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Catch per Unit Effort and Mortality Rates of Two Sparid Species, *Pagellus acarne* and *Pagellus erythrinus* from Bottom Trawl Fishery in Izmir Bay, Aegean Sea

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Abstract: This study was carried out by using experimental trawl surveys in Izmir bay (Aegean sea) with seasonal basis between 2007 and 2009. A total of 707 specimens of *P. acarne* sampled were ranged from 7 cm (7.5 g) to 19.8 cm (137.5 g) with average 12.4±0.06 cm FL (35.2±0.57 g) while a total of 1127 *P. erythrinus* specimens were also ranged from 4.6 cm (1.8 g) to 22.3 cm (247.8 g) with average 13.1±0.09 cm FL (50.8±1.02 g). The maximal CPUE was found in Autumn (0.53±0.14 kg h^{-1}) for *P. acarne* while in Spring (1.29±0.47 kg h^{-1}) for *P. erythrinus*. The high exploitation rates (E = 0.65 $year^{-1}$ for *P. acarne* and E = 0.61 $year^{-1}$ for *P. erythrinus*) indicates the over-fishing on both Pagellus populations in the Aegean sea.

Key words: *Pagellus acarne*, *Pagellus erythrinus*, CPUE, exploitation, mortality, Izmir bay, Aegean sea

INTRODUCTION

Axillary sea bream, *Pagellus acarne* (Risso, 1826) and common pandora, *Pagellus erythrinus* (Linnaeus, 1758) are two widely distributed Sparidae species whose distribution area encompasses both hemispheres from Scandinavia to Senegal and Angola. Both demersal schooling species are preferably inhabit the continental shelf-sandy or muddy-bottoms at depth of 40-200 m (Spedicato *et al*., 2002; Golani *et al*., 2006). These species are generally recognized as being hermaphroditic, protandrous (*P. acarne*) and protogynous (*P. erythrinus*) and spawning occurs in the Autumn for *P. acarne* in the eastern part of the Mediterranean and from Spring to Autumn for *P. erythrinus* (Hureau and Bauchot, 1986).

These species are commercially important and they are fished with a variety of fishing gears such as trawl, gillnet, longline and beach seine. The last Turkish official statistics (Tuik, 2010) shown that total capture production, all of breams was about 1000 tons of which 479 tons (48%) obtained from the Aegean sea. According to Turkish Fisheries Regulations Circular (TFRC), there is a general 15 cm Minimum Landing Size (MLS) limitation for the breams (Anonymous, 2008). Officially, there are no specific catch amount records and MLS for neither axillary sea bream nor common pandora. However, recent studies (Kinacigil *et al*., 2008; Metin *et al*., 2011) reported that the length at first maturity of *P. acarne* and *P. erythrinus* in the Aegean sea were 14.5 and 15.1 cm TL, respectively. Thus, the MLS with 15 cm in TFRC seems to be reasonable for both species. Studies on the populations of *P. acarne* and *P. erythrinus* species in Turkish seas are relatively scarce and therefore, various aspects of its biology (Tosunoglu *et al*., 1997; Akyol and Ozekinci, 2000; Metin *et al*., 2011), by-catch ratios (Akyol, 2003; Ozbilgin *et al*., 2006) and selectivity (Tosunoglu *et al*., 2003; Tosunoglu, 2007; Karakulak and Erk, 2008; Ates *et al*., 2010; Aydin *et al*., 2011) have been documented. The study of Akyol and Ozekinci (2000) given the mortality rates of *P. acarne* and *P. erythrinus* from beach-seining in the Aegean coasts however, Catch Per Unit Effort (CPUE) were not studied up to now in Turkish seas.

The aim of this study was to determine the stock abundance in relation to CPUE from trawling and mortality rates of *P. acarne* and *P. erythrinus* populations in Izmir bay (Aegean sea).

