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Seasonal distribution and migration pattern of the turbot (*Psetta maxima* Linnaeus, 1758) in the eastern Black Sea, Republic of Turkey

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Abstract

In order to determine the seasonal distribution and migration pattern of the Black Sea turbot, *Psetta maxima* (Linnaeus, 1758) specimens were collected off Trabzon, Turkey, in the eastern Black Sea. A total of 422 specimens were caught by 364 otter trawl hauls in 95 cruises from 24 July 1997 to 19 February 1999. Average catch per unit effort per thirty minutes by the otter trawls with the mouth opening of 15 m was 1.2 individuals. Turbots were distributed between 5 m and 70 m depth, where bottom water temperatures varied from 26.4°Cto 8.0°C. They were found mainly at 10 m in July - October and at 5 - 60 m in November - March. However, the turbot were found in high densities at < 20 m depth from April to June. Therefore, it appears that Black Sea turbot migrates from deeper water to shallow coastal watersduring the spawning season of April to June. Off Trabzon, P. maxima spawns in coastal areas < 20 m deep.

Keywords: Black Sea; turbot; CPUE; seasonal distribution; migration pattern

Özet

Karadeniz Kalkan balığının *Psetta maxima* (Linnaeus, 1758) mevsimsel dağılım ve göçünü tespit etmek amacıyla Doğu Karadeniz'den (Trabzon, Türkiye) örnekler toplanmıştır. 24 Temmuz 1997 19 Aralık 1999 tarihleri arasında 95 seferde 364 kere trol atılarak 422 örnek toplanmıştır. Ağ açıklığı 15 metre olan trol ile 30 dakikada birim çabada ortalama av 1,2 birey olmuştur. Kalkan balıkları su sıcaklığı 26,4°C ile 8 °C aralığında, derinliği5 m ile 70 m arasında değişen bölgeye dağılmışlardır. Kalkan balıkları, Temmuz ile Ekim arasında genellikle 10 m 'de, Kasım ile Mart arasında ise 5- 60 m arasında bulunmaktadır. Ancak, Nisan ile Haziran arasında daha derinde< 20 m bulunmaktadırlar. Bundan dolayı, Karadeniz kalkan balığı Nisan ile Haziran ayları arasında yumurtlama evresinde derin sulardan sığ sulara göç etmektedir. *P. maxima*'nın Trabzon'daki yumurtlama bölgesi kıyıdan < 20 m açıklarındadır.

Anahtar Kelimeler: Karadeniz, Kalkan, BCA, mevsimsel dağılım, göç

Introduction

Black Sea turbot, Psetta maxima (Linnaeus, 1758), usually caught by trawl nets and gill nets, is commercially important fish economically not only for Turkey, but also for the five other countries, Georgia, Russia, Ukraine, Bulgaria, and Romania all bordering the Black Sea. Average annual catches for this species are 197 t in Bulgaria, 74 t in Romania, 532 t in the former Soviet Union, and 1,991 t in Turkey from 1950 to 1992, respectively, while Turkey has taken 70 % of the total landing annually (Prodanov et al., 1997). According to Turkish fisheries statistics of the species from 1967 to 1997, it has amounted to between 435 and5,398 t

(mean catch 2,178 t) a year (Fisheries Statistics of Turkey, 1967 - 1997). However, the total catch of the species in the Black Sea began to decrease drastically until 530 t in 1985, presumably because of over-fishing and environmental pollution; therefore, Ukraine (former Soviet Union) prohibited harvesting by use of mechanical fishing gear from 1985 to 1995 (Prodanov et al., 1997).

Management of turbot fisheries in the Black Sea is necessary; however, there is only limited information available off Georgia given by Popova (1954). Other ecological information addressing foraging migration, distribution, occurrence, and spawning behavior in the Black Sea is poorly understood. The objective of the study is to clarify the seasonal distribution and migration patterns of Black Sea turbot off Trabzon in the eastern Black Sea.

Materials and Methods

According to Nielsen (Nielsen, 1986), the turbot has been grouped into two subspecies, P. maxima maxima and P. maxima maeotica the latter having been referred to as the Black Sea representative and an endemic subspecies. From our morphological study, they could not be clearly separated (Amaoka et al., 2001). Recently, genetic study conducted by Suzuki et al. (2004) concluded that pairwise genetic distances among samples from the Atlantic Ocean and from four secluded eastern basins of the Mediterranean (Aegean Sea, Sea of Marmara, Black Sea, and Sea of Azov) were small and considered to be at the intraspecific level and therefore there is no support for recognizing two different taxa among turbot. These results are followed in the present study.

