



**BIOLOGICAL MONITORING OF TURBOT (*SCOPHTHALMUS
MAXIMUS*) LANDINGS AT THE BULGARIAN BLACK SEA COAST
DURING 2022**

Institute of Fisheries and Aquaculture, Plovdiv

Agricultural Academy, Sofia

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Project № BG14MFOP001-3.003-0004, „Collection, management and use of data for the purpose of scientific analysis and implementation of the Common Fisheries Policy for 2022“, funded by the Maritime and Fisheries Program and co-financed by the European Union through the European Maritime and Fisheries Fund



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1. Aim and objectives

The aim of the biological monitoring of turbot landings at the Bulgarian Black Sea coast is to collect biological data which will be used for catch analyzes, as well as to form a database to track the structure of landings over the years. The collection of biological samples from turbot landings in 2022 includes the following main tasks and objectives:

- Collection of data from port landings, vessels for sample collection, number of samples collected, number of measured turbot, geographical data of turbot catch locations;
- Determination of size and weight structure of turbot landings;
- Characteristics of the reproductive biology of turbot;
- Determination of the age structure of the turbot landings;
- Analysis of the stomach content

2. Material and methods

2.1 Collection of biological data from turbot landings

The collection of the biological data from the turbot landings is conducted for each quarter of 2022 in the Bulgarian Black Sea coast.

2.1.1. Ports for collection of biological data

From the ports permitted for fish landings, biological data is collected from Kavarna, Varna, Pomorie, Tsarevo, Byala, Krapets, Shabla and Balchik.

2.1.2. Vessels for sample collection

In 2022, the biological data is collected from 58 landings from ships registered by EAFA according to the Fisheries and Aquaculture Act (Article 16, paragraph 1, item 4).

Table 1 contains data on ports and ships monitored for the collection of biological data from turbot landings in 2022. The used fishing gear is gill net with mesh size of 400 mm.

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Table 1. Ports and vessels monitored for collection of biological data from turbot landings in 2022.

Port	Quarter Data 2022			
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Kavarna	1. Hishtnik Kv 6262	-	2.Gondola Vn 4321 3.Vn 7822 4.Gondola Vn 4321 5.Kv 5562 6.Vn 4601 7.Kv 6296 8.Kv 6321 9.Kv 6296 10.Kv 5562 11.Vn 4321 12.Vn 4321 13.Vn 4321 14.Kv 5562 15.Vn 4321 16.Vn 4601 17.Vn 4496 18.Hishtnik Kv 6262 19.Gyliver Kv 5562 20.Gondola Vn 4321	21.Kv 5562 22.Kv 6321 23.Kv 6262 24.Vn 4321
Varna	1.Vn 7669 2.Lepher Vn 03	3.Iva-1 Vn 8194		
Pomorie	1. Mobi Dik Vn 8012	2.Toti i Pepi Bs 2848	3.Spitur 3 Pm 347 4.Mobi Dik Vn 8022	-
Tsarevo	1. Cyklama V Tsr 698	2.Zhizhi-2 Tsr 212	3.Cyklama V Ah 215	-
Byala	-	1.Sv. Nikola	-	-
Krapets	-	-	1.Kv 6245 2.Kv 6332 3.Shb 5927 4.Kv 6332	
Shabla	-	-	1.Vn 7919 2.Shb 6025 3.Shb 6025 4.Vn 7919 5.Vn 7919	-
Balchik	-	-	1.Kv 5562 2.Kv 7432 3.Kv 7432 4.Vn 7643 5.Vn 8112	6.Libra Vn 8311 7.Korsar Vn 7643



			8.Vn 8112 9.Vn 7432 10.Vn 7643 11.Vn 2998 12.Vn 2966 13.Vn 8112 14.Vn 8112	
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The landings are performed as follows: 24 at Kavarna port, 3 at Varna port, 4 at Pomorie port, 3 at Tsarevo port, 1 at Byala port, 4 at Krapets port, 5 at Shabla port and 14 landings at Balchik port.

2.1.3. Number of collected samples

From a total of 58 landings, biological data from 1088 fish is collected, which corresponds to the number of fish landed or 100% of the landings are measured (**Table 2**).

Table 2. Landing data for the monitored ports in 2022.

Port	Quarter Data 2022				Total number of fish
	Number of fish				
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	
Kavarna	12	-	303	68	383
Varna	111	98	-	-	209
Pomorie	20	37	23	-	80
Tsarevo	6	35	7	-	48
Byala	-	24	-	-	24
Krapets	-	-	32	-	32
Shabla	-	-	49	-	49
Balchik	-	-	195	68	263
Общо	149	194	609	136	1088



The biological data is collected as follows: 149 specimens in first quarter, 194 fish in the second quarter, 609 specimens in the third quarter and 136 turbot in the fourth quarter of 2022.

2.1.4. Number of studied turbot

The total number of specimens, from which biological data is collected, is 1088 with total weight of 2 978.55 kg.

2.1.5. Geographic data of turbot catch locations

The coordinates and the depths of the turbot catch locations of the vessels at the ports of Kavarna, Varna, Pomorie, Tsarevo, Byala, Krapets, Shabla and Balchik in 2022 are presented in **Table 3**.

Table 3. Coordinates and depths of turbot catch locations in 2022

№	Vessel	Coordinates of catch locations		Depth of catch location (m)
		latitude	longitude	
First Quarter 2022				
1.	Hishtnik Kv 6262	43°39'09.0"N	28°53'35.3"E	60-65
2.	Vn 7669	44°09'58.7"N	29°39'24.4"E	70
3.	Lefer Vn 03	43°39'37.6"N	29°40'23.4"E	60-65
4.	Mobi Dik Vn 8012	42°35'53.2"N	28°19'18.7"E	20-25
5.	Cyklama V Tsr 698	42°14'21.2"N	8°08'22.4"E	65-70
Second Quarter 2022				
1.	Zhizhi-2 Tsr 212	42°14'21.2"N	28°08'22.4"E	60
2.	Toti i Pepi Bs 2848	42°26'35.7"N	28°30'06.3"E	65-75
3.	Sv. Nikola	43°38'44.0"N	30°07'28.1"E	65-70
4.	Iva-1 Vn 8194	43°41'40.2"N	29°12'17.6"E	90
Third Quarter 2022				
1.	Gondola Vn 4321	42°52'46.6"N	28°48'22.6"E	60
2.	Vn 7822	42°52'44.5"N	28°48'16.4"E	55-60



3.	Gondola Vn 4321	42°52'44.0"N	28°48'09.8"E	45-55
4.	Kv 5562	42°52'46.9"N	28°48'09.6"E	55-65
5.	Vn 4601	42°55'15.2"N	28°33'04.2"E	55-60
6.	Kv 6296	42°55'21.8"N	28°33'11.3"E	65
7.	Kv 6321	42°55'26.0"N	28°33'07.6"E	50-65
8.	Kv 6296	42°55'25.3"N	28°33'05.0"E	60-70
9.	Kv 5562	42°55'27.9"N	28°32'59.6"E	70
10.	Vn 4321	42°55'31.2"N	28°32'56.6"E	55-65
11.	Vn 4321	42°55'37.6"N	28°33'01.4"E	65
12.	Vn 4321	43°16'22.0"N	28°39'09.2"E	50-65
13.	Kv 5562	43°40'38.2"N	28°51'33.0"E	60-70
14.	Vn 4321	43°40'41.6"N	28°51'31.7"E	30-40
15.	Vn 4601	43°40'48.9"N	28°51'37.2"E	20-30
16.	Vn 4496	43°28'16"N	29°01'27"E	30-40
17.	Hishtnik Kv 6262	43°22'31"N	28°54'51"E	50
18.	Gyliver Kv 5562	43°17'27"N	28°40'30"E	55-60
19.	Gondola Vn 4321	43°40'55.6"N	28°51'41.8"E	60
20.	Kv 6245	43°40'59.6"N	28°51'41.9"E	50-55
21.	Kv 6332	43°38'36.5"N	28°47'52.5"E	40-50
22.	Shb 5927	43°38'40.0"N	28°47'50.5"E	50
23.	Kv 6332	43°37'24.9"N	28°53'06.9"E	30-40
24.	Vn 7919	43°37'30.5"N	28°53'02.2"E	20-30
25.	Shb 6025	43°37'32.7"N	28°53'06.8"E	30-40
26.	Shb 6025	43°37'36.4"N	28°53'03.9"E	50
27.	Vn 7919	43°37'40.4"N	28°53'03.8"E	55-60
28.	Vn 7919	43°29'40.3"N	28°58'00.4"E	60
29.	Kv 5562	43°29'41.9"N	28°57'58.2"E	50-55
30.	Kv 7432	43°29'49.2"N	28°58'08.5"E	40-50
31.	Kv 7432	43°29'53.9"N	28°58'14.6"E	50
32.	Vn 7643	43°29'53.2"N	28°58'17.6"E	30-40
33.	Vn 8112	43°29'56.7"N	28°58'23.1"E	20-30
34.	Vn 8112	43°41'52.7"N	29°23'33.9"E	30-40
35.	Vn 7432	43°42'53.5"N	29°25'13.1"E	50
36.	Vn 7643	43°42'52.1"N	29°25'15.1"E	55-60
37.	Vn 2998	43°42'51.0"N	29°25'16.3"E	60
38.	Vn 2966	43°42'55.1"N	29°25'20.7"E	50-55



39.	Vn 8112	43°42'54.0"N	29°25'20.8"E	40-50
40.	Vn 8112	42°04'36"N	28°15'55"E	50
41.	Cyklama V Ah 215	42°38'25"N	28°23'53"E	30-40
42.	Spitur 3 Pm 347	42°38'41"N	28°16'55"E	20-30
43.	Mobi Dik Vn 8022	43°42'06.7"N	28°46'35.6"E	30-40
Fourth Quarter 2022				
1.	Kv 5562	43°42'00.8"N	28°46'40.4"E	50
2.	Kv 6321	43°42'36.0"N	28°46'56.0"E	40-50
3.	Kv 6262	43°42'16.1"N	28°46'40.6"E	40-50
4.	Vn 4321	42°38'41.3"N	28°19'53.2"E	50
5.	Libra Vn 8311	42°38'39.8"N	28°19'49.5"E	30-40
6.	Korsar Vn 7643	42°52'46.6"N	28°48'22.6"E	35-40

The catches are performed between the parallels 42°N and 43°N and the meridians 28°E and 29°E. The depth of the catch locations varies between 30 and 70 m

2.2. Determination of the size-weight structure of turbot landings

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The measurements of the fish are performed on the board of the ships, immediately after docking at the port, on fresh ice-cooled specimens. The weight is measured with an accuracy of 0.1 g and the measurements of the total and standard length with an accuracy of 0.1 cm. The relationship between length (L, cm) and weight (W, g) is calculated using LeCren (1951) equation:

$$W = a.L^b, \text{ where:}$$

W - weight (g);

L – total length (TL, cm);

a - constant;

b – growth coefficient.



