negative allometric growth (b<3; t-test, P<0.05). And there was a statistically significant difference among the estimated parameters between the two sexes ($p < 0.05$, ANCOVA).

Reproduction

The sex ratio proportion was found 1:1.3 (M: F). The females represented the 55.8 % and the males the 44.2 % of the analyzed population. The sex ratio proportion did not present statistical differences from 1:1 proportion ($p > 0.05$, $\chi 2$).

The monthly changes in the condition factor (KF) and GSI values for females are indicated in Figure 3. The KF values were low for summer and autumn, but were high in the spring. The observed changes in the GSI diagram showed that GSI values varied in opposite trend respect to KF values.

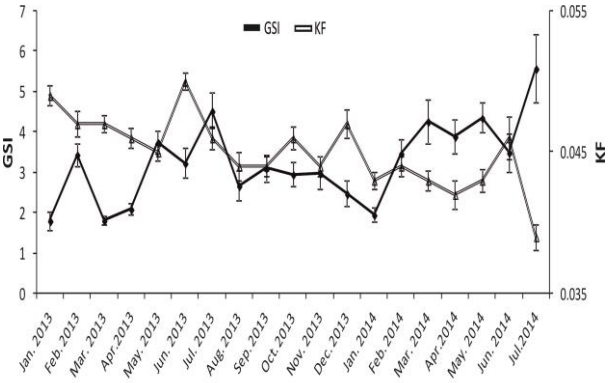

Figure 3. Monthly changes in GSI and KF values

The maturity process was classified in five stages. Each analyzed month presented the III and IV stages (which include mature individuals); on the other hand, during summer and autumn III, IV and V were the most frequent observed stages (Figure 4). The three years of monthly analyses indicates that changes in maturity stages, KF and GSI showed that reproduction of *P. longirostris* continued throughout the year with a peak of maturity during summer in the Marmara Sea. The size in which individuals reach 50 % maturity was determined at 27.3 mm CL (Figure 5).

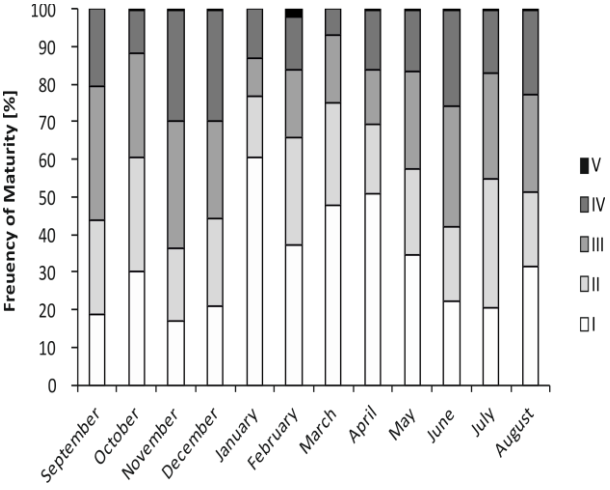

Figure 4. Monthly changes in reproductive stages of *P. longirostris*

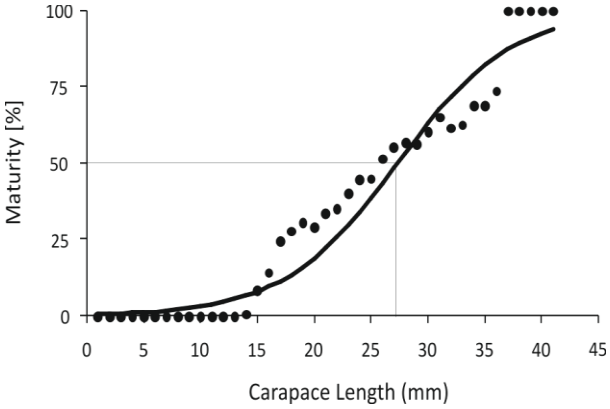

Figure 5. The first maturity length of *P. longirostris* (CL)

Growth

The growth parameters were determined as L_∞=41 mm, K=0.27 year^{-1}, t_0=-0.78 year in females, L_∞=36.8 mm, K=0.37 year^{-1}, t_0=-0.69 year in males and L_∞=42 mm, K=0.35 year^{-1}, t_0=-0.69 year for the combined sexes. The mean lengths were calculated for every age group. The maximum age was calculated as 4 for females and 3 for males (Table 1).

