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Original Article

Spatio-Temporal Patterns of Abundance and Biomass of *Parapenaeus longirostris* (Lucas, 1846) in the Sea of Marmara, Turkey

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ABSTRACT

The present research study investigated the catch-per-unit-effort (CPUE, kg/h) and biomass of *Parapenaeus longirostris* in consideration of three parameters, i.e. seasons, regions, and depth levels. Beam trawls were used to collect the specimens at a total of 229 sampling stations in the Sea of Marmara between September 2011 and July 2014. In the Sea of Marmara, the mean CPUE of *P. longirostris* was calculated to be 8.4±0.5 kg h^{-1} , and the mean biomass to be 354 kg/km^{-2}. The mean CPUE value was at its highest in summer and autumn, and the lowest was observed in winter and spring. The by-region mean CPUE value of *P. longirostris* was the highest in the northern Sea of Marmara (14.3±1.9 kg h^{-1}), and the lowest was detected in the south (3.6±1.0 kg h^{-1}). The highest biomass value was found at a depth of 50-100 m, in the northern Sea of Marmara, while the lowest was calculated in the southeastern Sea of Marmara.

Keywords: *Parapenaeus longirostris*, CPUE, Abundance, Biomass, Sea of Marmara

INTRODUCTION

The crustacean *Parapenaeus longirostris* is widely distributed from the eastern Atlantic to the Mediterranean Sea. In the Mediterranean Sea, *P. longirostris* is found between 20 and 900 meters but abundant between 100 and 400 meters (Politou, Tserpes, & Dokos, 2008).

P. longirostris is the most important commercially valuable crustacean along the coasts of the Mediterranean Sea (Sbrana, Viva, & Belcari, 2006). Besides, it is the primary crustacean species that is caught in the Sea of Marmara by beam trawl (Zengin et al., 2004). Since trawl fishing is forbidden, fishermen commonly use beam trawls for shrimp fishing. The southwestern part, especially the Kapıdağ Peninsula, is known as the most efficient fishing area for this species in the Sea of Marmara. Shrimp fishing with beam trawl can be legally performed in the Sea of Marmara between September 1 and December 1, and between February 1 and April 14

The amount of captured deep-water rose shrimp in the Turkish seas decreased between 2007 to 2018. The amount of shrimp in 2007, amounting to 2761 tonnes, decreased to 1413 tonnes in 2010. A capture of 2500 tonnes in 2014 sharply fell in the following years to rise to 3213 tonnes in 2018 (Figure 1), when 1854 tonnes of rose shrimp were captured in the Sea of Marmara, 1234 tonnes in the Aegean Sea, and 124 tonnes in the Mediterranean Sea. The per-kilogram price for *P. longirostris* increased from 10 Turkish Liras in 2014 to 20 Turkish Liras in 2018 (TUIK, 2019). Gradual year-to-year decrease in the captured shrimps translated into raised prices.

Despite its commercial importance, research on deep-water rose shrimp is exiguous. The related

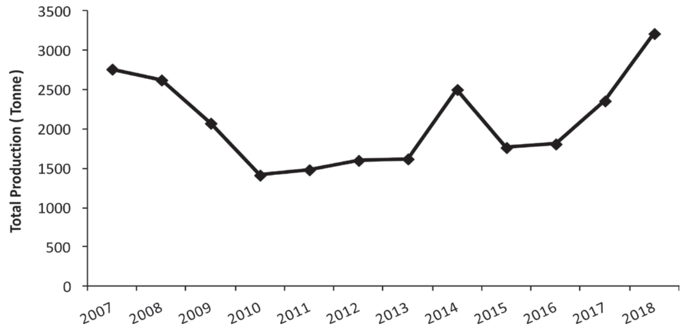

Figure 1. Total production of *P. longirostris* by years in the Turkish Seas.

literature incorporates some studies on its distribution, biology, bycatch, selectivity, and population in the Turkish waters (Deval, Bök, Ateş, & Özbilgin, 2006; Demirci & Hoşsucu, 2007; Manaşırlı, Avşar, & Yeldan, 2008; Tosunoğlu, Akyol, Dereli, & Yapıcı, 2009; Öztürk, 2009; Bök, Göktürk, & Kahraman, 2011). Moreover, a few studies were observed to investigate catch composition and CPUE in the Sea of Marmara (Zengin et al., 2004; Bayhan, Çiçek, Ünlüer, Akkaya, 2006; Erten, 2009; Yazıcı, Ismen, Altınağaç, & Ayaz, 2006). These studies do not cover the entire area and are limited to the northern and southern Sea of Marmara.