2.3. Determination of the age of the fish

The age of the turbot (100 specimens) is determined by the number of concentric zones of the otoliths that correspond to the periods of growth. The otoliths are removed through the gills of the fish without opening the skull, carefully separating each pair without breaking. The otoliths are cleaned and stored until observation with stereomicroscope under appropriate light.

2.4. Characteristics of the reproductive biology of turbot

To characterize the reproductive system in the period 2022, a total of 100 turbot are purchased, as in the spring-summer and autumn-winter period 50 turbot are purchased respectively. Based on the collected samples of gonads, the sex, the gonadosomatic index and the degree of maturity of the reproductive organs is determined.

- **Sex ratio**

The sex of 100 turbot has been determined. The ratio between females and males is established, as well as the correlation between sex and age of the fish and sex and total length of the body.

- **Gonadosomatic index (GSI,%)**

The gonadosomatic index (GSI,%) is determined on the basis of 100 individuals. It is calculated as a percentage of body weight for each individual, based on the data from the measurements of the body weight and gonads of females according to the formula of Wootton (1998):

$$\text{GSI (\%)} = 100W_g \cdot W^{-1}, \text{ where}$$

W_g – weight of the gonads, g;

W – body weight, g.



- **Fecundity of female fish**

The fecundity is determined on the basis of 34 female fish caught and purchased in the first half of April 2022. Data on the absolute and relative fecundity of the individuals is presented.

- **Determination of the degree of maturity of the reproductive organs**

The degree of maturity of the reproductive organs is established based on 50 turbot, caught and purchased in the first half of April 2022 and 50 turbot, caught and purchased in December 2022. The gonads are dissected and fixed in 4% formaldehyde solution for further processing to determine the degree of maturity of the ovary and testis. Paraffin sections are prepared, on the basis of which the degree of maturity is established.

2.5. Analysis of stomach content

The stomach contents of 100 turbot have been studied – 50 specimens in the second quarter of 2022 and 50 in the fourth quarter of 2022. The index of stomach fullness, ISF (Hureau, 1969), expressed as a percentage (%), is used to analyze turbot stomach contents. This indicator measures the ratio of food weight to body weight. ISF (%) is calculated by the following formula:

$$\text{ISF} = (\text{FW}/\text{W}) * 100, \text{ where}$$

- ISF – index of stomach fullness;
- FW – food weight;
- W – body weight of the fish.

For each component of the stomach content, the percentage share in the total number (C_N), the percentage share in the total biomass (C_W) and the frequency of occurrence (F) are determined. The index of relative significance, IRI (Pinkas et al., 1971) is established for all species that are part of the food spectrum of turbot. IRI is calculated by the following formula:

$$\text{IRI} = (C_N + C_W) * F, \text{ where}$$

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- IRI – index of relative significance;
- C_N – percentage share in the total number;
- C_W – percentage share in the total biomass;
- F – frequency of occurrence.

IRI, expressed as a percentage, is used to determine the significance of the food components (Cortes, 1997):

$$\%IRI_i = 100 * IRI_i / n \sum IRI_i, \text{ where:}$$

- IRI_i – index of relative significance of each food component;
- n – total number of taxonomic categories included in the food spectrum.



Picture 1-2. Landing and measurement of the fish at the port

3. Results

3.1. Number of turbot landed by vessels

The total number of fish, from which biological data is collected, is 1088. The number of turbot caught by each vessel is presented in **Fig. 1**.

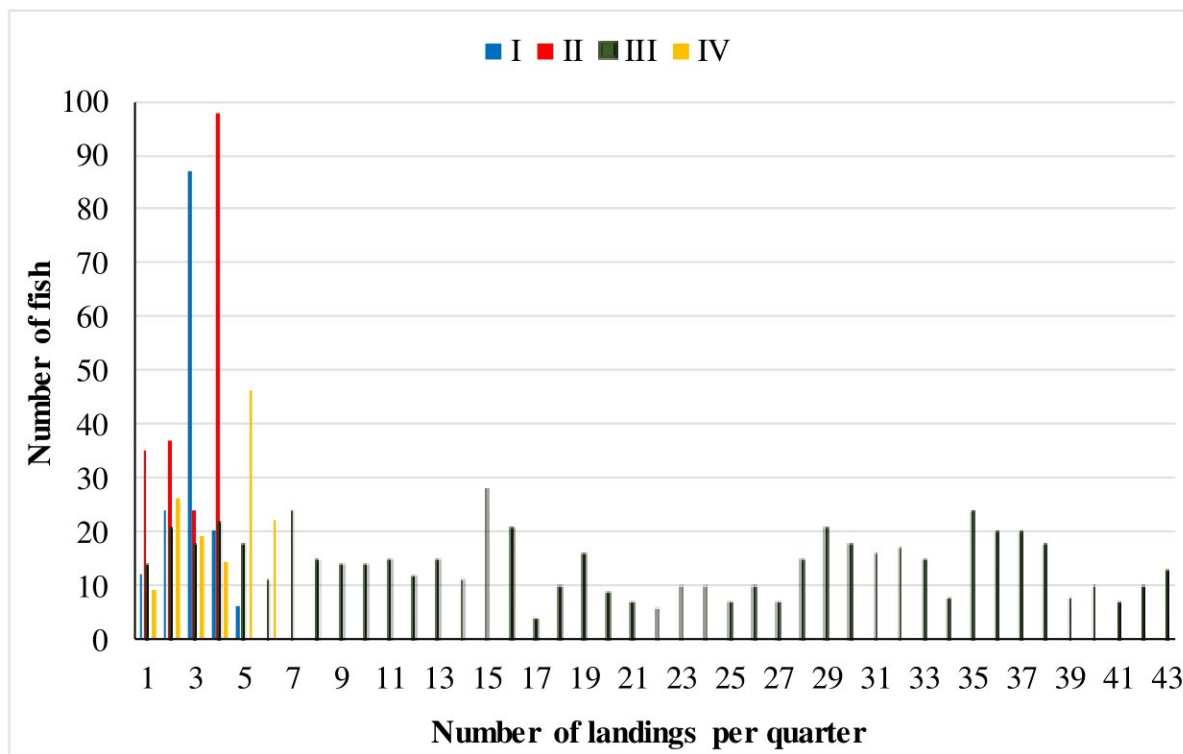


Fig. 1. Number of fish caught by vessel and landed in 2022.

In 2022 an average of 19 fish are caught per vessel or 51.35 kg/vessel, with a maximum of 98 fish (220.00 kg) and a minimum of 4 fish (13.10 kg).

3.2. Weight structure of turbot landings

The average weight of the measured specimens is 2.74 kg. The maximum measured weight is 7.50 kg, and the minimum - 1.20 kg.

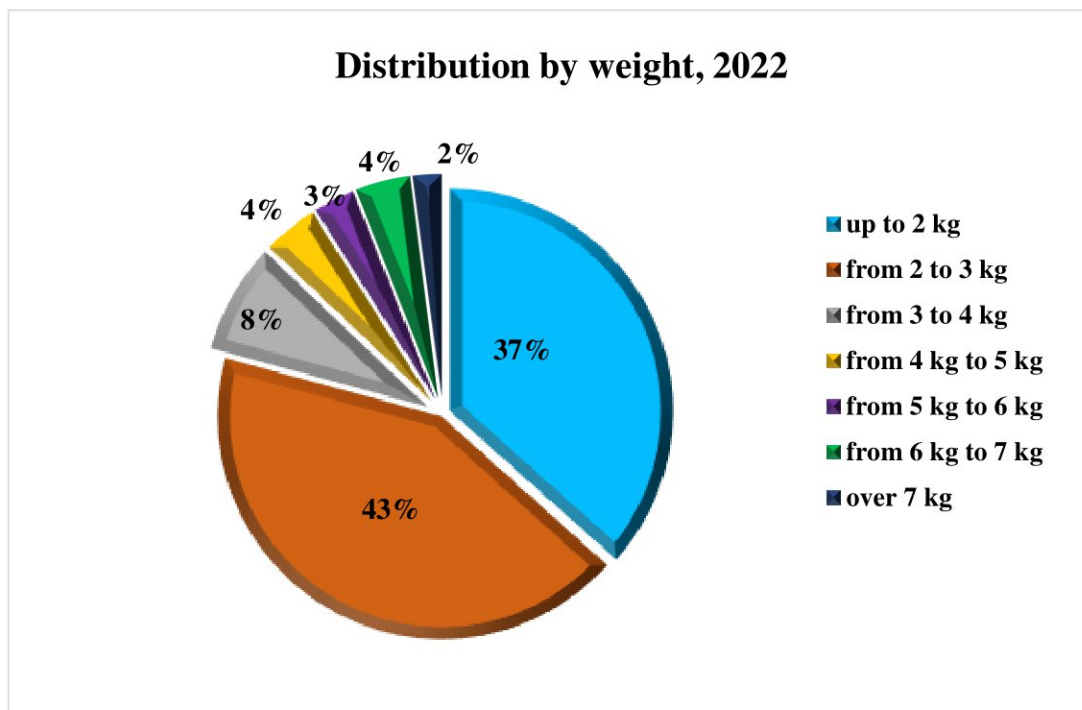


Fig. 2. Percentage distribution of turbot landings by weight in 2022.