Specimens were collected using the research vessel (R/V) belonging to the Central Fisheries Research Institute (CFRI) with otter trawl nets with an opening of 15 m, a net length of 32 m and a codend mesh size of 14 mm from 24 July 1997 to 19 February 1999. The survey was mainly conducted once or twice a week from a depth of 5 to 70 m at areas located from 40°58'to 41°01'N and from 39°46'to 39°50'E off Trabzon (Fig. 1). All nets were towed horizontally for thirty minutes along the horizontal line at depths of 5, 10, 15, 20, 30, 40, 50, 60, or 70 m at approximately 2.5 knots. Sampling points for water temperature between the seabed and surface layer were fixed as stations 1 - 9 at a depth of 5 - 80 m off Trabzon and measured by transparent plastic Nansen water samplers at least once a month during the survey periods (Fig. 1). In addition, the seabed temperature was measured by the same sampler when Black Sea turbot were collected by otter trawl nets. Total length and standard length were measured with digital calipers to the nearest 0.1 mm, andtotal body weight of specimens was measured with a digital balance to the nearest 0.1 g on the research vessel or in the laboratory. After the completion of measurements, all specimens collected by otter trawl nets were utilized as a broodstock in captivity for the purpose of seed production at CFRI.

In the present study, there were no significant differences ($P < 0.05$) shown by Wilcoxon signed-ranks test in the seabed temperature at 5 - 15 m, 20 - 30 m, and over 30 m depths among months during survey periods. Therefore, all data were combined as monthly results in the following topics. Kruskal - Wallis test followed by Scheffe's test ($P<0.05$) was applied to compare the relationships between month and collected depth of the turbot.

Results

Water temperature

Surface layer temperature varied from 7.5 to 27.3℃ at stations 1 - 9 during survey periods (Fig. 2). Data were divided into two groups: one for periods of increasing temperature from February to August; the other for periods of decreasing temperature from August to February during survey periods. In both periods, temperature changed as much as almost 20℃.

Results of vertical profiles of seabed temperature during survey periods are shown in Fig. 3. Based on data from seasonal temperature of the seabed at the same station, it varied from 8.1 to 11.1℃ between January and April at 5 - 70 m

depths. In contrast, thermal clines were observed in June at 40 m depths and in July - September at 40 m depths, respectively. It varied from 23.6 to 10.0℃ between July and September. Seabed temperature showed a tendency to decrease gradually through October - November; it varied from 14.2 to 14.8℃ at 5 - 40 m depths in December.

Catch per unit effort (CPUE)

In the present study, CPUE indicates catch number of the turbot per 0.5 h trawling. Distribution of CPUE by sampling date and depth are shown in Table 1. A total of 422 specimens were collected by 364 otter trawl nets during 95 cruises in the survey period and the average calculated CPUE was 1.2 ind/0.5 h. Based on data from the seasonal CPUE of the turbot, the highest values shown were of 2.1 in April, and 1.4 - 1.7 between July and August; the lowest value of 0.6 was shown in December and January. Data of CPUE at different depths indicated the highest value of 1.7 at 10 m depth. The next was 1.6 at 15 m and 20 m depths, respectively. In contrast, a value under 1.0 was obtained at 5 m and at 40 - 70 m depths. In the present study, CPUE showed a tendency to be higher at depths shallower than 20 m compared to depths deeper than 30 m depths.

Seasonal distribution of turbot

Seasonal and vertical changes in occurrence of the turbot at different depths are shown in Fig. 4. Their distribution was restricted by water temperature during the survey periods. Between July and August, they had a tendency to migrate to deeper layers, especially in August they distributed significantly in deeper layers ($P<0.05$). However, turbot widely distributed at 5 - 70 m depths between August and March; only in November and December were they found in shallow coastal areas at 5 - 10 m. In contrast, they were distributed densely at 10 - 40 m depths between April and July. They distributed significantly in shallow coastal areas at 10 - 20 m depths in April ($P<0.05$).

