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RESEARCH ARTICLE

Monitoring of weekly catch per unit effort (CPUE) and some biological features of bluefish (*Pomatomus saltatrix* Linnaeus, 1766) captured from southern Black Sea coasts of Turkey.

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ABSTRACT

In this study, changing of catch per unit effort (CPUE) and length composition of bluefish (*Pomatomus saltatrix* Linnaeus, 1766) caught in the southern Black Sea was monitored during the period of 8 weeks in October and November 2012. A total of 2255 kg bluefish was captured by pelagic trawl at the end of 32 hauls. The length-weight relationship of bluefish was established as $W=0.0037L^{3.3067}$ (positive allometric growth). The catch per unit effort (CPUE) and mean length were fixed as 14.43 kgh^{-1} and 17.5±0.03 cm, respectively. Differences between CPUE values of each week were found statistically significant ($P<0.05$). The highest and lowest mean total lengths of bluefishes were determined 18.9±0.08 cm (October) and 16.2±0.10 cm (November), respectively. It is determined that changing in size composition of the caught fishes is depending on time. Also, it can be expressed that fishing period affects catch per unit effort in bluefish fisheries.

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Introduction

Bluefish, *Pomatomus saltatrix*, are distributed worldwide seas (Salerno et al., 2001). Bluefish is a migratory pelagic species that appear in temperate and tropical waters on the continental shelf and in estuarine habitats around much of the world (Wilk, 1977). Bluefish is one of the important pelagic fish species caught in Turkey's seas (Akyol and Ceyhan, 2007). Bluefish production is at 6th place, among all pelagic species, with 1936 tons in fisheries production of Turkey (TUIK, 2018). Bluefishes have been mainly caught by active fishing gear such as purse seine, midwater trawl and demersal trawl also by passive fishing gears such as set nets and hand-lining (Ceyhan et al., 2005).

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Dominant species are whiting and red mullet in the Black Sea demersal trawl fisheries (Erdem, 2000; Erdem et al., 2007). However, many species are captured as bycatch in the demersal trawl fisheries (Aksu, 2012; Yıldız and Karakulak, 2018). Bluefish is one of the fish species captured as bycatch by the demersal trawl nets in September, October and November in the Black Sea (Özdemir et al., 2006; Özdemir et al., 2009a). But, bluefish is target species in the pelagic trawl fisheries. Bluefishes have been captured intensively by the midwater pair trawl, an effective and have excellent selectivity fishing gear, during October and November in the Black Sea coasts (Erdem and Özdemir, 2008; Özdemir et al., 2010).

Bluefish were given different names for certain size group only in Turkish waters. These names are defne yaprağı (≤ 10 cm), çinekop (10-18 cm), sarıkanat (18-25 cm), lüfer (25-35 cm) and kofana (≥ 35 cm) (Akşiray, 1987). The biggest size group, called as kofana, have been rarely found in the seas of Turkey anymore, but recently çinekop and sarıkanat size groups are the most exploited groups in Turkish fisheries. When minimum landing size (MLS) was 20 cm for the bluefish 2012-2016 fishing periods, MLS was determined as 18 cm in the Notification to Regulate Commercial and Recreational Fisheries for between 2016-2020 fishing seasons (Anonymous, 2016). It was a wrong decision taken in terms of the sustainability and maximum yield of the bluefish.

Coasts of Kızılırmak and Yeşilırmak deltas are preferred by trawl fishermen, which are important crossing points for bluefish and horse mackerel (Figure 1). Pelagic species can migrate for feeding during the day or seasonally owing to reproduction behavior (Ivanov and Beverton, 1985). The migrations affect abundance and size composition of fish schools in the transition fields. Size composition of the fishes varies with participation or separation of the fishes in different size groups from shoals in the area. It is indicated that size composition of the caught bluefish is affected by fishing area and used fishing gears (Özdemir et al., 2009b).

Most of the studies on bluefish has been carried out in the Marmara Sea and Aegean Sea. Some of them is about age, growth, maturity, fishing gear selectivity of bluefish (Ceyhan and Akyol, 2006; Akyol and Ceyhan, 2007; Ceyhan et al., 2007; Acarlı et al., 2013, Öztekin et al., 2018; Bal et al., 2018; İlkyaz, 2018). However, there are only few studies on bluefish in the Black Sea. Gillnet selectivity (36 mm, 40 mm and 44 mm) for the bluefish were determined in the Sinop Coasts of Black Sea by Sümer et al. (2010). Özdemir et al. (2014) tested codend selectivity (square mesh panel and diamond mesh) for the bluefish of demersal trawl used on the Black Sea coasts. Samsun (2017) examined meat yield and chemical composition of bluefish captured Black Sea coasts.