The distribution of the landings by fish weight is presented in **Fig. 2**. From 1088 turbot, 398 specimens (37%) have a weight up to 2 kg. The fish with weight from 2 to 3 kg take 43% - 465 specimens from the measured fish. The weight group from 3 kg 4 kg is represented by 86 specimens or 8% of the representative sample. The turbot with weight from 4 kg to 5 kg take 4% or 46 specimens from the studied individuals. The weight group from 5 to 6 kg consists of 28 sp. or 3% of measured turbot and the weight group from 6 kg to 7 kg is presented by 48 specimens or 4%. With the lowest percentage distribution are the fish with weight over 7 kg – 2% or 17 specimens.



3.3. Size structure (total and standard length) of measured turbot

The average value of the total length (TL, cm) of the measured specimens is 52.67 cm, with maximum measured 76.00 cm, and minimum measured - 45.50 cm. **Fig. 3** shows the dynamic of the distribution of the values of the total length (TL, cm) of the measured individuals.

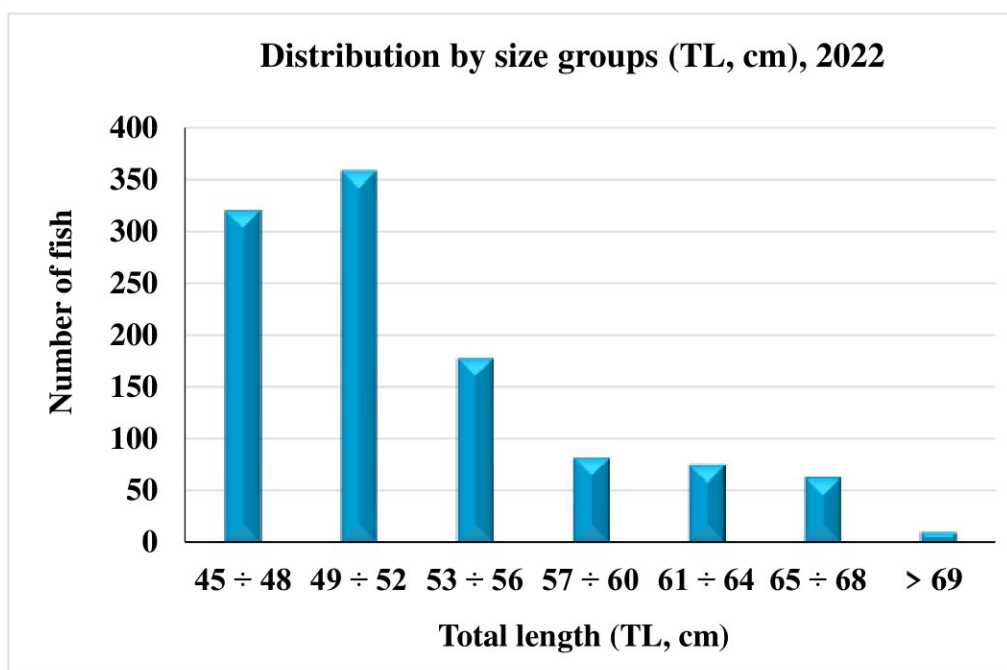


Fig. 3. Size structure (total length) of turbot landings in 2022.

From the distribution of individuals by size groups by total length (TL, cm) it is established that the most widely represented is the group of 49-52 cm. Turbots with total body length in the range of 49-52 cm represent 33.00% of the landings or 359 specimens, followed by the groups 45-48 cm (321 specimens; 29.50%) and 53-56 cm (178 specimens; 16.36%). The size groups 57-60 cm, 61-64 cm and 65-68 cm include 82 specimens (7.54%), 75 specimens (6.89%) and 63 specimens (5.79%), respectively. With the lowest percentage share is the size group over 69 cm, which consists of 10 individuals or 0.92%.

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Fig. 4 shows the dynamics of the distribution of the values of the standard body length (SL, cm) of the measured individuals for 2022. The average value of the standard body length (SL, cm) is 40.77 cm. The maximum measured standard length is 62.00 cm and the minimum measured - 32.00 cm.

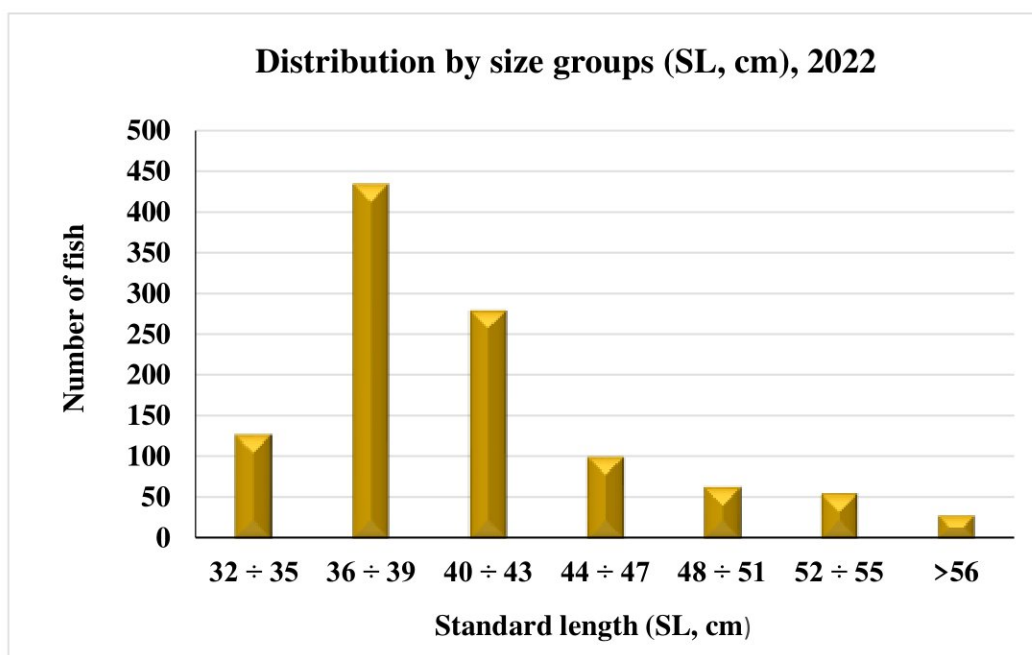


Fig. 4. Size structure (standard length) of turbot landings in 2022.

From the distribution of individuals by size groups according by standard length (SL, cm) it is established that the group 36-39 cm is represented most widely (435 specimens – 39.38%). It is followed by the groups 40-43 cm (280 specimens – 25.74%) and 32-35 cm (127 specimens – 11.67%). Individuals with a standard body length in the range of 44-47 cm are 100 specimens, which represents 9.19% of all measured specimens. Fish with standard body length in the groups 48-51 cm and 52-55 cm are 5.79% (63 specimens) and 5.06% (55 specimens), respectively. With the lowest percentage are turbot with a standard body length

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above 56 cm - 28 specimens or 2.57%. The correlation between turbot size and weight is shown in **Fig. 5**.

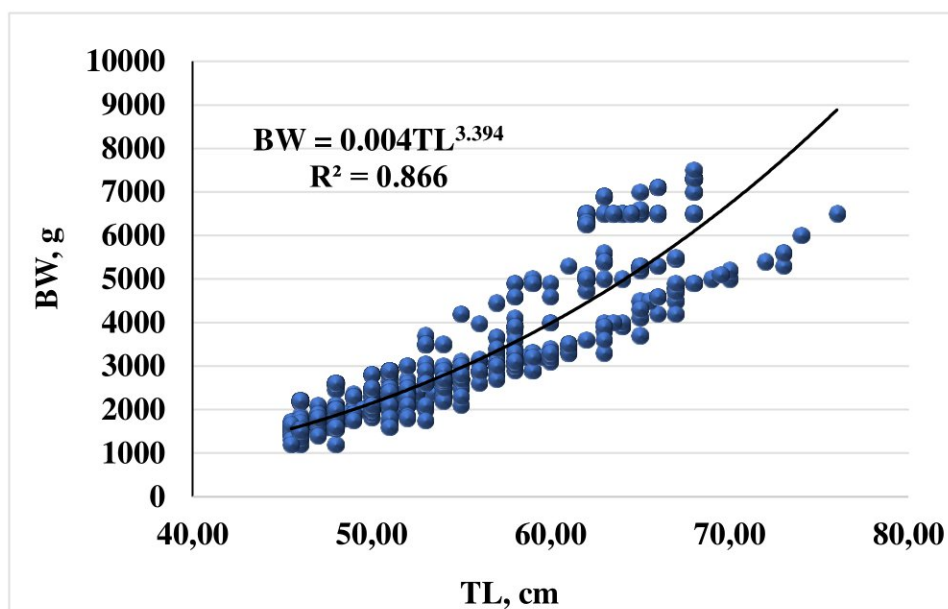


Fig. 5. Correlation between size and weight of turbot in 2022, n=1088.