Seasonal changes in total length and the relationship between total length and body weight

Seasonal changes in total length distribution of the turbot are shown in Fig. 5. From July to February, their total length distribution showed a broad range from 10 to 70 cm. In contrast, a clear strong peak was observed between 35 cm and 40 cm only in April, May, and June. Average total length, standard length, and total body weight of the sampled specimens collected by otter trawl nets in the present study were as follows: 34.7 cm (10.2 - 72.3 cm), 27.7 cm (7.9 - 58.5 cm), and 1,085.6 g (12.9 - 8,210.5 g), respectively. The relationship between total length (TL) and total body weight (W) can be expressed by the following equation during survey periods:

$$BW=0.011TL^{3.127}\ (r^2=0.984)\ \ n=273.$$

There was no clear tendency to observe total length distribution at different months, but a weak peak was observed between 20 - 30 cm and 30 - 40 cm in total length. In contrast, based on results from the total length distribution at different depths, a clear strong peak was observed between 35 cm and 40 cm only in April and May (Fig. 5).

Discussion

The present study found turbot to be distributed widely at seabed temperature of 8.0 - 26.4℃ and at 5 - 70 m depths during the survey periods. Their seasonal migrations were divided into three patterns determined by seabed temperature as follows: i) the turbot distribute mainly over 10 - 50 m depths between July and October when variance of the water temperature on seabed was wide; ii) turbot distributed widely at 5 - 60 m depths between November and March from deeper layers to shallow coastal areas when the temperature differential narrowed; iii) the turbot distributed densely between 20 and 30 m depths in April and May (Fig. 4).

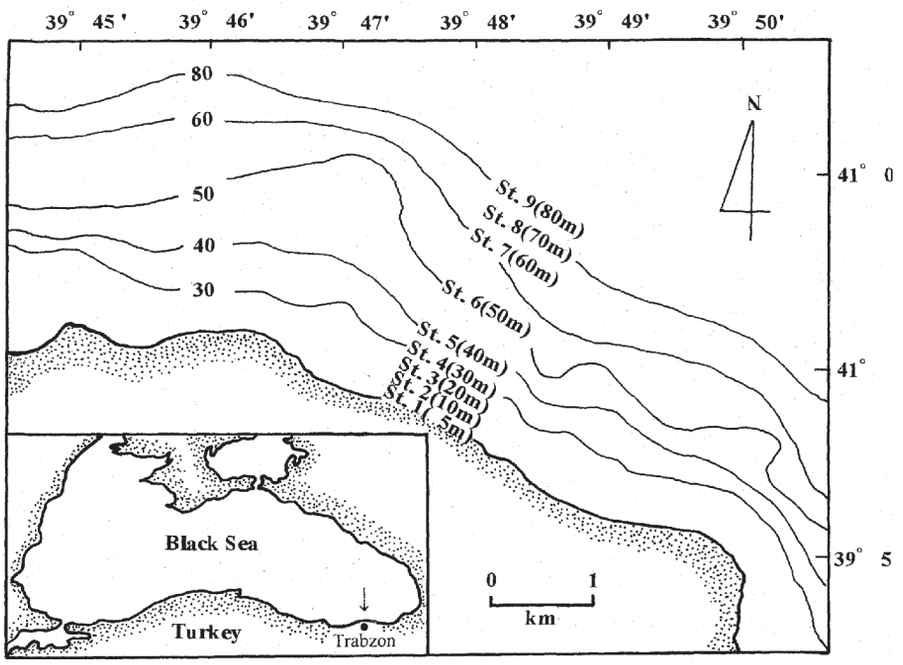

Fig.1. Location of the surveyed area and sampling points for water temperature indicates St. 1 St. 9 off Trabzon in the eastern of the Black Sea.

