

Determination of the Recruitment to Stock and Reproduction Period for Flounder (*Platichthys flesus luscus* Pallas, 1811) along the Trabzon-Rize Coast, Eastern Black Sea

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Abstract: The length and weight distribution of flounder (*Platichthys flesus luscus* Pallas, 1811) were 14.2-34.1 cm and 28.879-611.0 g, respectively. The samples were distributed between the 0 and VII age groups. Von Bertalanffy growth parameters for flounder were $L_t = 41.241[1 - e^{-0.161(t+3.240)}]$ for females, $L_t = 33.567[1 - e^{-0.181(t+3.525)}]$ for males and $L_t = 40.577[1 - e^{-0.142(t+3.105)}]$ for the sexes combined. Reproduction took place from December to March but peaked in December. Two recruitment periods were determined for flounder: the first was January to July, and the second August to November. The proportions of recruitment in the first and second periods were 68.13% and 31.87%, respectively.

Key Words: *Platichthys flesus luscus*, reproduction, growth, recruitment, Eastern Black Sea

Doğu Karadeniz, Trabzon-Rize Sahillerinde Pisi Balığında (*Platichthys flesus luscus* Pallas, 1811) Stoğa Katılım ve Üreme Döneminin Belirlenmesi

Özet: Bu çalışmada, pisi balığının (*Platichthys flesus luscus* Pallas, 1811) boy ve ağırlığının sırasıyla 14,2-34,1 cm, 28,879-611,0 g arasında dağılım gösterdiği tespit edilmiştir. Örnekler 0-VII yaş grupları arasında dağılım göstermiştir. *Platichthys flesus luscus*'un Von Bertalanffy büyüme parametreleri dişi bireyler için $L_t = 41.241[1 - e^{-0.161(t+3.240)}]$ erkek bireyler için $L_t = 33.567[1 - e^{-0.181(t+3.525)}]$ ve her iki eşey için $L_t = 40.577[1 - e^{-0.142(t+3.105)}]$ hesaplanmıştır. Üremenin Aralık-Mart ayları arasında yoğun olarak Aralık ayında meydana geldiği tespit edilmiştir. Pisi balığı için iki katılım döneminin olduğu belirlenmiştir. İlk periyodun Ocak-Temmuz, ikinci periyodun Ağustos-Kasım arasında olduğu tespit edilmiştir. 1. ve 2. dönemlerdeki katılım oranları sırasıyla % 68,13 ve % 31,87 tahmin edilmiştir.

Anahtar Sözcükler: *Platichthys flesus luscus*, üreme, büyüme, katılım, Doğu Karadeniz

Introduction

The Black Sea is the most productive of the seas surrounding Turkey (1). There are 168 fish species in the Black Sea. Twenty-six species were caught in quantities exceeding 100,000 t in 1960s and 1970s in the Black Sea whereas 5 economic species were exploited the 1980s. The migration of *Scomber scombrus*, *Sarda sarda*, *Pomatomus saltator*, *Thunnus thunnus* and *Xiphias gladius* to the Black Sea decreased in the 1970s. Similarly, *Psetta maetotica* has decreased in recent years. The flounder population, an important species for the Black Sea's ichthyofauna in the 1960s, has also decreased (2). Because of a lack of demand, flounder is not caught in large quantities in the Eastern Black Sea, whereas much is caught in the Aegean and Mediterranean seas (1). Few

studies have been carried out in the Black Sea about flounder, and they were on population parameters and ageing (3-7).

Most marine fish species show large year-to-year fluctuations in the recruitment of juveniles to parent stock (8-11), which implies that in these species density-dependent mortality factors are of relatively minor importance.

In most fish species egg production at spawning is supposed to be directly related to the size of the parent stock (12), or even to show an inverse relationship with parent stock size at higher stock levels (13). This implies that, between spawning and subsequent recruitment, density-dependent mortality factors must operate during early life stages. Although this concept has been generally

accepted in stock-recruitment models, actual information is hard to obtain, because in most species this density-dependent mortality is masked by simultaneously acting density-independent factors that generate large between-years fluctuations in recruitment (14).

This study was carried out to determine recruitment and the reproduction period for flounder (*Platichthys flesus luscus* Pallas, 1811) along the Trabzon-Rize coast.

Materials and Methods

Flounder specimens (n = 949) were collected from October 1999 to May 2001 by experimental fishing and from commercial fishermen fishing off the Eastern Black Sea coast of Turkey (Figure 1). Fish samples were generally caught by trawl with 18 mm codend mesh size, set nets with 18-22 mm mesh size and beach seine with 7 mm codend mesh size from depths not exceeding 110 m.

