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BIOLOGICAL MONITORING OF TURBOT (*SCOPHTHALMUS MAXIMUS*) LANDINGS AT THE BULGARIAN BLACK SEA COAST DURING 2021

Institute of Fisheries and Aquaculture, Plovdiv

Agricultural Academy, Sofia

2021

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Проект № BG14MFOP001-3.003-0002-C02, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2020-2021 г.“, финансиран от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство



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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 2021 includes the following main tasks and objectives:

- Collection of data from port landings, vessels for sample collection, number of samples collected, number of measured turbots, 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 2021 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 Shabla, Kavarna, Balchik, Varna, Byala, Nesebar, Pomorie, Sozopol and Tsarevo.

2.1.2. Vessels for sample collection

In 2021, the biological data is collected from 39 landings from ships registered by EAFA according to the Fisheries and Aquaculture Act (Article 16, paragraph 1, item 4).

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Table 1 contains data on ports and ships monitored for the collection of biological data from turbot landings in 2021. 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 2021.

Port	2021 quarter data			
	First quarter	Second quarter	Third quarter	Fourth quarter
Varna	-	1. VN 8396	2. Danchovoto Georgi 3. Hirisimov mladshi 4. Diana/VN 7669	5. RK Lefer 6. Bumerang VN 8250 7. RK Rusano
Kavarna	1. Sv. Nikolai/Vn 8190 2. Paldin/Kv 5642 3. Kaliakra/Vn 8110	4. Kaliakra/Vn 8110 5. Vn 7822	6. Kaliakra/Vn 8110 7. Libra/Vn 8311 8. Neptun/Kv 6321	9. Hishtnik Kv 6262 10. Ivana Kv 6231 11. Hishtnik Kv 6262 12. Ivana Kv 6231
Balchik	1.Kopcap/BH7643	-	-	-
Byala	-	-	-	1. Sv. Nikolai 2. Bl 2109
Shabla	-	-	1. Bh 7919	-
Pomorie	1. Spitur 3/Vn 347	-	2. Admiral III/Pm 323 3. Mechta/Ns 062 4. Mobi Dik/Vn 8012 5. Spitur III/Pm 347	6. Kaliakra Vn 8110 7. Vn 7822
Sozopol	-	1. RK 403/Bs 111	-	-
Tsarevo	1. Varda/Tsr 720	2. Elenka/Tsr 517 3. VardaTs 720	4. Gabriela/Tsr 548 5. Moni/Bs 2035	6. Omar Tsr 480 7. Cyklama 5 Ah 215
Nesebar	-	1. Sv. Nikola I/Bs175	-	-

The landings are performed as follows: 7 at Varna port, 12 landings at Kavarna port, 1 at Balchik port, 2 at Byala port, 1 at Shabla port, 7 at Pomorie port, 1 at Sozopol port, 7 at Tsarevo port and 1 landing at Nesebar port.

2.1.3. Number of collected samples

From a total of 39 landings, biological data from 928 fish is collected, which corresponds to the number of fish landed or 100% of the landings are measured (**Table 2**).

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Table 2. Landing data for the monitored ports in 2021.

Port	2021 quarter data				Total
	First quarter	Second quarter	Third quarter	Fourth quarter	
Varna	-	20	100	50	170
Kavarna	78	50	64	138	330
Balchik	39	-	-	-	39
Byala	-	-	-	38	38
Shabla	-	-	20	-	20
Pomorie	8	-	118	50	176
Sozopol	-	28	-	-	28
Tsarevo	2	39	9	38	88
Nesebar	-	39	-	-	39
Total	127	176	311	314	928

The biological data is collected as follows: 127 specimens in first quarter, 176 fish in the second quarter, 311 specimens in the third quarter and 314 turbots in the fourth quarter of 2021.

2.1.4. Number of studied turbots

The total number of specimens, from which biological data is collected, is 928 with total weight of 2785.50 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 Varna, Kavarna, Balchik, Byala, Shabla, Pomorie, Sozopol, Tsarevo and Nesebar in 2021 are presented in **Table 3**.

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Table 3. Coordinates and depths of turbot catch locations in 2021

№	Vessel	Coordinates of catch locations		Depth of catch location (m)
		latitude	longitude	
First quarter 2021				
1.	Varda/Tsr 720	42°17'57"N	28°10'59"E	60-65
2.	Spitur 3/Vn 347	42°28'38"N	28°09'16"E	80
3.	Korsar/Vn 7643	43°32'28"N	29°11'47"E	60-65
4.	Sv. Nikolai/Vn 8190	43°18'10"N	28°23'45"E	20-25
5.	Paldin/Kv 5642	43°16'59"N	28°35'28"E	65-70
6.	Kaliakra/Vn 8110	43°38'59"N	28°54'28"E	60-65
Second quarter 2021				
1.	Vn 8396	43°16'32"N	28°31'42"E	60
2.	Vn 7822	44°03'05"N	29°45'00"E	65-75
3.	Kaliakra/Vn 8110	44°03'12"N	29°46'16"E	65-70
4.	Sv. Nikola I/Bs 175	42°37'45"N	28°16'20"E	90
5.	RK 403/Bs 111	42°15'50"N	28°07'81"E	60-70
6.	Varda/Tsr 720	42°11'05"N	27°56'75"E	60-70
7.	Elenka/Tsr 517	42°13'98"N	28°05'79"E	65
Third quarter 2021				
1.	Danchovoto Georgi	43°43'10"N	28°57'52"E	60
2.	Hirisimov mladshi	43°37'12"N	29°14'41"E	55-60
3.	Diana/Vn 7669	43°31'55"N	29°35'04"E	45-55
4.	VN 7919	43°42'60"N	28°41'45"E	55-65
5.	Kaliakra/VN 8110	43°40'09"N	28°45'05"E	55-60
6.	Libra/VN 8311	43°42'08"N	28°45'06"E	65
7.	Neptun/Kv 6321	43°40'09"N	28°34'58"E	50-65
8.	Admiral III/Pm 323	42°37'43"N	28°40'58"E	60-70
9.	Mechta/Ns 062	42°25'40"N	28°36'22"E	70
10.	Mobi Dik/Vn8012	42°37'35"N	28°30'18"E	55-65
11.	Spitur III/Pm 347	42°36'28"N	28°32'16"E	65
12.	Gabriela/Tsr 548	42°15'27"N	28°20'47"E	50-65
13.	Moni/Bs 2035	42°17'18"N	28°23'50"E	60-70
Fourth quarter 2021				
1.	RK Lefer	43°23'41.9"N	28°49'29.9"E	50
2.	Bumerang Vn 8250	43°38'15.8"N	28°46'10.6"E	40-50
3.	RK Rusano	43°39'56"N	28°49'58"E	40-50