Mortality rates

The mortality rates were calculated separately for females, males, and total population. According to the calculated results of M, Z, F and Ec the values were 0.52, 1.09, 0.57, 0.52 in females; 0.66, 2.22, 1.56, 0.70 in males and 0.61, 1.60, 0.99, 0.62 in the total population, respectively.

Table 1. Age-carapace length key for female, male and combined sexes of *P. longirostris*

Ages	Calculated Mean Length		
	Female	Male	Total
1	17.6±0.7	16.5±2.4	13.9±3.4
2	26.2±0.7	21.2±1.1	21.1±2.9
3	33.0±0.6	25.6±2.5	26.7±2.7
4	38.7	-	33.9

Probability of capture

The probability of capture values L_{25}, L_{50}, and L_{75} were found to be 16.62 mm, 18.07 mm, 19.52 mm for females and 15.15 mm, 16.29 mm, 17.44 mm for males, respectively (Figure 6).

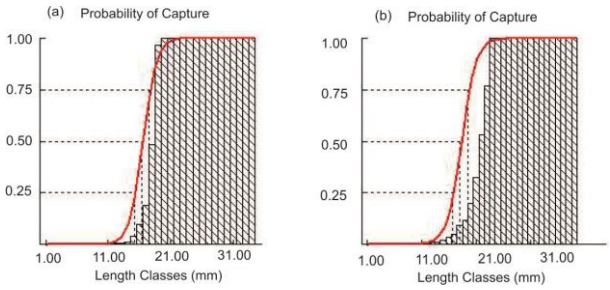

Figure 6. Probabilities of capture for males and females of *P. longirostris*

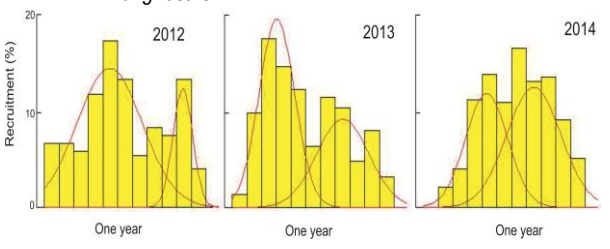

Figure 7. Recruitment patterns according to years

Recruitment pattern and Exploitation parameters

The recruitment patterns showed two annual pulses of recruitment during the three years of analysis. The recruitment peaks seem to occur in February and June in 2012, October and March in 2013, December and March in 2014 (Figure 7).

The relative Y/R and B/R analysis of the P. longirostris were estimated using the selection ogive procedure of FISAT II software (Figure 8). The required parameters that LC_{50}/L_∞ and M/K ratios of 0.49 and 1.78 for males and 0.53 and 1.93 for females were used as the input parameters for the analysis. LC_{50}/L_∞ of less than 0.5 indicates that small-sized shrimps are dominated for males, as distinct from females LC_{50}/L_∞ equal to 0.5. The analysis indicated the exploitation rates E_{max}, E_{50} and E_{10} as 0.74, 0.36, 0.60 for males and 0.75, 0.37, 0.62 for females, respectively. The Y/R and B/R were found to be 0.02, 0.35 for females and 0.03, 0.34 for males.

