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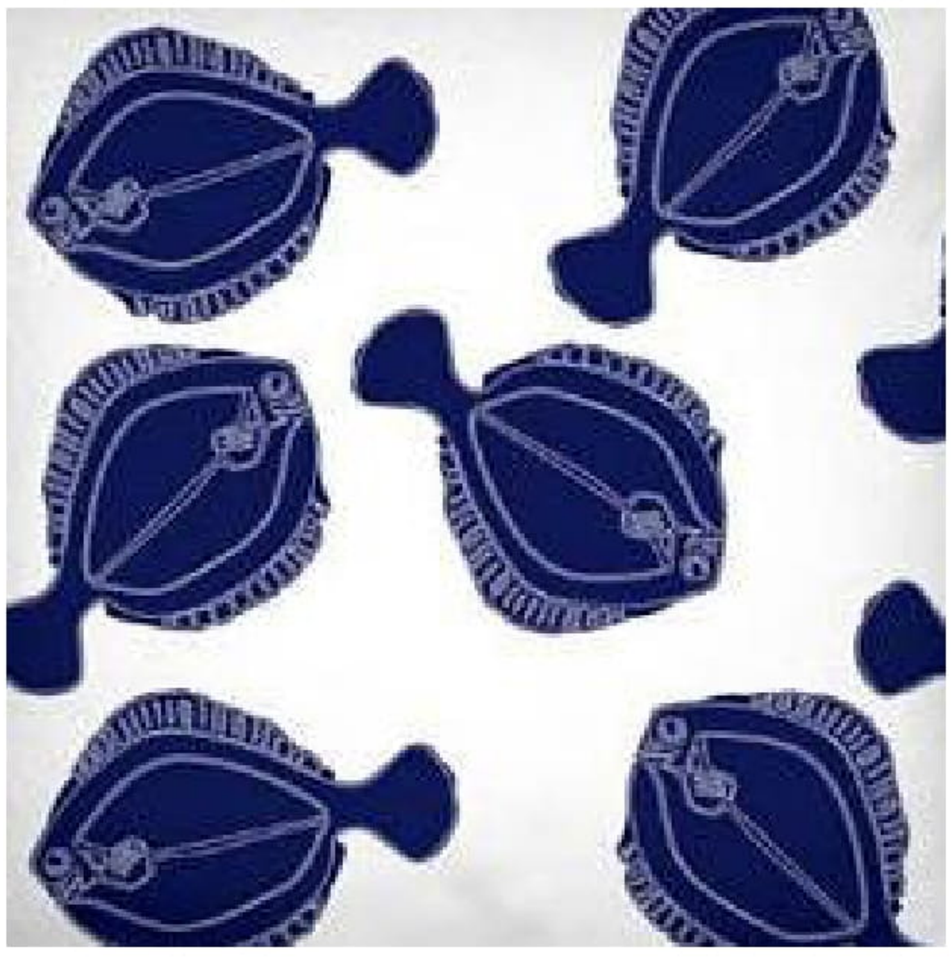

BIOLOGICAL MONITORING OF TURBOT (*SCOPHTHALMUS MAXIMUS*) LANDINGS AT THE BULGARIAN BLACK SEA COAST IN 2024

Institute of Fisheries and Aquaculture, Plovdiv

Agricultural Academy, Sofia

2024

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Project BG14MFPR001-1.002-0001 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2023-2024 г.“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund

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CONTENT

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Biological monitoring of turbot (*Scophthalmus maximus*) landings at the Bulgarian Black Sea coast in 2024

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 2024 includes the following main tasks and objectives:

1. Collection of data from port landings, vessels for sample collection, number of samples collected, number of measured turbots, geographical data of turbot catch locations;
2. Determination of size and weight structure of turbot landings;
3. Characteristics of the reproductive biology of turbot;
4. Determination of the age structure of the turbot landings;
5. Stomach content and food array analysis of turbot.

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 2024 at 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, Durankulak, Balchik, Krapets, Nesebar and Pomorie.

2.1.2. Vessels for sample collection

Biological data from the landings is collected from 42 landings. **Table 1** contains data on ports and vessels where monitoring was carried out to collect biological data from turbot landings in 2024. 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 2024

Port	Quarter Data 2024			
	First Quarter	**Second Quarter**	**Third Quarter**	**Fourth Quarter**
Kavarna	1. Ivana Kv 6231 2. Libra Vn 8311 3. Viking Vn 8406 4. Piranya Kv 6296		1. Gondola Vn 4321 2. Neptun 70 Kv 6321 3. Vn 7822 4. Neptun 70 Kv 6321 5. Hishtnik Kv 6262	1. Pyldin Kv 5642 2. Pyldin Kv 5643 3. Vn 4601 4. Hera Kv 6241 5. Ivana Kv 6321 6. Pyldin Kv 5642 7. Ivana Kv 6321
Varna	5. Vn 8147 6.Bumerang Vn 8250	1. Akula Vn 8535 2. Viking Vn 8406 3. Akula Vn 8535	-	-
Durankulak	7. Shb 5927	-	-	8. Veni Vn 2998 9. Afal1 Vn 4145 10. Shb 5927
Balchik	8. Drina Vn 2966 9. VN 8112 10. Bizone Vn 7432 11. Sv. Ilia Vn 7759	4. Delta Vn 390 5. Св. Илия Вн 7759 6. Sv. Ilia Vn 8042	6. Elis Bs 5322 7. Vn 8112 8. Elis Bs 5322 9. Vn 8112	11. Darina Vn 2966
Krapets	12. Shb 5927	-	-	-
Nesebar	-		-	12. Muko Ns 444 13. Mobi Dik 14. Burevestnik
Pomorie	-		-	15. Kaliakra Vn 8110

Biological data from the landings is collected as follows: 16 landings from Kavarna, 5 landings from Varna, 4 landings from Durankulak, 12 landings from Balchik, 1 landings from Krapets, 3 landings from Nesebar and 1 landings from Pomorie.

2.1.3. Number of collected samples

Biological data was collected for 1,644 fish from 42 landings, which corresponded to the number of fish landed or 100% of the landed quantity was measured (**Table 2**).

Table 2. Data on landings by ports for 2024

Port	Quarter Data 2024				Total Number of Fish
	Number of Fish				
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	
Kavarna	179	-	175	298	**652**
Varna	54	121	-	-	**175**
Durankulak	8	-	-	136	**144**
Balchik	216	149	79	52	**496**
Krapets	12	-	-	-	**12**
Nesebar	-	-	-	100	**100**
Pomorie	-	-	-	65	**65**
Total	**469**	**270**	**254**	**651**	**1644**

The data was collected as follows: 469 specimens from the first quarter, 270 fish from the second quarter, 254 fish from the third and 651 fish were sampled from the fourth quarter of 2024.

2.2. Number of studied turbots

The total number of specimens from which biological data was collected is 1,644 with a total weight of 4,259.00 kg.

2.3. Geographical data of turbot catch locations

The coordinates and depths of the turbot catch locations by the vessels at the ports of Kavarna, Varna, Durankulak, Balchik, Krapets, Nessebar and Pomorie in 2024 are shown in **Table 3.**

Table 3. Coordinates and depth of turbot catch locations for 2024

№	Vessel	Coordinates of catch locations		Depth of catch location (m)
		Latitude	Longitude	
First Quarter 2024				
1.	Ivana Kv 6231	43°29'48"N	28°56'72"E	60-65
2.	Libra Vn 8311	43°38'29.3"N	29°08'02.5"E	70
3.	Viking Vn 8406	43°38'29.3"N	29°08'02.5"E	60-65
4.	Piranya Kv 6296	43°36'30.7"N	29°02'16.3"E	20-25
5.	Shb 5927	43°39'39.3"N	28°54'25.1"E	65-70
6.	Kv 6332	43°38'20.6"N	28°50'09.1"E	50-55
7.	Drina Vn 2966	43°38'03.1"N	28°51'10.4"E	50
8.	Vn 8112	43°35'25.6"N	29°00'02.3"E	45-50
9.	Bizone Vn 7432	43°35'20.8"N	29°00'06.6"E	35-40
10.	Sv. Ilia Vn 7759	43°35'16.9"N	29°00'06.8"E	55-60
11.	Vn 8147	43°35'17.4"N	29°00'14.9"E	40-45
12.	Bumerang Vn 8250	43°20'56.7"N	29°01'07.2"E	50
Second Quarter 2024				
1.	Delta Vn 390	43°39'26.7"N	28°52'09.8"E	60
2.	Sv. Ilia Vn 7759	43°40'20.4"N	28°52'31.2"E	65-75
3.	Elekta Vn 8042	43°42'47.5"N	28°59'34.8"E	65-70
4.	Akula Vn 8535	43°41'29.8"N	28°54'32.4"E	90
5.	Viking Vn 8406	43°39'45.7"N	28°55'04.1"E	50-55
6.	Akula Vn 8535	43°39'45.7"N	28°55'04.1"E	35-40
Third Quarter 2024				
1.	Elis Bs 5322	43°35'25.2"N	28°53'14.1"E	60
2.	Vn 8112	43°43'29.9"N	28°59'06.7"E	55-60
3.	Elis Bs 5322	43°39'59.0"N	28°57'39.3"E	50
4.	Vn 8112	43°42'18.4"N	28°53'32.1"E	55-65
5.	Gondola Vn 4321	43°42'12.5"N	28°53'31.4"E	45-50
6.	Neptun 70 Kv 6321	43°44'23.8"N	28°56'39.7"E	50
7.	Vn 7822	43°42'04.5"N	28°57'44.0"E	55-60
8.	Neptun 70 Kv 6321	43°46'53.8"N	29°01'54.1"E	65-70
9.	Hishtnhik Kv 6262	43°46'53.8"N	29°01'54.1"E	40-45
Fourth Quarter 2024				
1.	Veni Vn 2998	43°41'23.3"N	28°38'23.0"E	50
2.	Afal1 Vn 4145	43°41'22.4"N	28°38'22.9"E	40-50
3.	Shb 5927	43°41'21.9"N	28°38'22.0"E	40-50
4.	Pyldin Kv 5642	43°43'16.4"N	29°01'16.1"E	50
5.	Pyldin Kv 5642	43°44'60.0"N	29°21'14.6"E	30-40
6.	Vn 4601	43°18'38.4"N	28°25'19.3"E	35-40

7.	Hera Kv 6241	43°40'47.4"N	28°56'58.1"E	55-60
8.	Hera Kv 6241	43°42'32.6"N	28°53'54.4"E	60
9.	Pyldin Kv 5642	43°42'42.7"N	29°06'49.9"E	35-40
10.	Ivana Kv 6321	43°42'40.5"N	29°06'53.3"E	40
11.	Darina Vn 2966	43°42'35.0"N	29°06'42.6"E	45-50
12.	Muko Ns 444	42°38'22.2"N	28°15'39.0"E	50
13.	Mobi Dik	42°36'27.6"N	28°01'40.6"E	65-70
14.	Burevestnik	42°36'25.9"N	28°01'38.2"E	55-60
15.	Kaliakra Vn 8110	42°46'58.8"N	28°00'47.3"E	40

The catches were made in the water area between the parallels 42°N and 43°'N and the meridians 28°E and 29°E. The depth of the catch sites varies between 30 and 70 m.

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

Fish measurements are made at the port, immediately after the vessels dock, on fresh, ice-chilled 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) was calculated, which is established by the LeCren equation (1951):

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

W - weight (g);

L – total length (TL, cm);

a - constant;

b – growth coefficient.

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2.5. Characteristics of the reproductive biology of turbot

To study the reproductive biology of turbot, a total of 100 fish are purchased - 50 fish during the spring-summer and 50 in the autumn-winter period. Based on the collected gonad samples, the sex, gonadosomatic index and degree of maturity of the gonads is determined.

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

The gonadosomatic index (GSI, %) is determined on the basis of 100 turbots. It is calculated as a percentage of the body weight for each individual, based on the data from the weight

measurements of the body and gonad weight of female fish using Wootton's formula (1998):

$$\mathbf{GSI = 100.W_G.BW^{-1}, where:}$$

W_G – weight of the gonad, g;

BW – body weight, g.

- **Fecundity of female fish**

When determining the fecundity of female fish for 2024, the required minimum of 35 fish is achieved under contract №149/10.03.2023 with EAFA, Burgas. Data on the absolute and relative fecundity of individuals are presented.

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

The degree of maturity of the gonads is established for 50 turbots caught and purchased in the first half of April 2024 and 50 turbots caught in December 2024. The gonads are dissected and fixed in 4% formaldehyde solution for further processing to determine the stage of maturity of the ovary and testis. Paraffin sections are prepared, on the basis of which the stage of maturity is established.

- **Age**

The age of 100 turbots 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.

2.6. Stomach content and food array analysis of turbot

The stomach contents of 50 turbots, caught and purchased in the second quarter of 2024 and 50 turbots in the fourth quarter of 2024, have been studied 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:

ISF = (FW/W) * 100, 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:

IRI = (C_N + C_W) * F, where

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):

%IRIi = 100 * IRIi / ni∑IRIi, where:

IRIi - index of relative significance of each food component;

n - total number of taxonomic categories included in the food spectrum.

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3. Results

3.1. Number of turbots landed by vessels

The total number of fish from which biological data is collected is 1 644. The number of turbot caught by each vessel is presented in **Fig. 1**.