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4.	Sv. Nikolai	43°43'10"N	28°57'52"E	50
5.	B1 2109	43°40'47.0"N	28°52'03.9"E	30-40
6.	Hishtnik Kv 6262	43°37'38.8"N	29°03'33.4"E	35-40
7.	Ivana Kv 6231	43°34'47.0"N	29°20'41.8"E	45
8.	Hishtnik Kv 6262	43°42'08"N	28°45'06"E	35-40
9.	Ivana Kv 6231	43°31'55"N	29°35'04"E	50
10.	Kaliakra Vn 8110	42°45'36.3"N	29°05'55.5"E	30-40
11.	Vn 7822	42°27'18.7"N	28°26'38.6"E	40
12.	Omar Tsr 480	42°22'24.2"N	28°14'22.7"E	40-50
13.	Cyklama 5 Ah 215	42°21'58.6"N	28°40'12.9"E	50

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

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:

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

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 turbots (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

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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 2021, a total of 100 turbots are purchased, as in the spring-summer and autumn-winter period 50 turbots 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):

$$\text{GSI (\%)} = \frac{\text{Wg}}{\text{W}} \cdot 100, \text{ where}$$

Wg – weight of the gonads, g;

W – body weight, g.

- **Fecundity of female fish**

The fecundity is determined on the basis of 22 female fish caught and purchased in the first half of April 2021. The fecundity of 30 female fish caught during a trawl survey in

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the period 9-19 May 2021 is also determined. 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 turbots, caught and purchased in the first half of April 2021 and 50 turbots, caught and purchased in December 2021. The degree of maturity of 30 female fish caught during trawl survey in the period 9-19 May 2021 has been determined. 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 turbots have been studied – 50 specimens in the second quarter of 2021 and 50 in the fourth quarter of 2021. 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:

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

- 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):

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

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

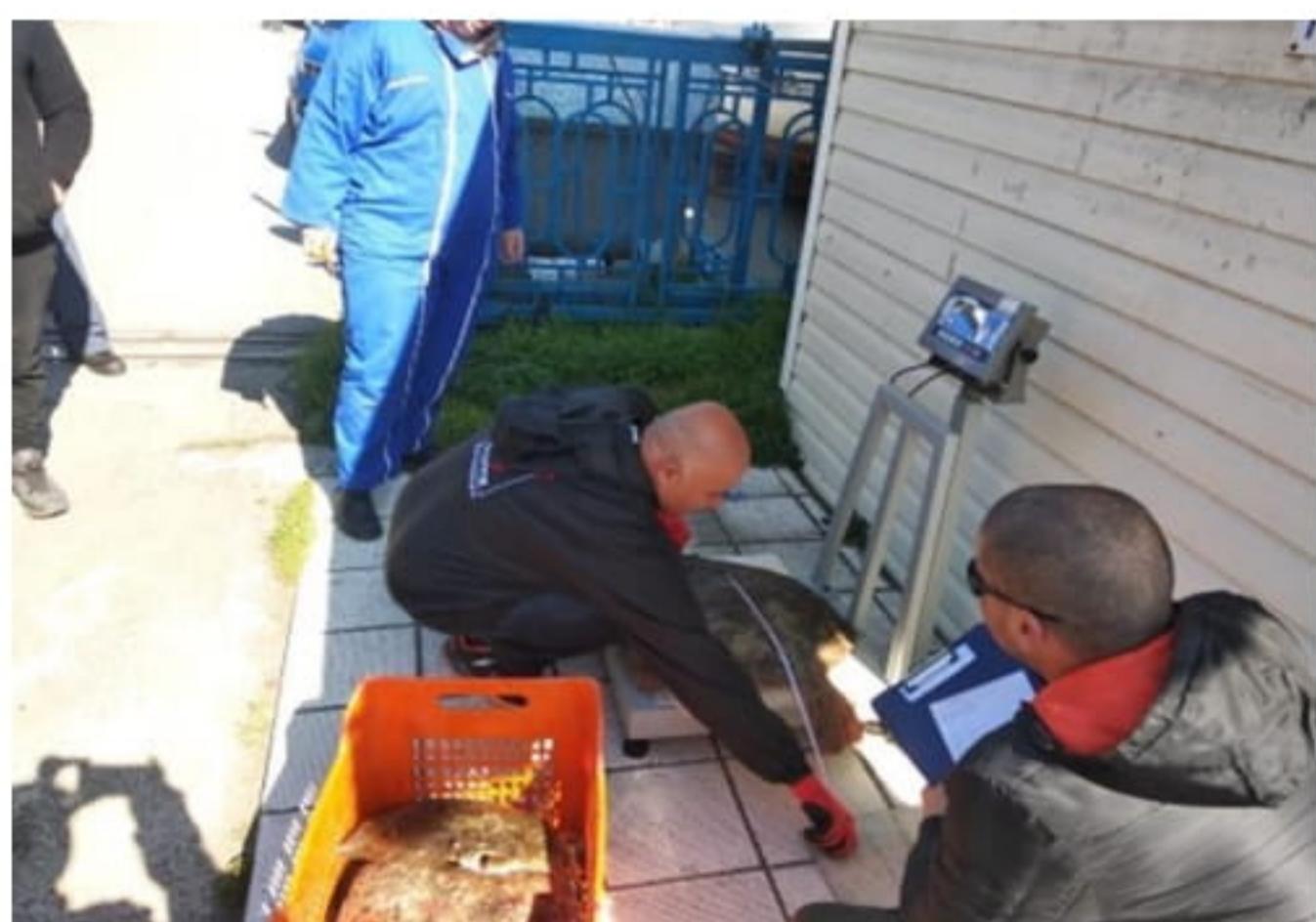


Image 1-2. Measurements of the fish at the port, immediately after docking of the vessels