The correlation between the size and weight of the turbot is clearly expressed, described by the equation: $BW = 0.04TL^{3.394}$.

3.4. Age structure and growth

To determine the age composition of turbot catches for 2022, 100 pairs of otoliths are studied. The age composition of the studied turbot specimens include from 3 to 7-year-old individuals, with four (48%) and five (28%) year-old fish being predominant. In total, they represent 76% of the total number of specimens studied (**Fig. 6**). The percentage of turbot age 3 and 6 years



is 19% and 4%, respectively. With the lowest percentage share is the group of seven-year-old fish, which consists of 1%.

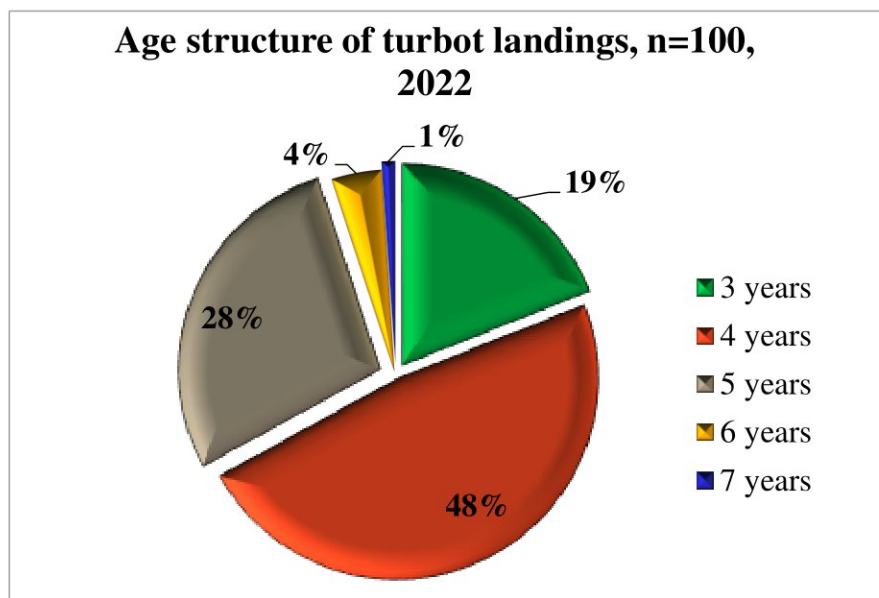


Fig. 6. Age structure of turbot landings in 2022, n=100.

The correlation between total length of the body and age is presented in **Fig. 7** for female fish (42 specimens) and in **Fig. 8** for male fish (58 specimens).

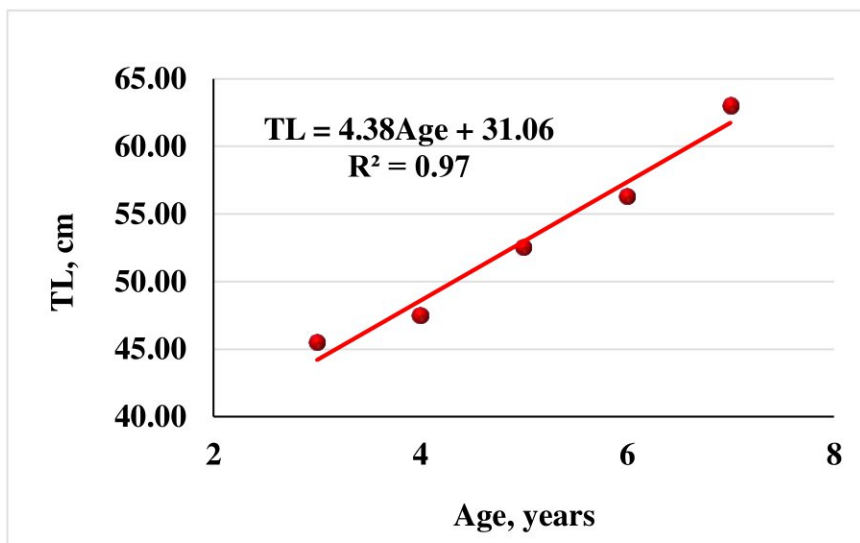


Fig. 7. Correlation between total length and age of female fish in 2022, n=42.

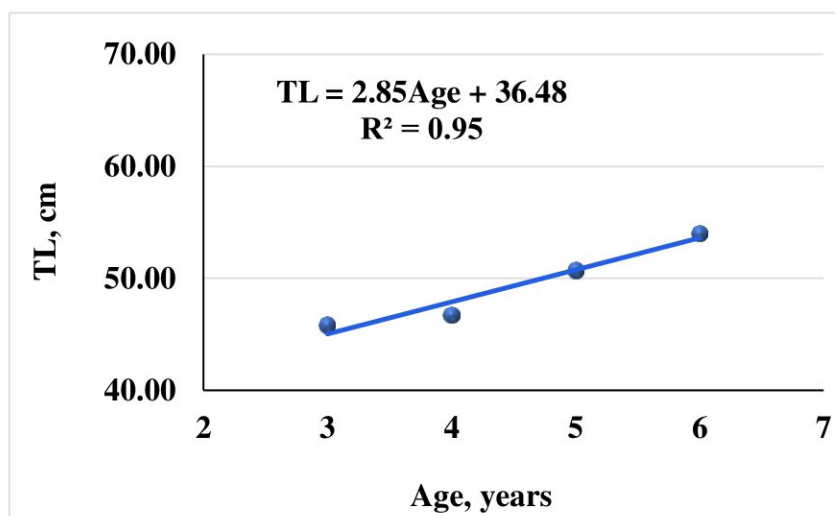


Fig. 8. Correlation between total length and age of male fish in 2022, n=58.

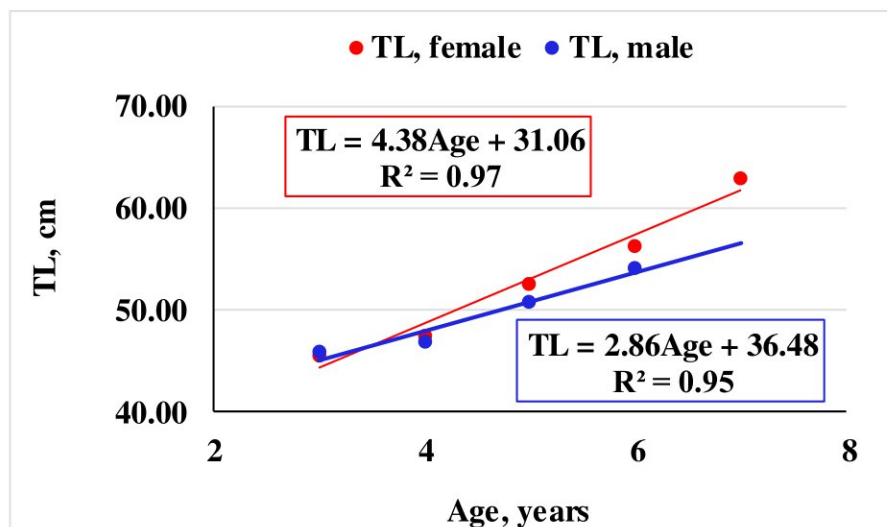


Fig. 9. Linear growth of turbot by age in 2022, n=100.

From **Fig. 9** it can be seen that females after 45 cm grow faster in length than males. The correlation between body weight and age is presented in **Fig. 10** for female fish (42 specimens) and in **Fig. 11** for male fish (58 specimens).

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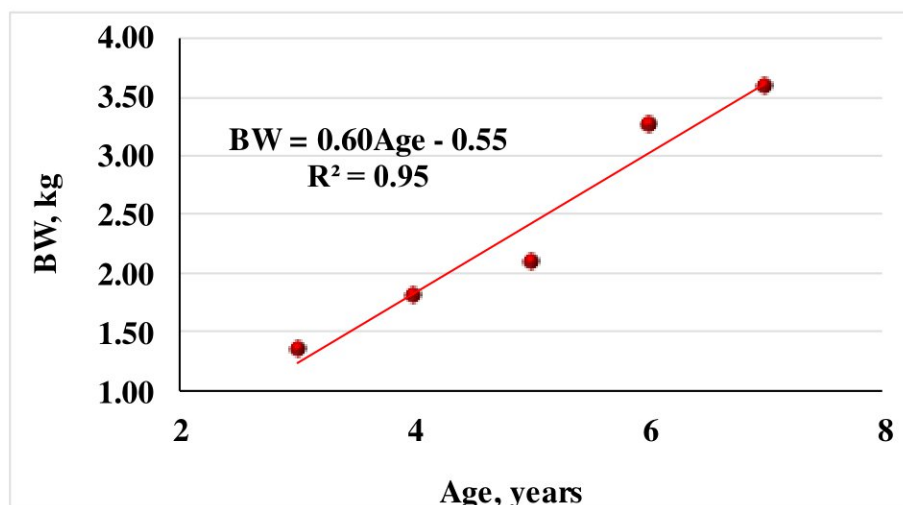


Fig. 10. Correlation between body weight (BW, kg) and age of female turbot in 2022, n=42.