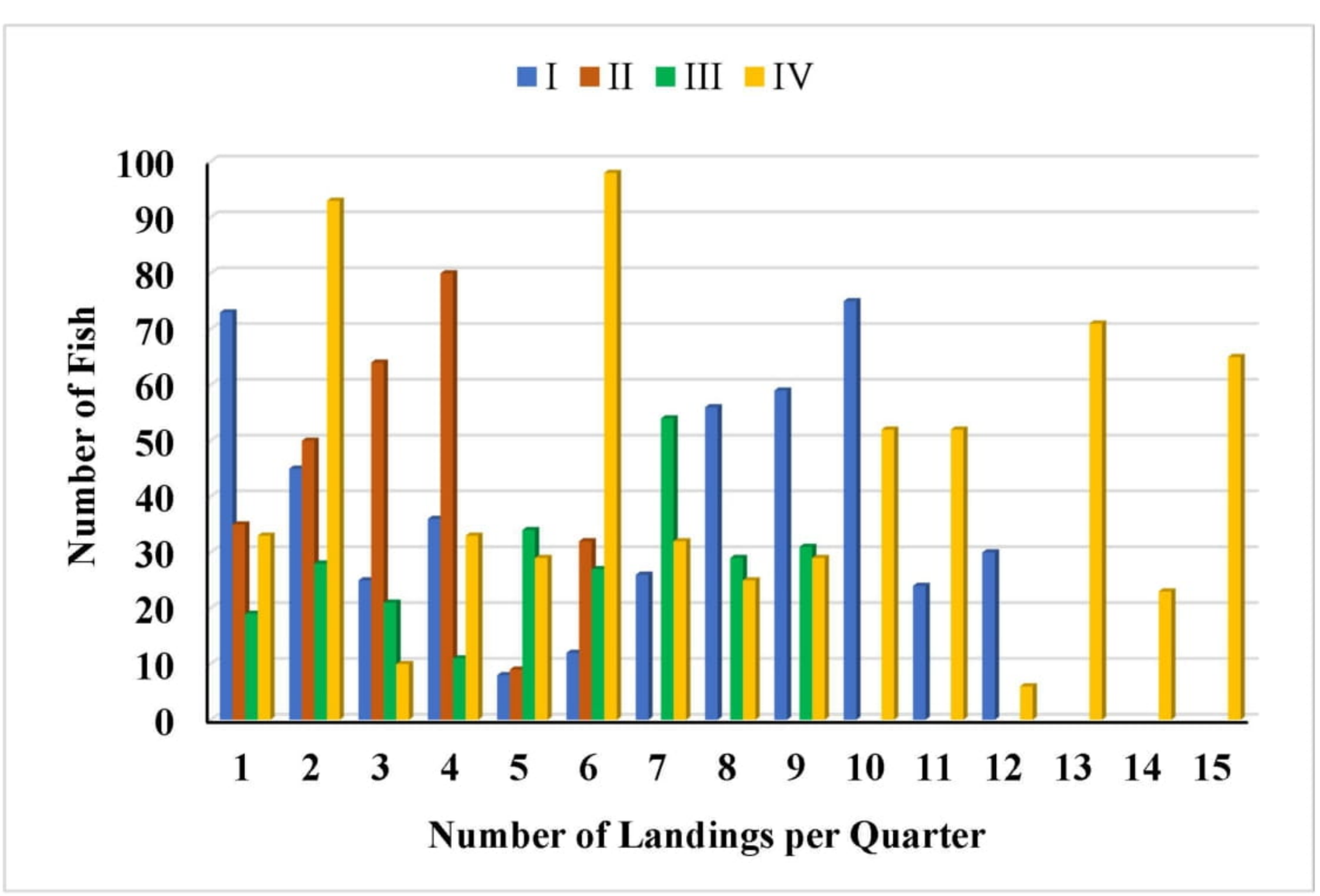

Fig. 1. Number of fish per vessel landed in 2024

In 2024, an average of 39 fish or 101.40 kg/ship were caught per vessel, with the maximum number being 98 (291.00 kg) in the fourth quarter, and the minimum being 6 (20.00 kg) also in the fourth quarter.

3.2. Weight structure of turbot landings

The average weight of the measured specimens is 2.59 kg. The maximum measured weight is 7.30 kg, and the minimum measured - 1.47 kg.

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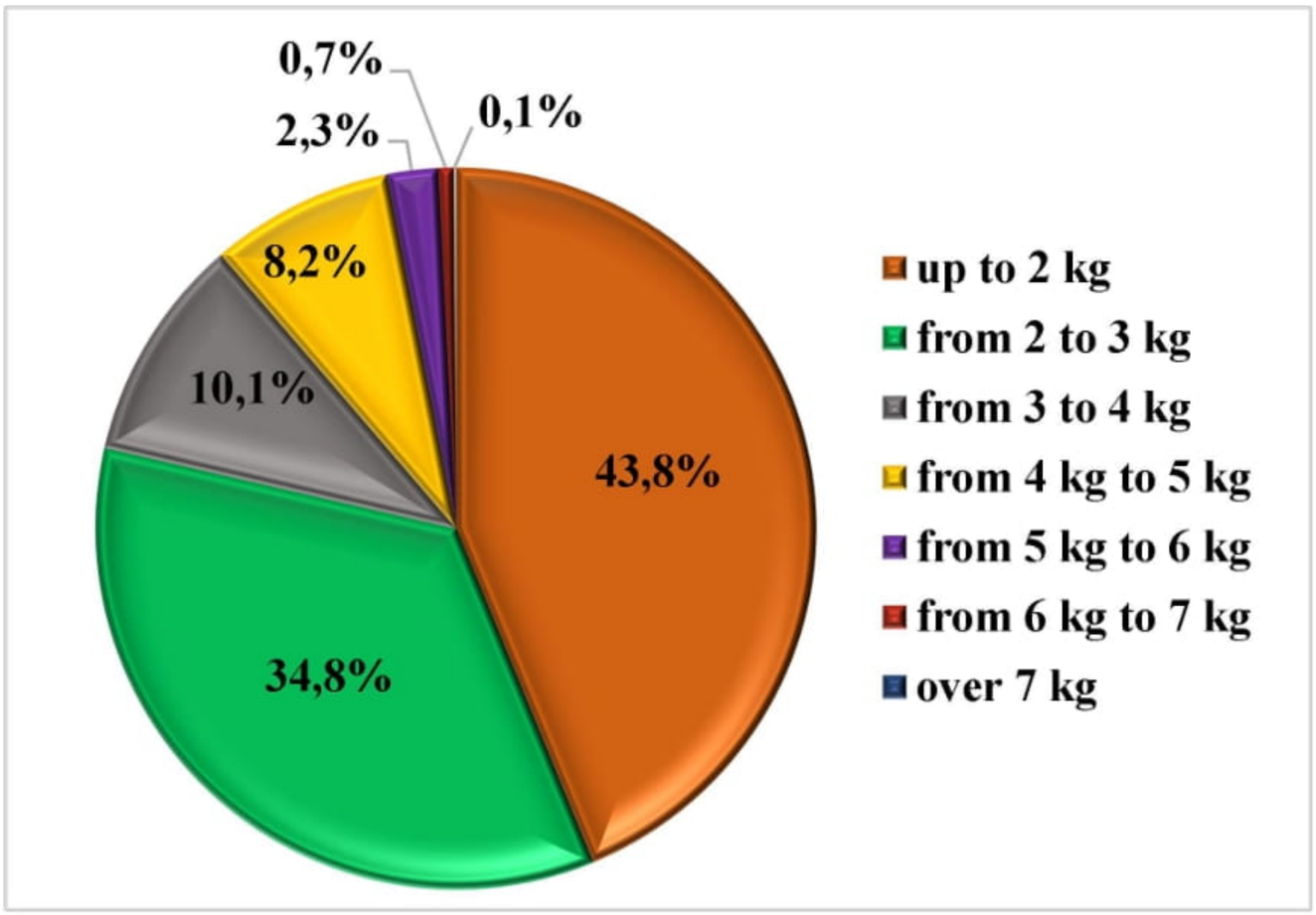

Fig. 2. Percentage distribution by weight of the measured fish in 2024

Fig. 2 presents the distribution of landings according to fish weight. Out of 1 644 turbot, 720 (43.8%) weighed up to 2 kg. Fish weighing from 2 to 3 kg accounted for 34.8% - 572 fish of the measured specimens. The weight groups from 3 kg to 4 kg and from 4 to 5 kg have a similar percentage share - 10.1% and 8.2% respectively, with the first group consisting of 166 fish and the second - 135 fish of the representative sample. The weight group from 5 to 6 kg consists of 38 fish or 2.3% of the measured turbot. The groups from 6 to 7 kg and over 7 kg have the lowest percentage share, with the first group occupying 0.7% or 11 fish and the second group - 0.1% or 2 fish.

3. 3. Size structure (total and standard body length) of measured turbots

The average total length (TL, cm) of the measured specimens is 53.23 cm, the maximum measured length is 80.00 cm, and the minimum measured length is 45.10 cm. **Fig. 3** shows the dynamics of the distribution of the total body length (TL, cm) values of the measured individuals.

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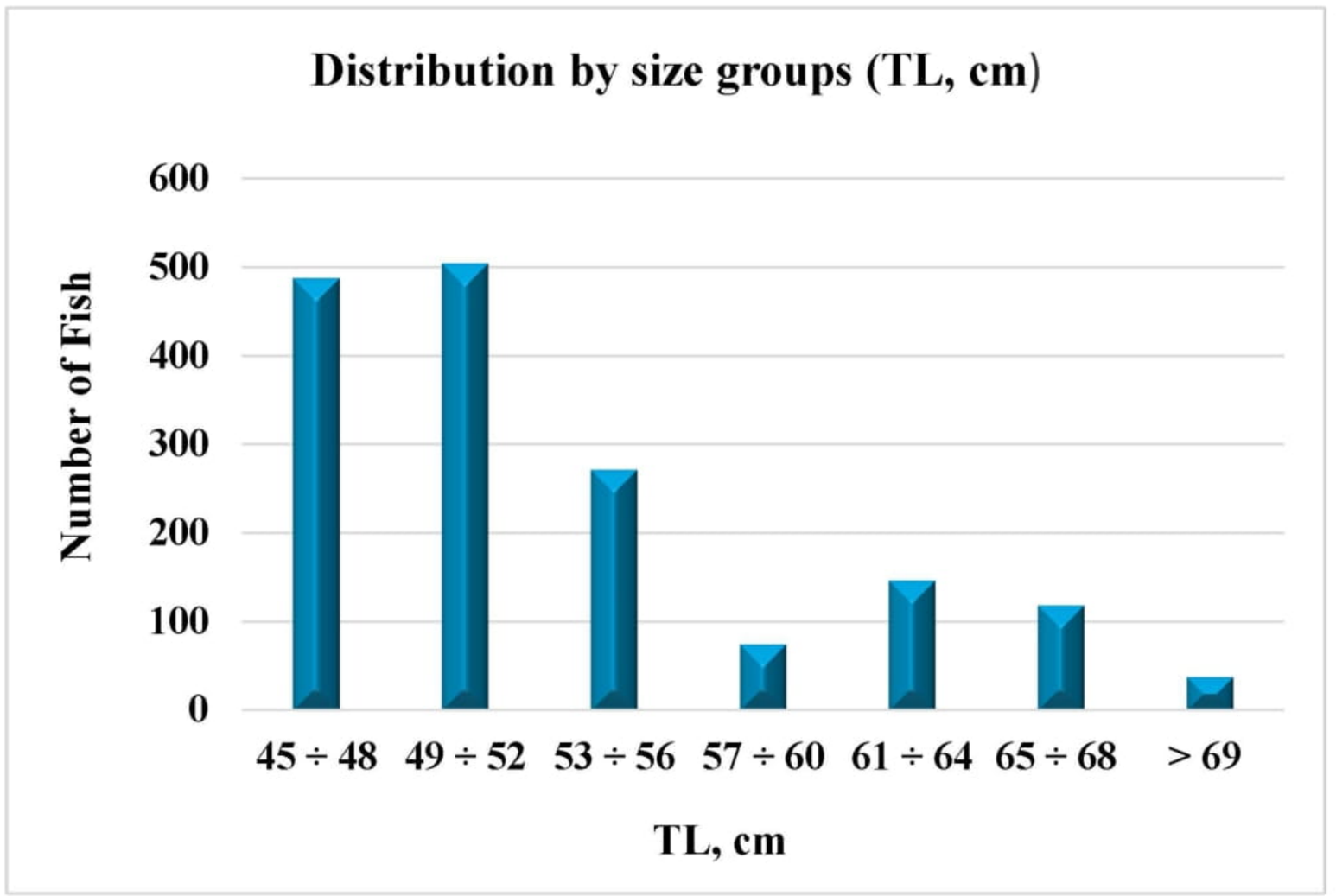

Фиг. 3. Size structure (total length) of turbot landings in 2024

The distribution of individuals by size groups according to the total length (TL, cm) shows that the most represented group is the 49-52 cm group consisting of 505 individuals or 30.7%, followed by the 45-48 cm group, which has percentage share of 29.7% or 488 individuals from the representative sample. Turbots with a total body length (TL, cm) in the range of 53-56 cm are 272 individuals (16.5%), followed by the groups 61-64 cm – 147 individuals (8.9%) and 65-68 cm – 119 individuals (7.2%). The size groups 57-60 cm and >69 cm have the lowest percentage share - 75 and 38 individuals or 4.6% and 2.3% respectively.

Fig. 4 shows the dynamics of the distribution of the values of standard body length (SL, cm) of the measured individuals in 2024. The average value of the standard body length (SL, cm) is 41.56 cm. The maximum measured standard length is 68.00 cm, and the minimum measured is 33.00 cm.