The subject of the present study is to determine weekly CPUE data and some biological characteristic of bluefish from southern Black Sea coasts of Turkey. In this study, changes in size composition and CPUE of bluefishes captured in October and November (during 8 weeks) were monitored. Additionally, length-weight relationship of bluefish were estimated. It was determined that how to changing of school structure and size composition of bluefish as depending on time.

Material and Methods

The study was carried out in the Samsun shores of the Black Sea throughout 8 weeks period of fishing season between October and November 2012. The sampling area is east and west coasts of Kızılırmak and Yeşilırmak estuary. The region is an important migration and stopover state of pelagic and demersal school fishes (Figure 1).

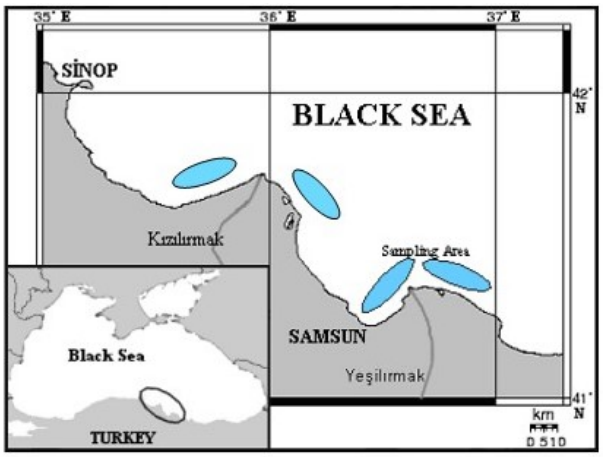

Figure 1. Survey areas of the study

A total 32 trawl surveys (4 days per week) was conducted during the experiment. Data were obtained from fishing operation of commercial midwater pair trawling boats in the region. The net has 600 mesh sizes in mouth and 18 mm mesh size in codend with a PE netting. The codend had 600 meshes around the circumference and a 27 m stretched length (Figure 2).

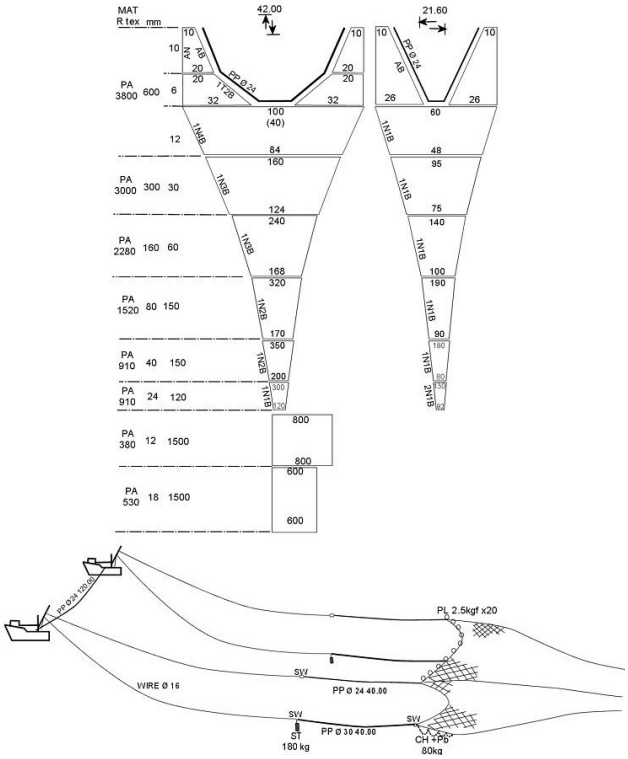

Figure 2. Technical plan of commercial midwater pair trawl

The amount of catch per unit effort (CPUE) for each net haul was calculated using the following formula by (Gulland, 1983):

$$U = \frac{\sum C}{\sum f}$$

In which; U is catch per unit effort, C is catch and f is effort.

The catch expressed in kg fish, the effort as sea time and the CPUE expressed in kg per unit of time spent at sea (Hoof and Salz, 2001). Duration of the net hauls were calculated in hours and it refers to 60-minutes net hauling. The total length (TL) and weight (W) of each fish were measured to the nearest 0.1 cm and 0.01 g (Figure 3).