Monthly length frequency data were compiled from sample length measurements during the study. The distributions were determined at 0.5 cm length (TL) intervals. Total body weights (W) were recorded to the nearest 0.1 g.

Age was determined by otolith reading and the Bhattacharya method (12-15). Otoliths (sagittae) were extracted from fish, cleaned with alcohol and stored in dry otolith form. The otoliths were placed in a blackened-bottom watch glass containing glycerine and were viewed under the reflected light of a stereo microscope (magnification X2 and X4) by 2 independent readers for corroboration. Two distinct types of rings were observed:

a white opaque ring and a dark translucent (hyaline) ring (16,17).

The gonads were removed and weighed (nearest 0.001 g) to calculate the gonadosomatic index: $(GSI) = [100 * (GW / (W - GW))]$.

Fish growth was assumed to follow von Bertalanffy's growth function (VBGF), which has the basic form $L_t = L_{\infty} [1 - \exp(-k(t - t_0))]$ (18,19). Estimates of the von Bertalanffy growth parameters, the asymptotic length (L_{∞}), the asymptotic weight (W_{∞}), the growth coefficient (k) and the age at length zero (t_0) were calculated using the least squares method (15). Recruitment periods and their percentages were estimated by the Fisat program, which uses growth parameters (20).

Results

Age and Length Distribution

A total of 949 *P. flesus luscus* specimens were examined. Total length (n = 949) ranged from 14.2 to 34.1 cm and weight from 28.879 to 611.00 g. Mean total length and weight were greater in females than in males but the differences were not statistically significant (t-test, $P > 0.05$) (Table 1).

Eight age classes, from 0 to 7 years, were determined by otolith readings. The flounder can be considered long-lived, taking into account the fact that the oldest female was estimated to be 7 years old and the oldest male 6 years old.

Age groups and mean lengths for the sexes combined were also determined by the Bhattacharya method (Figure 2, Table 2).

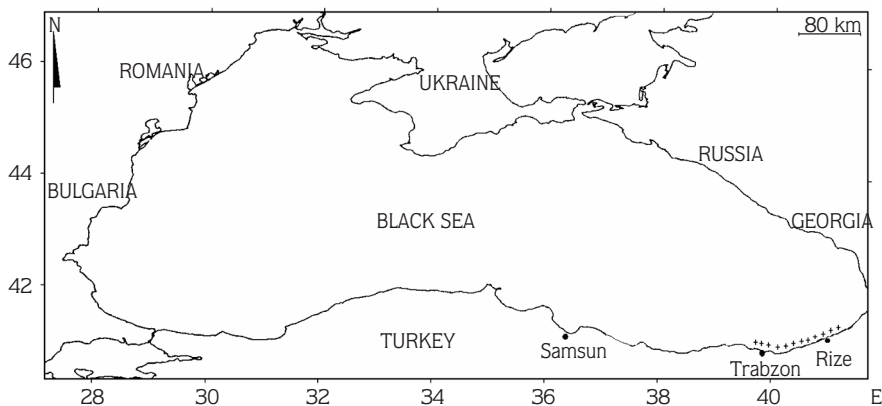


Figure 1. Sampling area.

Table 1. Average length and weight distribution of flounder in terms of sex and ages (N: Number of fish, W: weight (g), L: Length (cm), a: average).

Age	Female			Male			Sexes combined			P
	N	L	W	N	L	W	N	L	W	
0	6	---	---	---	---	---	8	15.74 ± 1.66	42.02 ± 16.30	P > 0.05
I	121	20.33 ± 1.13	89.06 ± 16.78	102	18.81 ± 1.20	75.65 ± 14.99	223	19.65 ± 1.39	84.73 ± 18.82	P > 0.05
II	136	23.58 ± 1.11	143.58 ± 25.17	130	21.13 ± 1.00	111.13 ± 16.11	266	22.58 ± 1.62	136.18 ± 32.00	P > 0.05
III	169	26.09 ± 1.06	198.93 ± 33.46	62	23.58 ± 0.84	158.38 ± 19.24	231	25.62 ± 1.50	190.61 ± 41.66	P > 0.05
IV	94	28.40 ± 1.25	251.31 ± 48.61	38	24.85 ± 0.52	197.44 ± 19.95	132	27.69 ± 1.95	251.36 ± 59.96	P > 0.05
V	36	30.00 ± 1.34	306.65 ± 59.68	27	26.31 ± 0.64	221.48 ± 32.43	63	29.40 ± 2.13	287.81 ± 64.70	P > 0.05
VI	14	32.19 ± 1.44	352.17 ± 79.71	7	27.70 ± 0.37	235.46 ± 31.68	21	31.19 ± 2.38	325.04 ± 85.60	P > 0.05
VII	5	33.20 ± 0.52	412.14 ± 49.79	---	---	---	5	33.20 ± 0.52	412.14 ± 49.79	P > 0.05
Total	581	^a 25.09 ± 3.68	^a 181.95 ± 81.16	368	^a 21.76.8 ± 2.75	^a 111.2 ± 46.71	949	^a 23.80 ± 3.72	^a 155.02 ± 79.57	