This study is the most detailed monitoring study including the highest number of data collection stations and sampling durations. The aim is to determine the existing stock status of the species and to obtain the much-needed data for the fishing management authority, which is important for the regional and seasonal restrictions. Furthermore, establishing the productive areas is another likely beneficial result considered important for fishermen due to the commercial value of this species.

MATERIALS AND METHODS

The monthly data were collected during the beam trawl surveys aboard the fishery vessel in the Sea of Marmara between September 2011 and July 2014. For the purpose of the study, 229 beam trawl hauls were carried out. The trawls feature a cod-end mesh size of 32 mm. The average towing speed was 2.5 knots for 30 min at depths ranging from 50 to 160 m within two depth contours, i.e 50-100 m and 100-200 m. Considering the fishing areas of shrimp fishermen, the Sea of Marmara was divided into six regions, namely 1: Erdek, 2: Tekirdağ, 3: Marmara Island, 4: the Kapıdağ Peninsula, 5: Yalova, and 6: Silivri (Figure 2).

The targeted, incidental, and discarded catches were separately weighed (Alverson, Freeberg, Murawski, & Pope, 1994). The length and weight measurements of all the species were performed in a laboratory.

The catch-per-unit-effort (CPUE) values (kg h^{-1}) were determined and the mean values were computed based on seasons, locations, and depths. Biomass (kg/km^2) estimations were calculated by the swept area method (Sparre & Venema, 1998). The swept area (a) for each hauling was estimated by the following formula; a = v×t×h×X (v=velocity of the trawl over the ground when trawling, t=time spent for trawling, h=length of the head-rope, X: fraction of the head-rope length which is equal to the width of the path swept by the beam trawl).

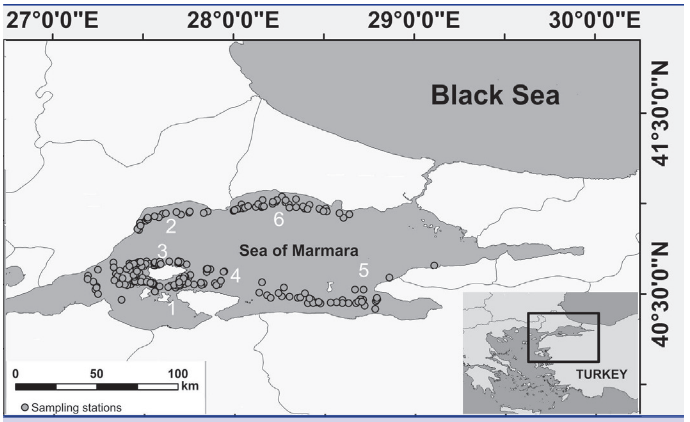

Figure 2. Study area (1. Erdek, 2. Tekirdağ, 3. Marmara Island, 4. Kapıdağ Peninsula, 5. Yalova, and 6. Silivri).

RESULTS AND DISCUSSION

A total catch of 4.2 tonnes were sampled by using beam trawls in the Sea of Marmara between September 2011 and July 2014. The most weight-wise abundant catch was observed for invertebrate species, accounting for 60% of the total capture except for *P. longirostris*. The target species *P. longirostris* comprised 1.05 tonnes (25%) of the total catch. The teleost and cartilaginous fish were a small part (13% and 2%, respectively) of the catch.

The mean CPUEs were calculated to be 36.6±4.8 kg h^{-1}, 4.7±0.3 kg h^{-1}, 0.8±0.1 kg h^{-1}, and 22.6±4.6 kg h^{-1} for the total catch, teleost fish, cartilaginous fish, and invertebrate species, respectively. The mean CPUE of *P. longirostris* was found to be 8.4±0.5 kg h^{-1} in the Sea of Marmara. The CPUE value was the highest in summer and autumn and the lowest in winter and spring. Considering the depths and seasons, the highest seasonal CPUE of *P. longirostris* was determined to be 14.7±2.0 kg h^{-1} in spring 2013 at a depth of 100-200 m. The difference between the CPUE values of summer 2013 and spring 2014 was found to be statistically significant ($p<0.05$, ANOVA) (Table 1). In terms of the depth contours, these values were calculated to 8.5 kg h^{-1} at 50-100 m and 7 kg h^{-1} at 100-200 m. However, no significant difference was observed for the two depth contours ($p>0.05$, ANOVA). The CPUE results in the present research was found to be similar to the other studies conducted in the Aegean Sea (Tosunoğlu et al., 2009) and the Mediterranean Sea (Manaşırlı et al., 2008), which report the highest CPUE value in the summer months.