Figure 3. Length measurement of bluefish

The relationships between length and weight is expressed by $W = a \times L^b$ which was converted to linear form as $\ln a + b \ln L$ where W is total body weight (g), L is the total length (cm), a is intercept and b is slope regression coefficients.

The b value for each species was tested with a t-test at the 0.05 level of significance to verify whether it was significantly different from the predicted values for isometric growth (Morey et al., 2003). Besides, t-test for two groups and One-way analysis of variance (ANOVA) for more than two groups was used in the statistical analysis of the size composition and CPUE data.

Results and Discussion

A total of 2255 kg bluefish was caught in the 32 midwater trawls hauls during the study period. Mean CPUE for all hauls was determined as 14.43 kg h^{-1} at the end of the study. The lowest and highest mean CPUE were established 5.53 kg h^{-1} and 28.46 kg h^{-1} in October. Mean CPUE was 13.38 kg h^{-1} for November and 15.48 kg h^{-1} for October.

In this study total length and wet weight of 3190 bluefish individuals were measured. Observed maximum, minimum length and calculated mean total length were 27.3 cm, 9.2 cm and 17.5±0.03 cm, respectively. Maximum, minimum and mean weight of bluefish were fixed 199.2 g, 7.7 g and 47.3±0.48 g respectively.

The most of fishes were captured in the çinekop size group. Few fishes were caught in the lüfer group. There is no kofana group in the all of the samples. Length frequency distributions (Figure 4) at çinekop group, sarıanat group and lüfer group showed major peaks of 17 cm, 18 cm, 22.5 cm in October, 16.5 cm, 18 cm, 27 cm in November and 17 cm, 18 cm, 26.5 cm in general.

Akyol and Ceyhan (2007) reported mean fork length 16.9±0.01 cm (8.4 – 45.3) for bluefish and also intensively captured çinekop and sarıkanat size groups in October and November in the Marmara Sea. The most of the lüfer size group only were determined in June. Özdemir et al. (2010) fixed mean total length of bluefish 17.52±0.09 cm (9.7 – 23.1) in the Black Sea coasts. Ceyhan (2005) determined mean fork length for bluefish 16.86±0.01 cm (8.4 – 45.3) in Marmara Sea and north Aegean Sea of Turkey. Bal et al. (2015) established mean total length of bluefish 20.57±0.17 cm (12.3 – 43.7) in Marmara Sea. İlkyaz (2018) reported mean total length 23.25±0.03 cm (16.5 – 35.3) for bluefish in Aegean Sea. Of all the study results show that bluefish (*Pomatomus saltatrix*) has been captured at çinekop and sarıkanat groups (juvenile size) in commercial fisheries of Turkish waters.

Length-weight relationship (LWR) of bluefish was determined as $W=0.0037L^{3.3067}$ (positive allometric growth, $p<0.05$). In the present study, the b-value was estimated to be 3.3067 for bluefish. It was identified that b values of bluefish varied from 2.5287 to 3.460 by other authors (Table 1). The variations in b-values may be ascribed to one or more factors: the seasons and effects of different areas, differences in salinity, temperature and pollution of aquatic environment, gender, nutrient quality and availability, differences in the quantity of fish analyzed, as well as in the observed size ranges of the sampled species (Goncalves et al., 1997; Froese et al., 2012).

For bluefish, six of fourteen studies had significantly different b-values, which reported negative allometric growth (Kalaycı et al, 2007; Bök et al., 2011) and isometric growth (Kasapoğlu and Düzgüneş, 2014; Bal et al., 2015, 2018; İlkyaz, 2018). Nevertheless, bluefish in the present study showed the b-values to be generally in agreement with similar results (positive allometric) in other studies (Table 1).