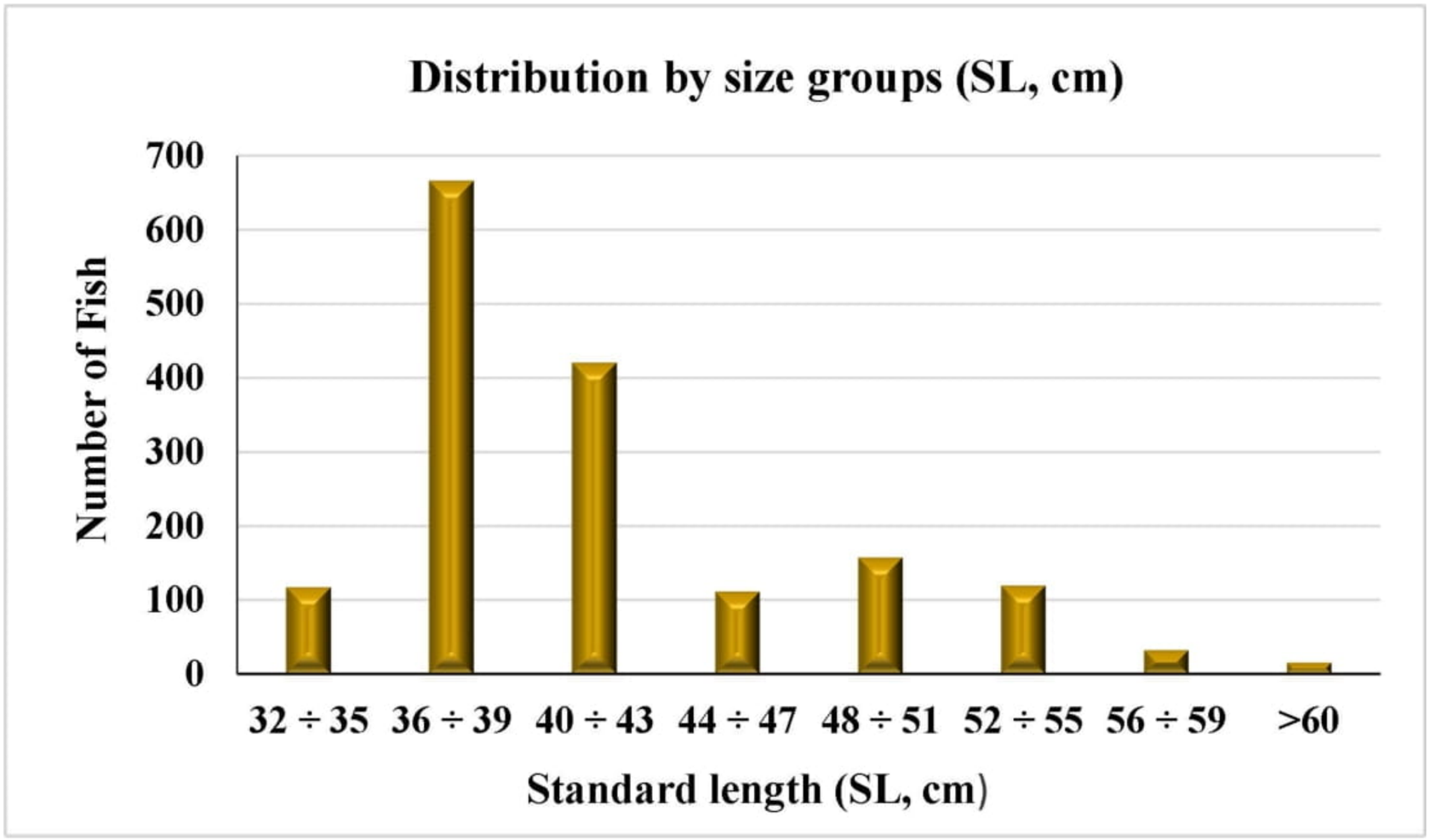

Fig. 4. Size structure (standard length) of turbot catches in 2024

The distribution of individuals by size groups according to the standard length (SL, cm) shows that the 36-39 cm group is represented most with 666 individuals or 40.51%, followed by the 40-43cm group (421 individuals – 25.61%). Individuals with a standard body length in the range of 48-51 cm are 158 individuals or 9.61%. The size groups 32-35 cm and 52-55 cm have a very close percentage share of 7.18% and 7.30% or 118 individuals and 120 individuals, respectively. They are followed by the 44-47 cm group, consisting of 112 individuals or 6.81%. The lowest percentage share is for turbots with a standard body length in the range of 56-59 cm and >60 cm, which consist of 33 and 16 individuals, or 2.01% and 0.97% respectively.

The correlation between the size and weight of turbot is presented in **Fig. 5**.

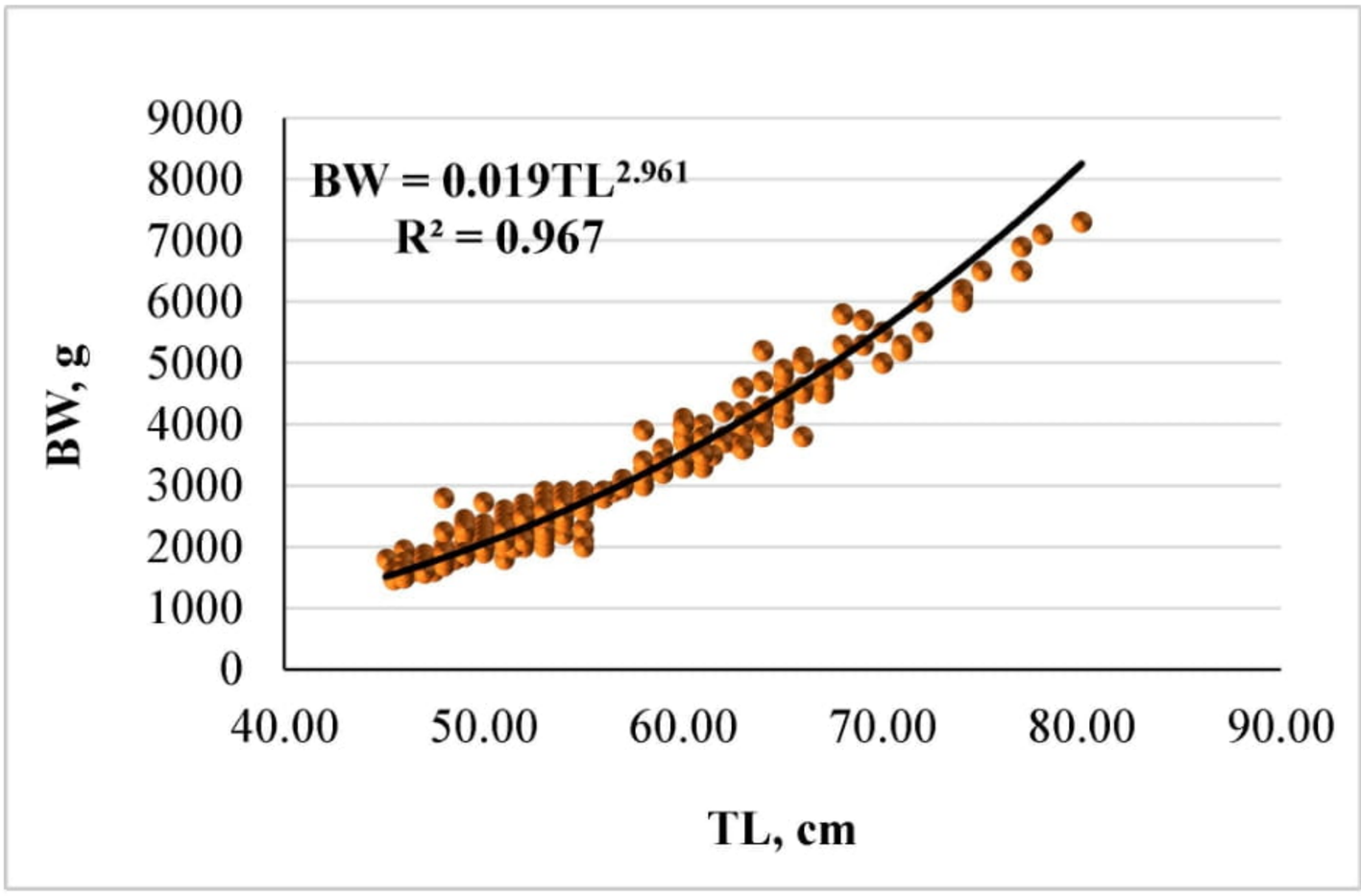

Fig. 5. Correlation between size and weight of turbot in 2024, n=1644

The correlation between the size and weight structure of turbot landings in 2024 is described by the equation: $\mathbf{BW = 0.019TL^{2.961}}$.

3.4. Characteristics of the reproductive biology of turbot

3.4.1. Sex ratio

The percentage distribution between male and female individuals is presented in **Fig. 6**. It is established that 41 specimens are female and 59 specimens are male. The percentage ratio between female and male individuals is 41% to 59% in favor of male individuals.

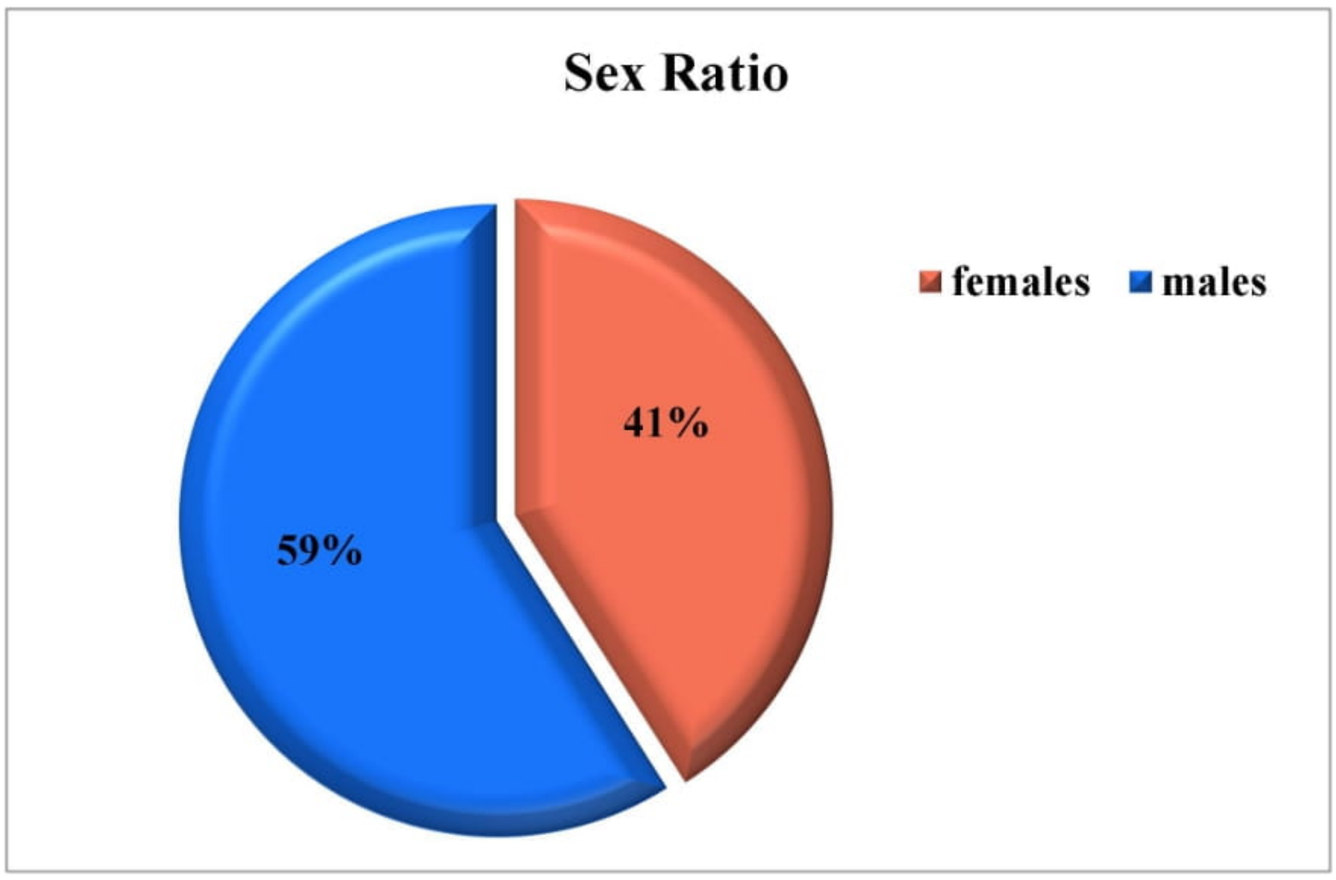

Fig. 6. Percentage ratio between female and male individuals in 2024, n=100

Fig. 7 presents the distribution between the two sexes depending on the total body length, distributed in size groups in every 3 cm.

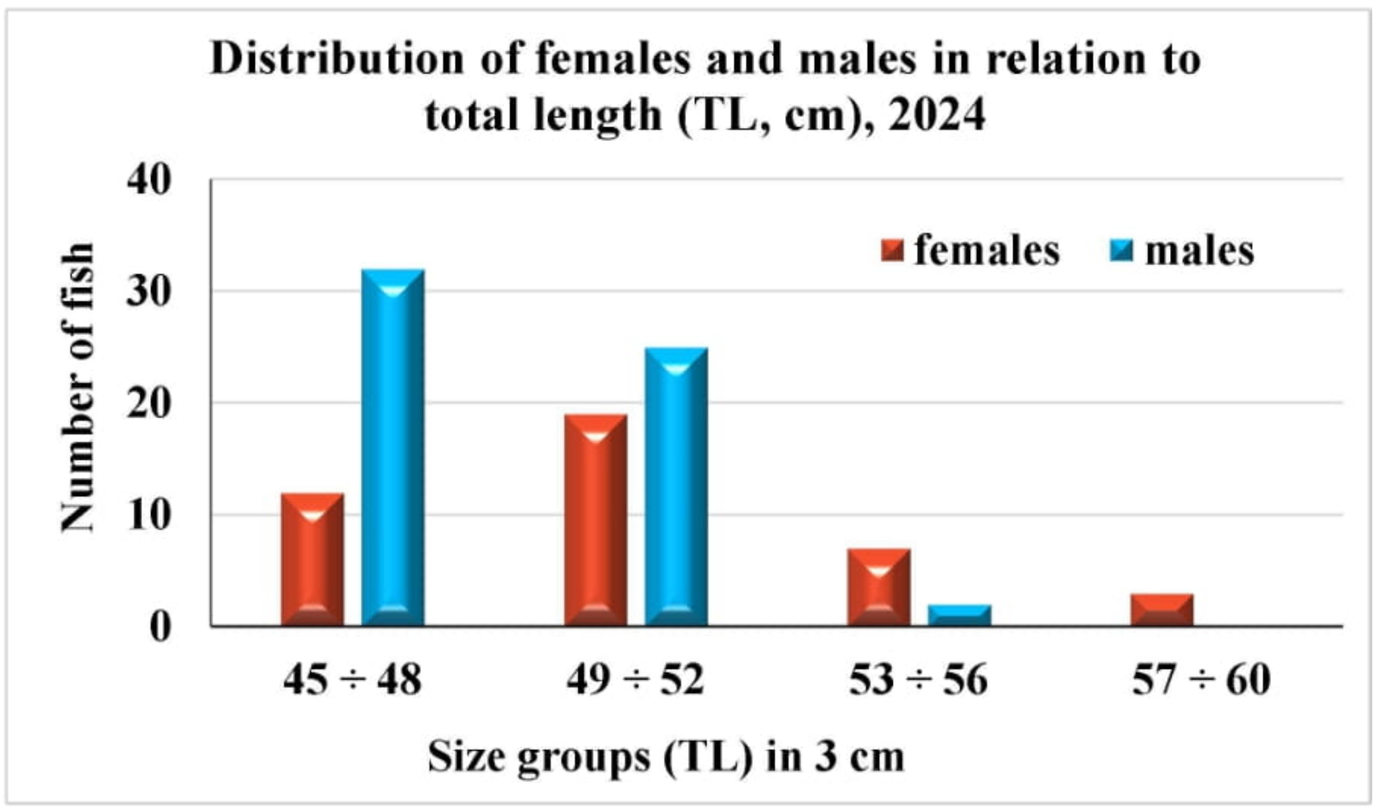

Fig. 7. Distribution between the two sexes depending on the total body length (TL, cm), (n=100; f=41, m=59)

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The highest number of male individuals (32 specimens) are in the size group 45-48 cm, followed by the group 49-52 cm, consisting of 25 specimens. The lowest number of male turbots (2 specimens) are in the the size group 53-56 cm. Among female individuals, the highest number (19 specimens) are in the size group 49-52 cm, followed by the size group 45-48 cm (12 specimens). The lowest number of female turbots are in the size groups 53-56 cm and 57-60 cm, represented by 7 specimens and 3 specimens, respectively. Male individuals dominate in the size groups 45-48 cm and 49-52 cm, with 20 specimens and 6 specimens, respectively. Female individuals dominate with 5 specimens in the size group 53-56 cm, and the size group 57-60 cm is represented only by 3 female individuals (**Table 4**).

