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Seasonal Dynamics of Biological Indicators of the European Flounder *Platichthys flesus* Linnaeus, 1758 in the Central Part of the Kola Bay in 2018

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Abstract

The data on the seasonal dynamics of biological indicators of European flounder are presented for the central part of the Kola Bay for the year of 2018. In particular, the size-age and population sexual structure, feeding, and distribution density of European flounder were considered. The constants of the power equation of the dependence of the fish body weight on its length were obtained, the peculiarities of the fish growth were revealed. It is assumed that European flounder is one of the important components of the coastal ecosystems of the Kola Bay.

Keywords: European flounder, *Platichthys flesus*, Kola Bay, Barents Sea, seasonal dynamics of size and age structure, population sexual structure, feeding.

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1. Introduction

European flounder *Platichthys flesus* Linnaeus 1758 is one of the most widespread and abundant fish species in the Kola Bay [1, 2]. This species has the economic importance in some areas of its geographical range; however, in the Kola Bay, European flounder does not belong to the commercial species. Nevertheless, being an element of the ichthyofauna of the communities of the Kola Bay, European flounder may play an important role in the formation of the diversity of the littoral and sublittoral fauna and in the processes of transformation of the matter and energy in these biotopes. As a rule, the available information on the biology of European flounder in the Kola Bay refers only to the fish inhabiting its southern part [1---9]. Therefore, the work aims at studying the biology of European flounder in the central part of the Kola Bay and analyzing the seasonal variability of its particular quantitative parameters.

2. Methods and Equipment

The sampling of primary material was carried out in May, July, and October 2018 in the central part of the Kola Bay, near the Belokamenka village, during low tide in the littoral and sublittoral zones. The European flounder was caught using a 15-meter minnow seine (height of 1.8 m; mesh size of 6 mm in the wings; 5 mm, in the center sac; 4 mm, in the cod end) and nets with mesh of 30, 40 and 50 mm (all of standard length of 10 m, height of 1.8 m). The area of one fishing by the minnow seine was 750 m^2. Nets with different meshes were installed for 24 hours perpendicular to the shore to a depth of 1.8 m to 4 m during the maximum low tide. The collected material was processed according to standard ichthyological methods [10---12]. The fish abundance and biomass were calculated only according to the catches of the active fishing gear (minnow seine), and biological analysis was performed for all specimens (Table 1). The length of the fish was measured with 0.1-cm accuracy, the weight, with 0.1-g accuracy. In order to determine the fish age, the otoliths were took out and the thin sections were analyzed under the binocular. The condition of the gonads and reproductive products was evaluated on the basis of visual observations on a maturity scale developed for this species by PINRO [11]. The average stomach filling index based on a 5-point system was applied to assess the intensity of feeding [13]. The frequency of occurrence of the food objects in the fish stomach was calculated taking into account empty stomachs as well.

Table 1: Study periods and the amount of material collected.

Parameter	Study period		
	May 17--18	July 16--17	October 9--10
Number of minnow seine catches	5	5	3
Number of net catches	6	6	6
Number of fish caught by minnow seine, ind.	12	49	1
Number of fish caught by nets, ind.	16	18	8
Total number of fish, ind.	28	67	9

3. Results

Size and age structure. In May, in the surveyed water area, the European flounder was represented by juvenile fish of 2+ age (7%) and adults, from 4+ to 11+ age (Figure 1); most of the fish were mature specimens aged 4+ to 6+ (68%). In July, juveniles aged 2+ and 3+ were also present (10%); the proportion of 5--7-year-olds increased up to 81%. In

October, the fish were mostly represented by the groups 5+ (56%) and 6+ (44%), which dominated throughout the study period.