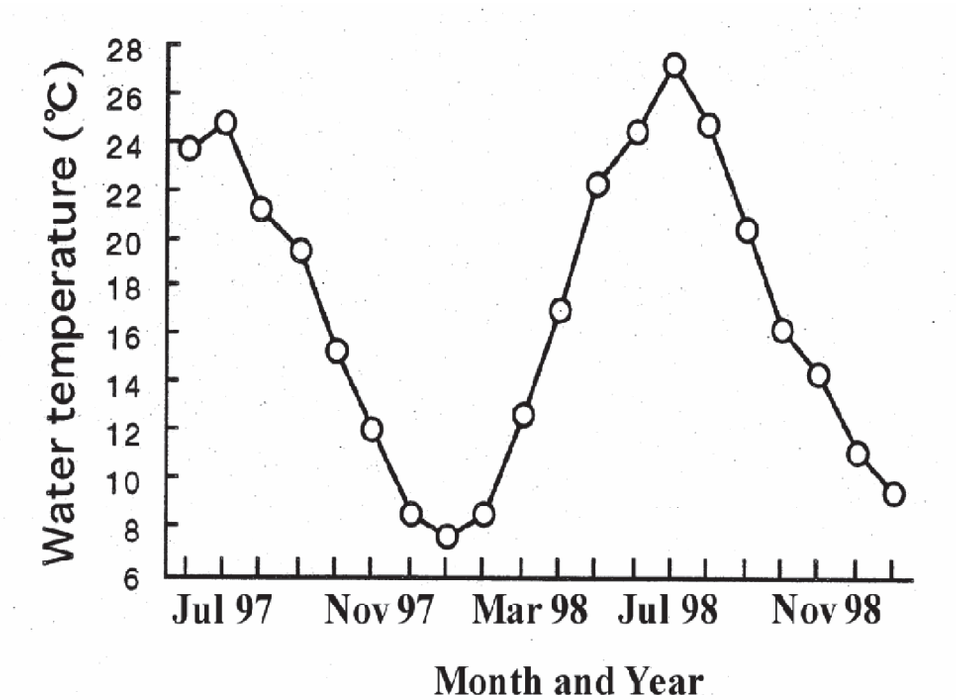

Fig. 2. Seasonal changes of the average water temperature at the surface layer off Trabzon from St. 1 to St. 9 in the Black Sea between July 1997 and February 1999.

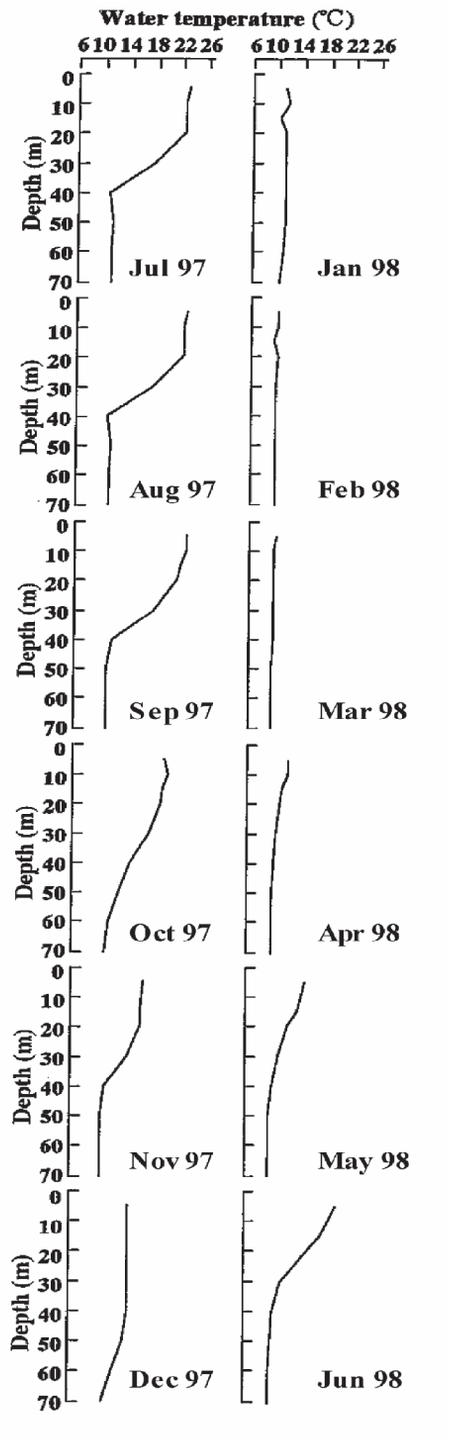

Fig. 3. Seasonal changes of the vertical distribution of mean water temperature on the seabed during the period from July 97 to June 98.