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

Total length (TL, cm) in size groups by 3 cm	45 - 48	49 - 52	53 - 56	57 - 60
Number of females	12	19	7	3
Number of males	32	25	2	0
Ratio females/males	0.37:1	0.76:1	3.5:1	-

3.4.2. Gonadosomatic index (GSI, %)

Gonadosomatic index – second quarter 2024

The average weight of male fish in the first half of April 2024 is 1.95 kg and it is in the range 1.47-2.73 kg. Gonad weight ranged between 5.60 g and 105.80 g, with an average value of 34.28 g (**Table 5**).

Table 5. Values of weight (BW, kg), total (TL, cm) and standard (SL, cm) body length, gonad weight (W_G, g), GSI, % and age of male individuals in the second quarter 2024

Second Quarter 2024						
№	BW, kg	TL, cm	SL, cm	W_G, g	GSI, %	Age
1	1.80	45.10	35.50	27.77	1.54	3
2	1.57	45.50	35.50	17.22	1.10	3
3	1.50	45.50	35.50	63.80	4.25	3
4	1.48	45.50	35.50	101.60	6.86	3
5	1.48	45.50	35.50	45.12	3.05	3
6	1.49	45.50	35.50	6.60	0.44	3
7	1.50	45.50	35.50	8.06	0.54	3
8	1.47	45.50	35.50	10.54	0.72	3
9	1.60	46.00	36.00	17.45	1.09	4
10	1.95	46.00	36.00	25.30	1.30	4
11	1.60	46.00	36.00	99.24	6.20	4
12	1.65	46.00	36.00	7.80	0.47	4
13	1.75	46.00	36.00	8.20	0.47	4
14	1.60	46.00	36.00	15.60	0.98	4
15	1.57	47.00	37.00	13.00	0.83	4
16	1.76	47.00	36.00	12.96	0.74	4
17	1.99	48.00	37.00	61.20	3.08	4
18	2.09	49.00	38.00	44.08	2.11	5
19	2.05	49.00	38.00	41.58	2.03	5
20	2.15	49.00	38.00	60.56	2.82	5
21	2.00	49.00	37.00	54.70	2.74	5
22	2.45	49.00	38.00	56.78	2.32	4
23	2.20	49.00	38.00	105.80	4.81	5
24	2.20	50.00	38.00	9.30	0.42	5
25	2.38	50.00	39.00	5.60	0.24	5
26	2.25	50.00	38.00	82.40	3.66	5
27	2.27	50.00	38.00	8.90	0.39	5
28	2.00	50.00	38.00	7.30	0.37	5

29	2.19	50.00	38.00	13.64	0.62	5
30	2.73	50.00	39.00	12.80	0.47	5
31	2.49	51.00	39.00	69.50	2.79	5
32	2.00	52.00	42.00	10.16	0.51	5
33	2.57	52.00	40.00	7.50	0.29	5
34	2.60	52.00	41.00	43.27	1.66	5
ave	**1.95**	**48.02**	**37.26**	**34.28**	**1.82**	**4**
min	**1.47**	**45.10**	**35.50**	**5.60**	**0.24**	**3**
max	**2.73**	**52.00**	**42.00**	**105.80**	**6.86**	**5**

The GSI, % values for male fish in the first half of April 2024 range from 0.24% to 6.86%, with an average value of 1.82%.

The average weight of female fish in the first half of April 2024 is 2.27 kg and it is in the range of 1.58-2.76 kg. Ovary weight range between 2.44 g и 83.36 g, with an average value of 26.99 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 female individuals in the first half of April 2024

Second Quarter 2024						
№	**BW, kg**	**TL, cm**	**SL, cm**	**W_G, g**	**GSI, %**	**Age**
1	1.60	45.50	35.50	49.35	3.08	3
2	1.58	46.00	36.00	9.36	0.59	4
3	1.88	47.00	36.00	2.44	0.13	4
4	2.24	48.00	38.00	38.60	1.72	4
5	2.30	49.00	38.00	6.99	0.30	4
6	2.18	49.00	37.00	5.00	0.23	5
7	2.25	49.00	39.00	65.11	2.89	4
8	2.40	49.00	38.00	2.89	0.12	4
9	2.30	50.00	38.00	8.20	0.36	4
10	2.19	50.00	39.00	10.10	0.46	4
11	2.30	51.00	39.00	52.30	2.27	5

12	2.60	51.00	39.00	78.00	3.00	5
13	2.60	51.00	40.00	83.36	3.21	5
14	2.50	51.00	39.00	5.73	0.23	5
15	2.70	52.00	40.00	6.60	0.24	5
16	2.76	53.00	39.00	7.75	0.28	5
ave	**2.27**	**49.47**	**38.16**	**26.99**	**1.20**	**4**
min	**1.58**	**45.50**	**35.50**	**2.44**	**0.12**	**3**
max	**2.76**	**53.00**	**40.00**	**83.36**	**3.21**	**5**

The values of GSI, % for female fish in the first half of April 2024 range between 0.12% and 3.21%, with an average value 1.20%.

Gonadosomatic index – fourth quarter 2024

The average weight of male fish in December 2024 is 2.05 kg and ranged from 1.43-3.02 kg. The weight of gonads is between 5.96 g and 55.52 g, with a mean of 25.00 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 male individuals in the fourth quarter 2024

Fourth Quarter 2024						
№	**BW, kg**	**TL, cm**	**SL, cm**	**W_G, g**	**GSI, %**	**Възраст**
1	1.78	45.50	35.50	16.18	0.91	3+
2	1.66	45.50	35.50	28.38	1.71	3+
3	2.44	52.00	41.00	19.24	0.79	5+
4	1.93	50.00	40.00	29.56	1.53	4+
5	2.40	45.50	35.50	30.13	1.26	3+
6	2.10	50.00	39.00	26.82	1.28	4+
7	1.61	45.50	35.50	17.28	1.07	3+
8	1.66	46.00	36.00	12.59	0.76	3+
9	1.66	45.50	35.50	23.86	1.44	3+
10	1.86	46.00	36.00	35.68	1.92	4+
11	2.00	49.00	38.00	13.63	0.68	4+
12	1.59	45.50	35.50	19.39	1.22	3+
13	1.96	46.00	36.00	32.53	1.66	4+
14	1.84	46.00	36.00	31.42	1.71	3+

15	1.82	48.00	36.00	8.08	0.45	4+
16	2.79	55.00	41.00	36.46	1.31	6+
17	2.13	47.00	36.00	14.24	0.67	4+
18	2.57	52.00	40.00	50.97	1.98	5+
19	1.98	48.00	38.00	12.22	0.62	4+
20	1.87	48.00	37.00	13.13	0.70	4+
21	1.43	45.50	35.50	5.96	0.42	3+
22	2.51	52.00	39.00	21.49	0.86	5+
23	2.32	51.00	39.00	30.94	1.33	5+
24	3.02	55.00	42.00	39.23	1.30	6+
25	2.31	49.00	38.00	55.52	2.40	5+
ave	**2.05**	**48.34**	**37.46**	**25.00**	**1.20**	**4+**
min	**1.43**	**45.50**	**35.50**	**5.96**	**0.42**	**3+**
max	**3.02**	**55.00**	**42.00**	**55.52**	**2.40**	**6+**

The GSI,% values for male fish in December 2024 ranged from 0.42% to 2.40%, with a mean of 1.20%. The mean weight of female fish in December 2024 is 2.52 kg, with a range of 1.50-3.92 kg. Ovary weight ranged from 12.32 g to 152.70 g, with a mean of 61.09 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 female individuals in the fourth quarter 2024

Fourth Quarter 2024						
№	**BW, kg**	**TL, cm**	**SL, cm**	**W_G, g**	**GSI, %**	**Age**
1	1.54	45.50	35.50	12.32	0.80	3+
2	1.55	45.50	35.50	18.65	1.20	3+
3	1.83	45.50	35.50	51.90	2.84	3+
4	1.50	45.50	35.50	21.20	1.41	3+
5	2.20	47.00	36.00	47.88	2.18	4+
6	2.13	48.00	39.00	66.37	3.12	4+
7	2.05	48.00	38.00	61.83	3.02	4+
8	1.85	48.00	37.00	42.26	2.28	4+
9	2.40	49.00	38.00	67.30	2.80	4+
10	2.39	50.00	38.00	63.90	2.67	4+
11	2.22	50.00	38.00	42.28	1.90	4+

12	2.51	50.00	38.00	52.78	2.11	4+
13	2.60	51.00	39.00	74.27	2.86	5+
14	2.51	51.00	39.00	69.07	2.76	5+
15	2.32	51.00	39.00	57.37	2.48	5+
16	2.39	52.00	41.00	39.00	1.64	5+
17	3.08	53.00	41.00	88.22	2.86	5+
18	2.79	53.00	41.00	64.39	2.31	5+
19	2.59	53.00	40.00	39.57	1.53	5+
20	2.86	53.00	40.00	91.60	3.21	5+
21	3.03	54.00	42.00	74.07	2.45	5+
22	3.17	55.00	42.00	66.75	2.11	5+
23	3.92	57.00	45.00	88.83	2.27	6+
24	3.70	57.00	44.00	72.62	1.96	6+
25	3.87	59.00	46.00	152.70	3.95	7+
ave	**2.52**	**50.84**	**39.32**	**61.09**	**2.35**	**5+**
min	**1.50**	**45.50**	**35.50**	**12.32**	**0.80**	**3+**
max	**3.92**	**59.00**	**46.00**	**152.70**	**3.95**	**7+**

The values of GSI, % for female fish in December 2024 ranged between 0.80% and 3.95%, with the average value being 2.35%.

Table 9 presents the average values of the gonadosomatic index (GSI, %) of female turbots in 2024.

Table 9. Average values of the gonadosomatic index (GSI,%) of female turbots in 2024.

Month / GSI, %	Second Quarter	Fourth Quarter
average	1.20	2.35
min	0.12	0.80
max	3.21	3.95

Table 10 presents the average values of the gonadosomatic index (GSI, %), male turbots in 2024.

Table 10. Average values of the gonadosomatic index (GSI,%) of male turbots in 2024

Month / GSI, %	Second Quarter	Fourth Quarter
average	1.82	1.20
min	0.24	0.42
max	6.86	2.40

3.4.3. Fecundity of female fish

The female fish (38 specimens) from April 2024, whose fecundity is determined, have an average weight of 2.34 kg. The average value of the total body length is 50.00 cm, and the average age is 5 years (**Fig. 8**).

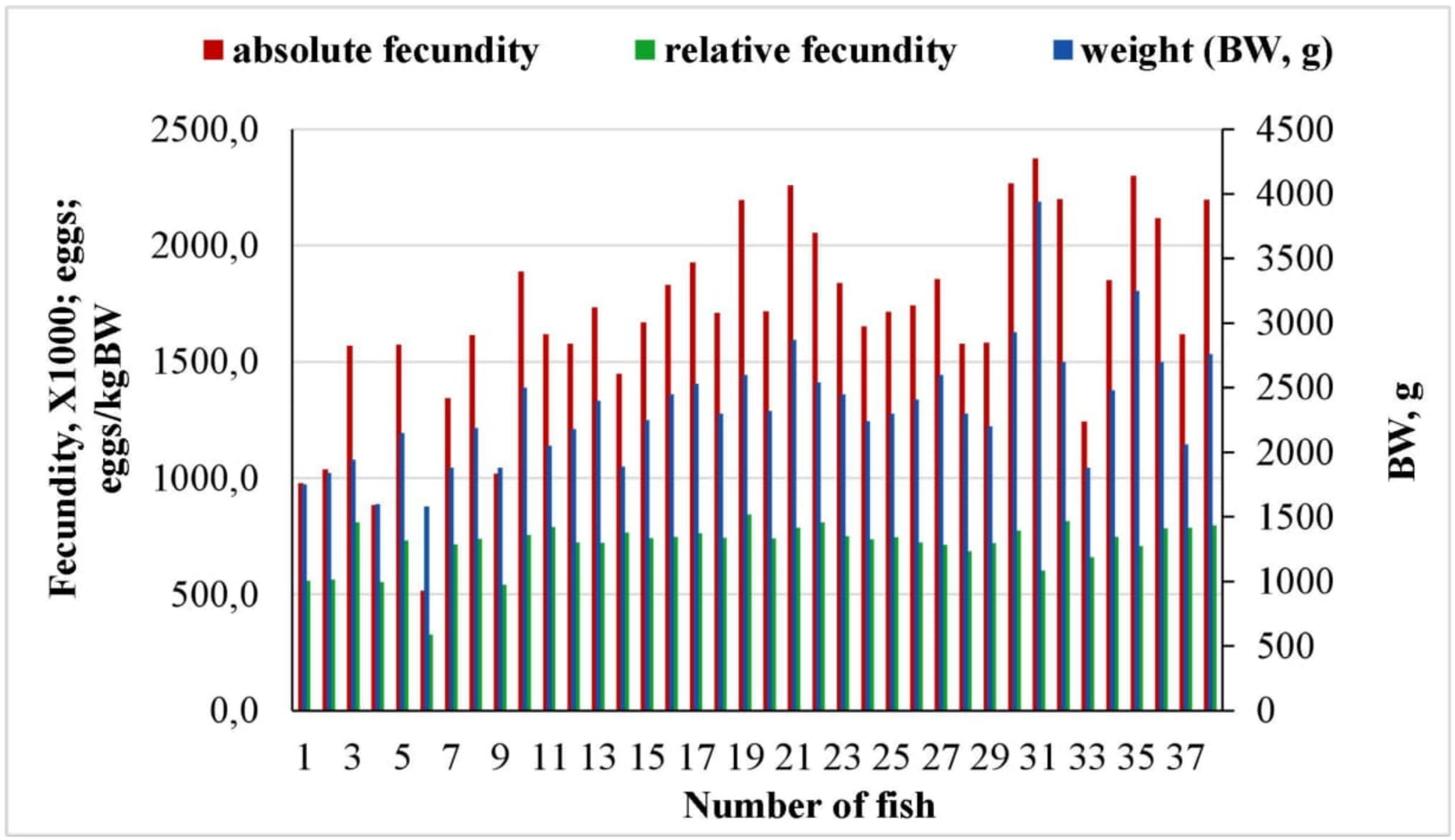

Fig. 8. Absolute and relative fecundity of female fish, first half of April 2024

The absolute fecundity in the first half of April 2024 is 1 692 369.7 number of eggs/individual, and the relative fecundity is 716 368.0 number of eggs/BW, g (**Table 11**).