The mean region-based CPUE value of *P. longirostris* was the highest (14.3±1.9 kg h^{-1}) in Silivri in the northern Sea of Marmara and the lowest (3.6±1.0 kg h^{-1}) in the southeast (Yalova). Furthermore, the analysis of depth-wise CPUE change by the regions revealed that the deep-water pink shrimp preferred the depths more than 100 m in Erdek and Yalova. In the Tekirdağ region, the CPUE was found to be remarkably low at depths of over 100 m. High human population density and polluting factors severely affect the northern Sea of Marmara. These regions have been reported in previous studies to be poor in oxygen, especially in the summer and spring (Satılmış et al., 2017). The among-region differences in the CPUE values were statistically significant ($p<0.05$, ANOVA). According to the Tukey's test, regions 1, 3, and 4 (Erdek, Marmara Island, and Kapıdağ Peninsula) are similar in comparison to region 2 (Tekirdağ) and 6 (Silivri) (Table 2). It is obvious that the Sea of Marmara was divided into two parts, namely the northern and southern Sea of Marmara, for the purpose of the study.

The annual CPUE was determined to be 7.7±0.6 kg h^{-1} in 2012, and the value rose up to 11.0±1.1 kg h^{-1} in 2013 and then decreased to the lowest value (6.5±0.9 kg h^{-1}) in 2014. Statistically significant values were observed in 2013 but not in the other years. ($p<0.05$, ANOVA). When we compared the results obtained in our study with those in the studies available in Table 3, we realized that our CPUE results were higher than theirs except for Yazıcı et al. (2006).

The mean biomass of *P. longirostris* was found to be 354 kg/km^2 in the Sea of Marmara. Biomass values were observed to vary by season, year, depth, and region. The highest biomass was represented in 2013 (480 kg/km^{-2}), followed by the one in 2012 (297 kg/km^{-2}), and the lowest in 2014 (283 kg km^{-2}) (Table 4).

With respect to depth, relatively higher values were recorded to be 355.9 kg km^{-2} at depths of less than 50-100 m (189.1 kg/km^{-2}; ≥100 m). The highest biomass value was obtained in the northern Sea of Marmara, whereas the lowest was calculated in the southeast. There is only one study to have revealed the biomass of *P. longirostris* in the Sea of Marmara. Zengin et al. (2004) have found the highest biomass values at 50-100 m in winter.

In previous research studies, it has been stated that different factors exert effects on the distribution of the species. Ungaro & Gramolini (2004) have found that water circulation, temperature, and geomorphological differences are effective in species distribution. Guijarro, Massutí, Moranta, & Cartes (2009) state that the spatial-temporal differences in the density of the species are related to seabed topography, sediment composition, hydrographic characteristics, and amount of nutrients in the Balearic Islands in the Mediterranean Sea. Tosunoğlu et al. (2009) report that water temperature is important for the distribution of *P.longirostris* in the Aegean Sea.

Table 1. CPUE values of P. longirostris by depths and seasons.

Seasons	Depth			ANOVA-Tukey Test
	50-100 m	>100 m	Mean	
	kg h^{-1}	kg h^{-1}	kg h^{-1}	
Aug. 11	9.9±1.6	-	9.9±1.6	AB
Win. 12	5.1±0.9	-	5.1±0.9	AB
Spr. 12	6.2±0.9	7.4±2.6	6.3±0.9	AB
Sum. 12	9.1±1.6	4.6	8.9±1.5	AB
Aug. 12	10.8±2.2	-	10.8±2.2	AB
Win. 13	9.1±1.7	13.6	9.3±1.7	AB
Spr. 13	10.9±2.6	14.7±2.0	11.3±2.4	AB
Sum. 13	13.7±2.7	6.1±0.1	12.9±2.5	A
Aug. 13	7.2±2.2	-	7.2±2.2	AB
Win. 14	4.7±0.7	5.1±1.7	4.7±0.7	AB
Spr. 14	4.7±1.7	3.3±1.3	4.6±1.5	B
Sum.14	12.0±3.1	5.4±0.6	11.2±2.7	AB
Mean	8.5±0.6	7.0±1.1	8.4±0.5	

A, B, AB: Data sets with at least one of the same letters are significantly similar.