3. Results

3.1. Number of turbots landed by vessels

The total number of fish, from which biological data is collected, is 928. The number of turbots caught by each vessel is presented in **Fig. 1**.

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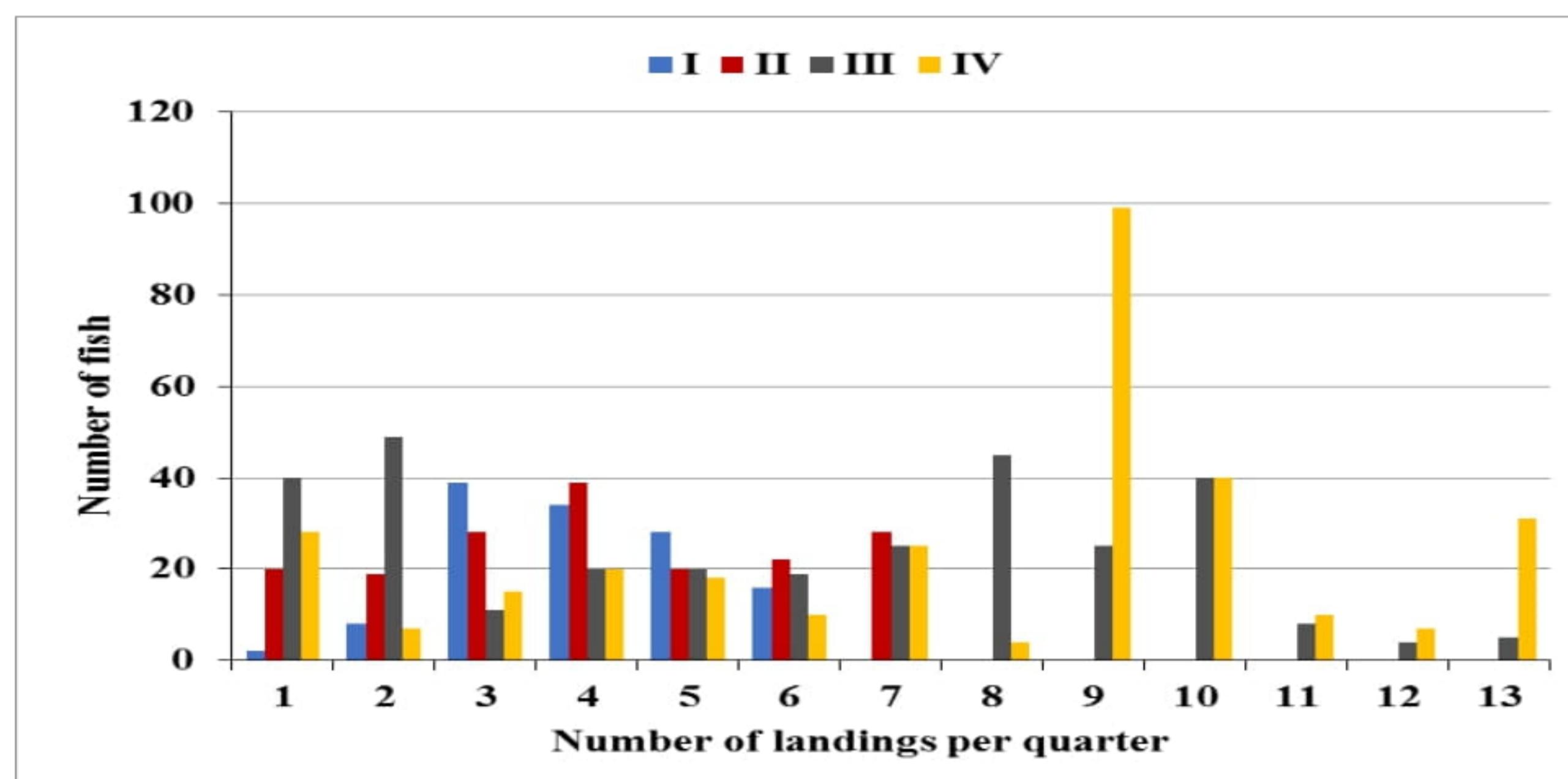


Fig. 1. Number of fish caught by vessel and landed in 2021

In 2021 an average of 24 fish are caught per vessel, with a maximum of 99 fish and a minimum of 2 fish.

3.2. Weight structure of turbot landings

The average weight of the measured specimens is 3.00 kg. The maximum measured weight is 9.75 kg, and the minimum - 1.60 kg.