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Table 11. Values of absolute and relative fecundity in turbot, first half of April 2024

Parameter	Average values
Number of female fish	38
Total length, TL (cm)	50.00
Body weight, BW (g)	2 339
Absolute fecundity, number of eggs/individual	1 692 369.7
Relative fecundity, number of eggs/g BW	716 368.0
Age, years	5

The established turbot fecundity in the first half of April 2024 of 1 692 369.7 eggs/individual is similar to the established fecundity in the same period in 2022 which is 1 698 957.1 eggs/individual and it is 25 459 eggs/individual lower compared to the absolute fecundity established by IFA, Plovdiv in the first half of April 2023. Aydin *et al.* (2019), establish an absolute fecundity of 2 400 000 eggs/individual during the reproductive period, which is 707 630 eggs/individual lower than that found in our study before the onset of the reproductive period. In their study of turbot reproductive biology, Aydin & Sahin (2011) calculated an absolute fecundity of 2 329 000 eggs/individual during the reproductive period, which averaged 2 329 000 eggs/individual during the reproductive period, which averaged 636 631 eggs/individual higher than that calculated in the present study.

Fig. 9 shows the correlation between absolute fecundity and total body length, with fecundity increasing with increasing body length.

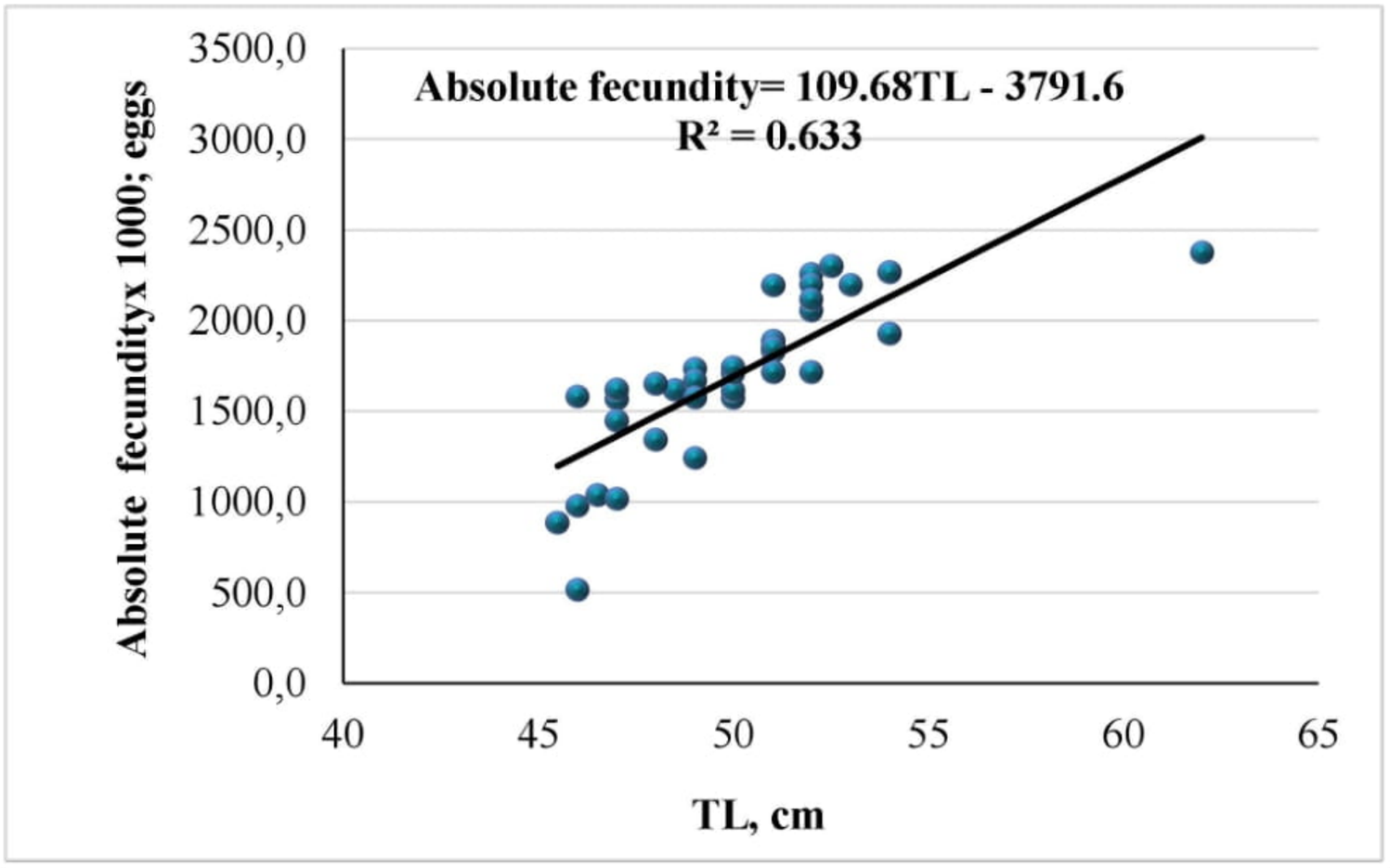

Fig. 9. Correlation between absolute fecundity and total length of female fish, first half of April 2024

Fig. 10 shows the relationship between absolute fecundity and the weight of female individuals.

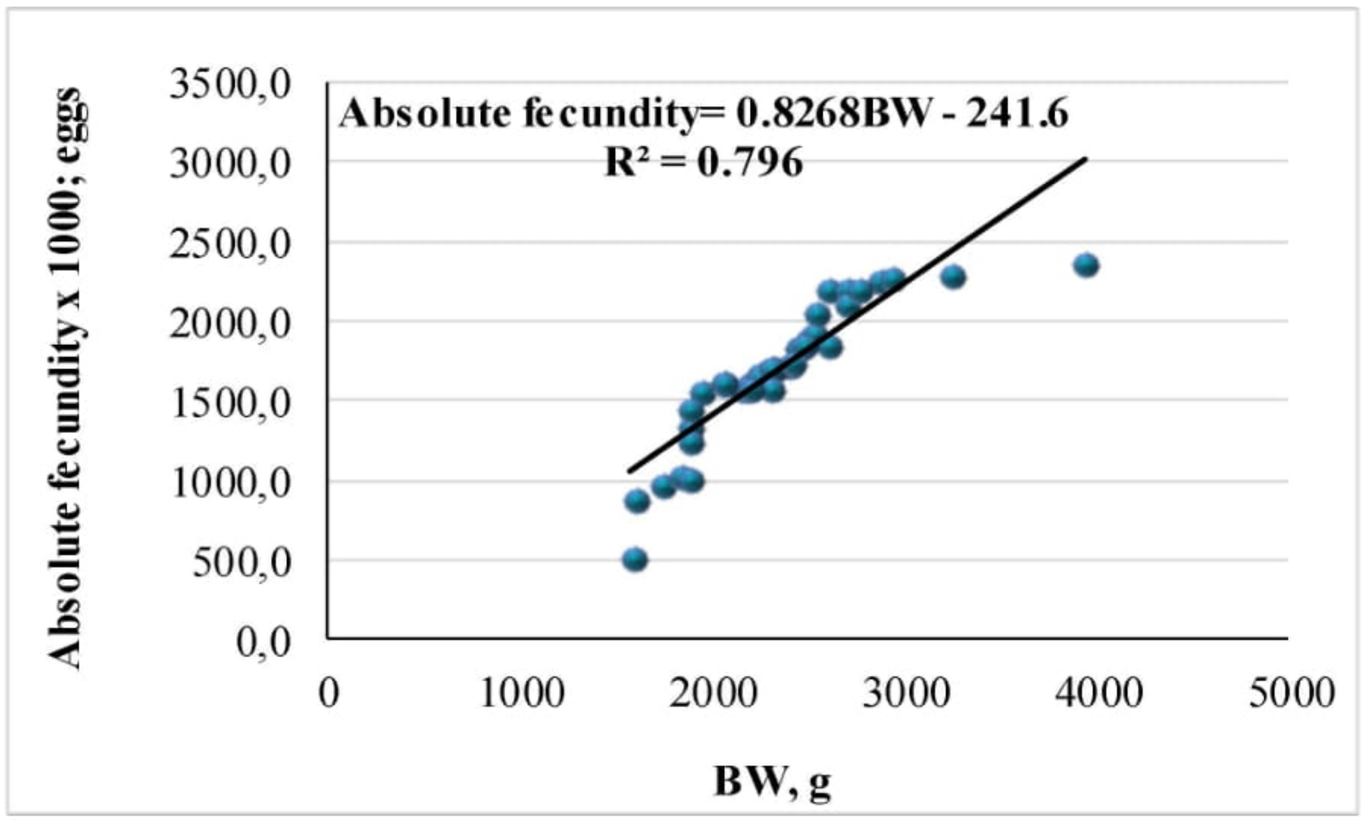

Fig. 10. Correlation between absolute fecundity and weight of female fish, first half of April 2024

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The correlation between absolute fecundity and age of female fish in April 2024, which is also positive, is presented in **Fig. 11**. The correlation is positive - as body weight increases, the absolute fecundity also increases.

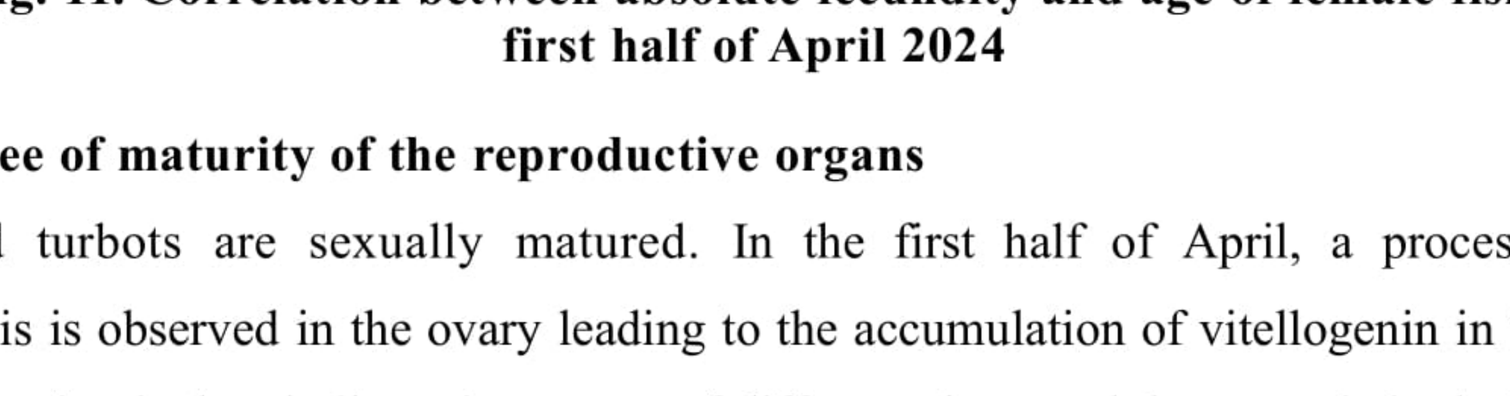

Fig. 11. Correlation between absolute fecundity and age of female fish, first half of April 2024

3.4.4. Degree of maturity of the reproductive organs

All studied turbots are sexually matured. In the first half of April, a process of active vitellogenesis is observed in the ovary leading to the accumulation of vitellogenin in the oocytes. The mass fraction is the vitellogenic oocytes of different sizes, and the ovary is in the III-IV stage of maturity.

In the ovary and testis of the studied individuals, III degree of maturity is reached in December. The main mass in the ovary is represented by previtellogenic follicles and in the testis by spermatids.

3.4.5. Age

To determine the age composition of the turbot in 2024, 100 pairs of otoliths are examined. The age composition of the studied turbot specimens includes individuals from three to seven years old, with the highest percentage share of five-year-old turbots - 23%. Next is the group of four-year-old fish, which is represented by 18%. The age groups of 3+ years old, 4+ and 5+ years age groups are represented by an equal percentage share of 15% each, followed by the group of three-year-old fish consisting of 9%. The groups of 6+ years old and 7+ years old turbot have the lowest percentage shares, 4% and 1% respectively **(Fig. 12)**.

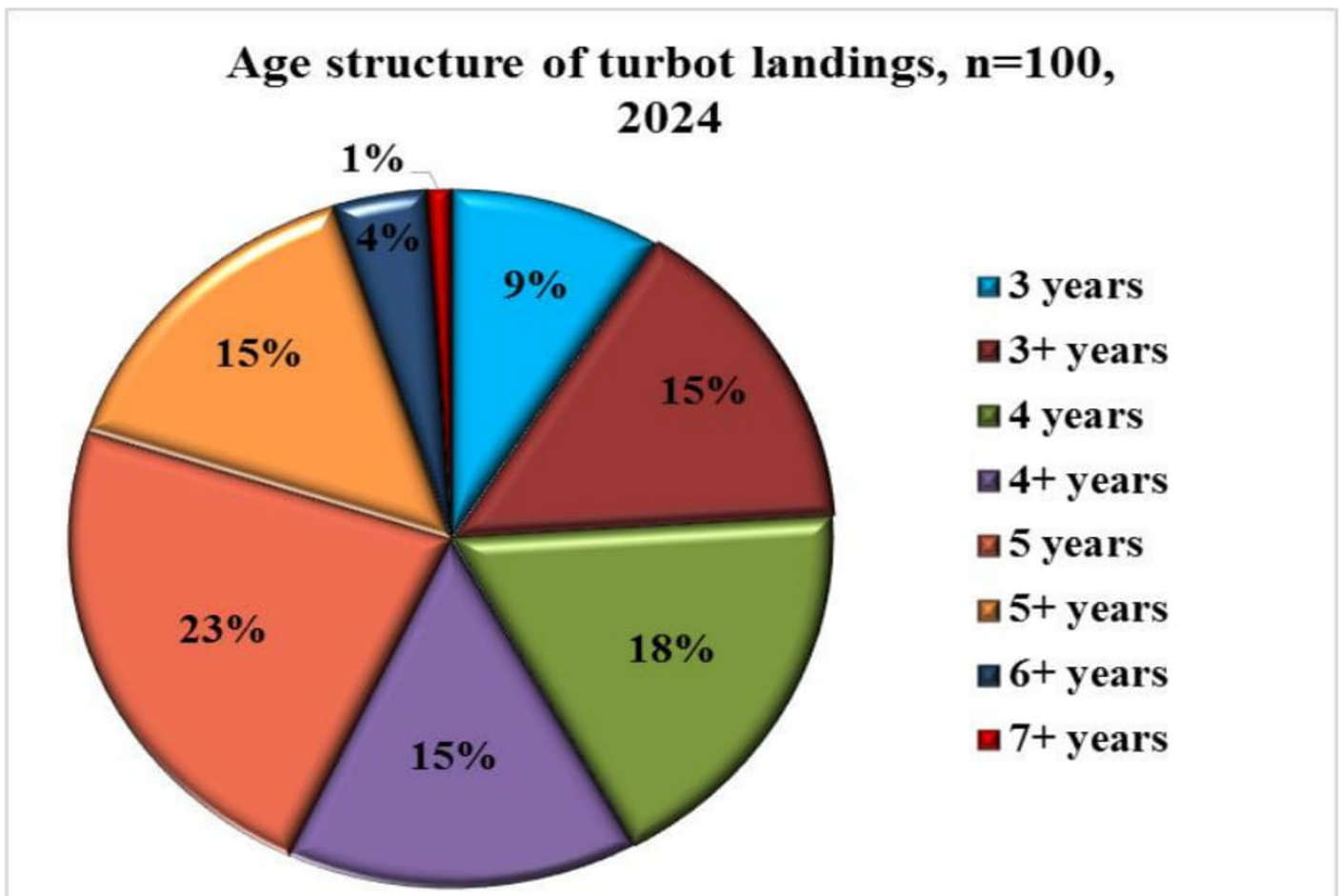

Fig. 12. Percentage distribution of age in turbot (n=100)

The correlation between total body length and age in female individuals (41 pcs.) is presented in Fig. **13**, and in males (59 pcs.) in Fig. **14**.