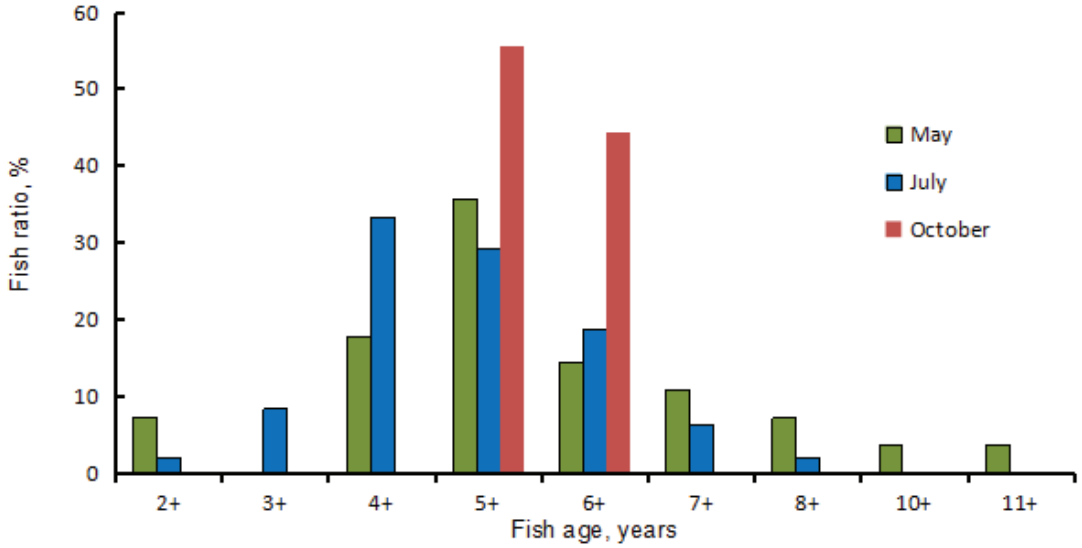

Figure 1: Age structure of the European flounder.

TABLE 2: Size and age composition of the European flounder in the central part of the Kola Bay in 2018.

Age, years	Body length, cm			Body weight, g		
	May	July	October	May	July	October
2+	12.3	20.5	--	27.0	113.3	--
3+	--	21.6±1.7	--	--	130.5±37.5	--
4+	21.8±1.4	23.5±1.8	--	129.6±62.1	150.1±35.6	--
5+	24.2±1.8	24.5±2.1	27.6±2.7	185.4±53.6	174.9±44.7	255.5±71.6
6+	27.5±2.2	26.9±1.3	28.8±1.2	260.6±139.5	219.6±37.0	314.7±29.5
7+	27.3±0.6	31.5±2.8	--	285.3±57.6	381.6±122.2	--
8+	29.8±1.8	28.3	--	297.5±26.8	215.5	--
10+	33.0	--	--	431.2	--	--
11+	34.5	--	--	486.5	--	--

Over the entire observation period, the length of the European flounder varied from 12.3 to 34.5 cm with an average length of 25.0 cm. The body weight ranged from 27.0 to 486.5 g, averaging 201.0 g.

Considering the age groups, it should be noted that the average body length of fish of all groups was increasing from May to October (Table 2). The average body weight of 5--6-year-old fish was decreasing from May to July, but increased by October. From May to July, the body weight of nine-year-olds was decreasing.

The dependences of the fish body weight on its length in the European flounder are approximated by the equations: $y = 0.0184x^{2,88}$ for females and $y = 0.0141x^{2,93}$ for males. No significant differences have been found in the growth rate of females and males.

Reproduction. The proportion of the females in May was larger (64%) than that of males (36%), but in July the proportion of males increased up to 57%, and in October they dominated absolutely (Figure 2).

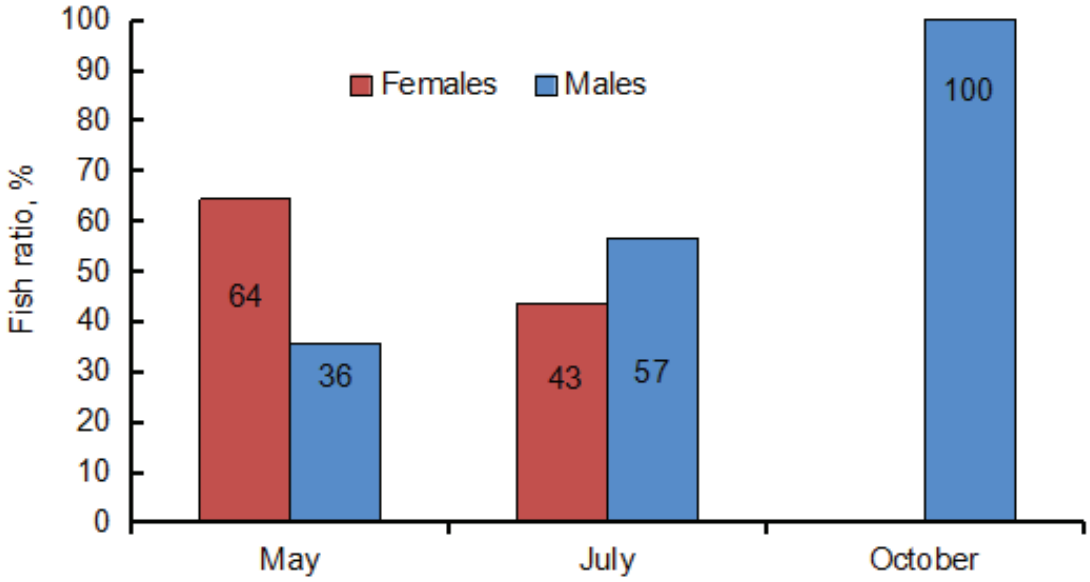

Figure 2: Population of sexual structure of the European flounder in the central part of the Kola Bay in 2018.