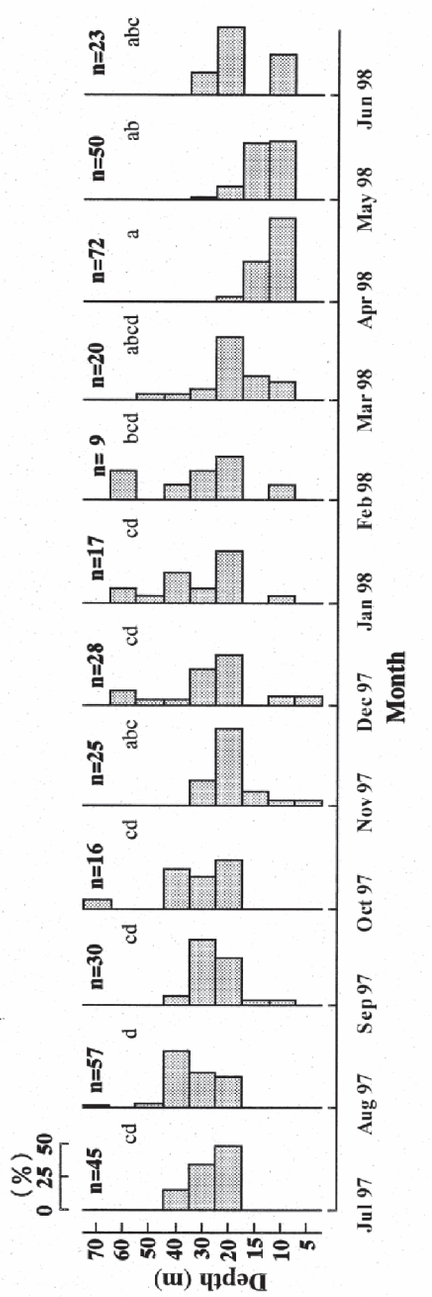

Fig. 4. Seasonal and vertical changes in occurrence (%) of Black Sea turbot off Trabzon in the Black Sea between July 97 and June 98, collected by otter trawl nets. Scale in the upper left-hand corner of the figure indicates percent of total catch at different depths. Different letters indicate significant differences among each month during experiments by Kruskal-Wallis Scheffe's test ($P<0.05$)

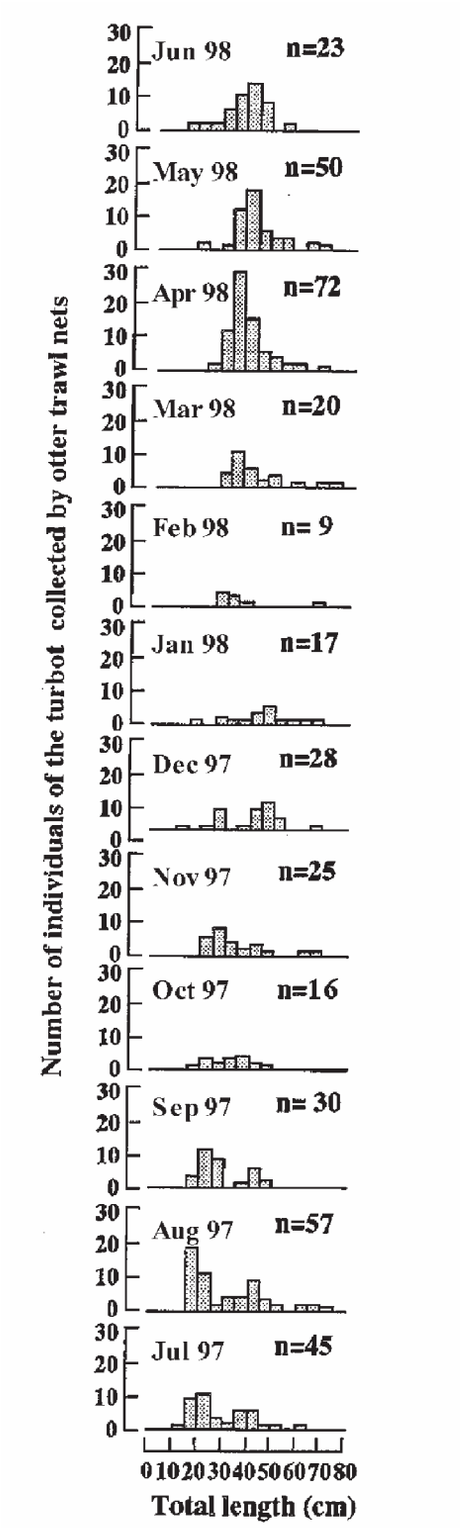

Fig. 5. Seasonal changes in total length distribution of the Black Sea turbot caught off Trabzon in the Black Sea during the period from Jul 97 to Jun 98.