Fig. 13. Correlation between total length and age in females, n=41, 2024

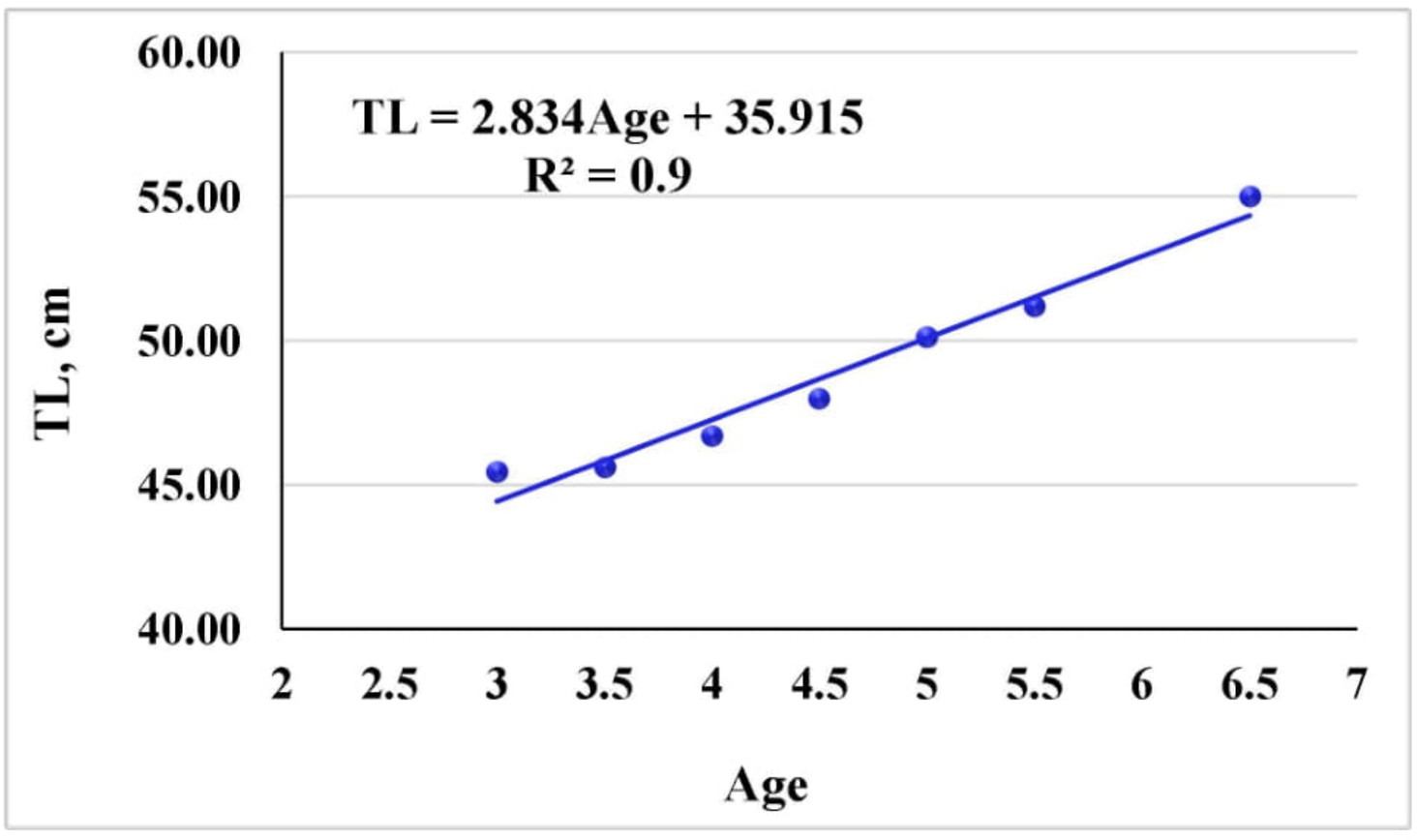

Fig. 14. Correlation between total length and age in males, n=59, 2024

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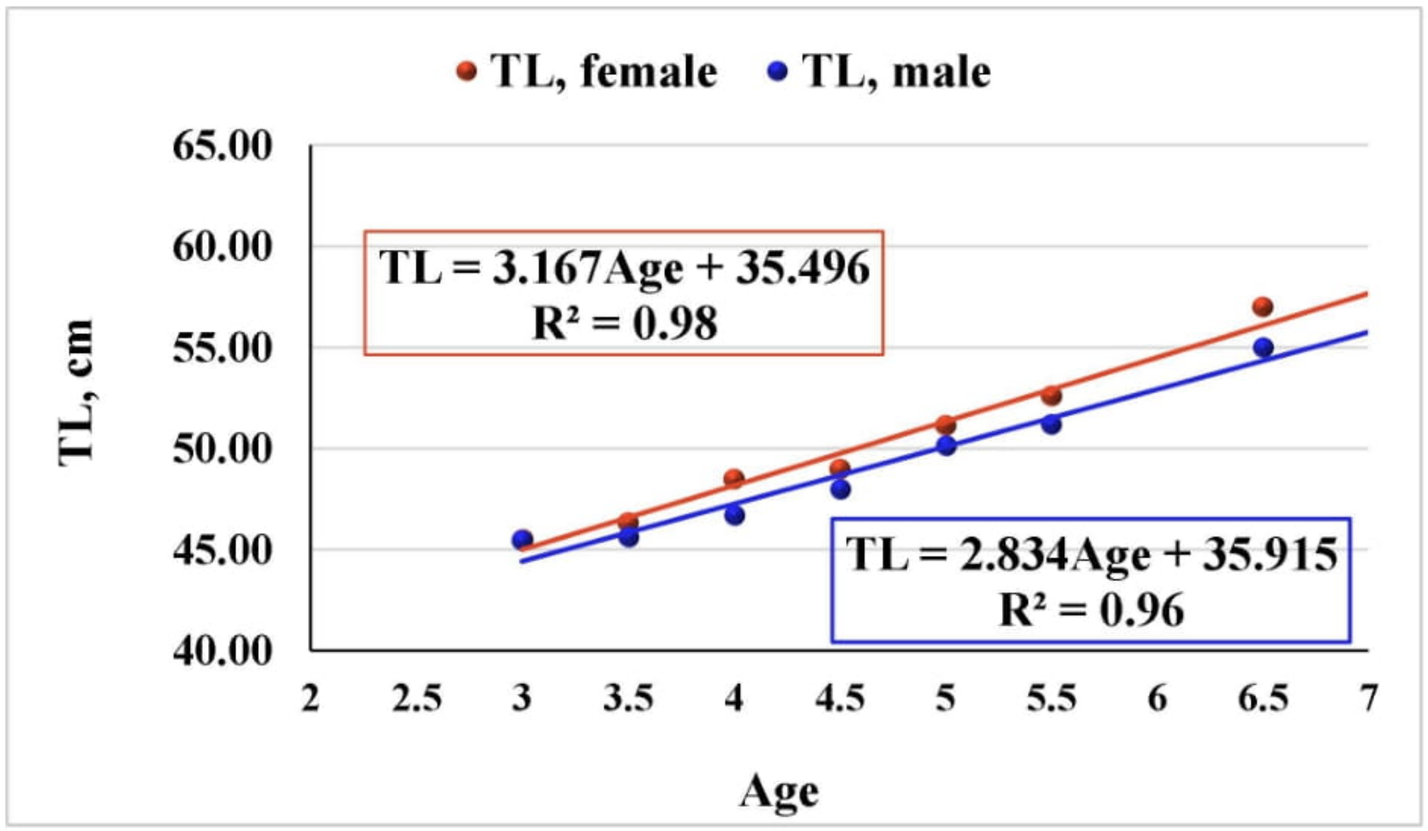

Fig. 15. Linear growth in turbot by age in years, n=100, 2024

Fig. 15 shows that females after 45 cm grow faster in length than males.

The correlation between body weight and age in females (41 individuals) is presented in **Fig. 16**, and in males (59 individuals) in **Fig. 17**.

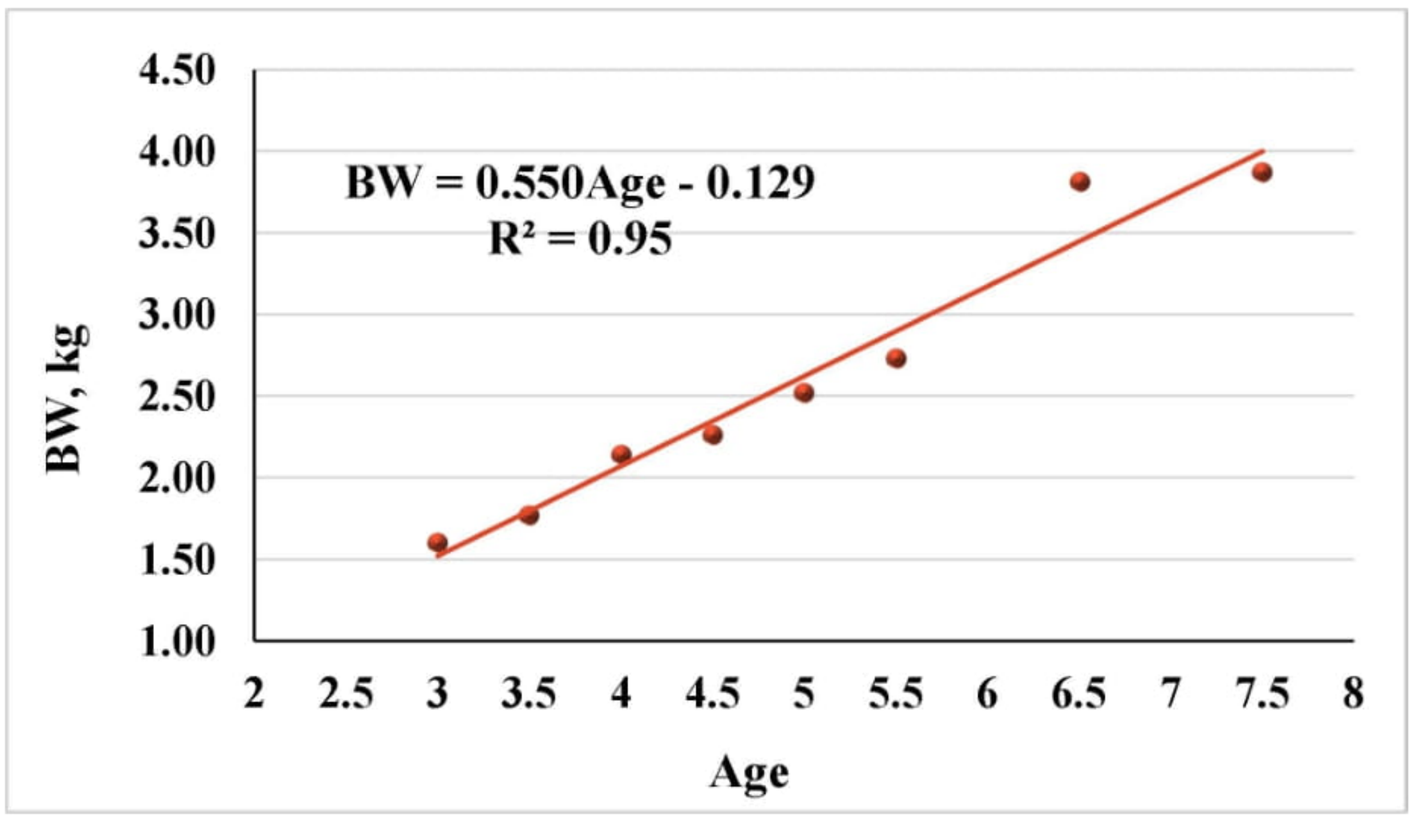

Fig. 16. Correlation between body weight and age in female turbot individuals, n=41, 2024