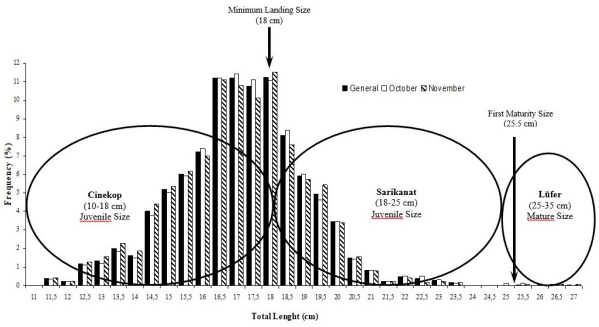

Figure 4. Frequency distribution of bluefish size groups for October and November 2012

Differences between mean lengths calculated from caught fishes at each trawl haul were found statistically significant ($p<0.05$). Mean lengths were determined by weekly performed sampling 4 times for both months in October and November. For October, the highest mean length was calculated as 18.9±0.08 cm at 2nd week and the lowest was 17.5±0.06 cm at 4th week. The highest and lowest values of mean length were determined for November 17.8±0.09 cm (2nd week), 16.2±0.10 cm (in 5th week), respectively. Additionally, it is determined that CPUE values and mean length values calculated in the same week showed a reverse relationship. Mean CPUE and total lengths established from weekly performed sampling for each month were given in Figure 5.

Table 1. Studies on some biological features and length-weight relationship of bluefish (*Pomatomus saltatrix*) in Turkish Seas

Authors	Region	Length (cm) (min-max)	Weight (g) (min-max)	n	a	b	R	Growth
Ceyhan (2005)	Aegean-Marmara Sea	8.4* – 45.3*	7.0 – 996.7	2817	0.0063	3.4600	0.98	+Allometric
Kalaycı et al. (2007)	Middle Black Sea	13.2 – 21.7	23.2 – 88.2	143	0.0130	2.8600	0.96	-Allometric
Ak et al. (2009)	Eastern Black Sea	11.6 – 21.2	12.0 – 131.0	14	0.0030	3.3400	0.98	+Allometric
Özdemir et al. (2009a)	Middle Black Sea	9.2 – 23.4	10.1 – 135.5	820	0.0037	3.3270	0.99	+Allometric
Özdemir et al. (2009c)	Middle Black Sea	-	-	628	0.0060	3.1950	0.98	+Allometric
Özdemir et al. (2010)	Middle Black Sea	9.7 – 23.1	9.8 – 126.9	529	0.0030	3.3990	0.99	+Allometric
Bök et al. (2011)	Marmara Sea	10.6 – 24.0	12.1 – 107.6	290	0.0325	2.5287	0.93	-Allometric
Özdemir and Duyar (2013)	Middle Black Sea	12.2 – 24.0	15.4 – 127.2	207	0.0050	3.2500	0.94	+Allometric
Kasapoğlu and Düzgüneş (2014)	Eastern Black Sea	12.5 – 20.2	16.0 – 75.2	25	0.0092	3.0050	0.93	Isometric
Bal et al. (2015)	Marmara Sea	12.3 – 43.7	18.9 – 794.1	1230	0.0107	2.9574	0.98	Isometric
Özpiçak et al. (2017)	Middle Black Sea	13.5 – 23.6	22.0 – 161.2	125	0.0080	3.1200	0.98	+Allometric
Samsun et al. (2017)	Western Black Sea	16.1 – 27.5	32.5 – 227.9	820	0.0050	3.2500	0.97	+Allometric
Bal et al. (2018)	Marmara Sea	12.3 – 47.3	18.7 – 794.1	1023	0.0107	2.9574	0.97	Isometric
İlkyaz (2018)	Aegean Sea	16.5 – 35.3	-	136	0.0103	2.9700	0.99	Isometric
Present study (2018)	Middle Black Sea	9.2 – 27.3	7.7 – 199.2	3190	0.0037	3.3067	0.99	+Allometric

Note: In this table, *n* indicates number of fish, *a* indicates condition factor, *b* indicates coefficient of chunky, *R* indicates correlation coefficient, * indicates the fork length.

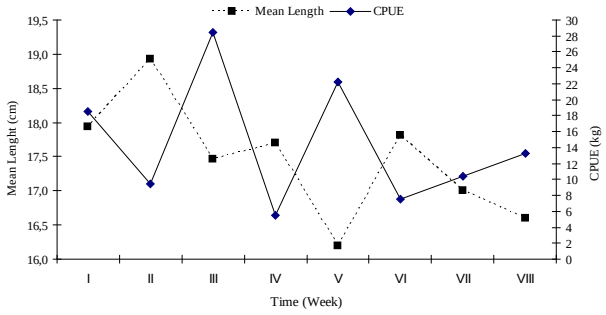

Figure 5. Weekly catch per unit effort (CPUE) and mean length of bluefish

Passive fishing gears (set nets and hand-lines) have optimum catch length (OCL) more than active fishing gears (purse seine and trawl) for bluefish. OCL for captured bluefish by hand-line with hooks number 1, 1/0, 2/0, 3/0 and 4/0 were reported as 19.18 cm, 21.88 cm, 24.14 cm, 27.02 cm and 28.19 cm (Öztekin et al., 2018). Acarlı et al. (2013) estimated that OCL of the gillnets with 22 mm, 23 mm, 25 mm, and 28 mm mesh size were 22.24 cm, 23.25 cm, 25.27 cm and 28.30 cm, respectively. Determined lengths for bluefish are higher than MLS (18 cm) but some lengths is lower than fist maturity size (25 cm) of bluefish.