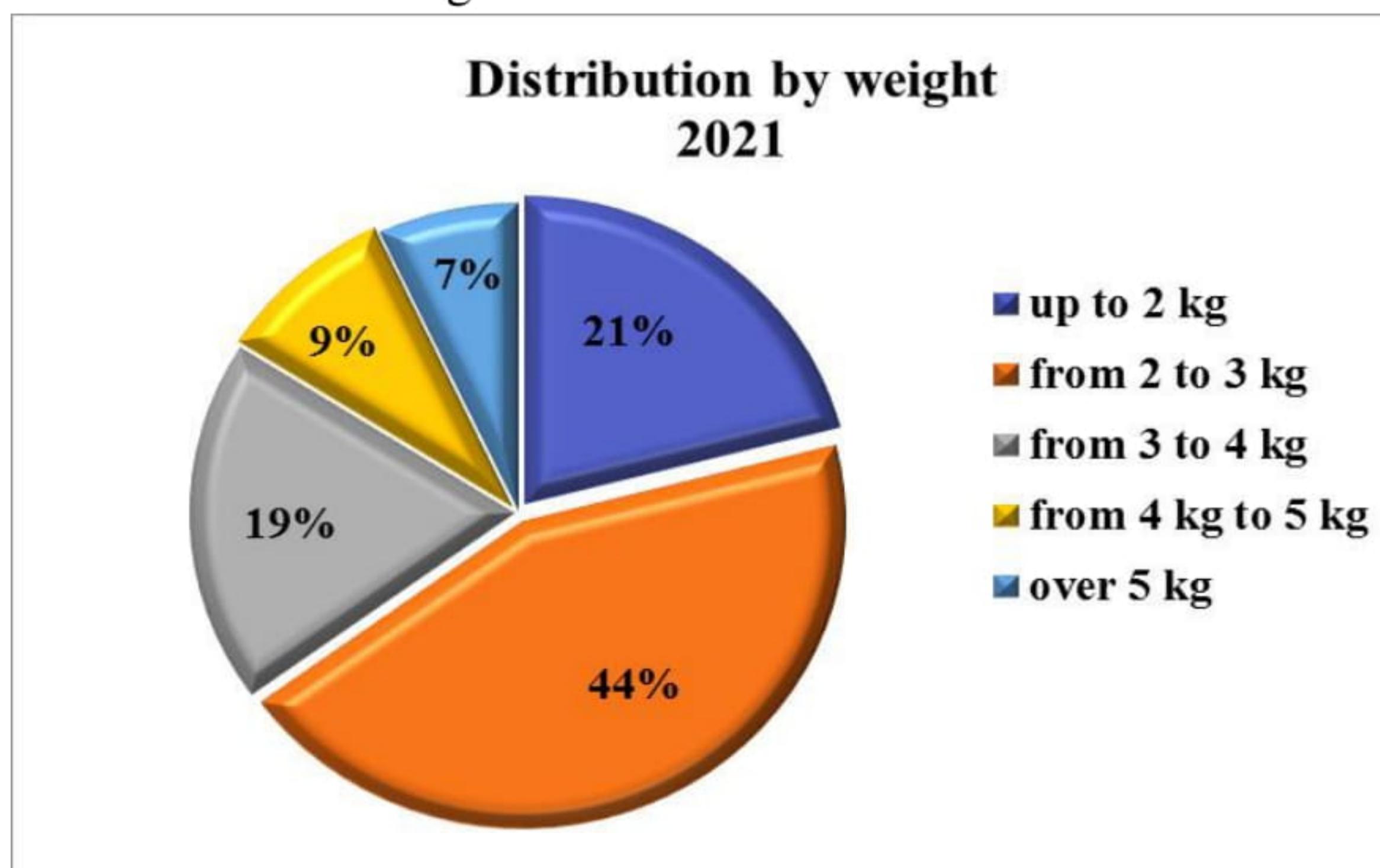


Fig. 2. Percentage distribution of turbot landings by weight in 2021

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The distribution of the landings by fish weight is presented in **Fig. 2**. From 928 turbots, 192 specimens (21%) have a weight up to 2 kg. The fish with weight from 2 to 3 kg take 44% - 412 specimens from the measured fish. The weight group from 3 kg 4 kg is represented by 175 specimens or 19% of the representative sample. The turbots with weight from 4 kg to 5 kg take 9% or 86 specimens from the studied individuals. With the lowest percentage distribution are the fish with weight over 5 kg – 7% or 63 specimens.

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

The average value of the total length (TL, cm) of the measured specimens is 55.66 cm, with maximum measured 78.00 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.

