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BIOLOGICAL MONITORING OF TURBOT (*SCOPHTHALMUS MAXIMUS*) LANDINGS AT THE BULGARIAN BLACK SEA COAST IN 2025

INSTITUTE OF FISHERIES AND AQUACULTURE, PLOVDIV

AGRICULTURAL ACADEMY, SOFIA

2025

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Project № BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, 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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Biological monitoring of turbot (*Scophthalmus maximus*) landings at the Bulgarian Black Sea coast in 2025

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 2025 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 turbot, 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 2025 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, Balchik, Tsarevo, Pomorie and Shabla.

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2.1.2. Vessels for sample collection

Biological data from the landings is collected from 47 landings. **Table 1** contains data on ports and vessels where monitoring was carried out to collect biological data from turbot landings in 2025. The used fishing gear is gill net with mesh size of 400 mm.

Table 1. Ports and vessels monitored for collection of biological data from turbot landings in 2025

Ports	Quarter Data 2025			
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Kavarna	1. Libra Vn 8311 2. Hishtnik Kv 6262 3. Delfin X Kv 6275 4. Sv. Nikolay Vn 8190 5. Ivana Kv 6231 6. Piranya Kv 6296	1. Hishtnik Kv 6262 2. Delfin X Kv 6275 3. Ambyr Vn 4496 4. Viking Vn 8406 5. Neptun 70 Kv 6321 6. Sigma Vn 7180	1. Kaliakra Vn 8110 2. Vn 7822 3. Delfin X Kv 6275 4. Sv. Nikolay Vn 8190 5. Libra Vn 8311 6. Gondola Vn 4321 7. Neptun 70 Kv 6321	1. Ivana Kv 6231 2. Libra Vn 8311 3. Sv. Nikolay Vn 8190 4. Viking Vn 8406 5. Neptun 70 Kv 6321
Varna	-		-	6. Akula 1
Balchik		7. Vn 8112 8. Elis Bch 5322 9. Veni Vn 2998	8. Elis Bch 5322	7. Bizone 1 Vn 7432
Tsarevo	7. Zhizhi 2 Tsr 212	10. Gabriela Tsr 548 11. Pr 466 12. Elenka Tsr 517 13. Zhizhi 2 Tsr 212	9. Gabriela Tsr 548	-
Pomorie	-	14. Mehta Ns 062 15. Toti i Pepi Bs 2848 16. Moby Dik Vn 8012	10. Ns 997	-
Shabla	-	-	11. Shb 6025	

Biological data from the landings is collected as follows: 27 landings from Kavarna, 1 landing from Varna, 6 landings from Balchik, 6 landings from Tsarevo, 5 landings from Pomorie and 1 landings from Shabla.

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2.1.3. Number of collected samples

Biological data was collected for 1 408 fish from 47 landings, which corresponded to the number of fish landed or 100% of the landed quantity was measured (**Table 2**).

Table 2. Port landing data for 2025

Port	Quarter Data 2025				Total Number of Fish
	Number of Fish				
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	
Kavarna	174	282	158	116	730
Varna	-	-	-	71	71
Balchik	-	148	19	37	204
Tsarevo	6	108	6	-	120
Pomorie	-	212	59	-	271
Shabla	-	-	12	-	12
Total	180	750	254	224	1408

The data was collected as follows: 180 specimens from the first quarter, 750 fish from the second quarter, 254 fish from the third and 224 fish were sampled from the fourth quarter of 2025.

2.2 Number of studied turbot

The total number of specimens from which biological data was collected is 1 408 with a total weight of 3 970.00 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, Balchik, Tsarevo, Pomorie and Shabla in 2025 are shown in **Table 3**

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Table 3. Coordinates and depth of turbot catch locations for 2025

№	Vessel	Coordinates of catch locations		Depth of catch location (m)
		Latitude	Longitude	
First Quarter 2025				
1.	Zhizhi 2 Tsr 212	42°22'38.8"N	28°01'0.7"E	60-65
2.	Libra Vn 8311	43°36'55.6"N	29°00'44.6"E	70
3.	Hishtnik Kv 6262	43°37'56.9"N	29°04'00.6"E	60-65
4.	Delfin X Kv 6275	43°37'53.8"N	29°04'00.5"E	45-50
5.	Sv. Nikolay Vn 8190	43°36'39.8"N	29°05'49.7"E	65-70
6.	Ivana Kv 6231	43°36'41.7"N	29°05'43.6"E	50-55
7.	Ivana Kv 6231	43°36'41.0"N	29°05'46.9"E	50
8.	Piranya Kv 6296	43°39'48.4"N	29°09'53.2"E	45-50
Second Quarter 2025				
1.	Gabriela Tsr 548	42°22'38.8"N	28°01'0.7"E	60
2.	Pr 466	42°09'50.6"N	27°56'53.5"E	65-75
3.	Elenka Tsr 517	42°10'20.8"N	27°56'14.0"E	65-70
4.	Zhizhi 2 Tsr 212	42°09'52.4"N	27°56'29.4"E	90
5.	Mechta Ns 062	42°35'35.2"N	28°00'13.3"E	50-55
6.	Toti i Pepi Bs 2848	42°35'28.0"N	27°52'29.2"E	35-40
7.	Moby Dik Vn 8012	42°35'28.1"N	27°52'26.6"E	70-75
8.	Hishtnik Kv 6262	43°39'49.8"N	28°53'06.8"E	45-50
9.	Delfin X Kv 6275	43°39'48.8"N	28°53'07.9"E	50
10.	Ambyr Vn 4496	43°31'46.0"N	28°59'58.6"E	55-60
11.	Viking Vn 8406	43°31'00.1"N	28°54'50.7"E	45-50
12.	Delfin X Kv 6275	43°31'45.9"N	28°59'53.2"E	45
13.	Neptun 70 Kv 6321	43°27'56.3"N	28°54'35.4"E	50-55
14.	Sigma Vn 7180	43°27'58.6"N	28°54'32.8"E	45-50
15.	Delfin X Kv 6275	43°27'57.3"N	28°54'25.8"E	60
16.	Ambyr Vn 4496	43°27'54.4"N	28°54'24.0"E	55-60
17.	Vn 8112	43°41'27.4"N	28°54'52.2"E	60-65
18.	Elis Bch 5322	43°41'28.1"N	28°54'48.8"E	70
19.	Veni Vn 2998	43°41'30.3"N	28°54'47.5"E	65-70
Third Quarter 2025				
1.	Elis Bch 5322	43°41'33.6"N	28°54'44.3"E	60
2.	Elis Bch 5322	43°41'32.3"N	28°54'42.5"E	55-60
3.	Kaliakra Vn 8110	43°41'34.7"N	28°54'39.7"E	50
4.	Vn 7822	43°31'05.3"N	29°06'47.8"E	55-65
5.	Delfin X Kv 6275	43°31'04.4"N	29°06'45.9"E	45-50
6.	Sv. Nikolay Vn 8190	43°31'04.4"N	29°06'45.9"E	50

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7.	Libra Vn 8311	43°31'04.4"N	29°06'45.9"E	55-60
8.	Gondola Vn 4321	43°29'50.2"N	28°55'46.6"E	65-70
9.	Neptun 70 Kv 6321	43°34'18.9"N	29°00'29.5"E	40-45
10.	Shb 6025	43°31'02.8"N	29°06'45.7"E	60-65
11.	Gabriela Tsr 548	43°31'02.8"N	29°06'45.7"E	50
12.	Ns 997	42°26'37.4"N	28°08'29.7"E	55-60
13.	Ns 997	42°25'39.0"N	28°05'43.0"E	45-50
Fourth Quarter 2025				
1.	Ivana Kv 6231	43°19'13"N	28°22'51"E	50
2.	Libra Vn 8311	43°41'34.7"N	28°54'39.7"E	40-50
3.	Sv. Nikolay Vn 8190	43°18'42"N	28°15'57"E	40-50
4.	Viking Vn 8406	43°18'42"N	28°15'57"E	50
5.	Bizone 1 Vn 7432	43°17'48"N	28°21'21"E	35-40
6.	Neptun 70 Kv 6321	43°37'42"N	29°3'21"E	45-50
7.	Akula 1	43°38'00"N	28°55'00"E	55-60

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 35 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):

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

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 turbot. 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):

$$\text{GSI} = 100 \cdot W_G \cdot BW^{-1}, \text{ where:}$$

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 №158/28.03.2025 with EAFA, Burgas. The fecundity of 21 female fish caught and purchased in the first half of April 2025 and of 25 female fish caught in the period 30.07.-21.08.2025 was determined. 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 turbot caught and purchased in the first half of April 2025 and 50 turbot caught in December 2025. 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.

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- **Age**

The age of 100 turbot 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 turbot, caught and purchased in the second quarter of 2025 and 50 turbot in the fourth quarter of 2025, 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:

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

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:

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

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):

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

IRI_i - index of relative significance of each food component;

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

3 Results

3.1. Number of turbot landed by vessels

The total number of fish from which biological data is collected is 1 408. The number of turbot caught by each vessel is presented in **Fig. 1**.