MATERIALS AND METHODS

This study was carried out in both free and closed areas for trawlers of Izmir bay (Fig. 1). Sampling was performed seasonal basis between 2007 and 2009 using experimental trawl surveys with R/V Egesuf (27 m in overall length, 550 hp in engine). Depth of trawl hauls were between 30 and 70 m. Trawl net had a cod-end mesh size of 44 mm from knot to knot. Speed and duration

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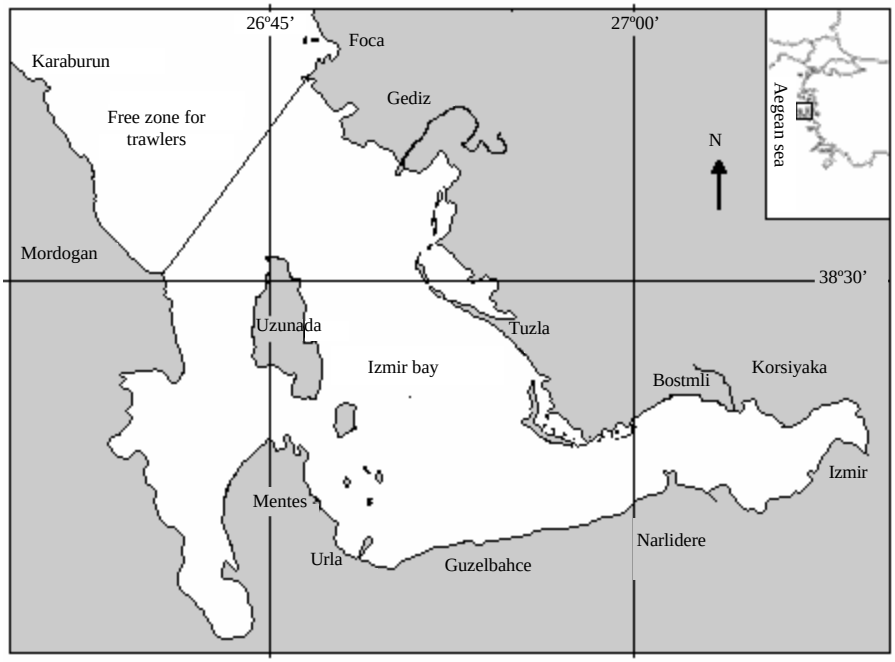

Fig. 1: Sampling area

of trawl operations were kept constant at 2.5 knot and 30 min, respectively. *P. acarne* was obtained from 56 hauls, 15 in Autumn; 16 in Winter; 13 in Spring and 12 in Summer while *P. erythrinus* was also collected from 69 hauls, 24 in Autumn, 15 in Winter, 17 in Spring and 13 in Summer.

The samples of *P. acarne* (n = 707) and *P. erythrinus* (n = 1127) were examined in the laboratory. Their size (FL in cm) and weight (g) were measured and weighed to the nearest ±0.1 cm and ±0.1 g, respectively. Ageing were made from sagittal otoliths in order to calculating the von Bertalanffy growth parameters (i.e., L_∞, K). The Catch Per Unit Effort (CPUE) was calculated according to Petrakis (1998) as kg h^{-1} (i.e., kg h^{-1}) of fishing: the total weight of the species was standardized to 1 h of towing:

$$W_i = w_i \times 60/t$$

Where:

W_i = Standardized weight
w_i = Actual weight
t = Duration of the tow

The CPUE was estimated as the mean of the standardized weight in the season. CPUE = OW_i/N where N is number of hauls in the season. Natural Mortality (M) of *P. acarne* and *P. erythrinus* were computed from Pauly (1980)'s following multiple regressions equation:

$$\log_{10}M = -0.0066 - 0.279\times\log_{10}L_\infty + 0.6543\times\log_{10}K + 0.4634\times\log_{10}T$$

Where:

M = Natural mortality in a given stock
L_∞ = Asymptotic length
K = Growth coefficient
T = The annual mean temperature (in °C) of the sea water