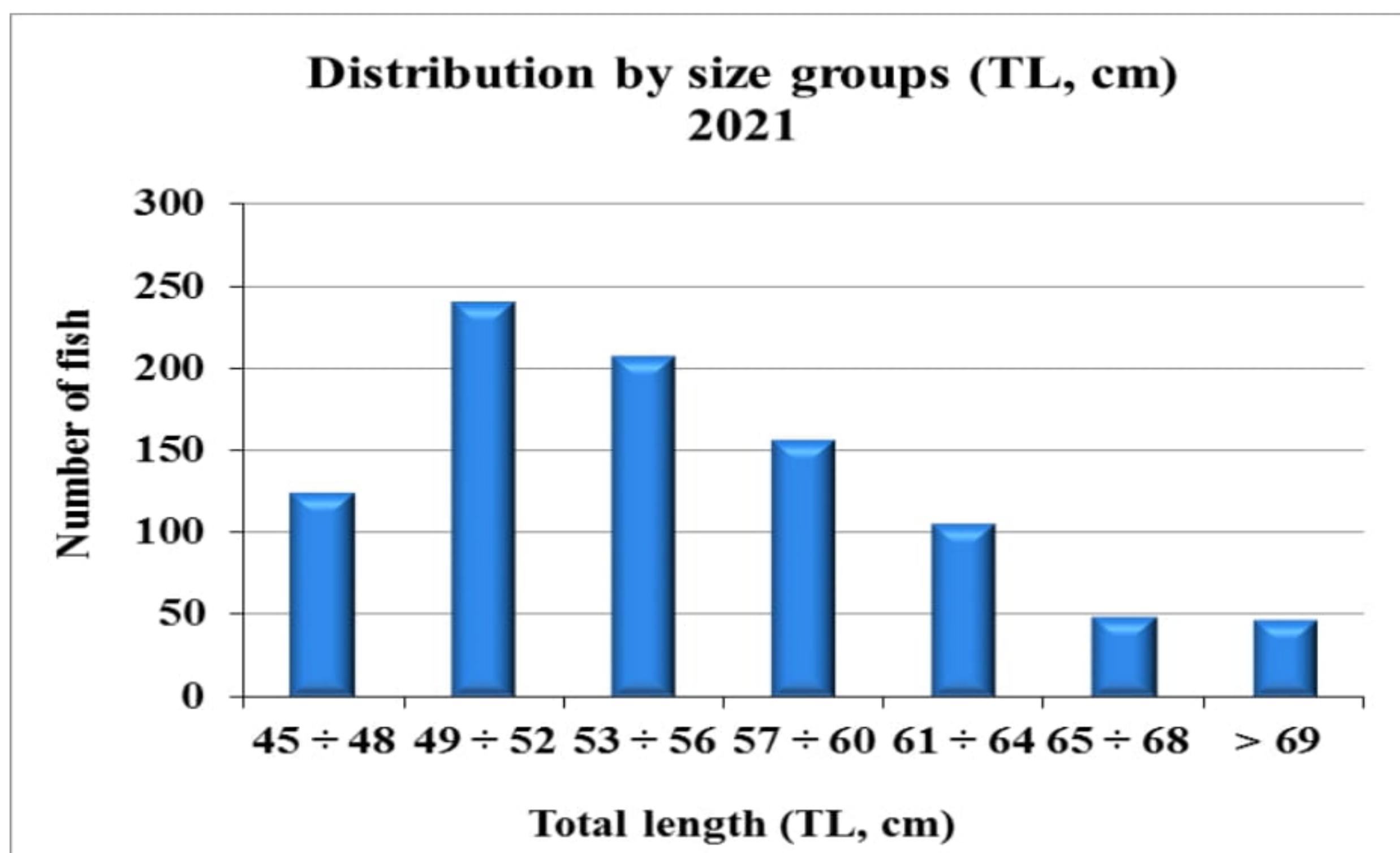


Fig. 3. Size structure (total length) of turbot landings in 2021



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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 25.86% of the landings, followed by the groups 53-56 cm (22.31%) and 57-60 cm (16.81%). The individuals with total body length in the range 45-48 cm are 124 specimens, which represents 13.36% of all measured specimens. Fish with a total body length between 61 cm and 68 cm are 154 specimens or 16.59% of all measured fish. Fish over 69 cm are 47 specimens or 5.06%.

Fig. 4 shows the dynamics of the distribution of the values of the standard body length (SL, cm) of the measured individuals for 2021. The average value of the standard body length (SL, cm) is 43.02 cm. The maximum measured standard length is 66.00 cm and the minimum measured - 32.00 cm.

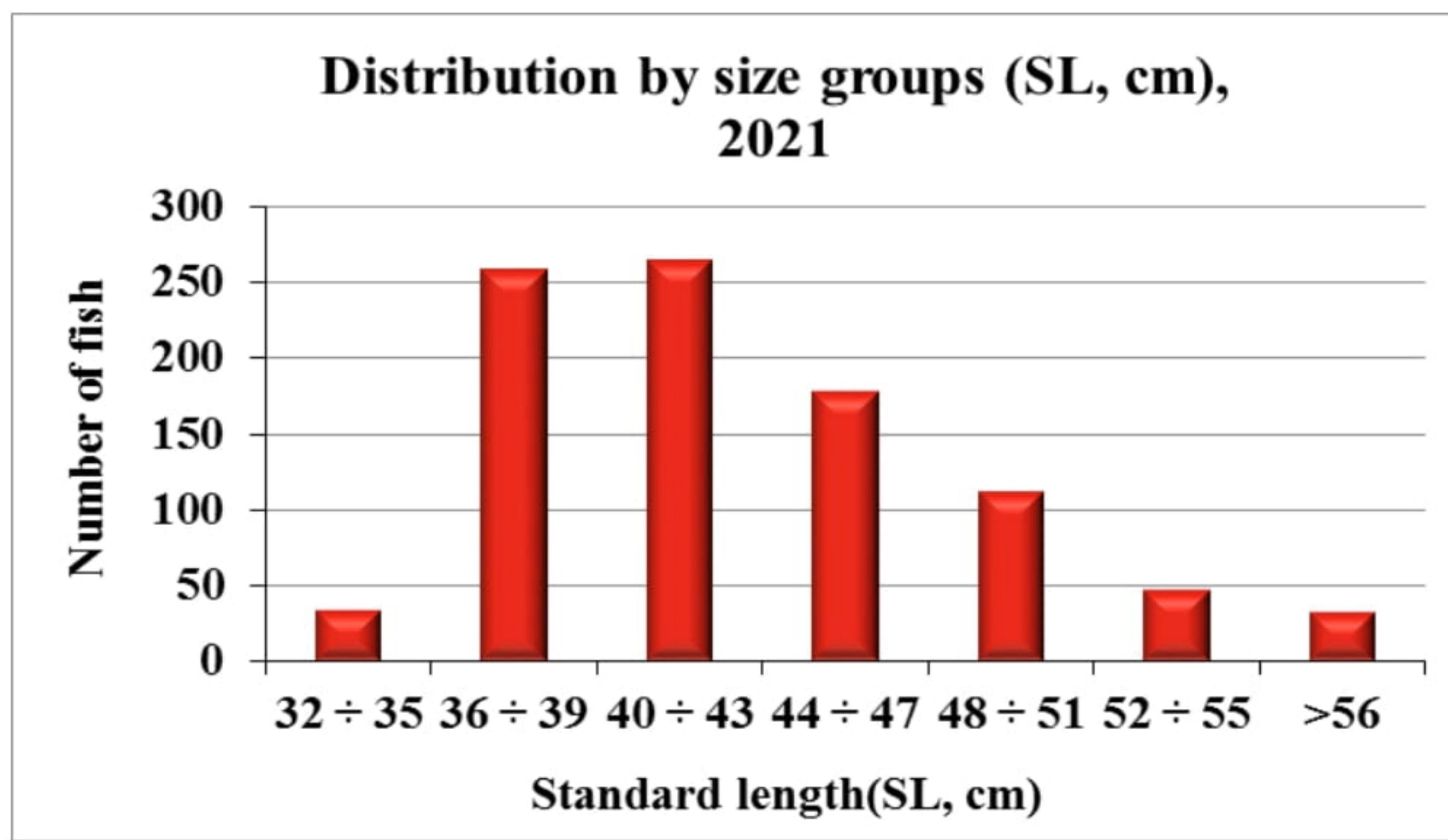


Fig. 4. Size structure (standard length) of turbot landings in 2021.