In the catches performed in May, a half of both females and males were represented by the specimens with mature reproductive products at the IV stage of maturity (Table 3). Among males, the specimens at the maturity stage VI-II (50%) were also found. Some of the spawning females (16.7%) had gonads at the maturity stage VI-III, in which a few mature eggs could be seen.

TABLE 3: Relative number of males and females of the European flounder at different stages of maturity, %.

Maturity stage	Males			Females		
	May	July	October	May	July	October
II	--	20	--	27.8	13	--
III	--	27	75	--	22	--
IV	50	3	--	50.0	--	--
V	--	3	--	--	--	--
VI--II	50	47	25	5.6	65	--
VI--III	--	--	--	16.7	--	--

In July, the proportion of the already spawned females increased and amounted up to 65%, while in males it remained almost unchanged, 47% (Table 3). The number of

males and females maturing for the first time (at maturity stage II) did not exceed 20%, and comprised 22--27% at maturity stage III.

In October, only males were recorded in the surveyed area, two specimens were at the maturity stage VI-II, and six ones, at the maturity stage III (Table 3).

Feeding. Throughout the entire period of research, the stomach filling index in the European flounder ranged from 0 to 4 points. The feeding rate of the analyzed specimens was the highest in May (an average of 1.9 points). In July, this indicator decreased down to 1.2 points, and in October, to 1.0. The total number of feeding specimens was 89.6% in the spring. The food spectrum was represented by polychaetes (frequency of occurrence was 84.6%), as well as mollusks and amphipods with a frequency of occurrence of 15.4%, respectively (Figure 3).

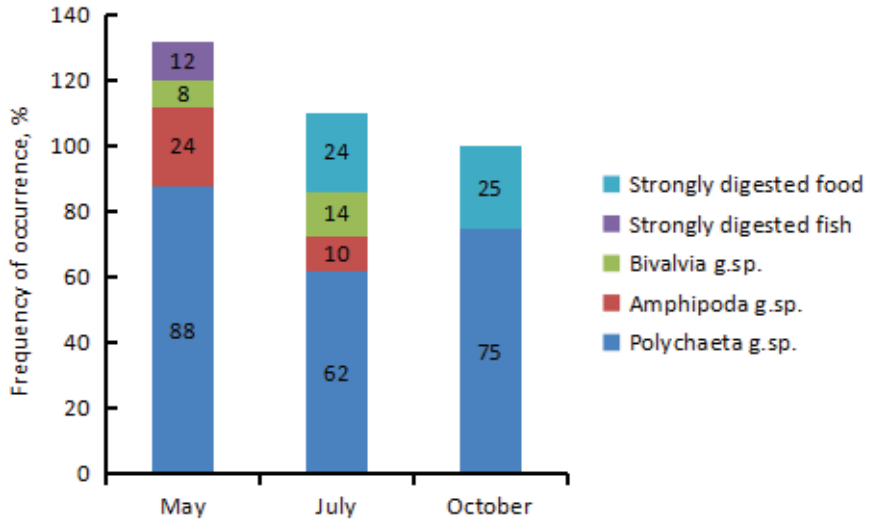

Figure 3: Feeding of the European flounder in the Kola Bay in 2018.

In the summer period, the proportion of the feeding fish decreased down to 62.8%. In a significant number of specimens, the stomach was poorly filled with mucus, and strongly digested objects were noted in the intestines (25.9%). In July, the European flounder also fed predominantly on polychaetes (59.3%). In October, half of the caught specimens did not have food, and a small amount of polychaetes was found in the stomachs of the feeding fish.

Distribution density. In May, the average fish density in the study area was 32 ind/ha, and the biomass was 8.5 kg/ha (Table 4). In July, these indicators significantly increased up to 130.0 ind./ha and 23.5 kg/ha; in October, they decrease down to the minimum values,4 ind./ha and 1.6 kg/ha, respectively.

The maximum catch rates when using the net were also observed in July and amounted to 3 ind./day per net and 0.48 kg/day per net (Table 4).

Table 4: Quantitative characteristics of the distribution density and catches of the European flounder in the Kola Bay in 2018.

Parameter	May	July	October
Average abundance, ind./ha	32.0	130.0	4.0
Average biomass, kg/ha	8.5	23.5	1.6
Average net catch, ind./day per net	2.6	3.0	1.3
Average biomass in the net catch, kg/day per net	0.45	0.48	0.36
Total fish biomass, kg	5.9	10.2	2.5

4. Discussion

The data obtained on the age composition of the European flounder in July are somewhat different from the data obtained for the adjacent area of the Lavna River estuary. There, in July 2005 and 2006, most of the European flounder were represented by the fish 7--10 years old (89%), and the largest number of specimens belonged to the age group of 8+ (45.8%) [8]. In general, the age composition of European flounder in the central part of the Kola Bay is comparable to that in its southern part [7]. Therefore, the average length and weight indicators obtained during our studies are quite close to the literature data. At the same time, in the spring-summer period, a decrease in the weight of 5--6-year-old fish has been noted, which is apparently associated with the spawning. If one considers body weight without taking into account the internal organs, then the fish body weight naturally increased from spring to autumn.