Commercial catches were dominated by fish between 11 and 23 cm fork lengths for the purse-seine fleets and by fish >23 cm for gill netters and hand-lines in Turkish waters (Akyol and Ceyhan, 2007). Also, length of bluefish captured by pelagic and demersal trawls were determined in the range 9-24 cm in the Black Sea coasts (Özdemir et al., 2009a).

While catch per unit effort (CPUE) of bluefish was increasing, mean length of bluefish were decreased in the study. Table 2 shows that the highest CPUE (3rd week) and mean length (2nd week) of bluefish is in October. Mean length of bluefish is just more than minimum landing size (18 cm) in the 2nd week haul. Mean length of bluefish is less than minimum landing size for all hauls except 2nd week haul. But average length of bluefish is 18.0 cm and limit of minimum landing size in October. Mean length of fishes is under of minimum landing size (MLS) in November. Differences among CPUE and mean total length of bluefish are significant for all weeks ($p<0.05$). According to results, it can be expressed that fishing period affects catch per unit effort in bluefish fisheries.

Table 2. Fishing time, mean total length (cm) and CPUE (kgh^{-1}) for bluefish

Months	Weeks	Mean total length	General	CPUE	General
October	1	17.9 ± 0.10^{a}	18.0 ± 0.08^{a}	18.48^{a}	15.48^{a}
	2	18.9 ± 0.08^{b}		9.45^{b}	
	3	17.5 ± 0.06^{a}		28.46^{c}	
	4	17.7 ± 0.09^{a}		5.53^{d}	
November	5	16.2 ± 0.10^{c}	16.9 ± 0.10^{b}	22.28^{c}	13.38^{a}
	6	17.8 ± 0.09^{a}		7.57^{bd}	
	7	17.0 ± 0.09^{d}		10.40^{bd}	
	8	16.6 ± 0.15^{cd}		13.25^{b}	

Note: Test for total length and CPUE: a, b, c, d (↓). Differences between groups showed with different letter is significant ($p<0.05$)

Lucena et al. (2002) reported that adult individuals of bluefishes were fished excessively and young individuals are not successful in ensuring the continuity of the stock. Salerno et al. (2001) were determined >34 cm (1+ and 2 age) first maturity size of bluefish in northern coasts of the USA. The bluefish has varied growth ratios between sexes, with females tending to be larger. The first maturity size of bluefish ranges from 25 cm to 43 cm in Brazil coasts (Cumplido et al., 2018). Furthermore, Ceyhan (2005) informed that the average fork length of bluefishes which are caught from the Aegean and Marmara Sea of Turkey is 16.9 cm, first maturity length is 25.4 cm for females and fishing pressure on the species is excessive. On the other hand, Bal (2015) determined that the reproduction of bluefish occurred between in July and August, also the first maturity of length is 25.5 cm and 25.0 cm for females and males were established.

Bluefish were generally exploited by purse seines, pelagic trawls and set nets in the Black Sea coasts. The landings are from juvenile individuals. There is over fishing pressure on bluefish in the Black Sea (Figure 4). The high exploitation ratio (0.62 and 0.66) and heavy

fishing pressure for bluefish were demonstrated by Akyol and Ceyhan (2007) and Bal (2015). Thus, authors recommend that minimum landing size (MLS) of bluefish has to be re-assessed for sustainable bluefish fishery.

Conclusion

The present study supplies utility data on CPUE of fishing gears, LWR, biology of fish in the other seas and ocean regions in terms of the some parameters estimation for the bluefish captured from the Black Sea coasts. Besides, this important data and results are usually used in the management of fish stocks, fisheries biology institution and scientists. Therefore, the relevant studies on CPUE, LWR, population dynamics and biological characteristic of fishes captured in the Mediterranean basin should be improved and appraised in the near future.

Conflict of Interest

The authors declare that there is no conflict of interest.

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