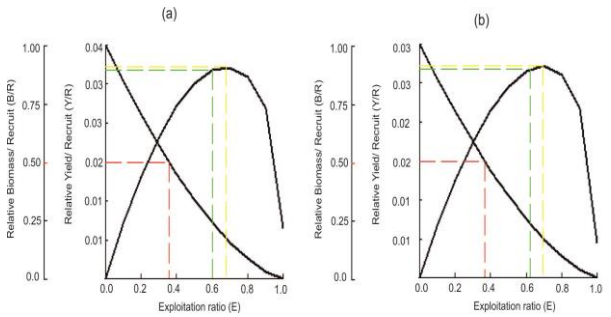

Figure 8. Relative Y/R and B/R using selection Ogive for male (a) and female (b)

DISCUSSION

Length-weight relationships (LWRs)

The carapace length-weight relationship equations of *P. longirostris* were calculated for females, males and combined sexes respectively. The results pointed to negative allometry. These results were similar to the other studies in the Marmara Sea, (Yazıcı, 2004; Zengin et al., 2004; Bayhan et al., 2005; Erten, 2009). Additionally, studies in the Aegean Sea and Mediterranean coasts have reported also negative allometry for the *P. longirostris* growth (Table 2).

Table 2. Length-weight relationship parameters reported in Mediterranean region and the Sea of Marmara (present study)

Author	Area	Sex	N	a	b	R^2
Levi et al., 1995	Sicilian Channel	M+F		0.0060	2.27	
Garcia-Rodriguez et al., 2009	Alicante Bay	M	4948	0.0029	2.48	0.91
		F		0.0024	2.56	0.96
		M+F		0.0020	2.61	0.96
Demirci and Hoşsucu, 2007*	North Eastern Mediterranean	M+F	100	1.8709	1.84	
Manaşırlı, 2008*	Babadillimanı Bay	M	923	0.0015	2.62	0.91
		F	2859	0.0009	2.82	0.96
		M+F	3886	0.001	2.79	0.95
Tosunoğlu et al., 2009	Sığacık Bay	M	1313	0.0001	2.76	0.94
		F	2456	0.0001	2.84	0.95
		M+F	3768	0.0001	2.83	0.95
Dereli, 2010*	Aegean Sea	M	1313	0.0012	2.69	0.94
		F	2456	0.0012	2.70	0.95
		M+F	3768	0.0012	2.70	0.95
Yazıcı, 2004	Marmara Sea	M	1073	0.0112	2.59	0.93
		F	869	0.0057	2.95	0.97
Zengin et al., 2004	Marmara Sea	M	1964	0.0093	2.70	0.91
		F	2483	0.0059	2.93	0.95
		M+F	4447	0.0053	2.97	0.95
Bayhan et al., 2005	Marmara Sea	M	1076	0.0059	2.86	0.96
		F	2679	0.0034	3.13	0.98
		M+F	3755	0.0031	3.16	0.97
Erten, 2009	Marmara Sea, Islands	M		0.0551	1.94	0.77
		F		0.0105	2.69	0.42
		M+F		0.0121	2.61	0.73
This study*	Marmara Sea	M	15904	0.0029	2.43	0.89
		F	20384	0.0023	2.50	0.94
		M+F	36288	0.0022	2.52	0.94

*analyzed with CL

Reproduction

The monthly condition factor varied between 0.47 and 0.50. The lowest KF for *P. longirostris* was observed in summer and early autumn (August-October) and the highest value in spring (April) (Figure 3). According to the monthly changes of GSI value the reproductive period of P. longirostris correspond with the summer periods in the Marmara Sea.

Zengin et al. (2004) reported that in the Marmara Sea the shrimp population showed intensive breeding throughout the year, the females lay their eggs in two separate periods during the year. The authors specified the periods during spring, early summer and Autumn, respectively. In the Mediterranean coasts and the Aegean Sea the reproduction is intense during November, December and February (Bayhan et al., 2005), April to June (Manaşırlı, 2008) and November to August (Guijarro and Massuti, 2006). The first sexual maturity in this study was found to be larger than the previous studies (Table 3). The differences between studies are because reproductive activity occurs at different times according to geographical areas.