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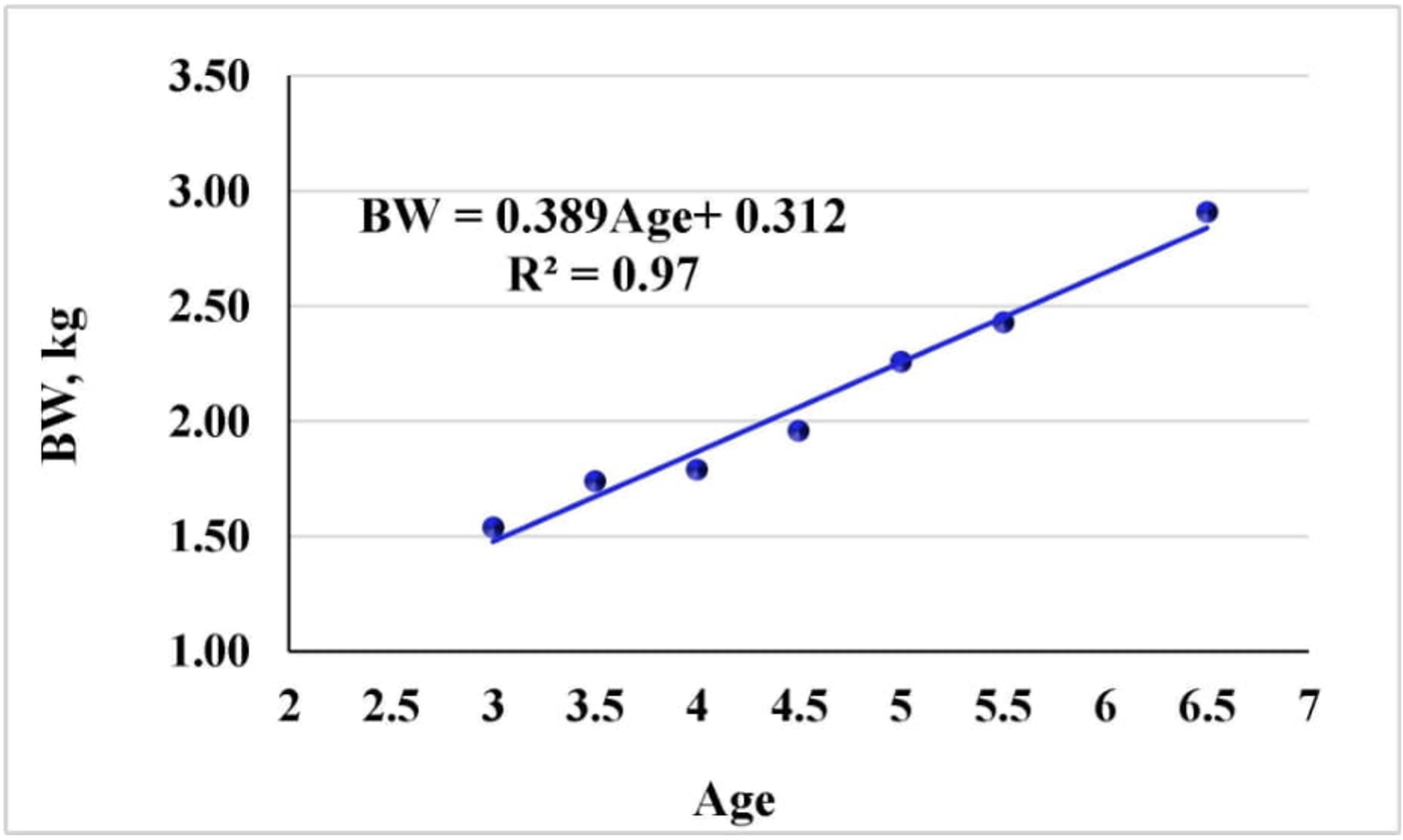

Fig. 17. Correlation between body weight and age in male turbot individuals, n=59, 2024

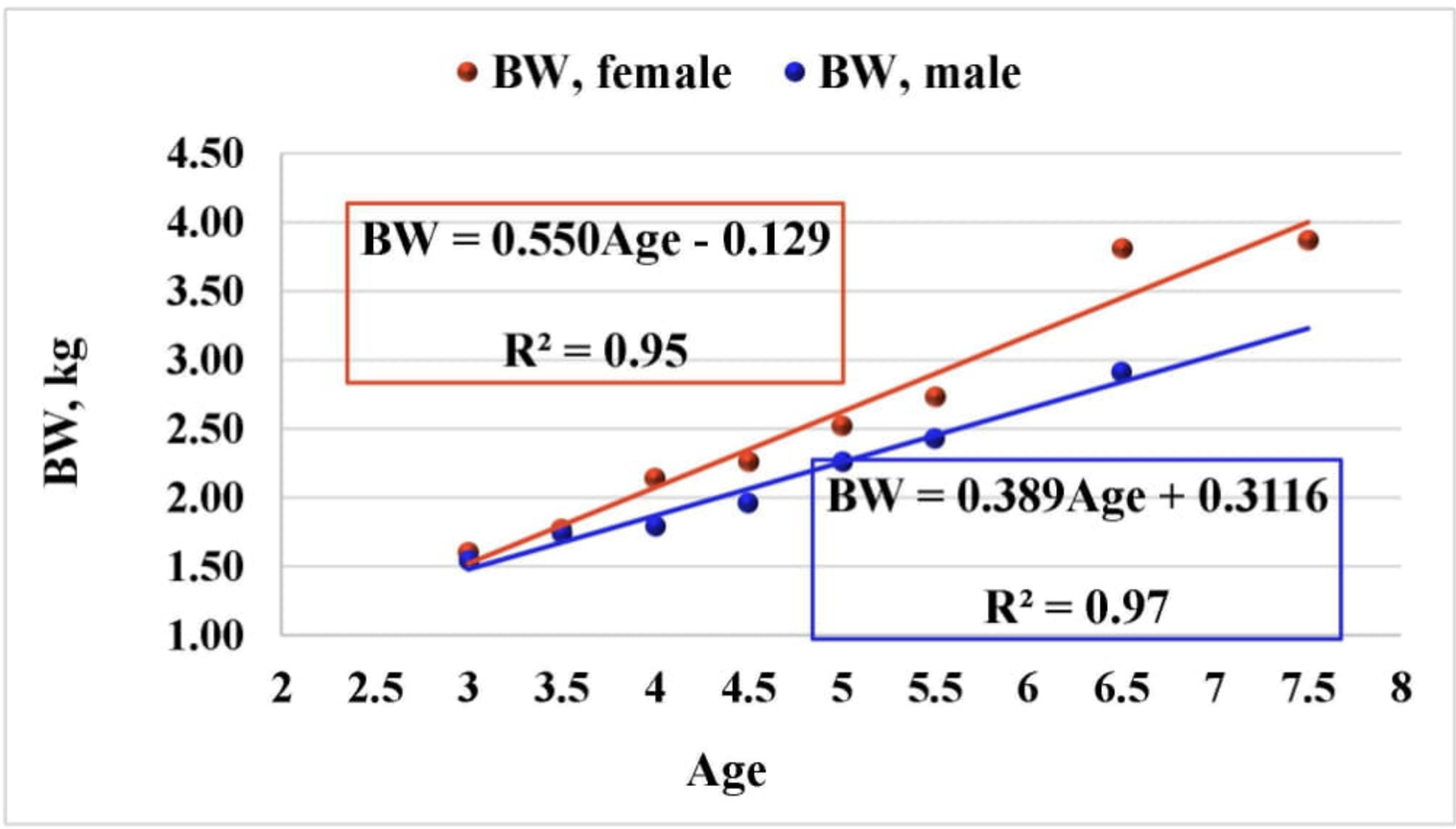

Fig. 18. Correlation between body weight and age in turbot, n=100, 2024

Fig. 18 shows that females after 1.50 kg grow faster in weight than males.

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Note: In the figures showing the correlation between total length (TL) and age (Fig. 13 – Fig. 15) and between body weight (BW, kg) and age (Fig. 16- Fig. 18), the age groups 3+, 4+, 5+, 6+ and 7+ are represented by decimal halves.

The distribution between the two sexes and the age of turbot is presented in **Fig. 19**.

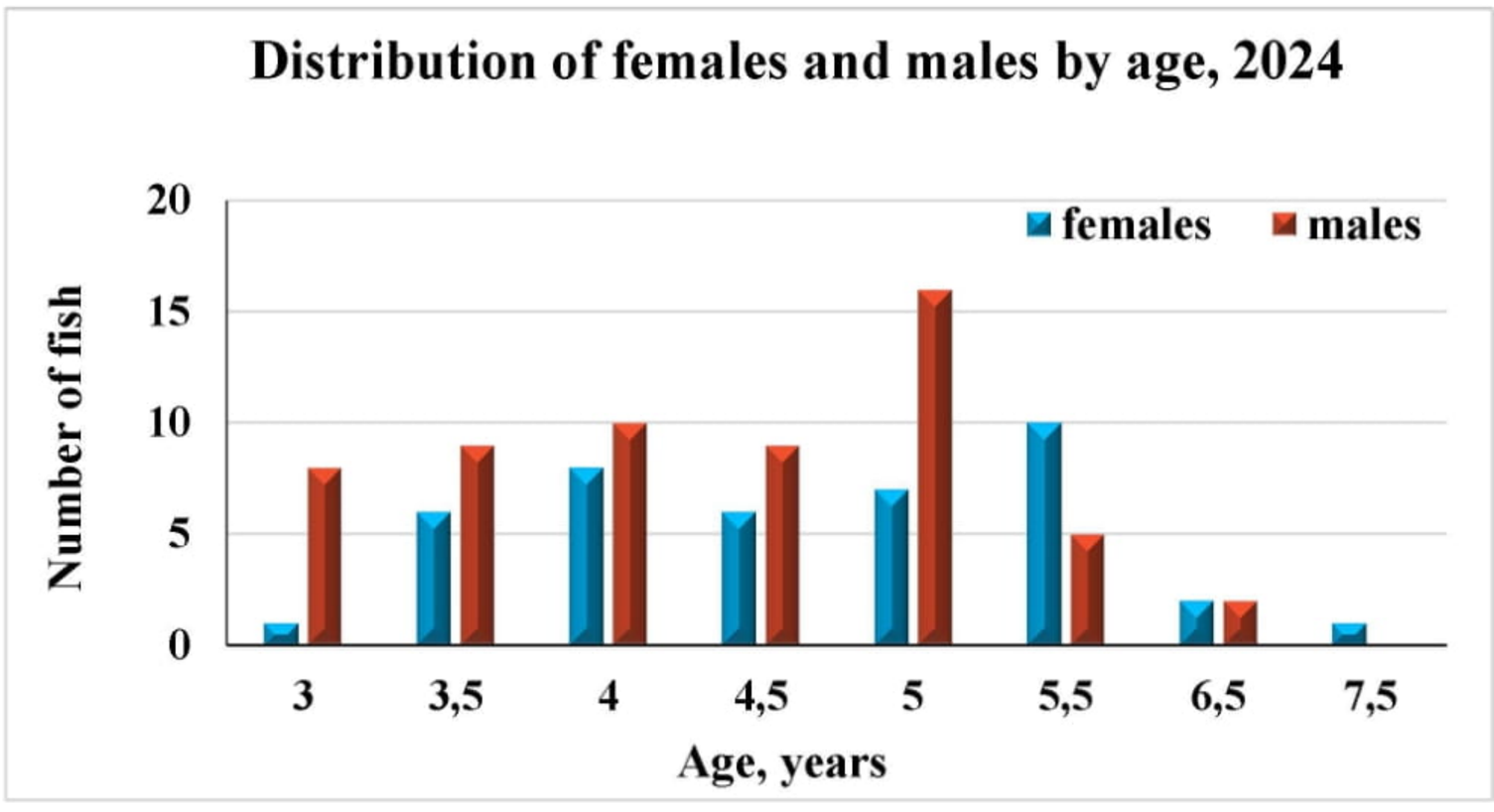

Fig. 19. Distribution between the two sexes according to the age of the individuals (n=100; f=41, m=59)

The ratio between females and males is listed in **Table 12**.

Table 12. Ratio between females and males to age

Age, years	3	3.5	4	4.5	5	5.5	6.5	7.5
Number of female fish	1	6	8	6	7	10	2	1
Number of male fish	8	9	10	9	16	5	2	0
Ratio females/males	0.12:1	0.66:1	0.80:1	0.66:1	0.44:1	2:1	1:1	-

The results show that among males, five-year-old turbot predominate, while among females, 5.5-year-old fish have the highest number.

3.5. Stomach content and food array analysis in turbot

In the first half of 2024, of all 50 fish examined for stomach content, most have an empty stomach (31 fish or 62%), which is due to the course of the breeding season. Fish with full stomach are 19 specimens or 38% of the individuals examined. The average ISF, % is 0.39%. In **Table. 13** the data for the fish with full stomach, the weight of the food (FW, g) and the index of stomach fullness (ISF, %) is presented.

Table 13. Index of stomach fullness (ISF, %) of turbots with full stomach in the first half of April 2024

№	BW, g	TL, cm	Full stomach, g	Empty stomach, g	FW, g	ISF, %
1	1570	47.0	47.50	28.70	18.80	1.20
2	1600	46.0	40.10	13.50	26.60	1.66
3	1990	48.0	47.30	15.00	32.30	1.62
4	2700	52.0	55.40	29.00	26.40	0.98
5	2090	49.0	40.00	27.50	12.50	0.60
6	2300	50.0	42.90	31.70	11.20	0.49
7	2570	52.0	43.70	19.00	24.70	0.96
8	2190	50.0	44.10	21.00	23.10	1.05
9	2250	50.0	53.30	18.00	35.30	1.57
10	1500	45.5	18.00	12.50	5.50	0.37
11	1600	46.0	43.90	16.50	27.40	1.71
12	2180	49.0	46.30	32.80	13.50	0.62
13	2760	53.0	42.40	19.00	23.40	0.85
14	1480	45.5	19.80	8.20	11.60	0.78
15	2600	51.0	51.30	22.00	29.30	1.13
16	1600	45.5	15.30	12.00	3.30	0.21
17	2450	49.0	63.20	27.50	35.70	1.46
18	2730	50.0	69.10	30.50	38.60	1.41
19	2200	49.0	50.30	36.60	13.70	0.62

In the first half of 2024 *Merlangius merlangus* has the highest value of the relative importance index - IRI=17576.96. Due to the fact that no other species have been identified in the stomach content of the studied turbots, *M. merlangus* had a dominant share of the percentage composition of food, respectively IRI, %=99.89%.

For the second half of 2024, out of all 50 fish examined for stomach contents, 22 fish (44%) had a full stomach. Fish with an empty stomach are 28 or 56% of the examined individuals. The average value of ISF, % is 0.56%. **Table 14** presents the data for fish with a full stomach, food weight (FW, g) and the fullness index (ISF, %).