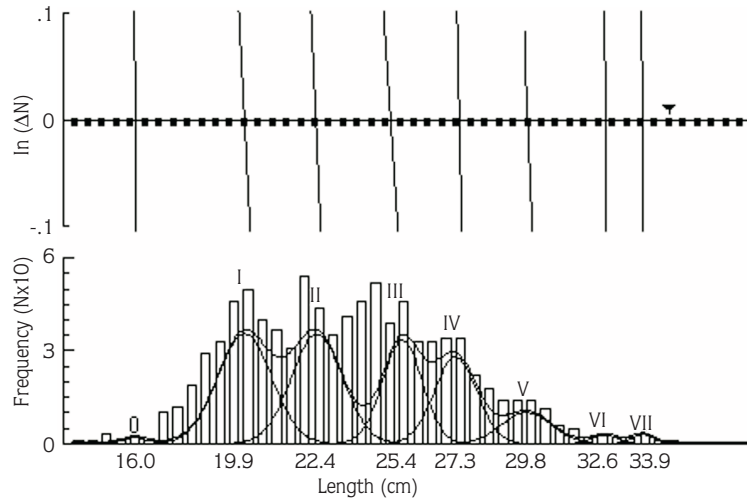


Figure 2. Age determination by the Bhattacharya method.

Table 2. Age and length distribution of *P. flesus luscus*.

Sex	Age group	Length (L, cm) (measured)	Length (L, cm) (Bhattacharya)
Sexes combined	0	15.74	16.00
	I	19.65	19.90
	II	22.58	22.40
	III	25.62	25.40
	IV	27.69	27.30
	V	28.40	29.80
	VI	31.19	32.60
	VII	33.20	33.90

There were no statistical differences between the measured and the calculated mean lengths in terms of ages ($P > 0.05$) (Table 2). Modal age for all fish was 2 (28.03%), followed by 3 (24.34%), 1 (23.50%), 4 (13.91%), 5 (6.64%), 6 (2.21%), 0 (0.84%) and 7 (0.53%) age groups (Table 1).

Reproduction

The gonadosomatic index was used in determining the reproduction period. A total of 575 gonadosomatic index values of female specimens were calculated. From the gonadosomatic index graphic, it was determined that spawning peaked between December and March (Figure 3).

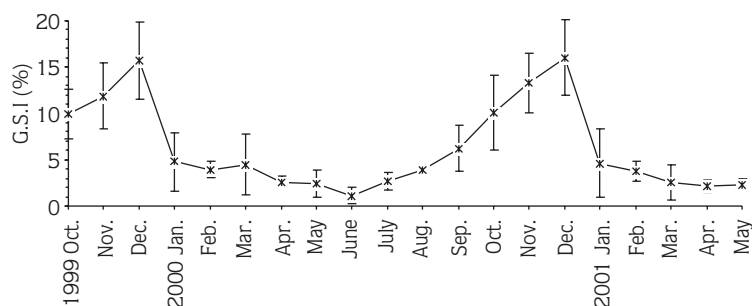


Figure 3. Gonadosomatic index of *P. flesus luscus* for female specimens.

Growth Parameters

Estimated parameters that describe growth in length were $L_{\infty} = 41.241$ cm (TL), $W_{\infty} = 786.191$ g, $K = 0.161$ y^{-1} and $t_0 = -3.240$ y for females; and $L_{\infty} = 33.567$ cm (TL), $W_{\infty} = 457.634$ g, $K = 0.181$ y^{-1} and $t_0 = -3.525$ y for males; and $L_{\infty} = 40.577$ cm (TL), $W_{\infty} = 746.306$ g, $K = 0.142$ y^{-1} and $t_0 = -3.105$ y for the sexes combined.