From the first migration pattern, we could not confirm the reason why the turbot select disparate water temperatures on the seabed at 10 - 26°C. From the second pattern, we inferred that it was a foraging migration due to the total length distribution showing a wide range (Fig. 4). Popova (1954) also summarized that turbot migrate from deeper layers to shallow coastal areas to forage for food in autumn off the coast of Georgia. The final migration pattern was inferred to be a spawning migration due to the yield of several million fertilized eggs by semi-dry fertilization techniques used collected broodstock between April and May. Moreover, seasonal changes in total length showed a clear strong peak between 35 cm and 40 cm; these lengths were considered mature size in April and May (Fig. 5). Hara et al. (2002) indicated that the spawning season peak is from April to May based on the gonosomatic index for consecutive years by monitoring fish purchased from the Trabzon market. From viewpoints of these results, there is no doubt that turbot densely distribute in shallow coastal areas under 20 m depths for spawning purposes. Rae and Devlin (1972) reported on the biology of the Atlantic turbot Scophthalmus maximus (L.) in the Scottish region; they pointed out that turbot begin to congregate for spawning only in the spawning season, although they did not confirm the spawning ground. This spawning aggregation behavior was observed only during the spawning season in the present study as found by Rae and Devlin (1972). Such behavior has been reported not only for turbot, but also for cresthead flounder *Limanda schrenki* (S.) in the Sea of Japan (Morita and Oohara, 1965), coral trout Plectropomus leopardus (L.) in the Geat Barrier Reef (Samoilys and Squire, 1994), and Pacific cod *Gadus macrocepalus* (T.) in the Sea of Japan (Fukuda et al., 1985; Yoseda et al., 1992).

Gordina and Morochkovskiy (1994) assumed that the spawning ground of the Black Sea turbot is confined to 40 - 50 m depths based on egg occurrences, and at seabed temperature of

10 - 12°C off the coast of Sevastopol in the Ukraine. Gordina (1999) recently described that the spawning ground of turbot was at 20 - 50 m depths based on analysis of collected eggs. In contrast, Deniel (1990) referred to their spawning ground as not shallow coastal areas but offshore areas on the west coast of Brittany. There are some differences in the depth of spawning grounds estimated among studies. Different sampling methods and differences in oceanographic conditions among regions could be possible explanations.

In summary, we concluded that Black Sea turbot migrate from deeper layers to shallow coastal areas to spawn during the spawning season (April - May). In addition, it is inferred that the species spawns in shallow coastal areas under 20 m depth in the survey sea area. However, we could not establish a clear mechanism of migration behavior explaining why turbot can distribute in a wide range of seabed water temperatures. Further ecological research on spawning and nursery grounds addressing fish from eggs to adults is necessary to sustain turbot fisheries.

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Table 1. Results of catch per unit of effort (CPUE) of Black Sea turbot,collected from off Trabzon in the Black Sea between July 1997 and February 1999. Each February 1999. Each trawls conducted along the horizontal line at a depth oftrawls conducted along the horizontal line at a depth of 5, 10, 15, 20, 30, 40, 50,60, or 70 m at apporomiximately 2.5 knots

	Depth										No. of
	5m	10m	15m	20m	30m	40m	50m	60m	70m	Total	trawls
24 - 31 July 1997											3
No. of turbot	0	–	0	12	12	5	0	–	–	29	
No. of 30 min trawls	2	–	2	4	2	3	1	–	–	14	
CPUE	0.0	–	0	3.0	6.0	1.7	0	–	–	2.1	
5 - 28 August 1997											8
No. of turbot	–	–	1	5	15	2	0	–	–	23	
No. of 30 min trawls	–	–	3	6	9	4	3	–	–	25	
CPUE	–	–	0.3	0.8	1.7	0.5	0	–	0.5	0.9	
11 - 30 September 1997											7
No. of turbot	–	1	1	11	15	2	0	–	–	30	
No. of 30 min trawls	–	2	3	8	11	6	3	–	–	33	
CPUE	–	0.5	0.3	1.4	1.4	0.3	0	–	–	0.9	
2 - 14 Octorber 1997											3
No. of turbot	–	–	0	1	1	5	0	0	–	7	
No. of 30 min trawls	–	–	1	2	3	3	1	1	–	11	
CPUE	–	–	0.0	0.5	0.3	1.7	0.0	0.0	–	0.6	
11 - 25 November 1997											4
No. of turbot	1	1	3	13	5	0	–	–	–	23	
No. of 30 min trawls	2	1	2	4	5	2	–	–	–	16	
CPUE	0.5	1	1.5	3.3	1.0	0	–	–	–	1.4	