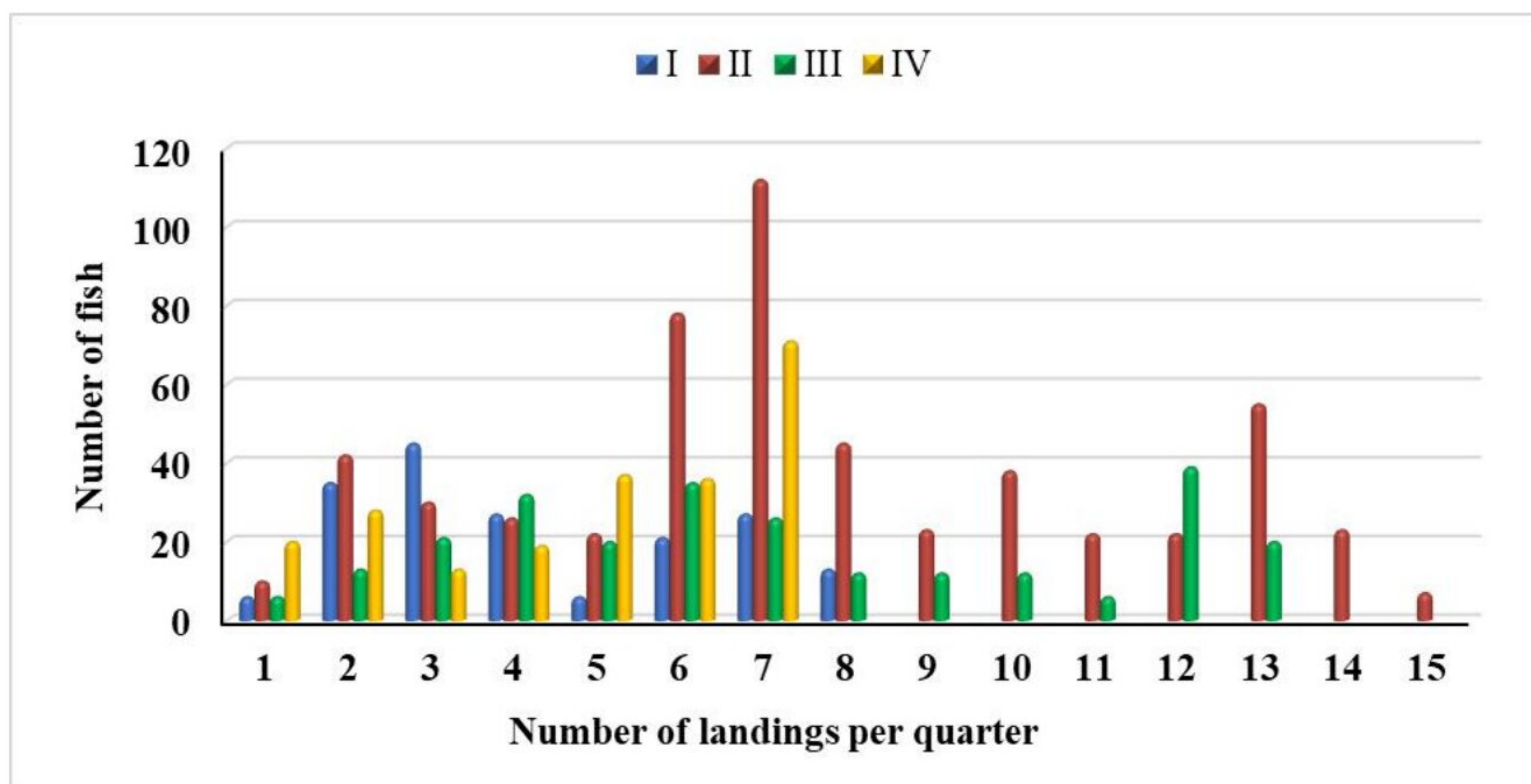


Fig. 1. Number of fish per vessel landed in 2025.

In 2025, an average of 30 fish or 84.47 kg/ship were caught per vessel, with the maximum number being 112 (381.00 kg) in the fourth quarter, and the minimum being 6 – two landings in the first quarter (27.50 kg and 16.00 kg) and two landings in the third quarter (11.00 kg and 11.50 kg).

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3.2. Weight structure of turbot landings

The average weight of the measured specimens is 2.82 kg. The maximum measured weight is 6.20 kg, and the minimum measured - 1.25 kg.

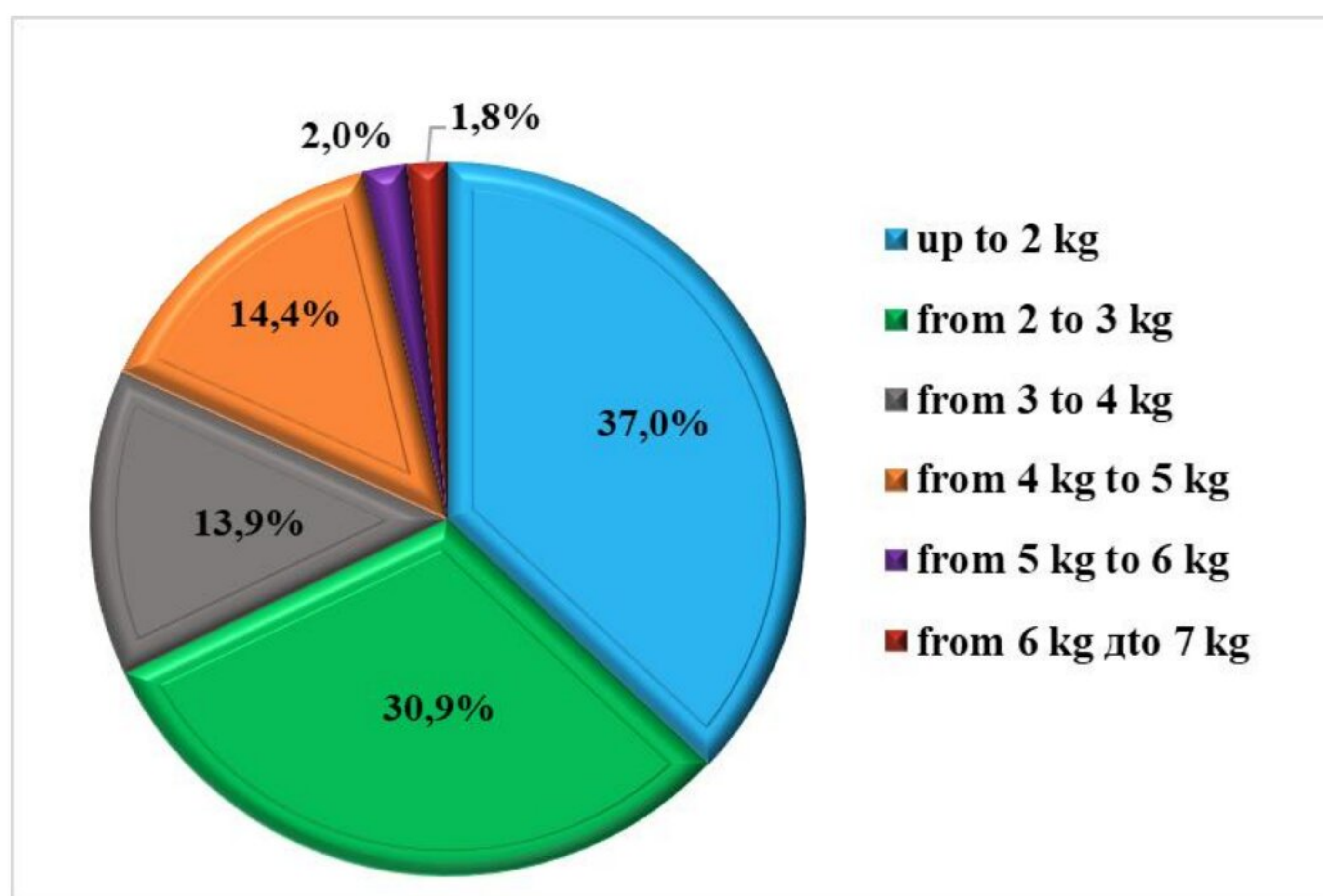


Fig. 2. Percentage distribution by weight of the measured fish in 2025

Fig. 2 presents the distribution of landings according to fish weight. Out of 1 408 turbot, 521 (37.0%) weighed up to 2 kg. Fish weighing from 2 to 3 kg accounted for 30.9% - 435 turbot of the measured specimens. The weight groups from 3 kg to 4 kg and from 4 to 5 kg have a similar percentage share - 13.9% and 14.4%, respectively, with the first group consisting of 196 specimens, and the second - 203 fish of the representative sample. The weight group from 5 to 6 kg consists of 28 fish or 2.0% of the measured turbot. The groups from 6 to 7 kg has the lowest percentage share of 1.8% or 25 fish.

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

The average total length (TL, cm) of the measured specimens is 54.89 cm, the maximum measured length is 77.50 cm, and the minimum measured length is - 45.50 cm. **Fig. 3** shows the dynamics of the distribution of the total body length (TL, cm) values of the measured individuals.

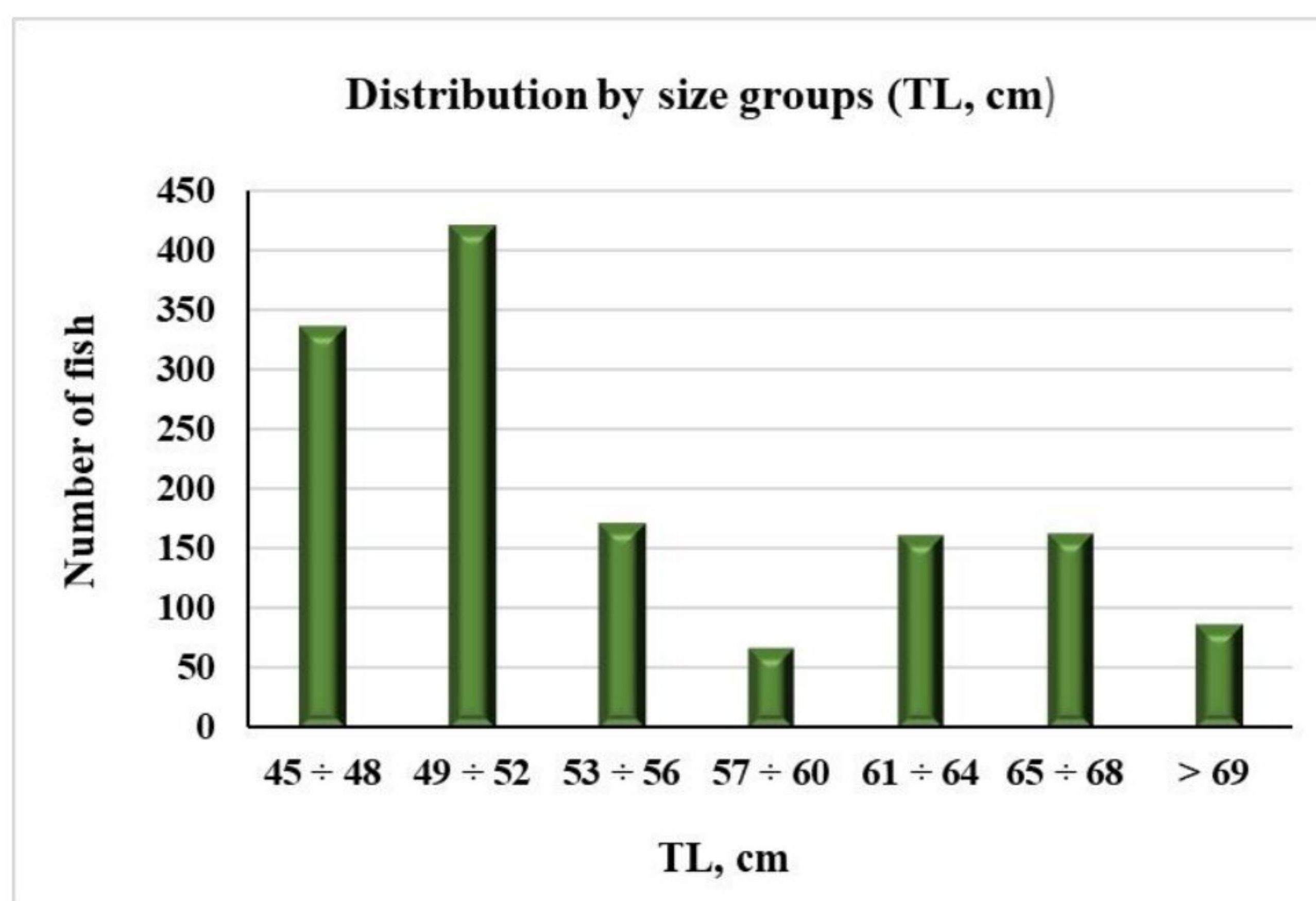


Fig. 3. Size structure (total length) of turbot landings in 2025

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 420 individuals or 29.8%, followed by the 45-48 cm group, which has percentage share of 23.9% or 336 individuals from the representative sample. Turbot with a total body length (TL, cm) in the range of 53-56 cm are 171 individuals (12.1%). The groups 61-64 cm and 65-68 cm, have similar percentage share of 11.5% (162 specimens) and 1.6% (163 specimens), followed by the size group >69 cm, which constitutes for 6.3% (88 specimens) from the representative sample.