Table 2. CPUE values of P. longirostris by depth and region.

Depth	Regions*						Mean
	1	2	3	4	5	6	
	kg h^{-1}	kg h^{-1}	kg h^{-1}	kg h^{-1}	kg h^{-1}	kg h^{-1}	kg h^{-1}
50-100 m	5.7±0.6	11.0±1.5	8.5±1.1	6.7±0.8	3.3±1.0	14.3±1.9	8.5±0.6
>100 m	7.8±1.7	4.8	6.6±1.6	-	10.0	-	7.0±1.1
Total	5.9±0.6	10.8±1.4	8.2±1.0	6.7±0.8	3.6±1.0	14.3±1.9	8.4±0.5
ANOVA-Tukey's Test	BC	AB	BC	BC	C	A	

*1. Erdek, 2. Tekirdag, 3. Marmara Island, 4. Kapıdağ Peninsula, 5. Yalova, 6. Silivri; A, C, AB, BC: Data sets with at least one of the same letters are significantly similar.

Table 3. Previous research studies on CPUE and biomass values of *P. longirostris.*

Author	Area	CPUE	Biomass	Gear type
Zengin et al (2004)	Marmara Sea	5.9 kg h^{-1}	-	b*
Bayhan et al (2006)	Marmara Sea	3.73 kg h^{-1}	-	b*
Yazıcı et al (2006)	Marmara Sea	10 kg h^{-1}	-	b*
Demirci & Hoşsucu (2007)	Eastern Mediterranean Sea	5.9 kg h^{-1}	141 kg km^{-2}	a*
Manaşırlı et al (2008)	Babadillimanı Bight	5.48 kg h^{-1}	203.0 kg km^{-2}	a*
Tosunoğlu et al (2009)	Sığacık Bay	6.40 kg h^{-1}	130.56 kg km^{-2}	a*
İşmen et al (2010)	Saros Bay	4.84 kg h^{-1}	85.4 kg km^{-2}	a*
Kapiris et al (2013)	South Ionian Sea	-	6.46 kg km^{-2}	a*
This study	Marmara Sea	8.4 kg h^{-1}	354 kg km^{-2}	b*

*a: bottom trawl, b: beam trawl

Table 4. Biomass values of *P. longirostris* by the season, region and year (kg/km^{-2}).

Seasons	Regions*						
	1	2	3	4	5	6	Mean
Aug. 11	483	430	588	257	67	-	383±61
Win. 12	232	243	-	180	77	297	197±33
Spr. 12	194	283	338	220	142	-	243±34
Sum. 12	242	548	218	305	46	627	351±58
2012	**258**	**362**	**407**	**239**	**88**	**533**	**297±25**
Aug. 12	294	700	436	523	415	335	470±97
Win. 13	287	235	704	331	739	511	406±72
Spr. 13	167	-	449	-	200	1529	633±188
Sum. 13	438	907	419	199	-	774	559±107
2013	**288**	**662**	**452**	**394**	**394**	**675**	**480±47**
Aug. 13	165	177	475	343	-	-	314±94
Win. 14	224	400	218	107	159	235	205±29
Spr. 14	94	220	124	113	75	439	199±66
Sum.14	174	835	210	-	55	873	488±119
2014	**178**	**386**	**222**	**187**	**87**	**572**	**283±40**
Mean	**246±24**	**445±63**	**343±42**	**279±36**	**151±43**	**611±83**	**354±23**

*1. Erdek, 2. Tekirdag, 3. Marmara Island, 4. Kapıdağ Peninsula, 5. Yalova, 6. Silivri

CONCLUSION

It was concluded that the knowledge of the spatio-temporal pattern of *P. longirostris* is crucial for understanding the differences and for sustainable exploitation of the stock in the Sea of Marmara. The amount of captured species decreased from year to year, which may have resulted from the increased fishing pressure on the species. The analyses of all the data showed that the Sea of Marmara had two different structures in terms of CPUE and biomass, namely Northern Marmara and Southern Marmara. Population density and polluting factors may have caused this partition. Considering the scarcity of data or estimates about beam trawl in Turkish fisheries, this study is thought to help guide future research in the studied area.

Conflict of interests: The authors have no conflicts of interest to declare.

Ethics committee approval: Ethics committee approval is not required.

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Disclosure: -

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