11 - 30 December 1997											4
No. of turbot	2	2	–	2	2	0	0	1	–	9	
Number of trawls	1	3	–	4	4	2	1	2	–	17	
CPUE	2.0	0.7	–	0.5	0.5	0	0	0.5	–	0.5	
7 - 27 January 1998											3
No. of turbot	–	1	–	3	1	2	–	0	–	7	
No. of 30 min trawls	–	2	–	3	1	3	–	1	–	10	
CPUE	–	0.5	–	1.0	1.0	0.7	–	0	–	0.7	
6 - 24 February 1998											5
No. of turbot	0	1	–	3	1	1	–	2	–	8	
No. of 30 min trawls	2	1	–	3	1	3	–	3	–	13	
CPUE	0	1.0	–	1.0	1.0	0.3	–	0.7	–	0.6	
4 - 27 March 1998											5
No. of turbot	–	3	4	11	2	1	1	0	0	22	
No. of 30 min trawls	–	4	2	6	2	3	1	2	2	22	
CPUE	–	0.8	2.0	1.8	1.0	0.3	1.0	0	0	1.0	
1 - 22 April 1998											8
No. of turbot	–	53	25	3	0	0	–	0	0	81	
No. of 30 min trawls	–	15	11	4	2	2	–	1	4	39	
CPUE	–	3.5	2.3	0.8	0	0	–	0	0	2.1	
7 - 18 May 1998											10
No. of turbot	–	27	26	6	1	0	–	–	0	60	
No. of 30 min trawls	–	13	12	6	2	1	–	–	2	36	
CPUE	–	2.1	2.2	1.0	0.5	0	–	–	0	1.7	
2 - 30 June 1998											5
No. of turbot	–	7	–	12	4	0	–	–	–	23	
No. of 30 min trawls	–	5	–	5	5	4	–	–	–	19	
CPUE	–	1.4	–	2.4	0.8	0	–	–	–	1.2	
8 - 28 July 1998											3
No. of turbot	0	0	–	10	4	2	–	–	–	16	
No. of 30 min trawls	1	2	–	3	3	3	–	–	–	12	
CPUE	0	0	–	3.3	1.3	0.7	–	–	–	1.3	
4 - 25 August 1998											4
No. of turbot	–	0	–	15	3	2	–	–	–	20	
No. of 30 min trawls	–	4	–	4	4	3	–	–	–	15	
CPUE	0	0	–	3.8	0.8	0.7	–	–	–	1.3	
1 - 30 September 1998											2
No. of turbot	–	1	–	6	0	0	–	–	–	7	
No. of 30 min trawls	–	2	–	2	2	2	–	–	–	8	
CPUE	0	0.5	–	3.0	0	0	–	–	–	0.9	
7 - 27 October 1998											3
No. of turbot	–	0	–	5	3	0	0	0	1	9	
No. of 30 min trawls	–	2	–	2	3	3	1	1	1	13	
CPUE	0	0	–	2.5	1.0	0	0	0	1.0	0.7	
18 - 26 November 1998											2
No. of turbot	–	0	–	2	0	0	0	–	–	2	
No. of 30 min trawls	–	1	–	2	1	2	1	–	–	7	
CPUE	0	0	–	1.0	0	0	0	–	–	0.3	
4 - 31 December 1998											9
No. of turbot	–	0	0	9	6	1	1	2	–	19	
No. of 30 min trawls	–	3	1	9	9	8	1	1	–	32	
CPUE	0	0	–	1.0	0.7	0.1	1.0	2.0	–	0.6	
4 -28 January 1999											9
No. of turbot	–	–	–	4	1	2	1	2	–	10	
No. of 30 min trawls	–	–	–	3	4	5	3	4	–	19	
CPUE	0	–	–	1.3	0.3	0.4	0.3	0.5	–	0.5	
17 -19 February 1999											2
No. of turbot	–	–	–	0	1	–	0	0	–	1	
No. of 30 min trawls	–	–	–	1	1	–	1	2	–	5	