Mean annual sea water temperature for Izmir bay was determined as 18.2°C during the sampling period. Total mortality (Z) was estimated from the mean size in the catch, developed by Beverton and Holt (1957). Z can be estimated from mean length in the catch from a given population by means of:

$$Z = K\times(L_\infty - L_{mean})/(L_{mean} - L')$$

Where:

L_∞ and K = Parameters of the von Bertalanffy growth equations
L_{mean} = The mean length in the catch
L' = Some length for which all fish of that length and longer are under full exploitation

L' is the lower limit of the corresponding length interval (Sparre and Venema, 1992). Fishing mortality (F) can be estimated from F = Z-M. Once values of F and M are available, an Exploitation ratio (E) can be computed from E = F/Z. Which allows one to assess if a stock is over fished or not on the assumption that the optimal value of E (E_{opt}) is about equal to 0.5 (Pauly, 1980).

All of the means were given with Standard Error (±SE). Comparisons of differences among means of CPUEs biomass of both species were tested by Student t-test. In addition, CPUE biomass ratios and the differences among seasons were tested by Kruskal-Wallis test ($\alpha = 0.05$).

RESULTS AND DISCUSSION

A total of 707 specimens of *P. acarne* sampled were ranged from 7 cm (7.5 g) to 19.8 cm (137.5 g) with average 12.4±0.06 cm FL (35.2±0.57 g) while a total of 1127 *P. erythrinus* specimens were also ranged from 4.6 cm (1.8 g) to 22.3 cm (247.8 g) with average 13.1±0.09 cm FL (50.8±1.02 g). The main group of fish was concentrated between 10 and 13 cm for *P. acarne* and between 10 and 15 cm for *P. erythrinus* (Fig. 2). Seasonally, the mean CPUEs (kg h^{-1}) for *P. acarne* and *P. erythrinus* were shown in Table 1 and Fig. 3. The maximal CPUE was found in autumn for *P. acarne* while in spring for *P. erythrinus*. There were no significant differences among the means of

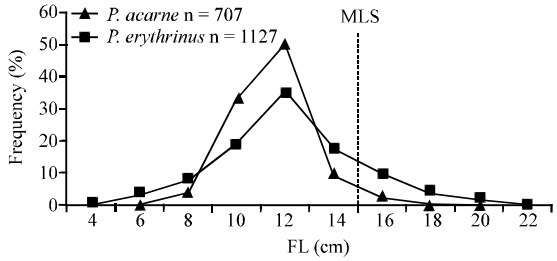

Fig. 2: Length frequency distributions of *P. acarne* and *P. erythrinus* in Izmir bay

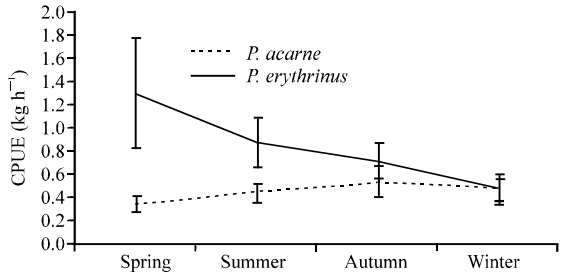

Fig. 3: The seasonal average CPUE fluctuations of *P. acarne* and *P. erythrinus* in Izmir bay (vertical bars indicate ±SE)

CPUEs by biomass for both *P. acarne* and *P. erythrinus* ($p>0.05$). Additionally, differences between CPUE biomass ratios and the seasons were not statistically significant for both species ($p>0.05$).

Mortalities of two *Pagellus* species from Aegean sea were shown in Table 2. In equations, L_∞, K, L_{mean} and L' were assumed as 22.23 cm, 0.276 $year^{-1}$, 12.4 and 11 cm for *P. acarne*; 28.37 cm, 0.151 $year^{-1}$, 13.1 cm and 11 cm for *P. erythrinus*, respectively.