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The size groups 57-60 cm has the lowest percentage share - 68 individuals or 4.8%.

Fig. 4 shows the dynamics of the distribution of the values of standard body length (SL, cm) of the measured individuals in 2025. The average value of the standard body length (SL, cm) is 43.37 cm. The maximum measured standard length is 66.00 cm, and the minimum measured is 34.00 cm.

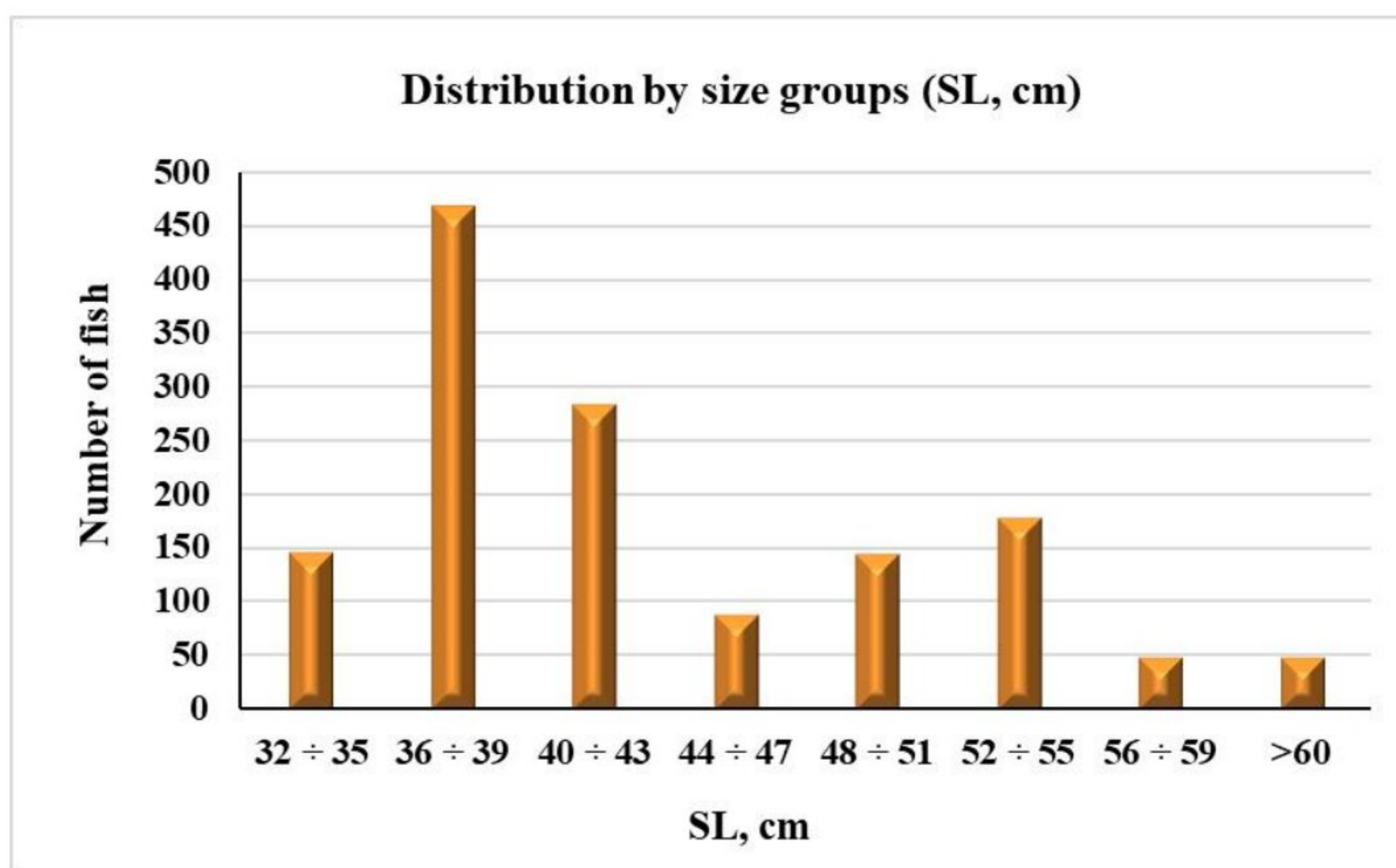


Fig. 4. Size structure (standard length) of turbot catches in 2025

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 468 individuals or 33.24%, followed by the 40-43 cm (284 individuals – 20.17%). Individuals with a standard body length in the range of 52-55 cm are 179 individuals or 12.71%. The size groups 32-35 cm and 48-51 cm, have a very close percentage share of 10.37% (146 fish) and 10.30% (145 fish), respectively. The size groups 56-59 cm and >60 cm have the same percentage share – 3.48% (49 fish).

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

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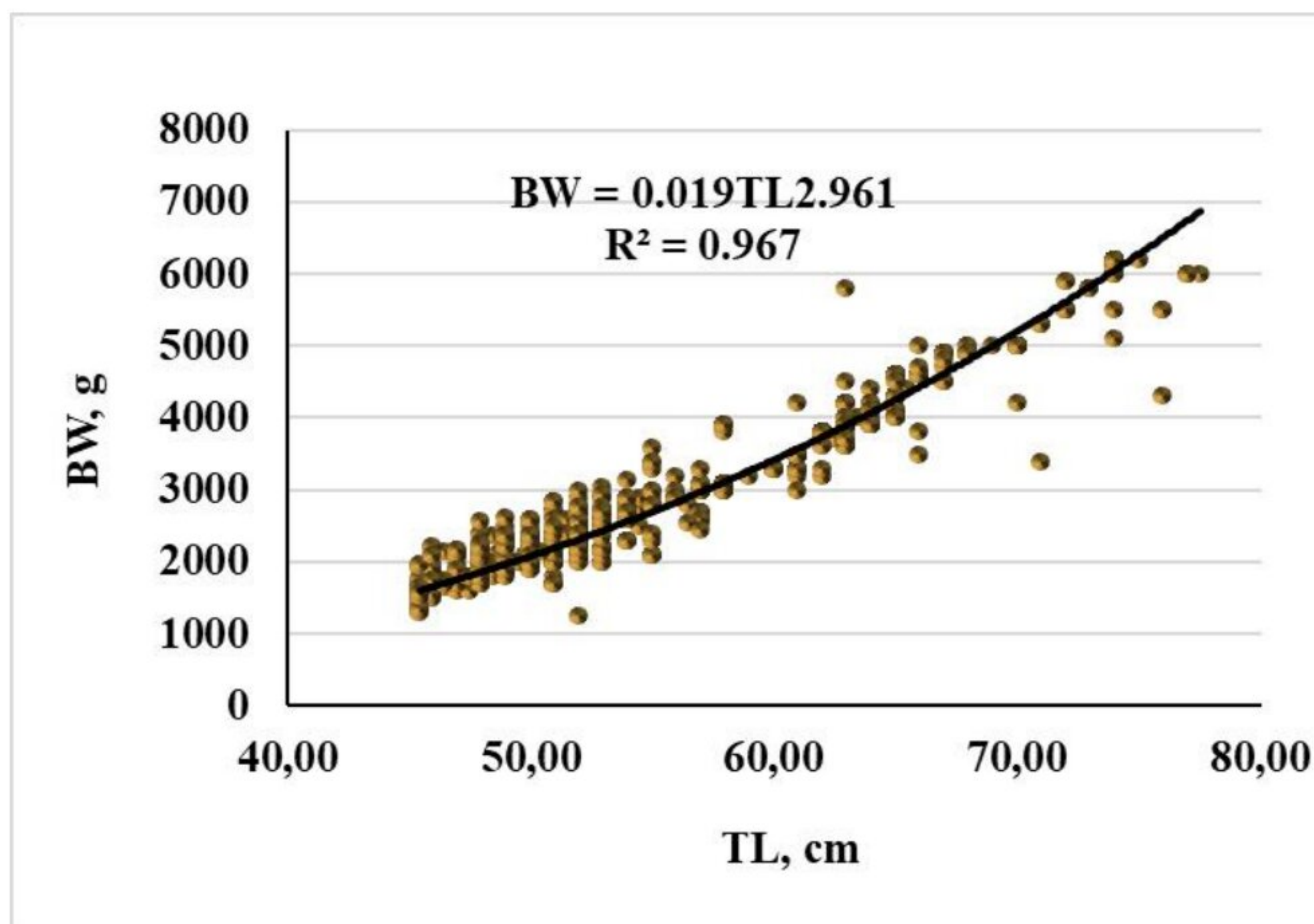


Fig. 5. Correlation between size and weight of turbot in 2025, n=1408

The correlation between the size and weight structure of turbot landings in 2025 is described by the equation: $BW = 0.019TL^{2.961}$.

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 35 are female and 65 specimens are male. The percentage ratio between female and male individuals is 35% to 65% in favor of male individuals.



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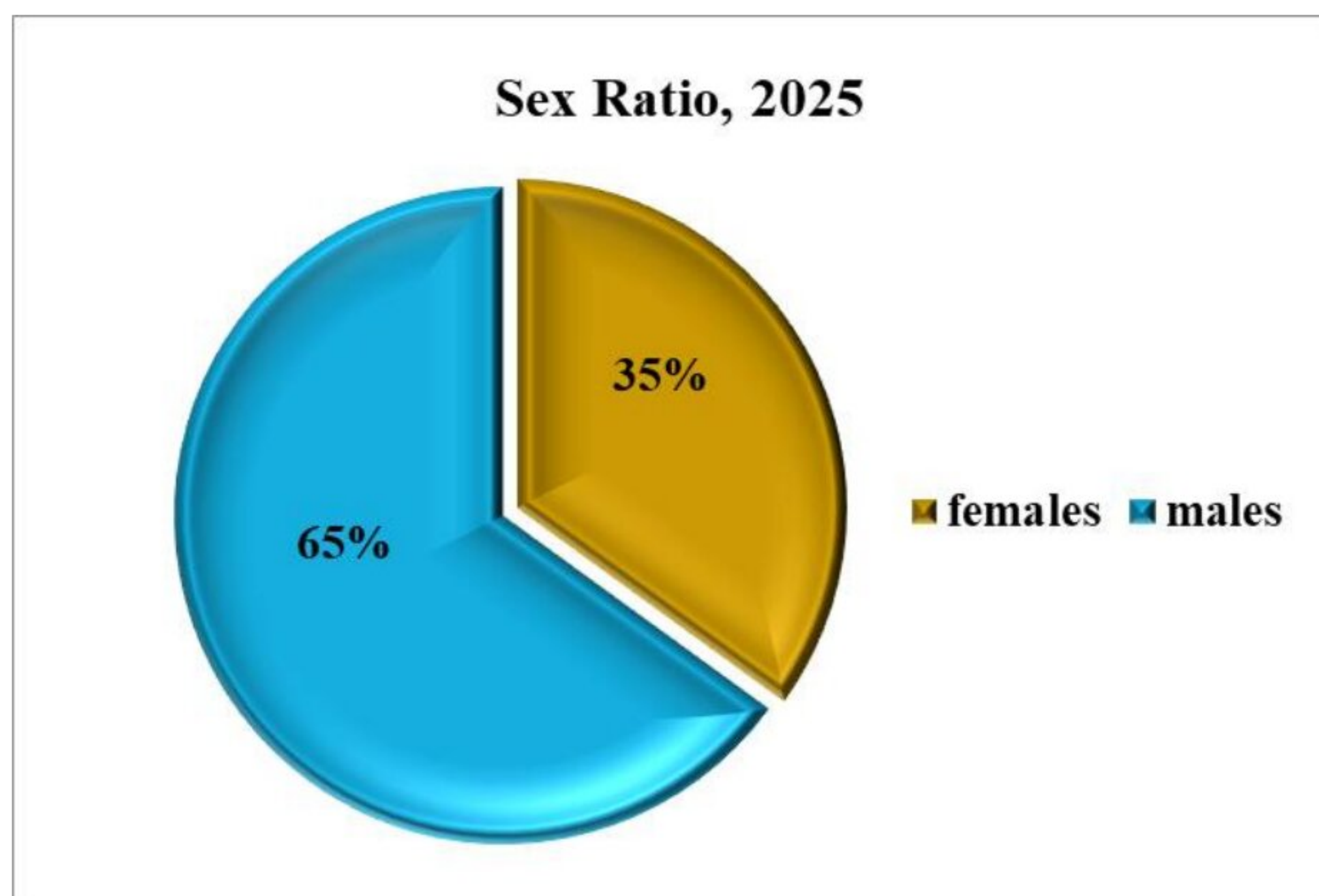