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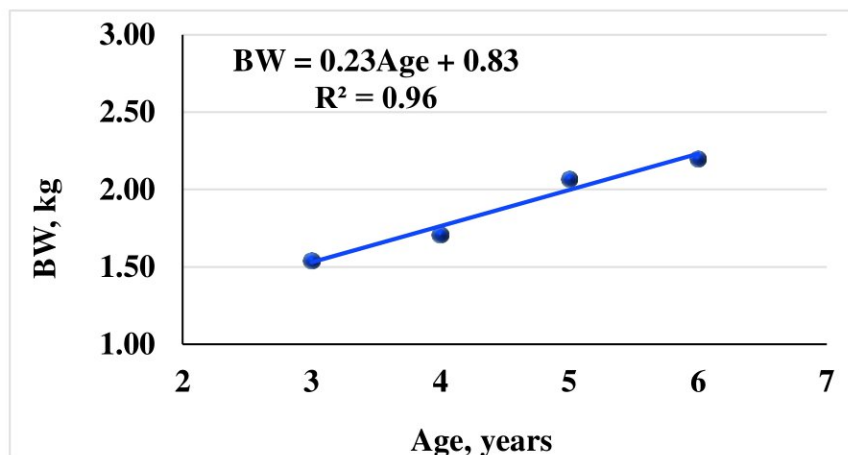


Fig. 11. Correlation between body weight (BW, kg) and age of female turbot in 2022, n=58.

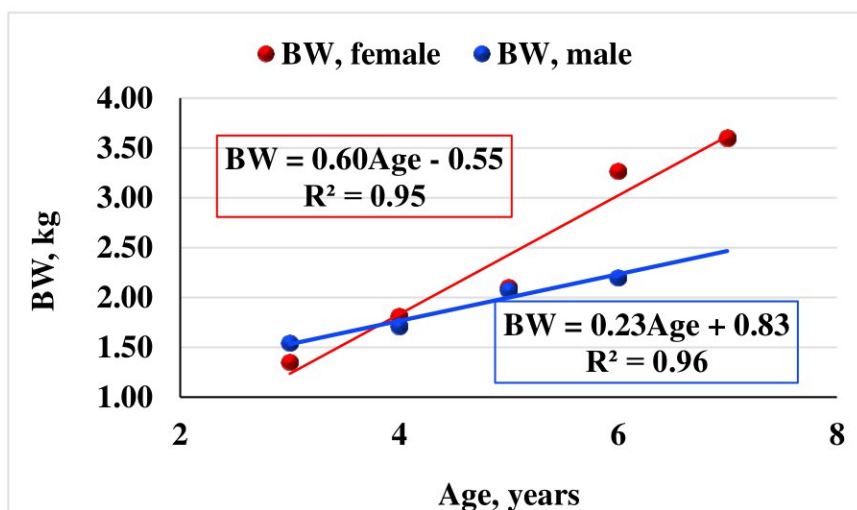


Fig. 12. Correlation between body weight and age of turbot in 2022, n=100.

From **Fig.12** it can be seen that females above 1.50 kg gain weight faster than males.



3.5. Characteristics of the reproductive biology of turbot

3.5.1. Sex ratio

The percentage distribution between male and female individuals is shown in **Fig. 13**. It is established that 42 specimens are female and 58 specimens are males. The percentage of females and males is 42% to 58% in favor of males.

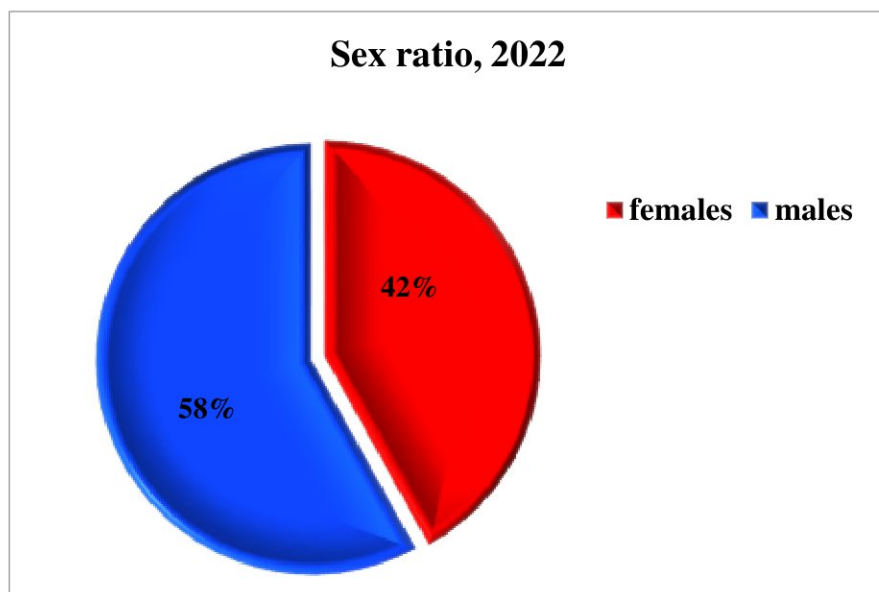


Fig. 13. Percentage distribution between female and male individuals in 2022, n=100.

3.5.2. Ratio between females and males to the total length of the body

Fig. 14 shows the distribution between females and males by total length of the body, divided into size groups of 3 cm.

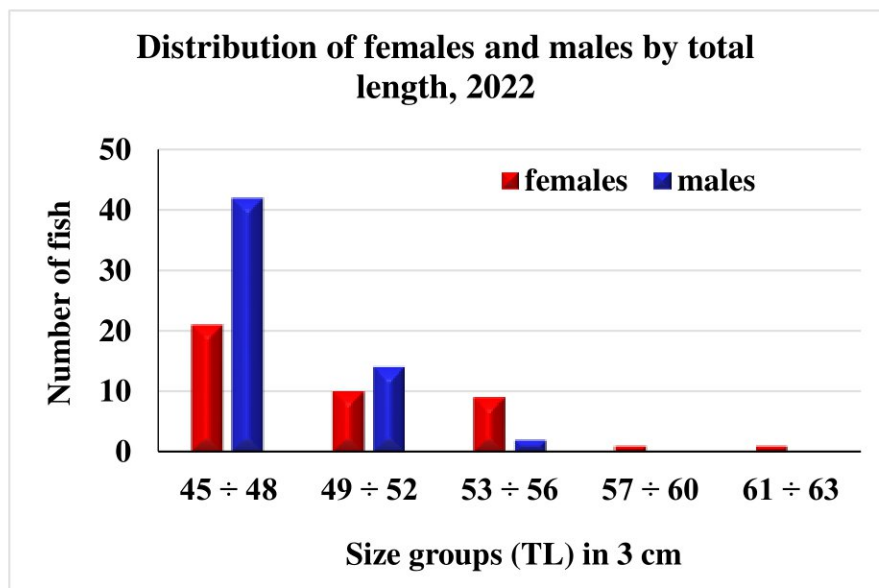


Fig. 14. Distribution of females and males by total length of the body (TL, cm), (n=100; f=42, m=58)

Males with a total body length of 45-48 and 49-52 cm are predominant. At a length of more than 53.00 cm, the percentage of female individuals increases, with the size groups of 57-60 cm and 61-53 cm consisting of only one individual (**Table 4**).

Table 4. Ratio between males and females in correlation to total length of the body (TL, cm) in groups by 3 cm.

Total length of the body (TL, cm) in groups of 3 cm	45 ÷ 48	49 ÷ 52	53 ÷ 56	57 ÷ 60	61 ÷ 63	45 ÷ 48
Number of male individuals	42	14	2	-	-	42
Number of female individuals	21	10	9	1	1	21
Ratio males/females	2:1	1.4:1	1:0.22	-	-	2:1



3.5.3. Ratio between females and males to the age of the individuals

The distribution of females and males and the age of the turbot is shown in **Fig.15**.

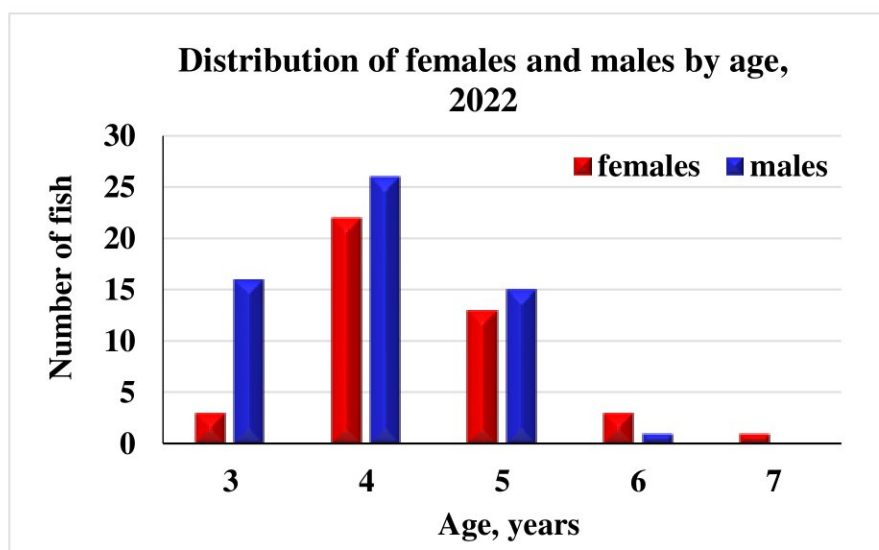


Fig. 15. Distribution of females and males in relation to age
(n=100; f=42, m=58)

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Table 5 presents the ratio of females and males to age.

Table 5. Ratio of the two sexes to age of the individuals.

Age, years	3	4	5	6	7	3
Number of male individuals	16	26	15	1	-	16
Number of female individuals	3	22	13	3	1	3
Ratio males/females	5.33:1	1.18:1	1.15:1	1:0.33	-	5.33:1

The results show that 4 and 3 year-old turbot predominate in males and 4 and 5 year-old fish - in females.



3.5.4. Gonadosomatic index (GSI,%)

Gonadosomatic index – second quarter of 2022

The average weight of male fish in the first half of April 2022 is 1.74 kg and it is in the range 1.41-2.28 kg. The weight of the gonads is between 5.10 g and 171.10 g, with an average value of 20.19 g (**Table 6**).