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From the distribution of individuals by size groups according by standard length (SL, cm) it is established that the group 40-43 cm is represented most widely (264 specimens - 28.45%). It is followed by the groups 36-39 cm (258 specimens - 27.80%) and 44-47 cm (178 specimens - 19.18%). Individuals with a standard body length in the range of 48-51 cm are 112 specimens, which represents 12.07% of all measured specimens. Fish with standard body length in the groups 52-55 cm and 32-35 cm are 5.17% and 3.77%, respectively. With the lowest percentage are turbots with a standard body length above 56 cm - 33 specimens or 3.56%. The correlation between turbot size and weight is shown in **Fig. 5.**

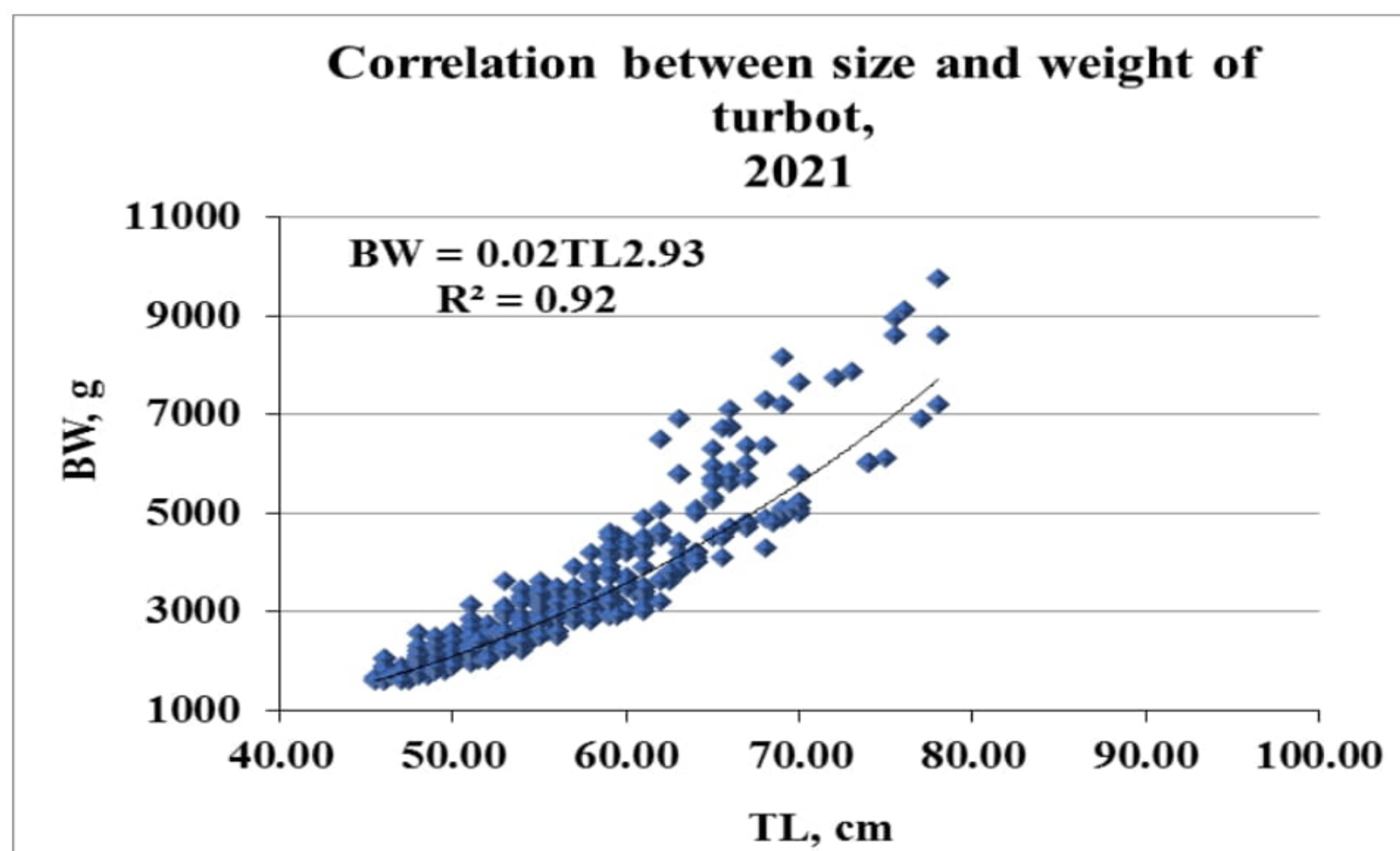


Fig. 5. Correlation between size and weight of turbot in 2021, n=928.

The correlation between the size and weight of the turbot is clearly expressed, described by the equation: **BW = 0.02TL^{2.93}**.



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3.4. Age structure and growth

To determine the age composition of turbot catches for 2021, 100 pairs of otoliths are studied. The age composition of the studied turbot specimens include from 3 to 8-year-old individuals, with five (42%) and six (25%) year-old fish being predominant. In total, they represent 67% of the total number of specimens studied (**Fig. 6**). The percentage of turbot age 4 and 7 years is 16% and 11%, respectively. The lowest percentage is of fish at 3 years and 8 years of age, respectively, with 3 specimens or 3% of the age composition.