Fig. 6. Percentage ratio between female and male individuals in 2025, n=100

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

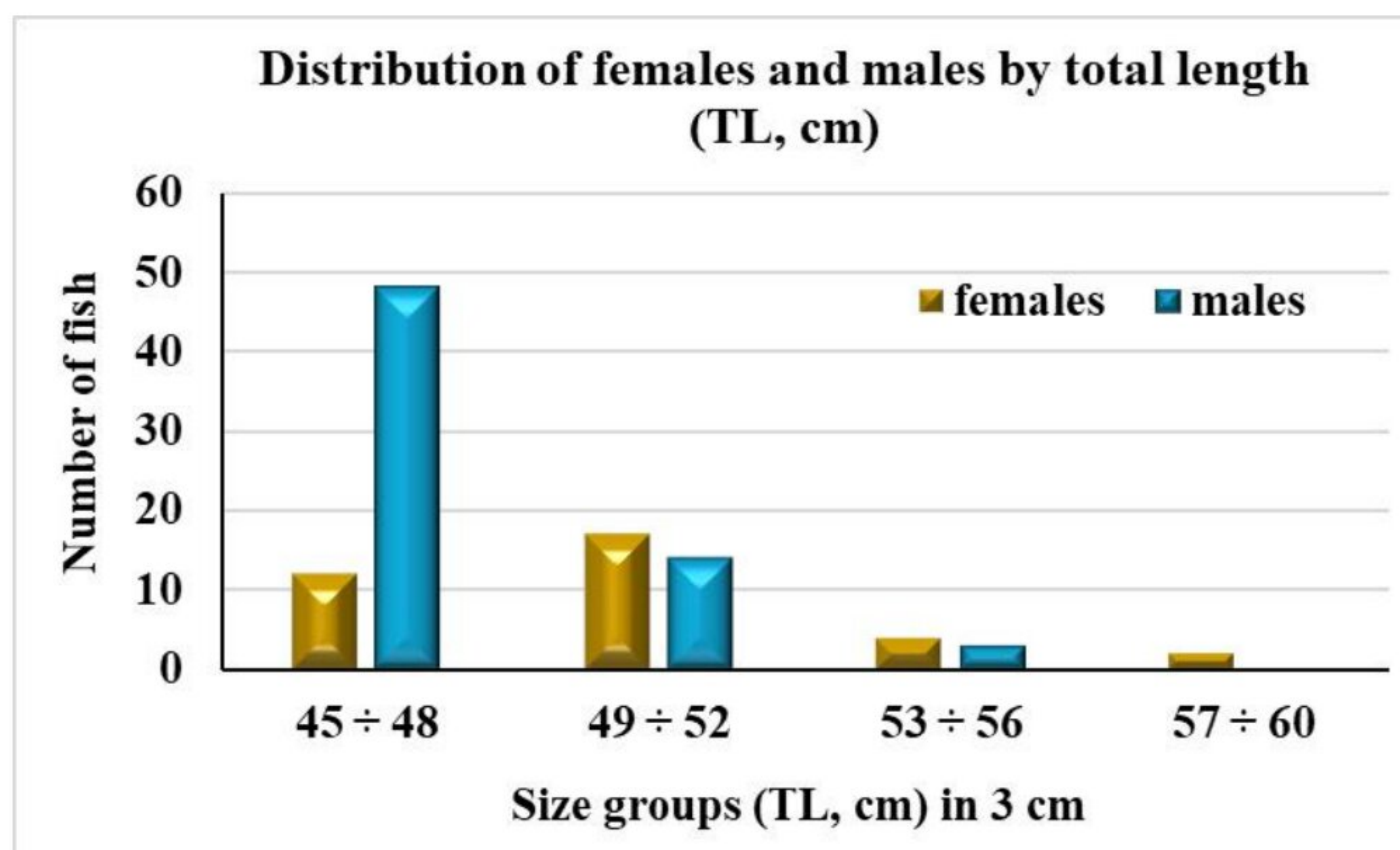


Fig. 7. Distribution between the two sexes depending on the total body length (TL, cm), (n=100; f=35, m=65)

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The highest number of male individuals (48 specimens) are in the size group 45-48 cm, followed by the group 49-52 cm, consisting of 14 specimens. The lowest number of male turbot (3 specimens) are in the size group 53-56 cm. Among female individuals, the highest number (17 specimens) are in the size group 49-52 cm, followed by the size group 45-48 cm (12 specimens). The lowest number of female turbot are in the size groups 53-56 cm and 57-60 cm, represented by 4 specimens and 2 specimens, respectively. Male individuals dominate in the size groups 45-48 cm, with 36 specimens. Female individuals dominate with 3 specimens in the size group 49-52 cm and with 1 specimens in the size group 53-56 cm. The size group 57-60 cm is represented only by 2 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	17	4	2
Number of males	48	14	3	0
Ratio females/males	1:4	1.2:1	1.3:1	-

3.4.2. Gonadosomatic index (GSI, %)

Gonadosomatic index – second quarter 2025

The average weight of male fish in the first half of April 2025 is 1.88 kg and it is in the range 1.30-2.50 kg. Gonad weight ranged between 4.45 g and 62.50 g, with an average value of 20.34 g (**Table 5**).

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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 2025

Second Quarter 2025						
Nº	BW, kg	TL, cm	SL, cm	W_G , g	GSI, %	Age
1	1.51	45.50	35.50	23.40	1.55	3
2	1.30	45.50	35.50	10.50	0.81	3
3	2.00	46.00	36.00	20.50	1.03	4
4	1.98	49.00	37.00	19.12	0.97	4
5	2.33	49.00	37.00	62.50	2.68	5
6	1.49	45.50	35.50	12.70	0.85	3
7	1.79	48.00	37.00	33.97	1.90	4
8	1.57	45.50	35.50	4.70	0.30	3
9	2.36	48.50	37.00	19.29	0.82	4
10	2.36	50.00	38.00	19.54	0.83	5
11	1.92	46.00	36.00	18.30	0.96	4
12	1.60	45.50	35.50	11.87	0.74	3
13	2.36	52.00	40.00	36.70	1.56	5
14	1.88	47.00	36.00	17.46	0.93	4
15	2.10	51.00	40.00	20.60	0.98	5
16	1.69	45.50	35.50	8.00	0.47	3
17	1.36	45.50	35.50	10.20	0.75	3
18	2.13	47.00	37.00	15.80	0.74	4
19	1.65	46.00	36.00	30.00	1.82	4
20	1.85	46.00	36.00	20.00	1.08	3
21	2.50	49.00	38.00	25.60	1.02	5
22	2.18	48.00	36.00	28.30	1.30	4
23	1.54	45.50	35.50	16.54	1.07	3
24	1.60	45.50	35.50	14.69	0.92	3
25	1.40	45.50	35.50	7.70	0.55	3
26	2.14	48.00	36.00	24.00	1.12	4
27	2.28	51.00	39.00	43.11	1.89	5

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28	1.96	47.00	36.00	10.24	0.52	4
29	1.59	45.50	35.50	4.45	0.28	3
ave	1.88	47.21	36.50	20.34	1.05	4
min	1.30	45.50	35.50	4.45	0.28	3
max	2.50	52.00	40.00	62.50	2.68	5

The GSI, % values for male fish in the first half of 2025, range from 0.28% to 2.68%, with an average value of 1.05%.

The average weight of female fish in the first half of April 2025 is 2.21 kg and it is in the range of 1.30-2.72 kg. Ovary weight range between 13.96 g and 408.37 g, , with an average value of 160.58 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 2025

Second Quarter 2025						
№	BW, kg	TL, cm	SL, cm	W_G, g	GSI, %	age
1	1.30	45.50	35.50	15.49	1.19	3
2	2.55	50.00	38.00	246.40	9.66	5
3	2.72	51.00	39.00	408.37	15.01	5
4	2.10	47.00	37.00	165.30	7.87	4
5	2.15	46.50	36.00	134.81	6.27	4
6	2.69	52.00	40.00	254.40	9.46	5
7	1.69	45.50	35.50	21.78	1.29	3
8	2.62	51.00	39.00	201.60	7.69	5
9	1.47	45.50	35.50	30.30	2.06	3
10	2.55	57.00	46.00	151.40	5.94	5
11	2.70	52.00	40.00	355.88	13.18	5
12	2.10	51.00	39.00	26.60	1.27	4
13	2.60	57.00	46.00	257.56	9.91	5
14	1.88	46.00	36.00	39.90	2.12	4
15	2.30	50.00	38.00	188.85	8.21	5

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16	1.72	46.00	36.00	18.40	1.07	4
17	2.29	52.00	40.00	61.34	2.68	5
18	1.50	45.50	35.50	13.96	0.93	3
19	2.59	50.00	38.00	307.47	11.87	5
20	2.40	50.00	40.00	304.87	12.70	4
21	2.47	50.00	39.00	167.54	6.78	4
ave	2.21	49.55	38.52	160.58	6.53	4
min	1.30	45.50	35.50	13.96	0.93	3
max	2.72	57.00	46.00	408.37	15.01	5

Стойностите на GSI,% за женските риби, през първата половина на месец април 2025 г., са в интервал между 0.93% и 15.01%, като средната стойност е 6.53%.