The breams are not fully targeted by trawlers in the Aegean sea however, many of these species are caught as by-catch and in general, they are evaluated commercially. In the Aegean sea, more than a hundred trawlers are fished from August to mid April. In addition, a large part of Izmir bay has been closed to the trawlers as well as beach-/purse-seiners since, 2000 in order to protection of this sensitive habitat which covers Posidonia grass. Thus, the bay has been gained a special nursery area for many of marine fish species since then in this study, very small size (4.6 and 7 cm) of two *Pagellus* species caught is evident to this situation.

The MLS for breams in Turkish waters is 15 cm (Anonymous, 2008). The majorities of the fish ranged from 10-13 cm for *P. acarne* and from 10-15 cm for *P. erythrinus* and 97 and 84% of populations were smaller than MLS, respectively. Tosunoglu *et al.* (1997) reported that the fork lengths of *P. acarne* and *P. erythrinus* in Izmir bay were between 9.8 and 14.8 cm and between 7 and 24.5 cm, respectively. Tosunoglu (2007) also given that the FL of *P. acarne* and *P. erythrinus* in Izmir bay were ranged from 8.4-15 cm and from 7.4-23 cm, respectively. Recently, Metin *et al.* (2011) determined that the total length of *P. erythrinus* was ranged from 4.1-27.8 cm in Izmir bay. All of the length ranges of two species from trawl samplings in Izmir bay were the similar.

Whereas Moutopoulos and Stergiou (2002) obtained seasonally both fish species with gillnets and longlines during 1997-98 from Cyclades (off Naxos Island, Greece) in the Aegean sea that the total length intervals were between 15.3 and 62.6 cm for *P. acarne* and between 13.1 and 37.6 cm for *P. erythrinus*. It seems that gillnet and longline are the most size selective than the trawl.

Table 1: The seasonal average CPUE values and total landings of *P. acarne* and *P. erythrinus* from bottom trawl surveys in Izmir bay

	Pagellus acarne				*Pagellus erythrinus*			
Seasons	No. of hauls	n	Landings (kg)	CPUE (kg h^{-1})	No. of hauls	n	Landings (kg)	CPUE (kg h^{-1})
Winter	16	200	7.30	0.46±0.10	15	173	6.89	0.46±0.13
Spring	13	94	4.35	0.33±0.07	17	380	21.90	1.29±0.47
Summer	12	205	5.15	0.43±0.09	13	220	11.29	0.87±0.21
Autumn	15	208	7.97	0.53±0.14	24	354	17.12	0.71±0.15
Total	56	707	24.77	0.44±0.05	69	1127	57.20	0.83±0.14

Table 2: Mortalities (M, F, Z) and Exploitation rate (E) of *P. acarne* and *P. erythrinus* in Izmir bay

Species	Natural mortality (M year^{-1})	Fishing mortality (F year^{-1})	Total mortality (Z year^{-1})	Exploitation rate (E year^{-1})
P. acarne	0.68	1.26	1.94	0.65
P. erythrinus	0.43	0.67	1.10	0.61

Santos *et al.* (1995) proved that the gillnet selectivity for both species in Algarve coast (South Portugal) were 15-25, 18-27and 20-29 cm for *P. acarne* and 15-25, 16-27 and 19-30 cm for *P. erythrinus*, respectively by the 60, 70 and 80 mm mesh sizes. In the Northern Aegean sea, Karakulak and Erk (2008) also determined that the selectivity of gillnet nets with 40 and 44 mm mesh for *P. acarne* were 15.23 and 16.76 cm, respectively.

Ozbilgin *et al.* (2006) computed that the ratio of by-catch from trawl fishery in Izmir bay in terms of MLS was 99% for *P. acarne* and 95% for *P. erythrinus*. Akyol (2003) also reported that the illegal landing percentage of *P. erythrinus* from beach-seining in the Aegean coasts was 75% concerning with MLS.