Table 3. Reproductive season and first maturity length reported in Mediterranean region and the Sea of Marmara (present study)

Author	Area	Reproductive Time	First reproductive length (mm)
Spedicato et al., 1996	South Tiran Sea		28.4 (CL)
Mori et al., 2000	Tiran Sea		22 (CL)
Ben Meriem et al., 2001	North Tunisian		20.1 (CL)
Guijarro and Massuti, 2006	Balear Island	November August	28 (CL)
Manaşırlı, 2008	Babadillimanı Bay	December -June	18.2 (CL)
Tosunoğlu et al., 2009	Sığacık Bay	Autumn - Spring	26.13 (CL)
Dereli, 2010	Aegean Sea		24.56 (CL)
Zengin et al., 2004	Marmara Sea	Spring	106.1 (TL)
Bayhan et al., 2005	Marmara Sea	Sep., Oct.-Dec.-Apr.-May	97 (TL)
Zengin and Tosunoğlu, 2006	Marmara Sea	Summer-Autumn	97 (TL)
This study	Marmara Sea	Summer	27.3 (CL), 126 (TL)

Growth

The growth parameters are given in Table 4. The calculated growth performance index (ϕ) was 2.70 for males, 2.66 for females and 2.79 for both sexes. The growth parameters of *P. longirostris* population were compared with previous reported studies (Table 4). Whole data were analyzed using Munro's Fi Test and presented statistical significant differences ($p<0.05$). Although the calculation method is the same about growth parameters, differences in study results may have been effective in regional differences, sample numbers, sex, and ecological factors. The maximum age calculated for *P. longirostris* in the Marmara Sea in this study was 4 years in case of females and 3 years in case of males. Other studies reported a maximum of 6 years in the Aegean Sea (Tosunoğlu et al., 2009). Around 4 and 3 years in the Mediterranean region, respectively (Demirci and Hoşsucu, 2007; Manaşırlı, 2008). One study conducted previously in the sea of indicated 3 years age of the shrimp (Zengin et al., 2004).

Mortality rates

In Table 5 are shown the analyzed mortality rates wich presented significant differences with studies that were conducted in the Mediterranean region. According to our results, *P. longirostris* population showed overfishing pressure, these results are similar to other studies carried out in the Turkish waters (Tosunoğlu et al., 2009; Deval et al., 2006; Manaşırlı, 2008).

Table 4. Growth parameters obtained by different authors for *P. longirostris* in the Mediterranean region and the Sea of Marmara (present study)

Author	Area	Sex	TL_∞	CL_∞	K	t_0	ϕ
Ardizzone et al., 1990	Tiran Sea	M	-	33.1	0.93	0.05	3.01
		F	-	44.4	0.74	0.13	3.16
Levi et al., 1995	Sicilian Channel	M+F	-	30.5	0.63	0.190	2.77
Abello et al., 2002	Mediterranean	M+F	-	47	0.49	-	3.03
Ragonese et al., 2002	Sicilian Channel	M	-	34.3	0.73	-	2.93
		F	-	40.9	0.71		3.07
Kapiris et al., 2013	Ionian Sea	M	-	33.2	0.68	-	2.87
		F	-	37.2	0.76		3.02
Garcia-Rodriguez et al., 2009	Alicante Bay	M	-	36	0.49	0.075	2.81
		F	-	47	0.44	0.134	2.99