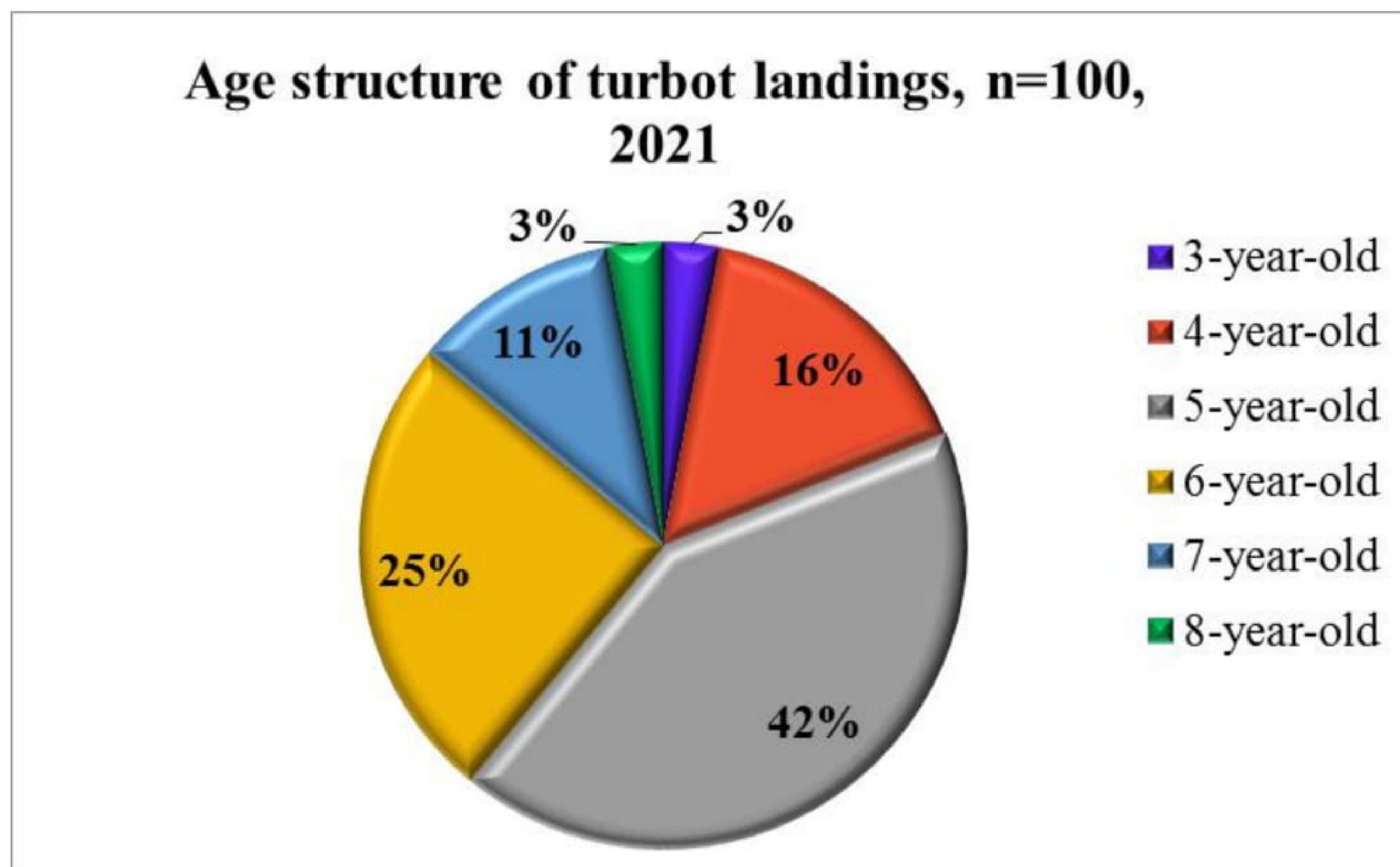


Fig. 6. Age structure of turbot landings in 2021, n=100.

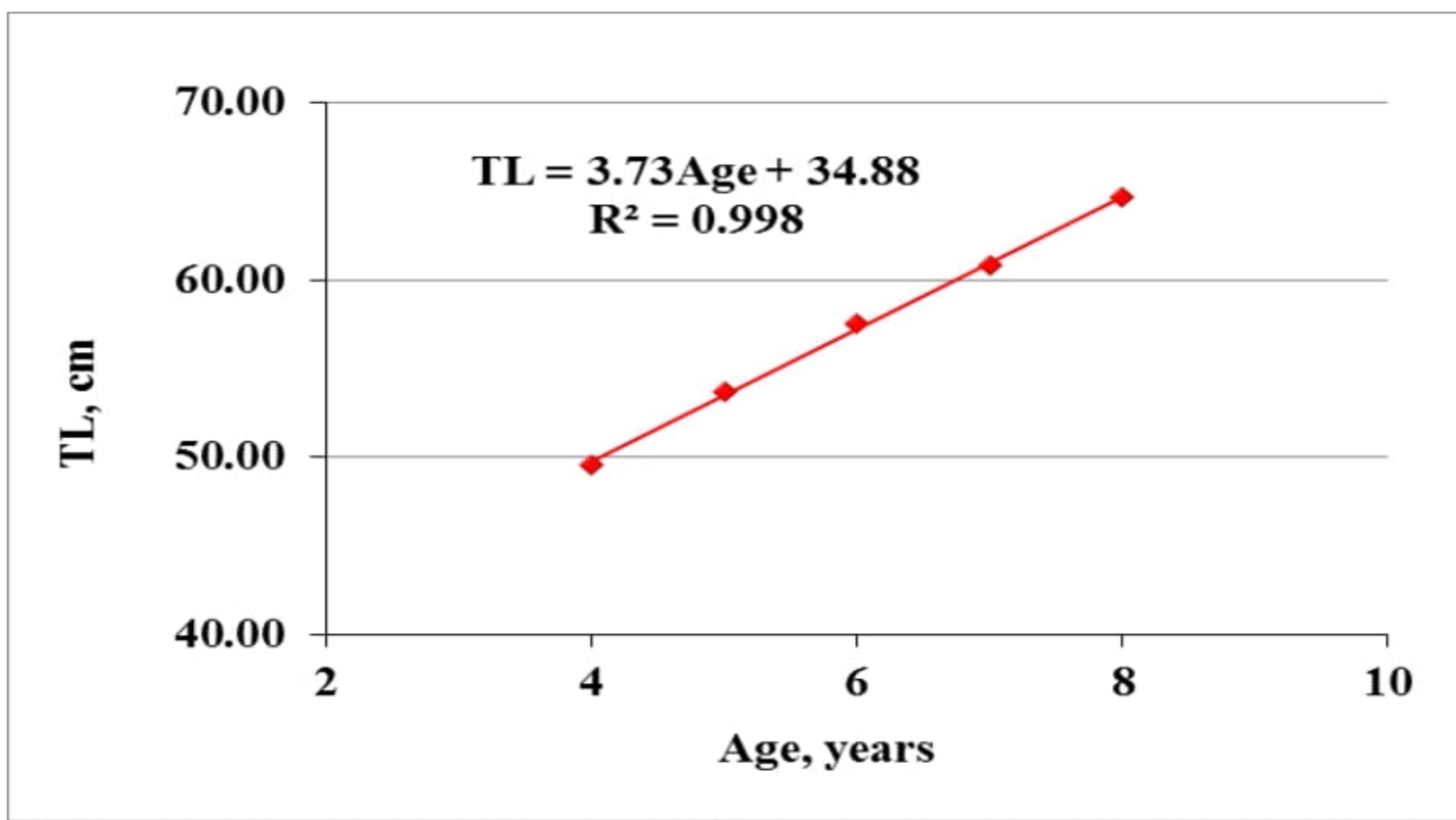
The correlation between total length of the body and age is presented in **Fig. 7** for female fish (57 specimens) and in **Fig. 8** for male fish (43 specimens).