Gonadosomatic index – fourth quarter 2025

The average weight of male fish in December 2025 is 2.10 kg kg and ranged from 1.35-3.38 kg. The weight of gonads is between 4.10 g and 42.89 g, with a mean of 17.70 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 2025

Fourth Quarter 2025						
№	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Възраст
1	1.35	45.50	35.50	13.73	1.02	3+
2	1.92	45.50	35.50	18.98	0.99	3+
3	1.94	48.00	36.00	12.82	0.66	4+
4	2.39	48.00	37.00	24.50	1.03	4+
5	2.23	49.00	37.00	22.36	1.00	4+
6	1.73	45.50	35.50	22.00	1.28	3+
7	2.26	48.00	37.00	35.00	1.55	4+
8	1.58	45.50	35.50	12.60	0.80	3+
9	2.39	49.00	37.00	15.51	0.65	4+
10	1.64	45.50	35.50	11.96	0.73	4+
11	1.53	45.50	35.50	4.10	0.27	3+
12	1.58	45.50	35.50	7.47	0.47	3+

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13	1.78	45.50	35.50	6.50	0.37	3+
14	2.90	53.00	41.00	16.49	0.57	5+
15	1.90	48.00	36.00	8.09	0.43	4+
16	2.05	48.00	39.00	21.47	1.05	4+
17	1.94	45.50	35.50	11.00	0.57	3+
18	2.28	50.00	40.00	16.70	0.73	5+
19	2.18	47.00	36.00	25.84	1.19	4+
20	1.92	46.00	36.00	42.89	2.24	3+
21	2.10	48.00	37.00	15.15	0.72	3+
22	1.74	46.00	36.00	11.00	0.63	3+
23	1.64	45.50	35.50	16.88	1.03	3+
24	2.18	47.00	36.00	6.20	0.29	4+
25	2.76	53.00	40.00	24.99	0.91	5+
26	2.19	48.00	36.00	29.78	1.36	4+
27	2.22	46.00	36.00	24.55	1.11	3+
28	1.96	45.50	35.50	17.26	0.88	3+
29	1.58	45.50	35.50	25.60	1.63	3+
30	3.38	55.00	41.00	6.58	0.19	6+
31	2.25	48.00	36.00	19.86	0.88	4+
32	2.76	52.00	40.00	31.56	1.14	5+
33	2.61	49.00	38.00	4.87	0.19	4+
34	2.36	49.00	38.00	16.71	0.71	4+
35	1.98	50.00	39.00	14.78	0.75	4+
36	2.37	50.00	38.00	21.54	0.91	4+
ave	2.10	47.81	36.92	17.70	0.86	4+
min	1.35	45.50	35.50	4.10	0.19	3+
max	3.38	55.00	41.00	42.89	2.24	6+

The GSI,% values for male fish in December 2025 ranged from 0.19% and 2.24%, with a mean of 0.86%.

The mean weight of female fish in December 2025 is 2.49 kg with a range of 1.25-3.58 kg. Ovary weight ranged from 15.58 g and 128.60 g, with a mean of 49.26 g (**Table 8**).

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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 2025

Fourth Quarter 2025						
Nº	BW, kg	TL, cm	SL, cm	W_G , g	GSI, %	Age
1	1.25	52.00	40.00	30.30	2.42	4+
2	2.70	52.00	40.00	64.20	2.38	5+
3	2.20	50.00	38.00	23.08	1.05	4+
4	2.60	50.00	38.00	55.18	2.12	4+
5	2.57	48.00	36.00	35.99	1.40	4+
6	2.57	52.00	41.00	21.72	0.85	5+
7	3.28	55.00	44.00	44.76	1.36	5+
8	2.94	53.00	41.00	128.60	4.37	5+
9	3.58	55.00	42.00	88.00	2.46	5+
10	2.09	48.00	37.00	18.92	0.91	4+
11	2.11	50.00	40.00	15.58	0.74	4+
12	2.10	46.00	36.00	59.13	2.82	3+
13	2.21	48.00	36.00	51.90	2.35	3+
14	2.70	53.00	40.00	52.25	1.94	4+
ave	2.49	50.86	39.21	49.26	1.94	4+
min	1.25	46.00	36.00	15.58	0.74	3+
max	3.58	55.00	44.00	128.60	4.37	5+

The values of GSI, % for female fish in December 2025 ranged between 0.74% and 4.37%, with the average value being 1.94%.

Table 9 presents the average values of the gonadosomatic index (GSI, %) of female turbot in 2025.

Table 9. Average values of the gonadosomatic index (GSI,%) of female turbot in 2025

GSI, % \ Month	Second Quarter	Fourth Quarter
average	6.53	1.94
min	0.93	0.74
max	15.01	4.37

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Table 10 presents the average values of the gonadosomatic index (GSI, %), male turbot in 2025.

Table 10. Average values of the gonadosomatic index (GSI,%) of male turbot in 2025

GSI, % \ Month	Second Quarter	Fourth Quarter
average	1.05	0.86
min	0.28	0.19
max	2.68	2.24

3.4.3. Fecundity of female fish

The female fish (21 specimens) from April 2025 whose fecundity is determined, have an average weight of 2.21 kg The average value of the total body length is 49.55 cm, and the average age is 4 years (**Fig. 8**).

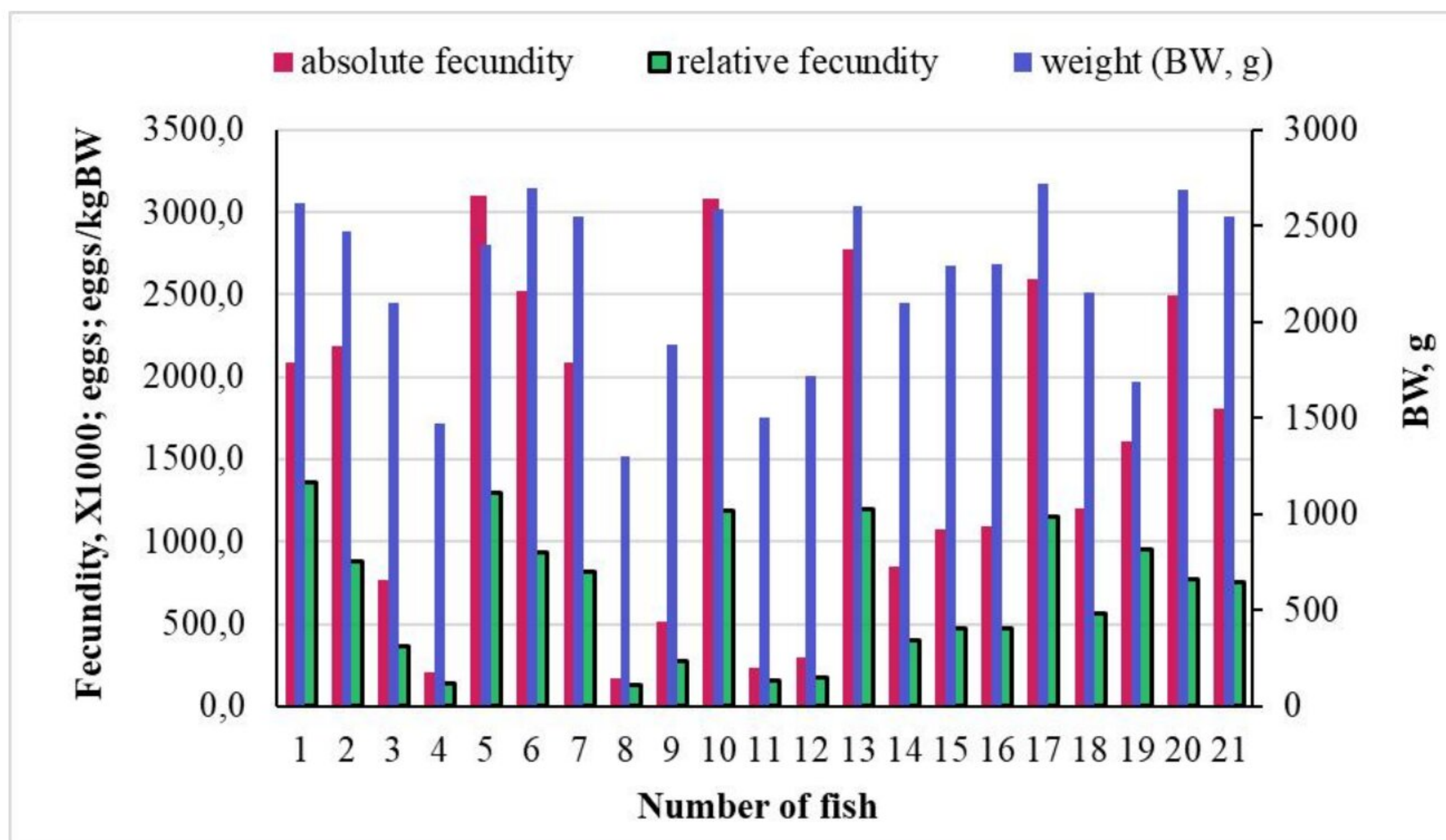


Fig. 8. Absolute and relative fecundity of female fish, first half of April 2025

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The absolute fecundity in the first half of April 2025 is 1 559 542.2 number of eggs/individual, and the relative fecundity is 651 047.6 number of eggs/BW, g (**Table 11**).

Table 11. Values of absolute and relative fecundity in turbot, first half of April 2025

Parameter	Average values
Number of female fish	21
Total length, TL (cm)	49.55
Body weight, BW (g)	2 209
Absolute fecundity, number of eggs/individual	1 559 542.2
Relative fecundity, number of eggs/g BW	651 047.6
Age, years	4

The established turbot fecundity in the first half of April 2025 of 1 559 542.2 eggs/individual is 132827.5 eggs/individual lower compared to the absolute fecundity established in the first half of April 2024 by IFA, Plovdiv. Aydin *et al.* (2019), establish an absolute fecundity of 2 400 000 eggs/individual during the reproductive period, which is 840 458 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 is an average of 769 458 eggs/individual higher than that calculated in the present study.