		M+F	-	45	0.39	0.102	2.90
Guijarro et al., 2009	Balearic Island	M	-	31.3	1.0	0.49	2.99
		F	-	44	0.67	0.21	3.11
		M+F	-	40	0.84	0.49	3.13
Manaşırlı, 2008	Babadıllimanı Bay	M	-	31.2	0.76	0.39	2.87
		F	-	32.3	0.77	0.39	2.90
		M+F	-	32.1	0.76	0.39	2.89
Demirci and Hoşsucu, 2007	Mediterranean	M+F	-	34.6	0.480	1.010	2.76
Bilgin et al., 2009	Saros Bay	M	-	27.0	1.49	0.88	3.04
		F	-	34.7	1.05	0.95	3.10
Tosunoğlu et al., 2009	Sığacık Bay	M+F	-	42	0.5	-	2.95
		M	-	34.99	0.41	1.016	2.70
		F	-	41.26	0.31	1.039	2.73
Baran and Öztürk, 1990	Marmara Sea	-	147	-	-	-	-
Zengin et al., 2004	Marmara Sea	M	157.9	-	0.380	1.422	3.98
		F	170.2	-	0.581	0.962	4.23
This study	Marmara Sea	M	-	36.8	0.37	0.69	2.70
		F	-	41	0.27	0.78	2.66
		M+F	-	42	0.35	0.69	2.79

Table 5. Reported natural mortality (M), fishery mortality (F), total mortality (Z) and exploitation rate (Ec) of *P. longirostris* in the different areas and the Sea of Marmara (present study)

Author	Area	Sex	M	F	Z	Ec
Levi et al., 1995	Kelibia and Lampedusa				1.239	
Abello et al., 2002	South Aegean	M+F			3.22	
Abello et al., 2002	North Aegean	M+F			2.41	
Ragonese et al., 2002	Scilian Channel	M	1.30		3.33	
		F	1.20		3.37	
Baran and Öztürk, 1990	Marmara Sea				5.2	
Zengin et al., 2004	Marmara Sea	M+F	0.85	1.06	1.91	0.50
Demirci and Hoşsucu, 2007	Northern East Mediterranean	M+F	1.29	0.34	1.635	0.21
Deval et al., 2006	Sea of Marmara	M	0.97	1.86	2.83	0.65
		F		1.57	2.13	0.54
		M+F		0.60	1.16	0.38
Manaşırlı, 2008	Babadillimanı Bay	M	1.31	3.86	5.17	0.74
		F	1.29	2.12	3.41	0.62
		M+F	1.29	2.71	4.00	0.67
Bilgin et al., 2009	Saros Bay	M	3.51		0.88	
		F	4.73		1.19	
Tosunoğlu et al., 2009	Sığacık Bay	M	0.67	0.54	1.21	0.45
		F	0.77	1.71	2.48	0.69
		M+F	0.77	1.18	1.95	0.60
This study	Marmara Sea	M	0.66	1.56	2.22	0.70
		F	0.52	0.57	1.09	0.52
		M+F	0.61	0.99	1.60	0.62

Probabilities of capture

The probability of capture L50 was referred as the length at first capture, in females the Lc/L∞ ratio revealed that this ratio was 0.5 inferior to males. This result indicated that catches were dominated by small individuals. The L50 values were smaller than the length at first maturity (27.3). Therefore, overfishing of non-mature individuals could be a first sight of declining populations in the Marmara Sea.

Recruitment pattern and exploitation parameters

The recruitment patterns showed that there are two peaks each year, those recruitment peaks seem to occur in February and June in 2012, October and March in 2013, December and March in 2014 (Figure 7). The recruitment of new specimens has been in the winter seasons.

Our result of the relative Y/R and B/R analysis for the stock of *P. longirostris* showed overexploitation for males and exploitation within safe limits for females. Levi et al. (1995) presented an exploitation rate Ec=0.8 bigger than the E_{max}=0.67, $E_{0.5}$=0.41, $E_{0.1}$=0.66 in the Central Mediterranean in the late 1980's. After that, in the late 1990's the overfishing was confirmed by IRMA–CNR (1999) in the Strait of Sicily. According to GFCM report the *P.longirostris* population has overexploitation (FAO, 2015).

In conclusion, our study provided new knowledge of the population parameters and stock assessment of *P. longirostris* in the Marmara Sea, where is important to understand the differences/similarities or changes in biological properties and management/sustainable production of this valuable species.

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