Table 6. Values of weight (BW, kg), total (TL, cm) and standard (SL, cm) body length, gonad weight (W_G, g), GSI,% and age of males in the first half of April 2022

First half of April 2022						
Nº	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	1.46	47.00	36.00	11.90	0.82	3
2	1.52	47.00	36.00	13.70	0.90	4
3	2.07	49.00	37.00	23.70	1.14	5
4	1.89	47.00	36.00	20.00	1.06	4
5	1.78	48.00	36.00	21.90	1.23	4
6	1.79	47.00	36.00	16.60	0.93	4
7	2.16	50.00	38.00	27.60	1.28	5
8	1.62	45.50	35.00	28.60	1.77	3
9	1.95	47.00	35.00	9.60	0.49	3
10	1.69	47.00	36.00	9.20	0.54	4
11	1.52	45.50	35.00	5.10	0.34	3
12	1.96	48.00	37.00	19.70	1.01	4
13	1.95	50.00	38.00	21.90	1.12	5
14	1.66	45.50	35.00	14.80	0.89	3
15	1.81	50.00	48.00	13.50	0.75	5
16	1.72	45.50	35.00	14.40	0.84	4
17	2.27	49.00	38.00	18.10	0.80	5
18	2.08	47.00	36.00	17.30	0.83	4
19	2.28	51.00	38.00	15.00	0.66	5



20	1.85	46.00	35.00	20.40	1.10	4
21	1.61	46.00	34.00	6.90	0.43	4
22	1.55	46.00	35.00	21.40	1.38	3
23	1.83	48.00	37.00	18.10	0.99	4
24	1.49	45.50	35.00	7.30	0.49	4
25	1.42	45.50	35.00	171.00	12.04	3
26	1.42	45.50	35.00	13.90	0.98	4
27	1.64	47.00	35.00	12.30	0.75	4
28	1.41	45.50	35.00	13.10	0.93	3
29	1.63	47.00	36.00	10.50	0.64	4
30	1.78	46.00	35.00	16.20	0.91	4
31	1.53	45.50	35.00	8.10	0.53	3
32	1.55	45.50	35.00	6.80	0.44	4
33	1.54	45.50	35.00	17.70	1.15	4
ave	1.74	46.98	36.15	20.19	1.22	4
min	1.41	45.50	34.00	5.10	0.34	3
max	2.28	51.00	48.00	171.00	12.04	5

The GSI values,% for male fish in the first half of April 2022 are in the range of 0.34% and 12.04%, with an average of 1.22%.

The average weight of female fish in the first half of April 2022 is 2.13 kg and it is in the range of 1.54-3.97 kg. The weight of the ovary is between 53.10 g and 510.00 g, with an average value of 149.05 g (**Table 7**).



Table 7. Values of weight (BW, kg), total (TL, cm) and standard (SL, cm) body length, gonad weight (W_G , g), GSI,% and age of females in the first half of April 2022

First half of April 2022.						
№	BW, kg	TL, cm	SL, cm	W_G, g	GSI, %	Age
1	2.43	50.00	38.00	107.60	4.43	4
2	1.77	47.00	37.00	84.50	4.77	4
3	2.00	49.00	38.00	53.10	2.66	4
4	3.97	56.00	44.00	51.,00	12.85	6
5	1.54	45.50	35.00	56.90	3.69	3
6	1.88	48.00	37.00	73.60	3.91	4
7	2.17	50.00	39.00	320.00	14.75	5
8	2.08	50.00	39.00	131.00	6.30	5
9	1.91	47.00	35.00	134.40	7.04	4
10	2.65	53.00	40.00	173.00	6.53	5
11	1.58	45.50	35.00	75.00	4.75	4
12	2.45	48.00	37.00	172.80	7.05	4
13	1.98	48.00	37.00	85.30	4.31	4
14	1.88	49.00	38.00	123.80	6.59	4
15	1.73	45.50	35.00	232.30	13.43	4
16	1.95	48.00	37.00	117.50	6.03	4
17	2.16	50.00	39.00	83.00	3.84	4
ave	2.13	48.79	37.65	149.05	6.64	4
min	1.54	45.50	35.00	53.10	2.66	3
max	3.97	56.00	44.00	510.00	14.75	6

GSI values,% for female fish in the first half of April 2022 are in the range between 2.66% and 14.75%, with an average of 6.64%.



Gonadosomatic index – December 2022

The average weight of male fish in December 2022 is 1.80 kg and it is in the range of 1.20-2.30 kg. The weight of the gonads is between 2.70 g and 35.20 g, with an average value of 15.17 g (Table 8).

Table 8. Values of weight (BW, kg), total (TL, cm) and standard (SL, cm) body length, gonad weight (W_G, g), GSI, % and age of males in December 2022

December 2022 r.						
N _o	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	1.40	45.50	35.00	6.50	0.46	3
2	1.60	45.50	35.00	6.50	0.41	3
3	1.60	45.50	35.00	4.70	0.29	3
4	1.65	45.50	35.00	3.60	0.22	3
5	1.70	46.00	35.00	2.70	0.16	3
6	1.20	46.00	36.00	8.50	0.71	3
7	1.50	46.00	36.00	12.60	0.84	4
8	1.35	46.00	36.00	5.60	0.41	3
9	1.50	46.00	36.00	5.10	0.34	4
10	2.10	47.00	37.00	22.03	1.05	4
11	1.75	47.00	36.00	9.40	0.54	4
12	1.80	47.00	36.00	16.10	0.89	4
13	1.75	48.00	38.00	28.60	1.63	4
14	1.80	48.00	36.00	19.20	1.07	4
15	1.55	48.00	38.00	10.00	0.65	4
16	1.75	49.00	37.00	5.80	0.33	5
17	2.00	50.00	39.00	13.46	0.67	5
18	2.10	51.00	40.00	16.22	0.77	5
19	1.70	51.00	40.00	25.60	1.51	5
20	2.20	52.00	41.00	33.40	1.52	5
21	2.30	52.00	40.00	20.40	0.89	5
22	2.30	52.00	41.00	25.55	1.11	5
23	2.10	52.00	41.00	35.20	1.68	5

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24	2.00	53.00	43.00	23.20	1.16	5
25	2.20	54.00	42.00	19.17	0.87	6
ave	1.80	48.52	37.76	15.17	0.81	4
min	1.20	45.50	35.00	2.70	0.16	3
max	2.30	54.00	43.00	35.20	1.68	6

GSI values,% for male fish in December 2022 are in the range of 0.16% and 1.68%, with an average value of 0.81%.

The average weight of female fish in December 2022 is 1.94 kg and it is in the range of 1.20-3.60 kg. Ovarian weight is between 10.00 g and 133.60 g, with an average value of 57.10 g (Table 9).

Table 9. Values of weight (BW, kg), total (TL, cm) and standard (SL, cm) body length, gonad weight (W_G, g), GSI, % and age of females in December 2022

December 2022 r.						
N _o	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	1.30	45.50	35.00	10.00	0.77	3
2	1.20	45.50	35.00	14.30	1.19	3
3	1.50	46.00	34.00	27.90	1.86	4
4	1.35	46.00	36.00	59.40	4.40	4
5	1.55	46.00	36.00	36.30	2.34	4
6	1.50	46.00	36.00	13.50	0.90	4
7	1.90	47.00	37.00	50.20	2.64	4
8	1.40	47.00	37.00	57.20	4.09	4
9	2.00	48.00	37.00	48.70	2.44	4
10	1.20	48.00	38.00	43.55	3.63	4
11	2.00	48.00	38.00	18.90	0.95	4
12	1.60	48.00	38.00	17.80	1.11	4
13	1.80	51.00	40.00	49.20	2.73	5
14	1.60	51.00	40.00	89.50	5.59	5
15	1.85	52.00	41.00	131.70	7.12	5
16	1.80	52.00	40.00	51.00	2.83	5

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17	2.10	53.00	41.00	56.20	2.68	5
18	1.75	53.00	41.00	67.60	3.86	5
19	2.50	54.00	43.00	71.40	2.86	5
20	2.65	54.00	43.00	64.70	2.44	5
21	2.10	55.00	43.00	44.73	2.13	5
22	2.30	55.00	43.00	64.16	2.79	5
23	3.15	56.00	44.00	121.50	3.86	6
24	2.70	57.00	46.00	84.41	3.13	6
25	3.60	63.00	49.00	133.60	3.71	7
ave	1.94	50.68	39.64	57.10	2.88	5
min	1.20	45.50	34.00	10.00	0.77	3
max	3.60	63.00	49.00	133.60	7.12	7

GSI values,% for female fish in December 2022 are in the range between 0.77% and 7.12%, with an average of 2.88%.

Table 10 presents the average values of the gonadosomatic index (GSI,%) for female turbot in 2022.

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Table 10. Average values of gonadosomatic index (GSI, %), female turbot 2022.

GSI,%	Month	Second quarter	Fourth quarter
average		6.64	2.88
min		2.66	0.77
max		14.75	7.12

Table 11 presents the average values of the gonadosomatic index (GSI, %) for male turbot in 2022.

Table 11. Average values of gonadosomatic index (GSI, %), male turbot 2022.

GSI,%	Month	Second quarter	Fourth quarter
average		1.22	0.81
min		0.34	0.16
max		12.04	1.68



3.5.5. Fecundity of female fish

The female fish (34 specimens), caught and purchased in the first half of April 2022, based on which fertility is determined, have an average body weight of 2.38 kg. The average total body length is 50.94 cm and the average age is 4 years (**Fig. 16**).