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

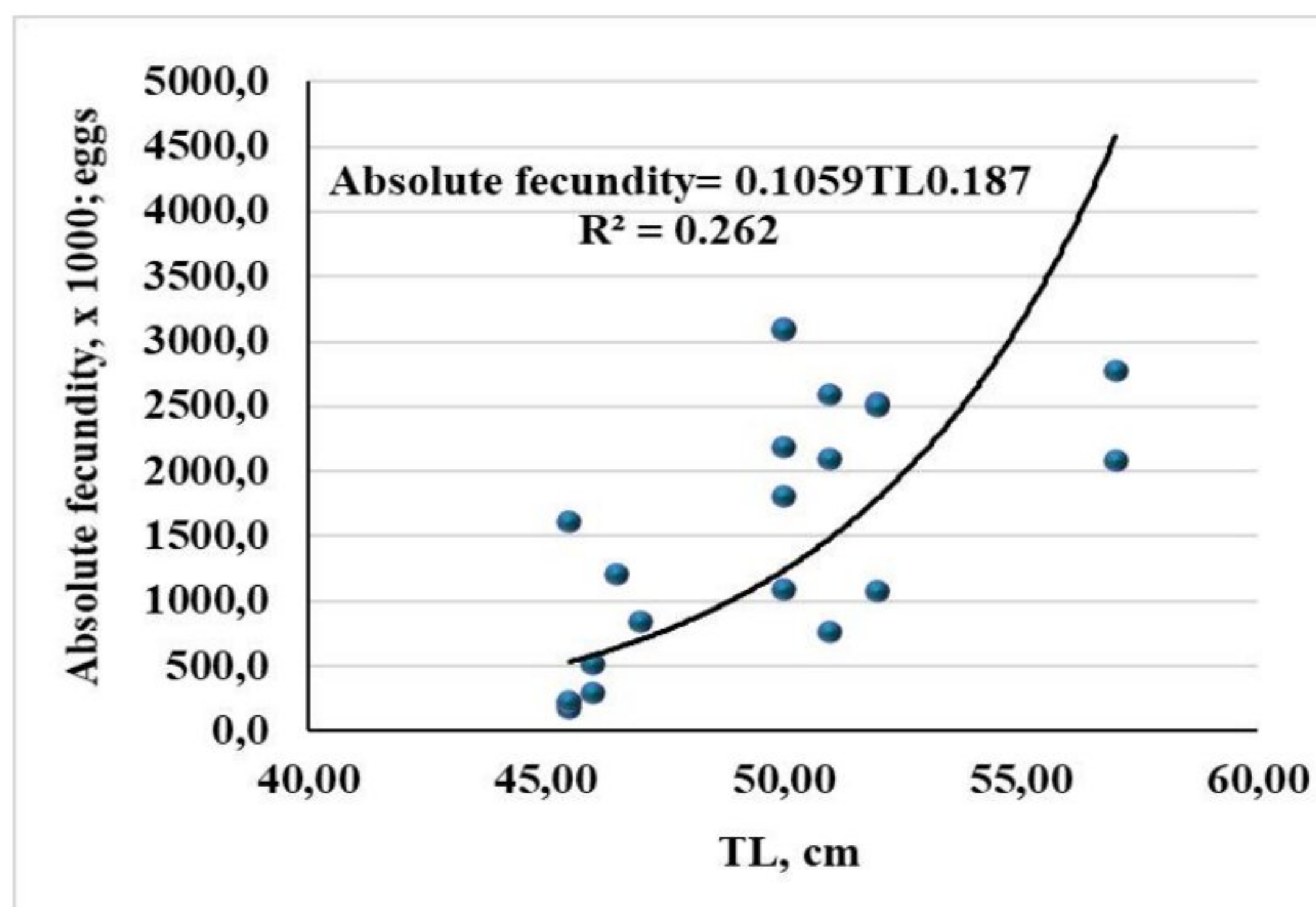


Fig. 9. Correlation between absolute fecundity and total length of female fish, first half of April 2025

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

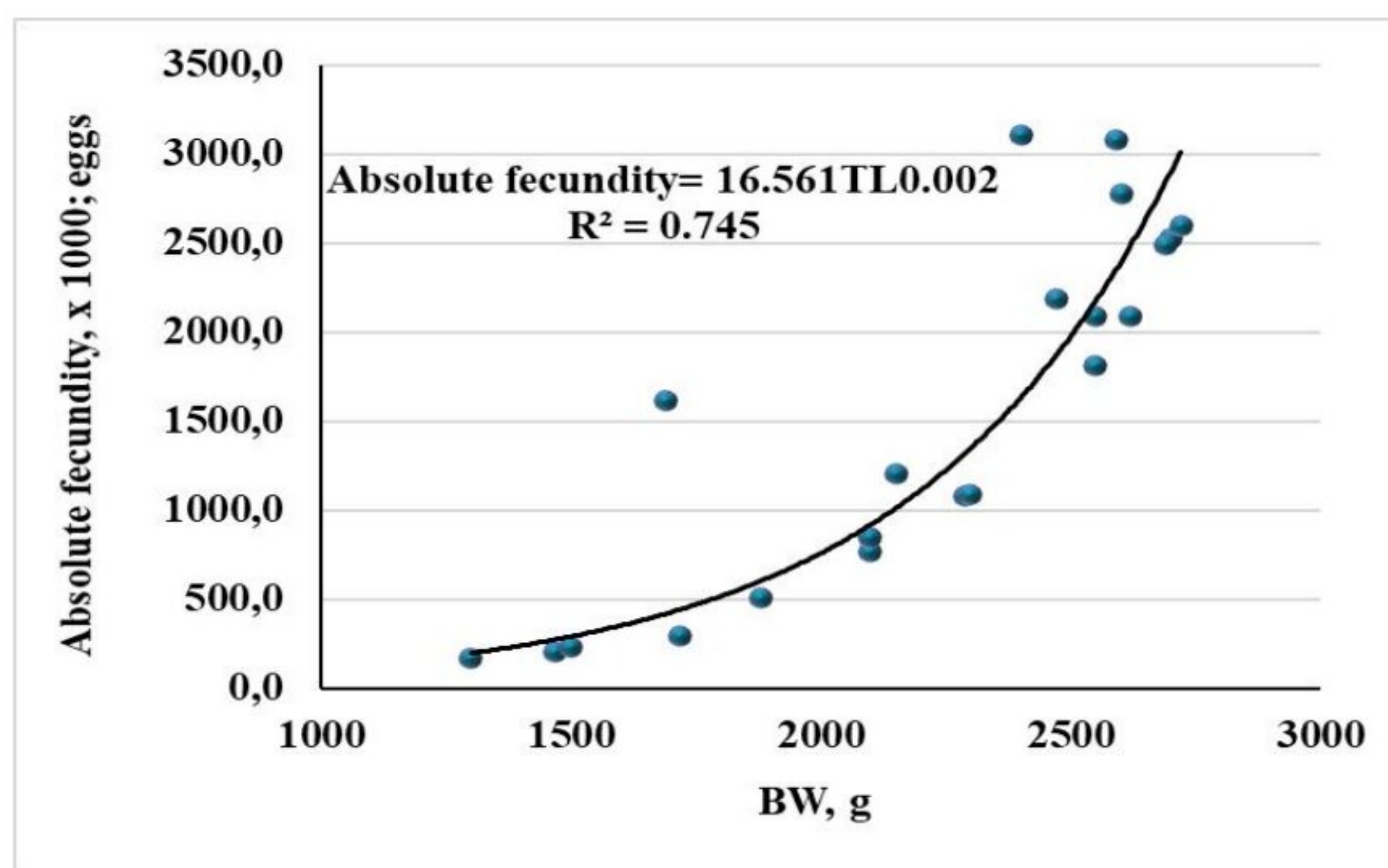


Fig. 10. Correlation between absolute fecundity and weight of female fish, first half of April 2025

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The correlation between absolute fecundity and age of female fish in April 2025, which is also positive, is presented in **Fig. 11**. The correlation is positive - as body weight increases, the absolute fecundity also increases.

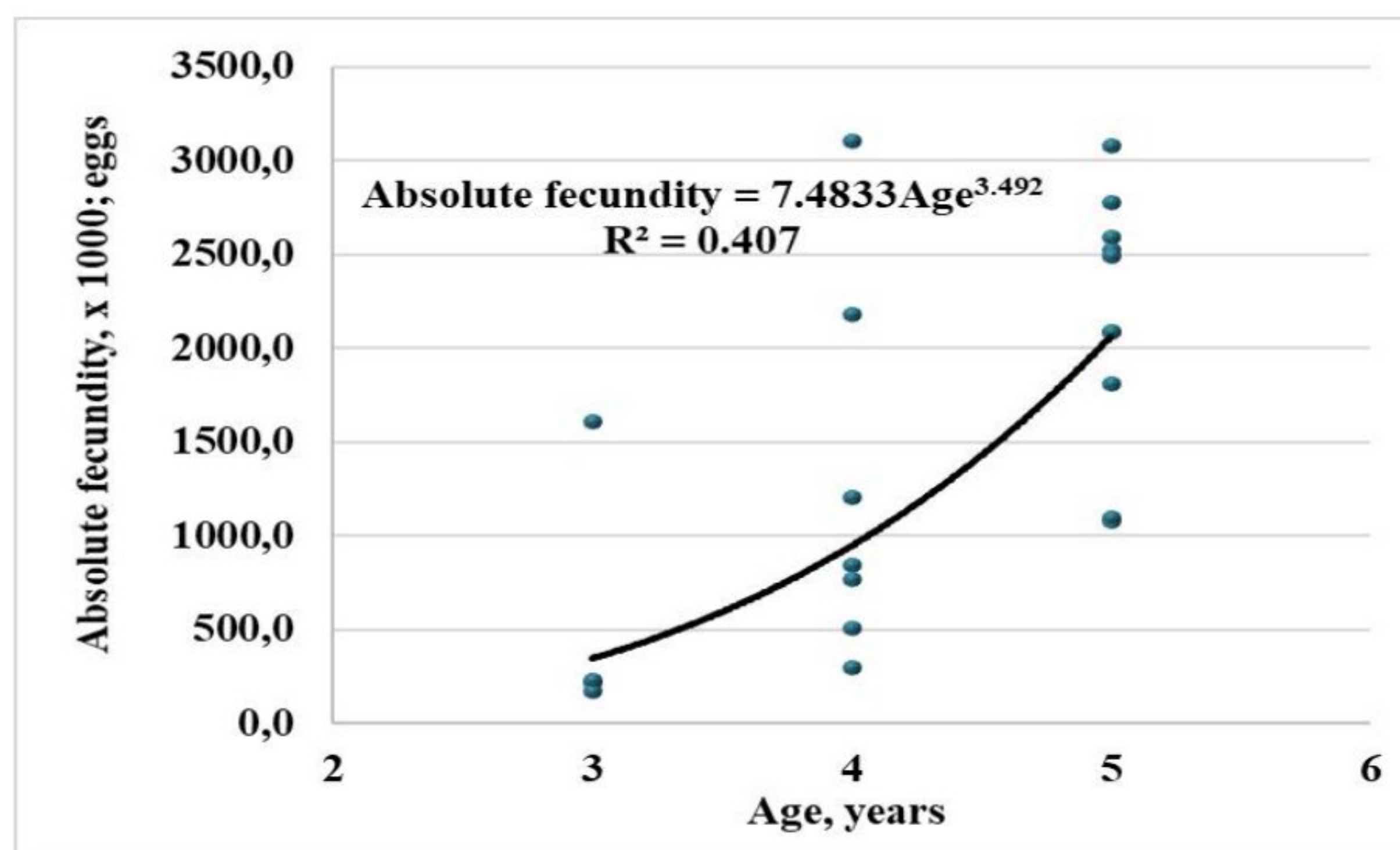


Fig. 11. Correlation between absolute fecundity and age of female fish, first half of April 2025

The 25 female turbot, caught in the period 30th of June – 21st of August 2025, have an average weight of 3.34 kg. The average total length is 57.56 cm and the average age - 6 years (**Fig. 12**).