References

Amaoka, K., Yoseda, K., Şahin, T., Üstündağ , C., Çiftci, Y., 2001. Field guide: Flatfishes (order Pleuronectiformes) found in the Black Sea and its adjacent waters. Special Publication No. 1. Trabzon: Central Fisheries Research Institute, Ministry of Agriculture and Rural Affairs, Turkey and Japan International Cooperation Agency.

Fisheries Statistics, 1967-1997. Institute of Statistics Prime Ministry, Republic of Turkey, Ankara: Republic of Turkey.

Deniel, C., 1990. Comparative study of growth of flatfishes on the west coast of Brittany. J. Fish Biol. 37, 149-166.

Fukuda, S., Yokoyama, K., Hayakawa, Y., Nakanishi, H., 1985. On tagging experiments of adult Pacific cod in the entrance of Mutsu Bay, Aomori Prefecture. Saibai Giken. 14, 71-77. (in Japanese).

Gordina, AD., Morochkovskij, VA., 1994. Number and distribution of spawn of turbot *Psetta maeotica* (Pallas) (Scophthalmidae, Pisces) in the Sevastopol region. J. Hydrobiol. 30, 99-108. (in Russian).

Gordina, AD., Morochkovskij, VA., 1994. Number and distribution of spawn of turbot *Psetta maeotica* (Pallas) (Scophthalmidae, Pisces) in the Sevastopol region. J. Hydrobiol. 30, 99-108. (in Russian).

Gordina, AD., 1999. Multiyear fluctuations in the number of eggs for Psetta maeotica (Scophthalmidae) near Sevastopol. J. Ichthyol. 39, 850- 853. (in Russian) .

Hara, S., Özongun, M., Güneş, E., Ceylan, B., 2002. Broodstock rearing and spawning of Black Sea turbot, Psetta maeotica. Turkish Journal of Fisheries and Aquatic Science. 2, 13-17.

Morita, S., Ohohara, M., 1965. Ecological studies of "Kurogashiragarei" *Limanda schrenki* (SCHMID) of Hokkaido. (11). Consideration on the population. Bulletin of Hokkaido Regional Fisheries Research Raboratory. 30, 60-66 . (in Japanese).

Niellsen, JG., 1986. Scophthalmidae. In Fishes of the North-Eastern Atlantic and Mediterranean. Vol.III . In: Whitehead, PJP., Bauchot, M.-L., Hureau, J.-C., Nielsen, J., Tortonese, E. (Eds,), UNESCO: Paris, pp. 1287-1293.

Popova, VP., 1954. Distribution of flatfish in the Black Sea near Karadgh. Tr. Vses. Nauchno- Issled. Inst. Morsk, Rybn, Khoz, Okeanogr. 28, 151- 159 (in Russian).

Prodanov, K., Mikhailov, K., Daskalov, G., Maxim, K., Chashin, A., Arkhipov, A., Shlyakhov, V., Ozdamar, E., 1997. Environmental management of fish resources in the Black Sea and their rational exploitation. No. 68, FAO: Fish. Circ., Rome, pp. 100- 110.

Rae, BB., Devlin, SDE., 1972. The turbot, its fisheries and biology in the Scottish area. Mar. Res.1, 1- 27.

Samoilys, MA., Squire, L.C., 1994. Preliminary observation on the spawning behavior of coral trout, *Plectropomus leopardus* (Pisce: Serranidae), on the Great Barrier Reef. Bull. Mar. Sci. 54, 332-342.

Suzuki, N., Nishida, M., Yoseda, K., Amaoka, K., 2004. Phylogenetic relationships within the Mediterranean turbot inferred by mitochondrial DNA haplotype variation. J. Fish Biol. 65, 580-585.

Yoseda, K., Hirokawa, J., Nagakura, Y., Aritaki, M., Kobayashi, M., 1992. Maturity condition of adult Pacific cod and distribution of Pacific cod eggs, larvae and juveniles in adjacent waters of Notojima, Ishikawa Prefecture, Japan. Saibai Giken. 21, 21-30. (in Japanese).