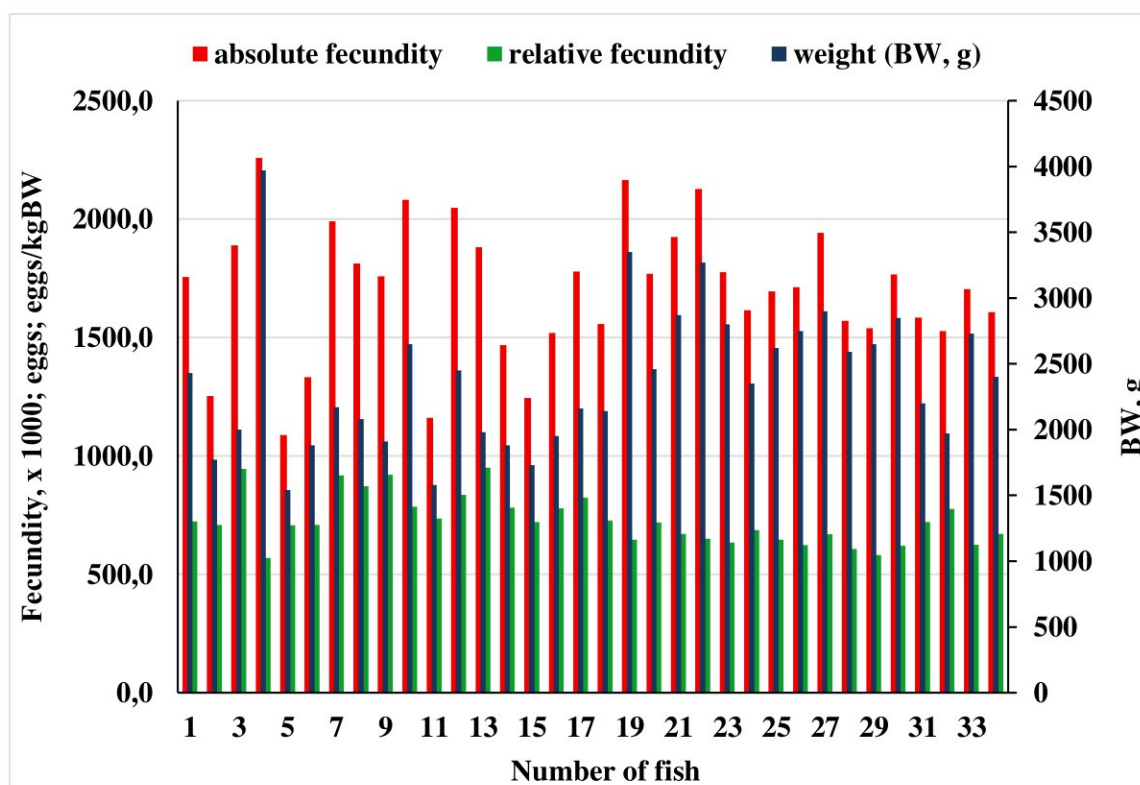


Fig. 16. Absolute and relative fecundity of female turbot in the first half of April 2022

The absolute fecundity of female turbot caught and purchased in the first half of April 2022 is 1 703 145.8 eggs, and the relative fecundity – 727 960.9 eggs (**Table 12**).



Table 12. Values of absolute and relative fecundity of turbot in the first half of April 2022

Parameter	Average values
Number of female fish	34
Total body length, TL (cm)	50.94
Body weight, BW (g)	2 383
Absolute fecundity, number of eggs/ind	1 703 145.8
Relative fecundity, number of eggs/BW, g	727 960.9
Age, years	5

The established fecundity of 1 703 145.8 eggs/individual is 50 470.6 eggs/individual lower than those established by Aydin *et al.* 2019, who report an absolute fecundity of 2 400 000 eggs/individual, which is an average of 696 855 eggs/individual lower than those found in the present study before the beginning of the reproductive period. In their study on the reproductive biology of turbot Aydin & Sahin (2011) established an absolute fecundity of 2 329 000 eggs/individual during the breeding season, which is an average of 625 854 eggs/individual higher than those found in the present study.

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The correlation between absolute fecundity and total body length, with fecundity increasing with the increasing body length, is presented in **Fig. 17**.

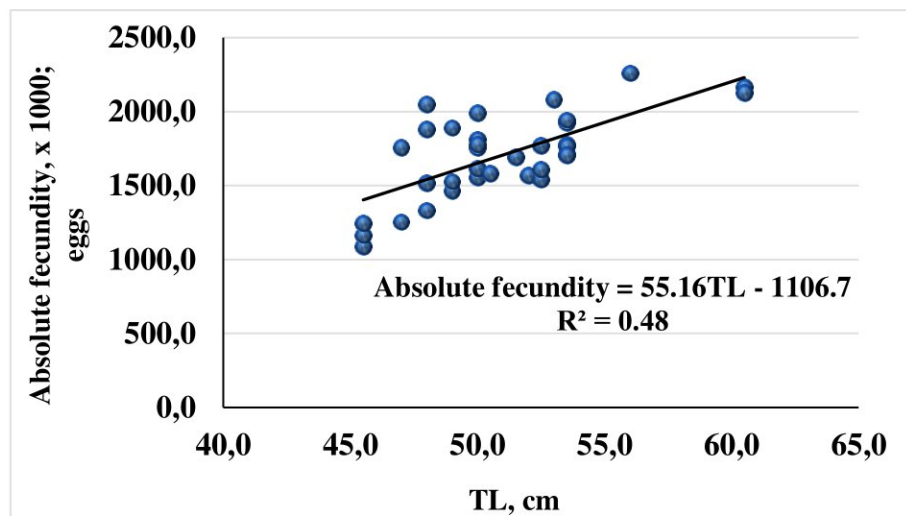


Fig. 17. Correlation between absolute fecundity and total length of female turbot in the first half of April 2022

The correlation between absolute fecundity and body weight of female turbot is presented in Fig. 18.

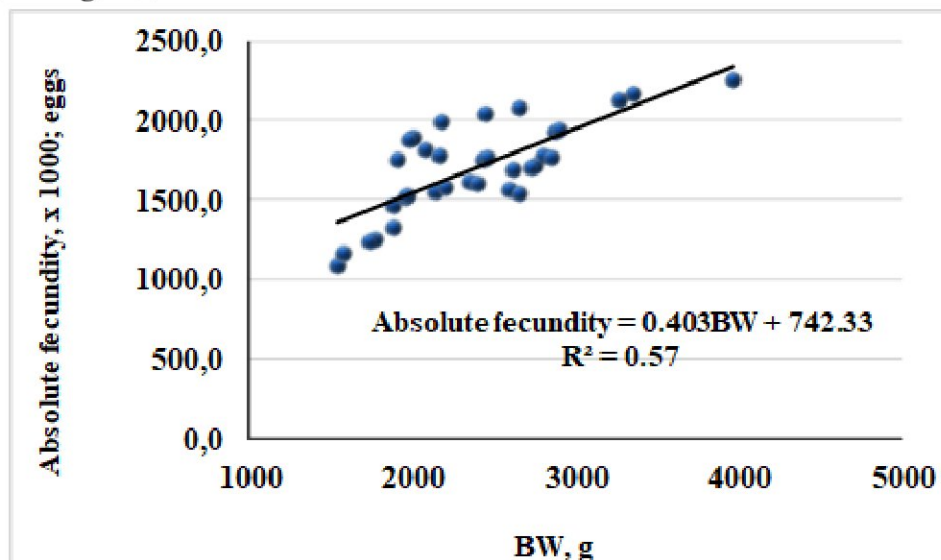


Fig. 18. Correlation between absolute fecundity and body weight of female fish in the first half of April 2022



The correlation is positive - with the increasing body weight, the absolute fecundity increases.

The correlation between absolute fecundity and age of female turbot in April 2022 is presented in **Fig. 19**.

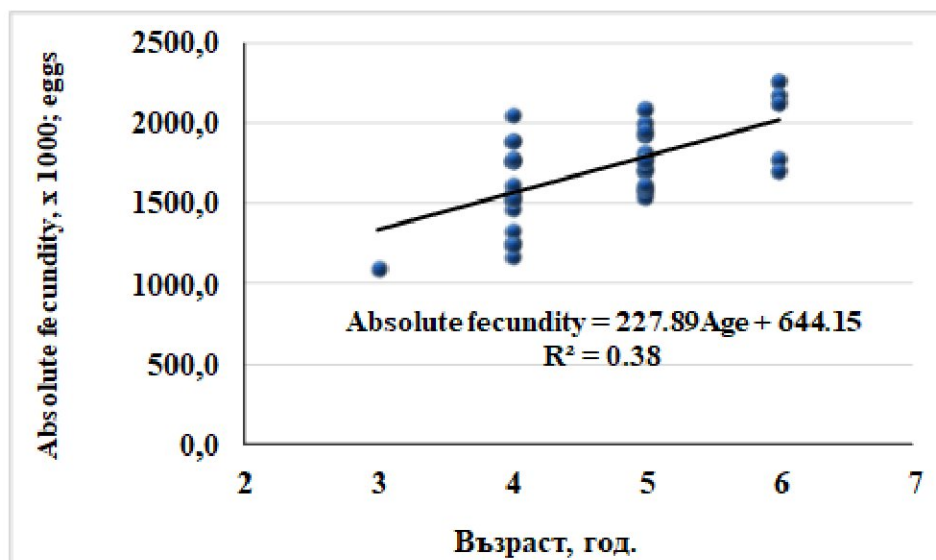


Fig. 19. Correlation between absolute fecundity and age of female turbot, in the first half of April 2022

3.5.6. Degree of maturity of the reproductive organs

During the first half of April, a process of active vitelogenesis is observed in the ovary, leading to the accumulation of vitellogenin in the oocytes. The mass fraction is vitelogenic oocytes of different size, and the ovary is in III-IV degree of maturity.