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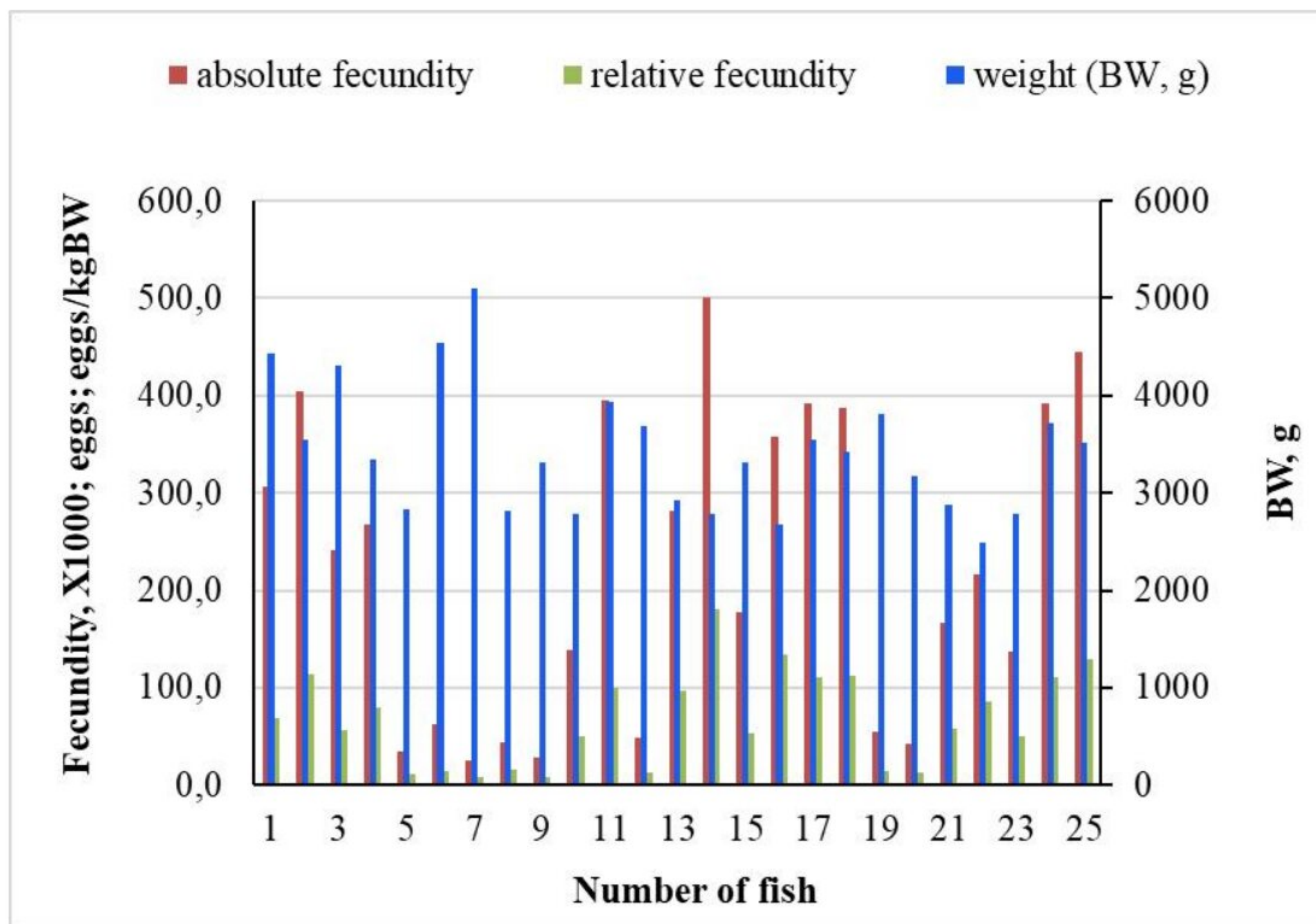


Fig. 12. Absolute and relative fecundity of female fish, August 2025

The absolute fecundity of female fish is 221 943.5 eggs/ind. and the relative fecundity is 67 644.2 number of eggs/kg BW (Table 12).

Table 12. Values of absolute and relative fecundity in turbot, August 2025

Parameter	Average values
Number of female fish	25
Total length, TL (cm)	57.56
Body weight, BW (g)	3 426
Absolute fecundity, number of eggs/individual	221 943.5
Relative fecundity, number of eggs/kg BW	67 644.2
Age, years	6

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The established fecundity (221 943.5 eggs/individual) is almost 10 lower compared to the results by Aydin & Sahin (2011) (2 554 500 eggs/individual), 9 times lower when compared to the study by Aydin et al. (2019) (2 400 000 eggs/individual) and 8 times lower compared to the results established by IFA, Plovdiv in 2024 (1 692 369 eggs/individual). This is due to the fact that the samples from the cited studies were taken immediately before or during the breeding season, while the analyzed samples were taken almost two months after the end of the breeding season (in August 2025).

The current results for turbot fecundity are close in value to those established by the IFA, Plovdiv (183,622.7 eggs/individual) in 2020, as the samples were also taken after the end of the breeding season, in July.

3.4.4. Degree of maturity of the reproductive organs

All studied turbot 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 analysis of the results shows that the percentage participation of female and male individuals aged 4+ years occupies the largest share of the total age structure – 23%. Fish at age 3+ and 4 years old have low percentage share of 17% and 18%, respectively. The turbot at age of 3 and 5

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years have the same percentage share - 16%, with the lowest percentage share are the fish of 7+ years of age - 1% (**Fig. 13**).

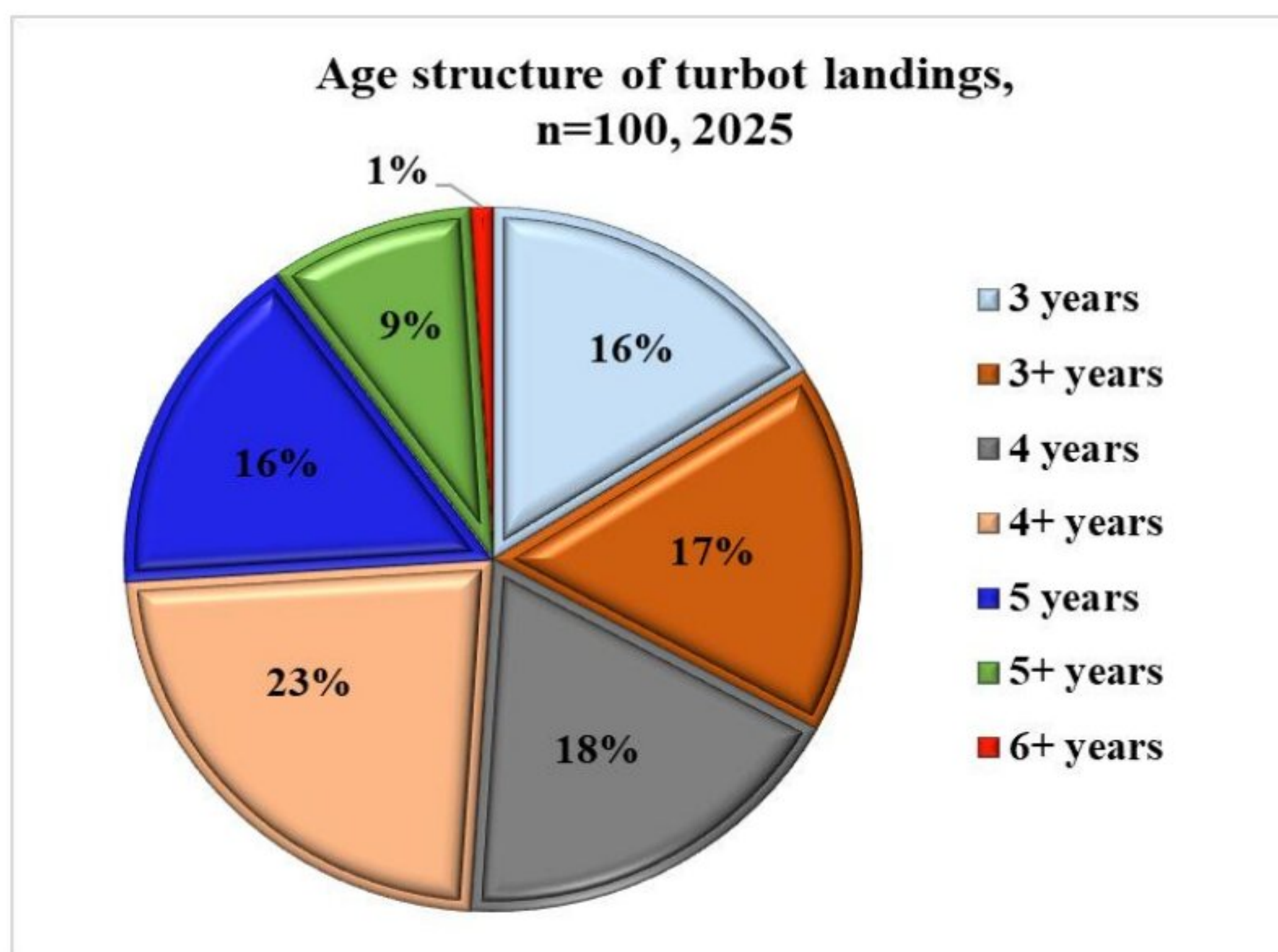


Fig. 13. Percentage distribution of age in turbot (n=100)

The distribution between the two sexes and the age of turbot is presented in **Fig. 14**.