The proportion of females in the spring-summer period of 2018 decreased from 64 to 43%. Earlier, the reported ratio of females and males in the southern part of the Kola Bay was 1.2--1.3:1.0 [7].

Some differences have been also observed in regard to the number of already spawned specimens. According to O.Yu. Yunacheva [6], in May 2002, most of males of the European flounder were at the II stage of maturity (71.4%), the ratio of specimens at the III and IV stages of maturity did not exceed 14.3% in total, and the proportion of females ready for spawning was 33%. In July 2002, the ratio of spawned females was also about 50%, and the other part was represented by specimens at the IV and V stages of maturity, spawned males were absent [6]. Our data indicate extended spawning until July, while according to published data, the peak of reproduction falls to May [6].

The feeding of the European flounder, which is a bottom feeder, has been studied quite well [3, 5, 6, 8, 9, 14---17]. It should be noted that the feeding of European flounder in the central part of the Kola Bay in July 2018 differs significantly from that obtained for the southern part of the bay in July 2005 and 2006, when amphipods comprised 73% and polychaetes, 46% [8]. These groups of organisms were also noted in the diet of juvenile European flounder caught in April 2010 near the Lavna River estuary, where the frequency of occurrence of polychaetes in the fish stomachs was 75%, amphipods and mollusks, 25% and 25%, respectively [9]. The feeding of the European flounder in the southern part of the bay was more intense, the average stomach filling index varied from 1.9 to 3.2 [7, 8]. Analyzing the materials obtained in 2018 and the literature data on the feeding of the European flounder, one can conclude that the ratio of the food items depends on the season of the year, age and size of the fish, as well as on abiotic environmental factors. For example, there were no mollusks in the food spectra of the European flounder caught in 1940 in the inlets along the East Murman Coast, whereas in 1939 they formed the food basis. The last is explained by the harsh winter, as a result of which the littoral mollusks have died [16].

The maximum population density of European flounder (130 ind./ha) was noted in July, which exceeded sixfold that observed in the area of the Lavna River in the summer period of 2006 (21.6 ind./ha) [8]. In the work of R.A. Linnikov [8], the fish population density was presented taking into account the capturability coefficient equal to 0.6. In order to compare our data, a re-calculation was performed without taking this coefficient into account, so the fish biomass in July 2006 varied from 2.46 to 19.5 kg/ha [8]. In 2002---2003, the biomass of the European flounder in the southern part of the Kola Bay was 2.0---3.0 kg/ha [7], which was significantly less comparing to our data.

Such a high quantitative indicators of European flounder in the spring and summer of 2018 may be explained by abnormally warm waters in the coastal zone. When looking on climatic data, the year of 2002 refers to warm years, 2003, to normal, 2006 and 2010, to abnormally warm [18---22]. The data on the biomass and abundance of the European flounder in July 2006 are the only values close to that obtained in 2018. European flounder prefers sandy sediments [23]. The bottom relief and the sediments of the southern part of the Kola Bay differ from that observed in the central part of the bay. Silty sands prevail in the southern part at the shallow depths (0--6 m) in the sublittoral zone with a bottom slope of 45 degrees. In the central part, the bottom slope in the sublittoral zone reaches 25 degrees (with a barrow of 45--50 degrees), the middle-size boulders appear on the pier barrow, where the share of aleurite sand

does not exceed 5% [24, 25]. However, the abundance of the European flounder in the central part of the Kola Bay, in its estuarine areas, remains significant.

5. Conclusion

The age structure of the European flounder in 2018 is represented mainly by 5--7-year-old specimens. The average fish body length of all age groups increases from May to October, the average body weight of 5--6-year-old fish decreases from spring to summer, and increases from July to October.

In spring, the proportion of females is higher than that of males; in the summer, the proportion of males increases and the number of females decreases; in the autumn, only males remain in the study area. In May, a half of both males and females had the gonads at the IV stage of maturity, and the others had already spawned. In July and October, both females and males with ripening gonads were caught.

The feeding rate of the European flounder decreases during the summer period; polychaetes are its main food object (59.3--84.6%), followed by amphipods and mollusks.

During the spring period, the abundance and biomass of the European flounder do not correspond to the previously published data, according to which the peak of reproduction is observed in May, the highest values of quantitative indices are observed in July followed by decrease in autumn.

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Conflict of Interest

The author has no conflict of interest to declare.

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