In Izmir bay, Tosunoglu (2007) calculated that the retention lengths (L_{50}) of *P. acarne* and *P. erythrinus* in bottom trawl nets (44 mm diamond mesh) were 13.6 and 12.4 cm, respectively. This result shows that the legal mesh size (44 mm) of Turkish bottom trawl nets is still unselective for both species. Whereas the better selection for both fish have achieved with enlarged mesh size by Aydin *et al.* (2011). The researchers proved that the 50 mm diamond mesh cod-end for *P. acarne* (L_{50} = 15.3 cm) and for *P. erythrinus* (L_{50} =15 cm) is more selective than 44 mm.

In fishBase, maximum-common lengths of *P. acarne* and *P. erythrinus* are 36-25 and 60-25 cm SL, respectively (Froese and Pauly, 2011). Thus, two *Pagellus* species' populations in Izmir bay were not even reach to the common length.

In general, CPUE is used as an index of abundance meaning that a proportional change in CPUE is expected to represent the same proportional change in stock size (FAO, 1999). In this study, the highest mean CPUEs from trawl surveys were determined as 0.53±0.14 kg h^{-1} in Autumn for *P. acarne* and 1.29±0.47 kg h^{-1} in Spring for *P. erythrinus*. In fact, when the CPUE of *P. acarne* was increasing, CPUE of *P. erythrinus* was decreased. On the other hand, there was a seasonally cross-correlation regarding fish abundance between *P. acarne* and *P. erythrinus*. In total, abundance of *P. erythrinus* in terms of landings and CPUE was about two-fold of *P. acarne*. Hureau and Bauchot (1986) stated that in Winter, *P. erythrinus* population moves to the deeper waters depending on the cold water conditions. Thus, this behavior of *P. erythrinus* explains that why we could compute the least CPUE value in Winter. Klaoudatos *et al.* (2010) reported that the mean CPUEs of *P. acarne* and *P. erythrinus* from the Aegean trawl samplings were 4.17 and 17.18 kg h^{-1} in Thermaikos Gulf (Northern Aegean) and 15.32 and 40.58 kg h^{-1} in Argolikos Gulf (Southern Aegean), respectively. It seems that the CPUE values of two *Pagellus* species in Greek Aegean coasts are the higher than those of Izmir bay however, both species in Southern Aegean are the most abundant than those of Northern Aegean sea according to CPUEs.

In this study, many of the smaller specimens of both fish species caught seem that there is growth over-fishing on the both fish stocks. Two Pagellus populations can not get growth opportunity due to the heavy fishing pressure. However, the exploitation rates (E = 0.65 for *P. acarne* and E = 0.61 for *P. erythrinus*) also present the good evidence. The E was higher than 0.50 for both species. Therefore, the stocks of the two *Pagellus* species in Izmir bay are being heavily exploited. Ragonese (2009) stated that the growth over-fishing derives from the huge number of recruits and juveniles which are almost exclusively caught by trawlers. Akyol and Ozekinci (2000) calculated that the exploitation rates of both fish from beach-seining in the Aegean sea were 0.84 for *P. acarne* and 0.76 for *P. erythrinus*.

After the banning of beach-seiners in all Turkish territorial waters since 2001, it seems that the exploitation rate is begun to decline. However, some changes in the fishing legislation may be necessary. Carlucci *et al.* (2009) stated that in such a situation, action to protect recruits becomes quite urgent in order to prevent further stock depletion and this can be achieved through season and/or area closure and/or applying larger mesh size in the cod-end of the trawl net or nets with different geometry (square vs. diamond).

CONCLUSION

The results clearly indicated that the two *Pagellus* species population is over-fished and further studies on population dynamics of these fish should be made for sustaining their stocks and regulating its fishery. For the time being, the fisheries authority should stipulate the 50 mm diamond mesh size for trawl nets in order to protect the some fish by-catch species which have different body forms and MLS of 15 cm for *P. acarne* should be placed in TFRC.

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