Table 14. Index of stomach fullness (ISF, %) of turbots with full stomach in the fourth quarter of 2024

	BW, g	TL, cm	Full stomach, g	Empty stomach, g	FW, g	ISF, %
1	2130	48.00	48.60	28.63	19.97	0.94
2	1780	45.50	44.63	19.38	25.25	1.42
3	1660	45.50	84.59	39.32	45.27	2.73
4	1930	50.00	45.06	31.78	13.28	0.69
5	2400	45.50	66.54	36.42	30.12	1.26
6	1550	45.50	21.52	15.41	6.11	0.39
7	1660	45.50	30.68	18.43	12.25	0.74
8	1860	46.00	89.91	28.78	61.13	3.29
9	1835	46.00	38.46	18.70	19.76	1.08
10	2385	52.00	34.39	25.33	9.06	0.38
11	1825	45.50	38.20	17.21	20.99	1.15
12	1850	48.00	23.50	20.00	3.50	0.19
13	1500	45.50	66.00	14.12	51.88	3.46
14	3700	57.00	81.00	31.00	50.00	1.35
15	2570	52.00	97.73	21.22	76.51	2.98
16	3870	59.00	63.72	47.34	16.38	0.42
17	3025	54.00	52.96	30.72	22.24	0.74

18	2600	51.00	52.71	29.92	22.79	0.88
19	2785	53.00	43.06	29.53	13.53	0.49
20	3170	55.00	57.15	35.82	21.33	0.67
21	2400	49.00	57.45	34.39	23.06	0.96
22	2310	49.00	37.08	23.40	13.68	0.59

In the second half of 2024, the highest value of the relative importance index was for whiting, *Merlangius merlangus*, respectively IRI=9179.94 (**Fig. 20**), and in terms of the percentage composition of the food, according to the relative importance index (IRI, %), *M. merlangus* had a dominant share, respectively 84.13% (**Fig. 21**).

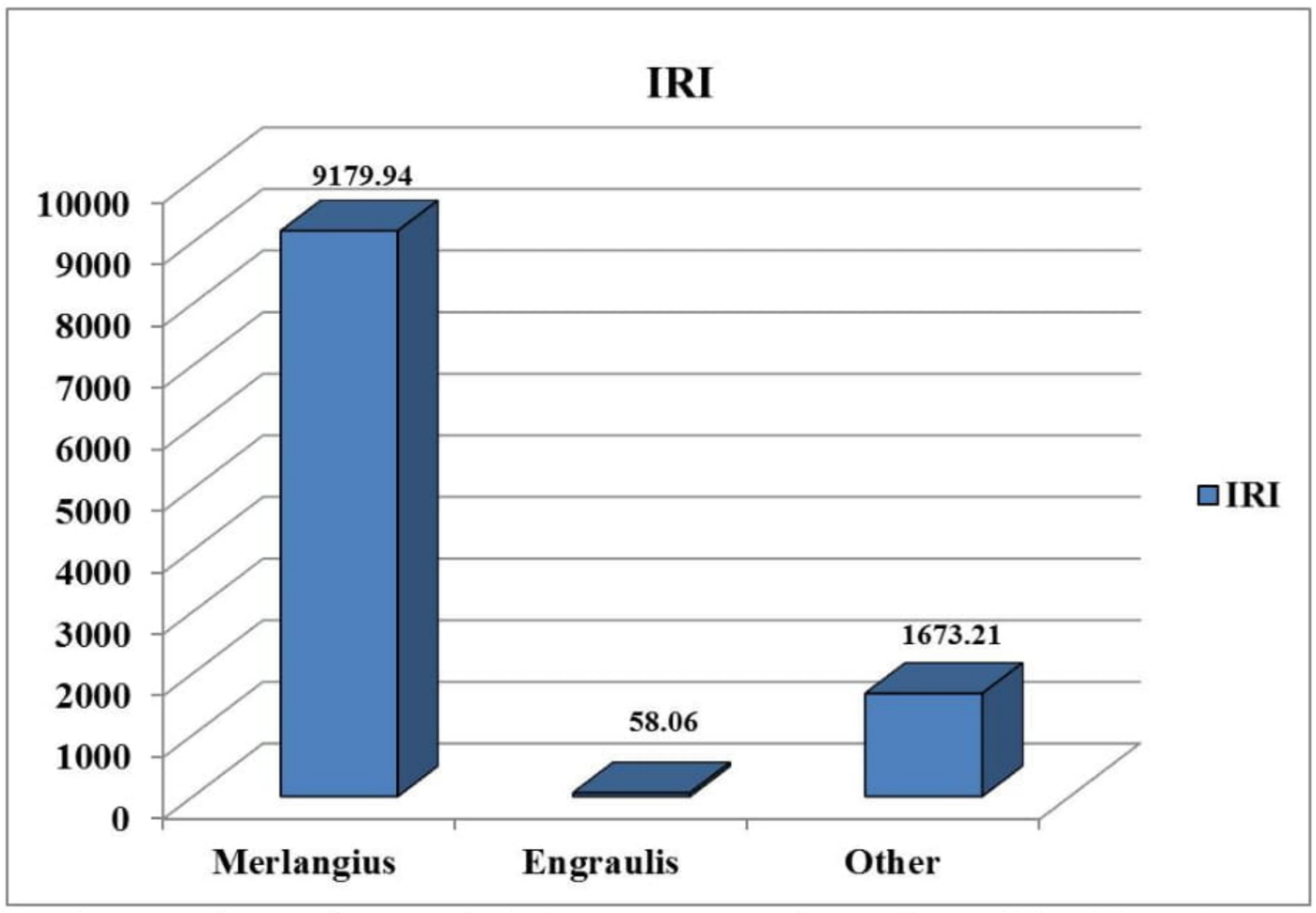

Fig. 20. Relative importance index (IRI) values by taxa found in the stomach contents of turbot in the second half of 2024

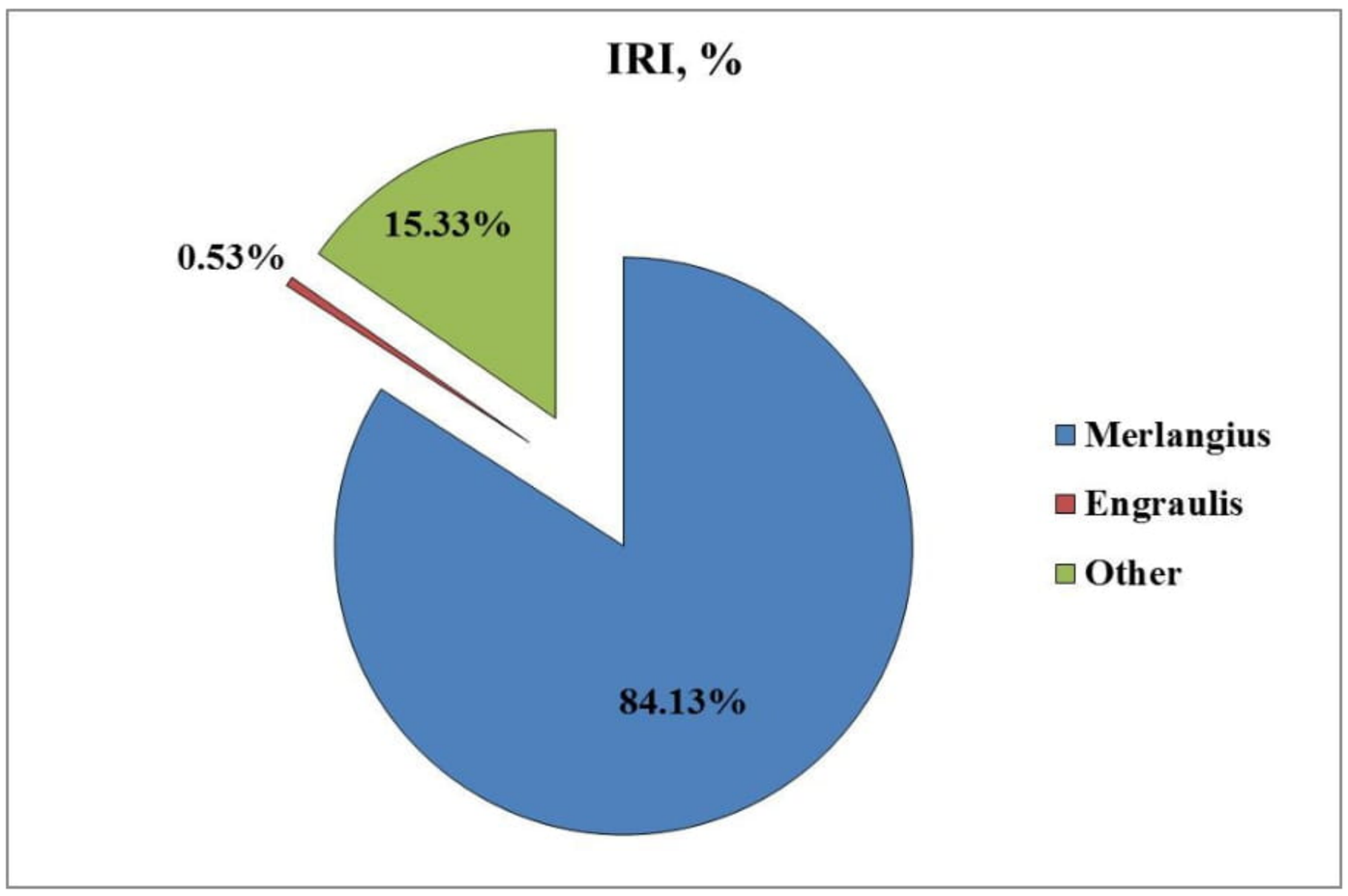

Fig. 21. Percentage composition of the food according to the index of relative importance (IRI, %) by taxa found in the stomach contents of turbot in the second half of 2024

In the stomach contents of the studied individuals, decomposed remains of fish (category "Other") are found, on the basis of which an accurate taxonomic identification cannot be made. A small share of the stomach contents is occupied by representatives of the genus *Engraulis*, respectively 0.53%.

4. Conclusions and recommendations

Based on the results obtained from the biological monitoring of turbot landings at the Bulgarian coast of the Black Sea in 2024, the following conclusions and recommendations can be made:

1. The fishing vessels have unloaded an average of 39 turbots. The maximum catch per vessel is 98 fish, and the minimum is 6 fish.
2. From a total of 42 landings at the ports of Kavarna, Varna, Durankulak, Balchink, Krapets, Nesebar and Pomorie a 1 644 turbots with an average weight of 2.59 kg and average value of the total length 53.23 cm.
3. The maximum measured weight is 7.30 kg, and the minimum weight - 1.47 kg.
4. The maximum measured values of the total length are 80.00 cm, and the minimum is 45.10 cm.
5. From a total number of 1 644 turbots 720 (43.8%) are with weight up to 2 kg. The fish with weight from 2 to 3 kg are 34.8% - 572 specimens. The weight group from 3 kg to 4 kg and from 4 to 5 kg are with similar percentage share, 10.1% (166 specimens) and 8.2% (135 specimens), relatively. The weight group from 5 to 6 kg consists of 38 turbots or 2.3% of the measured fish. With the lowest percentage share are the weight groups from 6 to 7 kg (0.7% - 11 specimens) and up to 7 kg (0.1% - 2 specimens).
6. From the distribution of the individuals by size groups (in 3 cm) according to the total length (TL, cm), it is established that the size group 49-52 cm is the largest - 505 specimens or 30.7%, followed by the group 45-48 cm - 29.7% or 488 specimens. With the lowest percentage share are the groups 57-60 cm and >69 cm consisted of 75 and 38 specimens, respectively 4.6% and 2.3%.
7. The distribution of individuals by size groups according to the standard length (SL, cm) shows that the 36-39 cm group is most represented by 666 specimens or 40.51%, followed by the 40-43cm group (421 specimens – 25.61%). The lowest percentage share is that of

Project BG14MFPR001-1.002-0001 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2023-2024 г.“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund

turbot with a standard body length in the range 56-59 cm and >60 cm, which consist of 33 and 16 specimens, or 2.01% and 0.97% respectively.

8. The correlation between the size and weight structure of turbot landings in2024 is described by the equation: **BW = 0.019TL 2.961**.
9. The percentage ratio between female and male individuals is 41% to 59% in favor of male individuals.
10. The age composition of the 100 turbot specimens studied in 2024 includes individuals from three to seven years old, with the highest percentage share of five-year-old turbots - 23%. Next is the group of four-year-old fish, which is represented by 18%. The age groups of 3+ years old, 4+ years old and 5+ years old are represented by an equal percentage share of 15% each, followed by the group of three-year-old fish consisting of 9%. The groups of 6+ years old and 7+ years old turbots have the lowest percentage share, 4% and 1% respectively.
11. In 2024, five-year-old turbot predominated among males, and 5+ year-old fish predominated among females.
12. The average weight of male fish in the first half of April 2024 was 1.95 kg and ranged from 1.47-2.73 kg. The weight of gonads ranged from 5.60 g to 105.80 g with an average of 34.28 g. The GSI, % values for male fish in the first half of April 2024 ranged from 0.24% to 6.86% with an average of 1.82%.
13. The average weight of female fish, in the first half of April 2024, was 2.27 kg and was in the range of 1.58-2.76 kg. The weight of the ovary was between 2.44 g and 83.36 g, with an average value of 26.99 g. The values of GSI, % for female fish, in the first half of April 2024, were in the range between 0.12% and 3.21%, with the average value being 1.20%.
14. The average weight of male fish in December 2024 was 2.05 kg and was in the range of 1.43-3.02 kg. The weight of gonads was between 5.96 g and 55.52 g, with a mean of 25.00

g. The GSI, % values for male fish in December 2024 were in the range of 0.42% and 2.40%, with a mean of 1.20%.

15. The average weight of female fish in December 2024 is 2.52 kg and is in the range of 1.50-3.92 kg. The ovary weight is between 12.32 g and 152.70 g, with a mean value of 61.09 g. The GSI, % values for female fish in the month of December 2024 are in the range between 0.80% and 3.95%, with a mean value of 2.35%.
16. The absolute fecundity, for April 2024, is 1 692 369.7 eggs/individual, and the relative fecundity is 716 368.0 eggs/BW, kg.
17. . In the first half of April, a process of active vitellogenesis is observed in the ovary, leading to the accumulation of vitellogenin in the oocytes. The mass fraction is the vitellogenic oocytes of different sizes, and the ovary is in the III-IV stage of maturity.
18. In the ovary and testis of the studied individuals, the III degree of maturity is reached in December. The main mass in the ovary is represented by previtellogenic follicles, and in the testis by spermatids.
19. Out of 50 fish examined for stomach content in the first half of 2024, 19 fish (38%) had a full stomach and 31 (62%) had an empty stomach. The average value of ISF, % is 0.39%. *Merlangius merlangus* has the highest value of the index of relative importance (IRI=17576.96) and a dominant share of the percentage composition of the food (IRI, %), respectively 99.89%.
20. In the second half of 2024, the highest value of the relative importance index was for whiting, *Merlangius merlangus*, respectively IRI=9179.94, and in terms of the percentage composition of the food, according to the relative importance index (IRI, %), *M. merlangus* had a dominant share, respectively 84.13%.

We would like to express our gratitude to EAFA, Burgas, Agricultural Academy, Sofia and the commercial fishing sector for the assistance provided during the research activities under contract № 149/10.03.2023 г. with EAFA, Burgas.