In the ovary and testis of the studied individuals in December III degree of maturity is reached. The main part in the ovary are previtelogenic follicles, and in the testis - spermatids.



3.6. Analysis of stomach content and determination of the food spectrum of turbot

For 2022, of all 100 fish studied for stomach content, 42 had a full stomach and 58 had an empty stomach (**Table 13**). The average value of ISF, % for 2022 is 0.47%. In the second quarter, most of the 50 fish studied have an empty stomach (35 fish or 70%), due to the breeding season. In the fourth quarter of the 50 fish studied, 27 had a full stomach (54%), which corresponds to the preparation for the next period of reproduction and accumulation of food reserves.

In the second and fourth quarters of 2022, *Merlangius merlangus* has the highest value of the index of relative importance, respectively $IRI = 3493.28$ and $IRI = 4963.56$.

According to the index of relative importance (IRI, %) in the second and fourth quarters of 2022 *M. merlangus* has a dominant share in the composition of the food spectrum, of all successfully identified taxa, respectively 52.65% and 92.64%.

Table 13. Index of stomach fullness (ISF, %) of turbot with full stomachs in 2022.

№	BW, g	TL, cm	Пълен стомах, g	Празен стомах, g	FW, g	ISF, %
1	2430	50.0	41.40	20.40	21.00	0.86
2	2070	49.0	30.90	20.90	10.00	0.48
3	1890	47.0	75.00	72.00	1.50	0.08
4	1780	48.0	31.60	17.00	14.60	0.82
5	2000	49.0	31.30	20.00	11.30	0.57
6	3970	56.0	39.60	25.00	14.60	0.37
7	1540	45.5	32.10	17.00	15.10	0.98
8	1720	45.5	24.10	13.00	11.10	0.65
9	1910	47.0	26.70	24.00	2.70	0.14
10	2650	53.0	44.10	35.00	9.10	0.34
11	2080	47.0	29.80	20.00	9.80	0.47
12	1580	45.5	22.50	12.00	10.50	0.66
13	2450	48.0	38.00	14.60	8.00	0.33



14	1490	45.5	32.10	19.00	13.10	0.88
15	2070	49.0	30.90	20.90	10.00	0.48
16	2200	52.00	53.20	42.00	11.20	0.51
17	2300	52.00	39.90	30.00	9.90	0.43
18	2300	52.00	38.10	27.00	11.10	0.48
19	2100	47.00	46.20	25.00	21.20	1.01
20	2700	57.00	38.64	30.00	8.64	0.32
21	2100	55.00	46.70	30.00	16.70	0.80
22	2300	55.00	62.29	37.50	24.79	1.08
23	2100	53.00	61.30	48.00	13.30	0.63
24	1900	47.00	42.30	25.50	16.80	0.88
25	1500	46.00	25.50	15.50	10.00	0.67
26	1750	49.00	37.90	24.00	13.90	0.79
27	3600	63.00	86.30	41.20	45.10	1.25
28	1350	46.00	72.70	31.00	41.70	3.09
29	1400	47.00	44.30	20.00	24.30	1.74
30	1550	48.00	46.20	29.00	17.20	1.11
31	1650	45.50	104.80	33.00	71.80	4.35
32	3150	56.00	49.50	29.00	20.50	0.65
33	1300	45.50	25.80	12.00	13.80	1.06
34	2500	54.00	110.50	64.00	46.50	1.86
35	2000	48.00	80.10	32.00	48.10	2.41
36	1500	46.00	28.60	12.00	16.60	1.11
37	2650	54.00	26.30	17.00	9.30	0.35
38	1350	46.00	54.20	30.00	24.20	1.79
39	1800	52.00	46.40	40.40	6.00	0.33
40	1750	53.00	66.70	20.00	46.70	2.67
41	1500	46.00	100.30	20.00	80.30	5.35
42	1600	48.00	65.10	37.00	28.10	1.76



4. Conclusions and recommendations

Based on the results of the biological monitoring of turbot landings at the Bulgarian Black Sea coast in 2022, the following conclusions and recommendations can be made:

1. Fishing vessels unload an average of 19 turbot per vessel. The maximum catch is 98 fish and the minimum is 4 fish.
2. From a total of 58 landings at the monitored ports - Kavarna, Varna, Pomorie, Tsarevo, Byala, Krapets, Shabla and Balchik, 1088 turbot are measured with an average weight of 2.74 kg and an average total body length of 52.67 cm.
3. The maximum measured weight is 7.50 kg and the minimum - 1.20 kg.
4. The maximum measured values for the total body length are 76.00 cm, and the minimum - 45.50 cm.
5. From the 1088 turbot, 398 (37%) weigh up to 2 kg. Fish weighing from 2 to 3 kg make up 43% of the measured specimens (465 specimens). The weight group from 3 kg to 4 kg is represented by 86 specimens. or 8% of the representative sample. Turbot weighing from 4 kg to 5 kg represent 4% or 46 specimens of the studied individuals. Turbot weighing from 5 kg to 6 kg represent 3% or 28 specimens of the studied individuals. Turbot weighing from 6 kg to 7 kg represent 4% or 48 specimens of the studied individuals. In the landings of the monitored ports, within the performed monitoring, with the lowest percentage distribution are fish weighing more than 7 kg - 2% or 17 specimens.
6. From the distribution of individuals by size groups by total length (TL, cm) it is established that it is most widely represented is the size group 49-52 cm. Turbot with total body length (TL, cm) in the range of 49-52 cm represent 33.00% of the landings (359 specimens), followed by the groups 45-48 cm (22.05%-321 specimens) and 53-56 cm (16.36%-178 specimens). The individuals with total body length in the range of 57-60 cm



are 82 specimens, which represents 7.54% of all measured specimens. Fish with a total body length between 61 and 64 cm are 75 specimens or 6.89% of all measured fish and fish with a body length in the range of 65-68 cm are 63 specimens or 5.79%. Fish over 69 cm are 10 specimens or 0.92%.

7. From the distribution of individuals by size groups by standard length (SL, cm) it is established that the group 36-39 cm is most widely represented (435 specimens – 39.98%). It is followed by the groups 40-43 cm (280 specimens - 25.74%) and 32-35 cm (127 specimens – 11.67%). Individuals with a standard body length in the range of 44-47 cm are 100 specimens, which represents 9.19% of all measured specimens. Fish with standard body length in the groups 48-51 cm and 52-55 cm are 5.79% (63 specimens) and 5.06% (55 specimens), respectively. Last, with the lowest percentage are turbot with a standard body length greater than 56 cm - 28 specimens or 2.57%.
8. The correlation between the size and weight of turbot is clearly expressed and it is described by the equation: $BW = 0.004TL^{3.394}$.
9. The percentage of females and males is 42% to 58% in favor of males.
10. The age composition of the studied 100 specimens of turbot in 2022 includes from 3 to 7-year-old individuals, with four (48%) and five (28%) year-old fish predominating. In total, they represent 76% of the total number of studied specimens. The percentage of turbot aged 3 and 6 years is 19% and 4%, respectively. The lowest percentage is of fish at 7, with 1% of the age composition.
11. Males with a total body length of up to 45-48 cm and 49-52 cm predominate. At lengths over 53.00 cm the percentage of female individuals increases.
12. In males, 4 and 3 year-old turbot predominate, and in females 4 and 5 year-old fish.
13. The average weight of male fish in the first half of April 2022 is 1.74 kg and it is in the range of 1.41-2.28 kg. The weight of the gonads is between 5.10 g and 171.00 g,



- with an average value of 20.19 g. The GSI, % values for male fish in the first half of April 2022 are in the range of 0.34% and 12.04%, with an average value of 1.22%.
14. The average weight of female fish in the first half of April 2022 is 2.13 kg and it is in the range of 1.54-3.97 kg. The weight of the ovary is between 53.10 g and 510.00 g, the average value is 149.05 g. GSI, % values for female fish in the first half of April 2022 range between 2.66% and 14.75%, with an average of 6.64%.
15. The average weight of male fish in December 2022 is 1.80 kg and it is in the range of 1.20-2.30 kg. The weight of the gonads is between 2.70 g and 35.20 g, with an average value of 15.17 g. GSI, % values for male fish in December 2022 are in the range of 0.16% and 1.68%, with an average of 0.81%.
16. The average weight of female fish in December 2022 is 1.94 kg and it is in the range of 1.20-3.60 kg. The weight of the ovary is between 10.00 g and 133.60 g, the average value is 57.10 g. GSI,% values for female fish in December 2022 range between 0.77% and 7.12%, with an average value of 2.88%.
17. It is established that the absolute fecundity of female turbot caught and purchased in the first half of April 2022 is 1 703 145.8 eggs, and the relative fecundity – 727 960.9 eggs/kg BW.
18. During the first half of April, a process of active vitelogenesis is observed in the ovary, leading to the accumulation of vitellogenin in the oocytes. The mass fraction is vitelogenic oocytes of different size, and the ovary is in III-IV degree of maturity.
19. In the ovary and testis of the studied individuals in December III degree of maturity is reached. The main part in the ovary are previtelogenic follicles, and in the testis - spermatids.
20. For 2022, of all 100 fish studied for stomach content, 42 had a full stomach and 58 had an empty stomach. The average value of ISF,% for 2022 is 0.47%.



21. In the second and fourth quarters of 2022, *Merlangius merlangus* has the highest value of the index of relative importance, respectively $IRI=3493.28$ and $IRI=4963.56$.
22. According to the index of relative importance (IRI, %) in the second and fourth quarters of 2022 *M. merlangus* has a dominant share in the composition of the food spectrum, of all successfully identified taxa, respectively 52.65% and 92.64%.

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