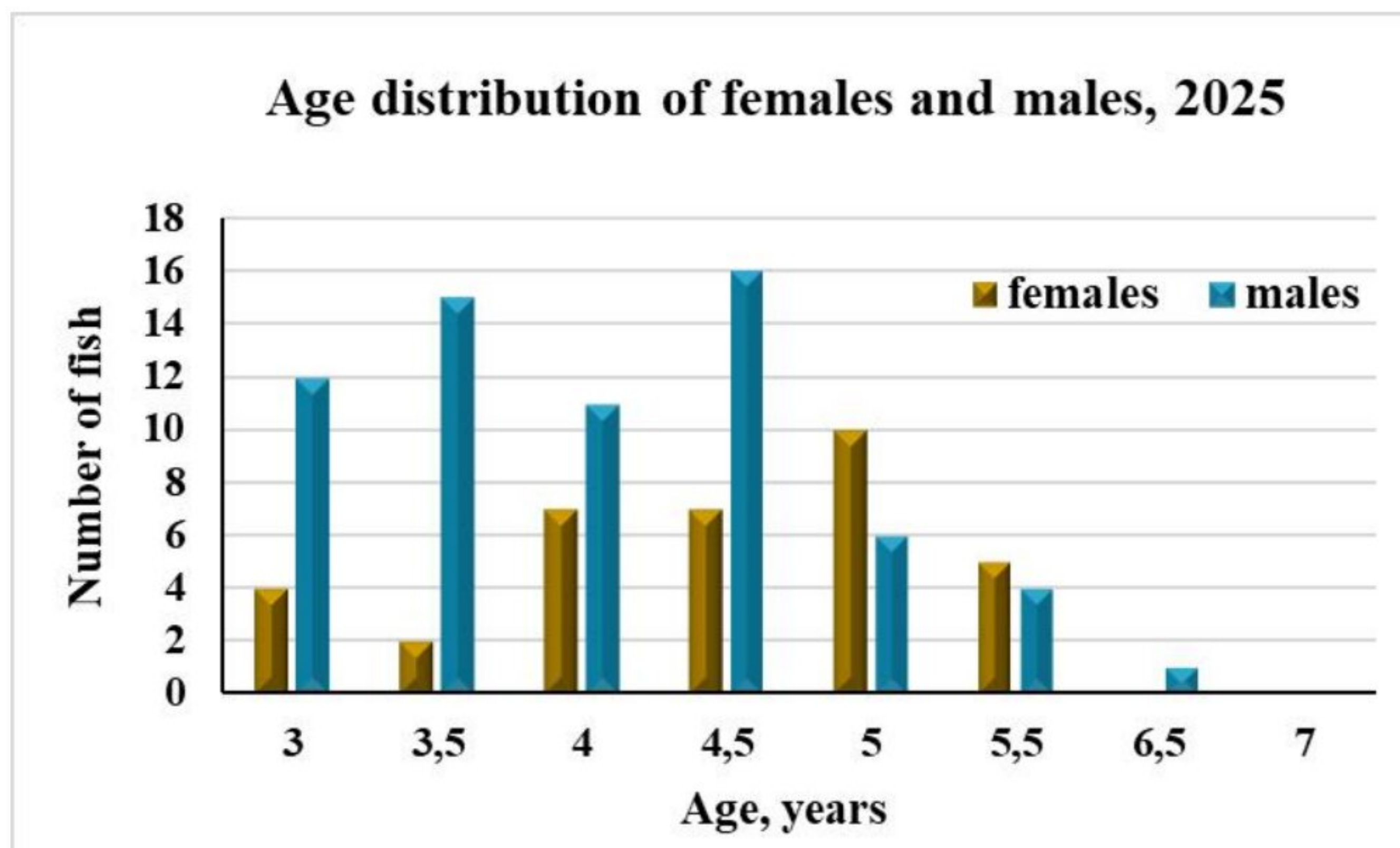


Fig. 14. Distribution between the two sexes according to the age of the individuals (n=100; f=35, m=65)

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The ratio between females and males is listed in **Table 13**.

Table 13. Ratio between females and males to age

Age, years	3	3.5	4	4.5	5	5.5	6.5
Number of female fish	4	2	7	7	10	5	-
Number of male fish	12	15	11	16	6	4	1
Ratio females/males	1:3	1:7.5	1:1.6	1:2.3	1.6:1	1.3:1	-

The results show that among males 4.5 year-old turbot predominate, while among females 5 year-old fish have the highest number.

3.5. Stomach content and food array analysis in turbot

In the first half of 2025, 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. The fish with full stomach are 19 specimens or 38% of the studied individuals. The average ISF, % is 0.53% (**Table 14**).

Table 14. Index of stomach fullness (ISF, %) of turbot with full stomach in the first half of 2025

№	BW, g	TL, cm	Full stomach, g	Empty stomach, g	FW, g	ISF, %
1	2000	46.00	81.65	22.05	59.60	2.98
2	2330	49.00	47.11	25.91	21.20	0.91
3	2720	51.00	97.77	57.27	40.50	1.49
4	2100	47.00	63.60	26.20	37.40	1.78
5	2360	48.50	97.90	22.80	75.10	3.18
6	2360	50.00	55.82	22.21	33.61	1.42
7	1915	46.00	60.60	16.52	44.08	2.30
8	1600	45.50	42.20	26.10	16.10	1.01
9	1690	45.50	33.62	19.12	14.50	0.86
10	2620	51.00	43.30	30.70	12.60	0.48
11	1470	45.50	38.10	21.10	17.00	1.16
12	2700	52.00	62.30	44.10	18.20	0.67
13	1690	45.50	35.80	10.00	25.80	1.53

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14	2600	57.00	47.00	23.90	23.10	0.89
15	2130	47.00	39.50	22.00	17.50	0.82
16	1540	45.50	32.80	17.60	15.20	0.99
17	2140	48.00	24.50	16.94	7.56	0.35
18	2280	51.00	85.87	29.39	56.48	2.48
19	1960	47.00	42.00	19.70	22.30	1.14

In the first half of 2025 *Merlangius merlangus* has the highest value of the relative importance index - IRI=11901.50 and has a dominant share of the percentage composition of food, respectively 82%. Decomposed remains of fish were found in the stomach content of the studied individuals, on the basis of which an accurate taxonomic identification cannot be made.

In the second half of 2025 of all 50 fish examined for stomach content 26 fish (52%) have full stomach. The fish with empty stomach are 24 specimens or 48% of the studied turbot. The average value of ISF, % is 0.39%. (**Table 15**).

Table 15. Index of stomach fullness (ISF, %) of turbot with full stomach in the second half of 2025

№	BW, g	TL, cm	Full stomach, g	Empty stomach, g	FW, g	ISF, %
1	1252	52.00	87.82	43.33	44.49	3.55
2	2700	25.00	50.40	35.00	15.40	0.57
3	1920	45.50	25.72	19.00	6.72	0.35
4	1940	48.00	25.80	17.50	8.30	0.43
5	2390	48.00	59.39	17.00	42.39	1.77
6	1725	45.50	47.22	45.50	1.72	0.10
7	2260	48.00	65.66	29.00	36.66	1.62
8	2565	48.00	45.49	27.00	0.00	0.00
9	2385	49.00	43.75	25.50	18.25	0.77
10	2570	52.00	35.78	34.00	1.78	0.07
11	1530	45.50	34.90	24.00	10.90	0.71

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12	1775	45.50	27.92	20.50	7.42	0.42
13	2900	53.00	74.75	26.50	48.25	1.66
14	3280	55.00	78.06	33.00	0.00	0.00
15	1940	45.50	38.04	22.50	15.54	0.80
16	1915	46.00	50.45	25.00	25.45	1.33
17	2095	48.00	43.20	23.50	19.70	0.94
18	1640	45.50	46.36	21.00	0.00	0.00
19	2175	47.00	34.34	32.50	1.84	0.08
20	2085	48.00	39.15	17.50	0.00	0.00
21	2190	48.00	22.30	15.00	7.30	0.33
22	2220	46.00	49.32	22.70	26.62	1.20
23	2100	46.00	43.98	24.00	19.98	0.95
24	2210	48.00	37.56	19.00	18.56	0.84
25	2610	49.00	42.79	32.00	10.79	0.41
26	2360	49.00	42.95	28.50	14.45	0.61

In the second half of 2025, the highest value of the relative importance index was for decomposed remains of fish and/or other organisms (category "Other"), respectively $IRI=7950.91$, as compared to the percentage composition of the food, according to the relative importance index (IRI, %), are the dominant share, respectively 75.36%. Single individuals of Mollusca and Cnidaria have been identified.

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 2025, the following conclusions and recommendations can be made:

1. The fishing vessels have unloaded an average of 30 turbot. The maximum catch per vessel is 112 fish, and the minimum is 6 fish.
2. From a total of 47 landings at the ports of Kavarna, Varna, Blachik, Tsarevo, Pomorie and Shabla a 1 408 turbot with an average weight of 2.82 and average value of the total length 54.89 cm.

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3. The maximum measured weight is 6.20 kg, and the minimum weight - 1.25 kg.
4. The maximum measured values of the total length are 77.50 cm, and the minimum is 45.50 cm.
5. From a total number of 1408 turbot, 521 fish (37.0%) are with weight up to 2 kg. The fish with weight from 2 to 3 kg are 30.9% - 435 specimens. The weight group from 3 kg to 4 kg and from 4 to 5 kg are with similar percentage share, 13.9% and 14.4%, respectively. The weight group from 5 to 6 kg consists of 28 turbot or 2.0% of the measured fish. With the lowest percentage share are the weight groups from 6 to 7 kg with 1.8% or 25 fish.
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 - 29.8%, followed by the group 45-48 cm with percentage share of 23.9%. Turbot with total length of 53-56 cm represent 12.1% of the landings. With the lowest percentage share is the group 57-60 cm, which consist of 4.8%.
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 468 fish or 33.24%, %, followed by the 40-43 cm group -20.17%. Turbot with standard body length of 52-55 cm represent 12.71%. with close percentage share are the length groups 32-35 cm and 48-51 cm, with 10.37% and 10.30%, respectively. The size groups 56-59 cm and >60 cm have the same percentage share – 3.48% (49 specimens).
8. The correlation between the size and weight structure of turbot landings in 2025 is described by the equation: $BW = 0.019TL^{2.961}$.
9. The percentage ratio between female and male individuals is 35% to 65% in favor of male individuals.
10. The age composition of the 100 turbot specimens studied in 2025 includes individuals from 3 to 6+ years old, with the highest percentage share of 4+ year-old turbot - 23%.

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The age groups of 3+ and 4 years old have low percentage share 17% and 18%, respectively. Turbots at the age of 3 and 5 years have percentage share of 16%, with the lowest percentage share are turbot at 6+ years old - 1%.

11. The average weight of male fish in the first half of April 2025 was 1.88 kg and ranged from 1.30-2.50 kg. The weight of gonads ranged from 4.45 g and 62.50 g with an average of 20.34 g.
12. The GSI, % values for male fish in the first half of April 2025 ranged from 0.28% to 2.68%, with an average of 1.05%.
13. The average weight of female fish, in the first half of April 2025 was 2.21 kg and was in the range of 1.30-2.72 kg. The weight of the ovary was between 13.96 g and 408.37 g, with an average value of 160.58 g.
14. The values of GSI, % for female fish, in the first half of April 2025 were in the range between 0.93% and 15.01%, with the average value being 6.53%.
15. The average weight of male fish in December 2025 was 2.10 kg and was in the range of 1.35-3.38 kg. The weight of gonads was between 4.10 g and 42.89 g, with a mean of 17.70 g.
16. The GSI, % values for male fish in December 2025 were in the range of 0.19% to 2.24%, with a mean of 0.86%.
17. The average weight of female fish in December 2025 is 2.49 kg and is in the range of 1.25-3.58 kg. The ovary weight is between 15.58 g and 128.60 g, with a mean value of 49.26 g.
18. The GSI, % values for female fish in the month of December are in the range between 0.74% and 4.37%, with a mean value of 1.94%.
19. The absolute fecundity, for April 2025 is 1 559 542.2 eggs/individual, and the relative fecundity is 651 047.6 eggs/BW, kg.
20. The absolute fecundity in August 2025 is 221 943.5 eggs/individual, and the relative fecundity is 67 644.2 eggs/BW, kg.

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21. 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.
22. 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.
23. In the first half of 2025 *Merlangius merlangus*. has the highest value of the index of relative importance (IRI=11901.50), and a dominant share of the percentage composition of the food (IRI, %), respectively 82%.
24. In the first half of 2025 the highest value of the relative importance index was for decomposed remains of fish and/or other organisms (IRI=7950.91) IRI=7950.91 a dominant share of the percentage composition of the food (IRI, %), respectively 75.36%.

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 №158/28.03.2025 with EAFA, Burgas.

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