Recruitment Period

Von Bertalanffy growth parameters (for the sexes combined) were used to calculate the recruitment period using the Fisat program. Two recruitment periods were determined for *P. flesus luscus*. The first was from January to June. As can be seen in Figure 4 intensive recruitment occurred in April (30.50%). Recruitment was lower in June (1.97%). The total recruitment rate was 68.13% for the first period. The second recruitment period was from August to November. The total recruitment rate was 31.87% for the second period (Figure 4).

Discussion

During this study, a total of 949 *P. flesus luscus* specimens were examined. Mean length and weight were 14.2-34.1 cm and 28.88-611.0 g, respectively. Eight age groups were determined. In a study carried out off the Eastern Black Sea coast from 1994 to 1996, length and weight distribution were 5-38 cm and 1.62-684.40 g respectively (6). However, in a study on the central Black Sea coast, length and weight distribution were 14.1-30.1 cm and 37.27-185.17 g, respectively (4). In another study on the central Black Sea coast 6 age classes, from 0 to 5 years, were determined from different bony structures and 5 age classes were

determined from otolith readings (7). The differences among the studies probably result from gear selectivity and the sampling areas.

In our study, the von Bertalanffy growth parameters were $L_t = 41.241[1 - e^{-0.161(t+3.240)}]$ for females, $L_t = 33.567[1 - e^{-0.181(t+3.525)}]$ for males and $L_t = 40.577[1 - e^{-0.142(t+3.105)}]$ for the sexes combined. In a previous study carried out in the same area, growth parameters were $L_t = 44.980[1 - e^{-0.197(t+1.433)}]$ for females and $L_t = 33.001[1 - e^{-0.215(t+2.215)}]$ for males (6). Furthermore, in a study performed in the Bay of Biscay (21), maximum length and weight values were $L_{\infty} = 58.00$ cm and $W_{\infty} = 1915.0$ g for females and $L_{\infty} = 47.00$ cm and $W_{\infty} = 1130.0$ g for males. These results show that flounder living in the Bay of Biscay grow more than those in the Black Sea. The differences among the studies probably result from sea temperature, genetic features and feeding.

Reproduction of the flounder in our region took place from December to March but peaked in December. Studies carried out in the same area report similar findings (4-6). Flounder living in the North Sea are reported to reproduce in February and March (22). Reproduction off the coast of France has also been reported to occur in February and March (23).

The results for the Central and Eastern Black Sea coast were similar. The results for different countries differed because of abiotic factors.

The recruitment of flounder off the Eastern Black Sea coast occurred from January to July, peaking in April and March. The specimens recruited to the population were nearly at age group I. A second recruitment period was estimated from August to November. Of total recruitment, 68.13% took place in the first period and

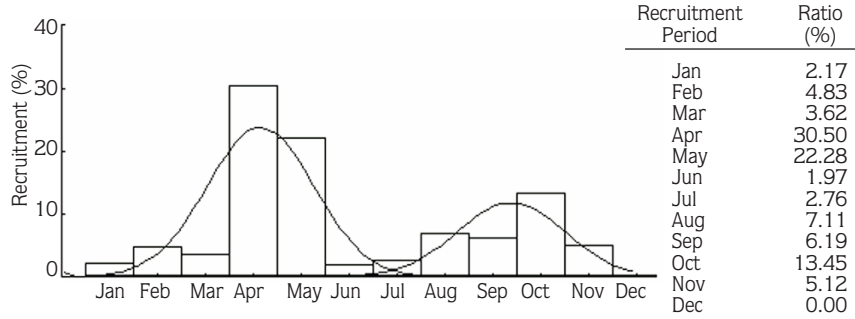


Figure 4. Recruitment period for Flounder (*P. flesus luscus*).

31.87% in the second. We found no study on recruitment in flounder off the Turkish coast. In a study in the Baltic Sea, Muller and Friess (24) stated that flounder specimens were recruited to the population after age 2. In another study, in northwest Europe, van der Veer et al. (25) reported that recruitment for flounder was in July, and in terms of sea temperature it can be in August and September and the impact of predation by crustaceans (*Crangon crangon*, *Rapana* sp.) affected recruitment. Rijnsdorp et al. (26) stated that recruitment variability is largely generated by density independent factors (abiotic) acting during the pelagic egg and larval phases.

In our study, the recruitment period and age of flounder were different from the results of studies carried out in Europe. The difference between the studies

probably resulted from sea temperature, feeding and genetic factors.

In conclusion, new research should be carried out to determine recruitment age and period for flounder in Turkey. Flounder fishing should be banned during the reproduction period and newly recruited specimens should not be caught. This precaution is extremely important for protecting the flounder population.

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