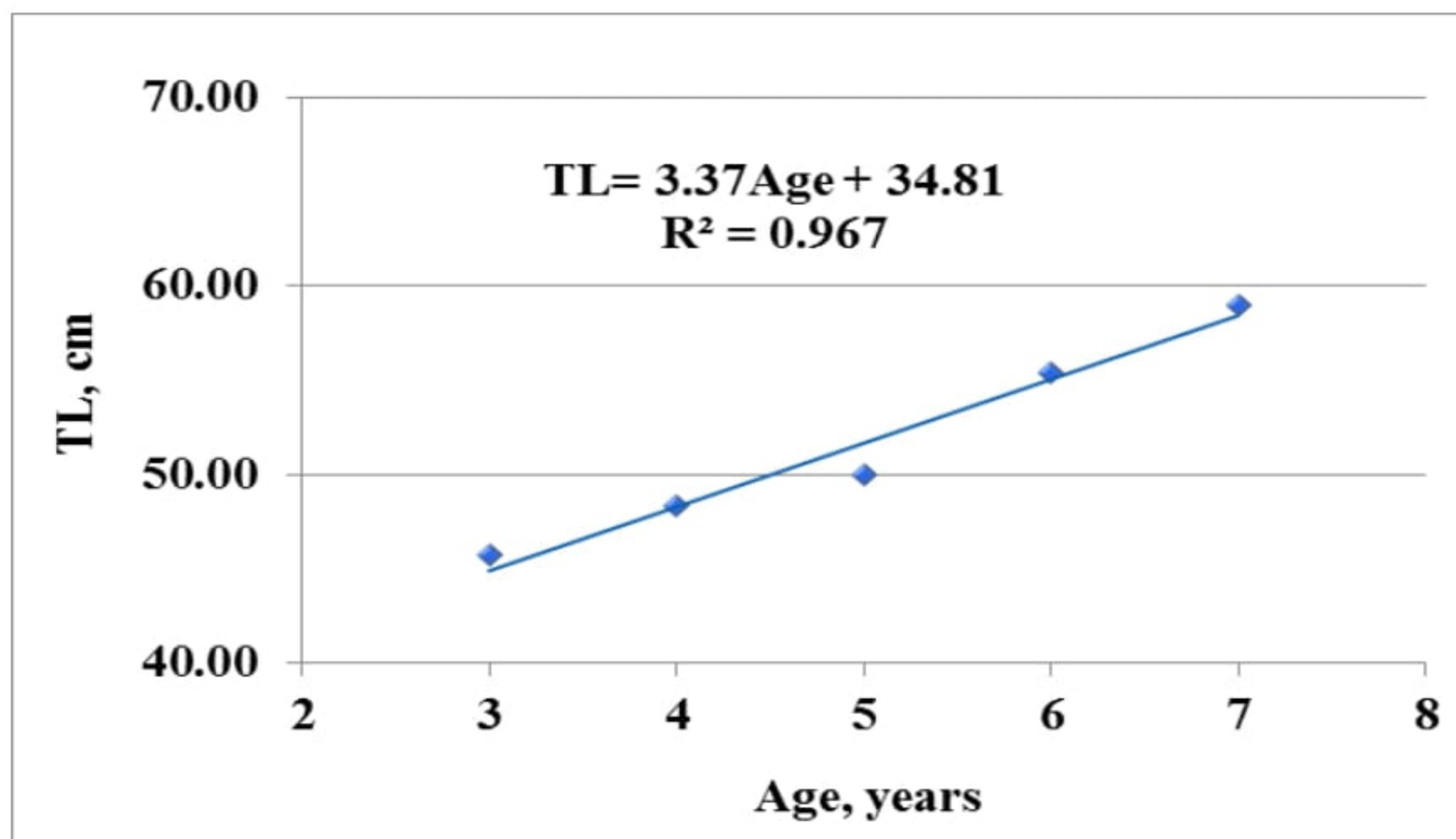
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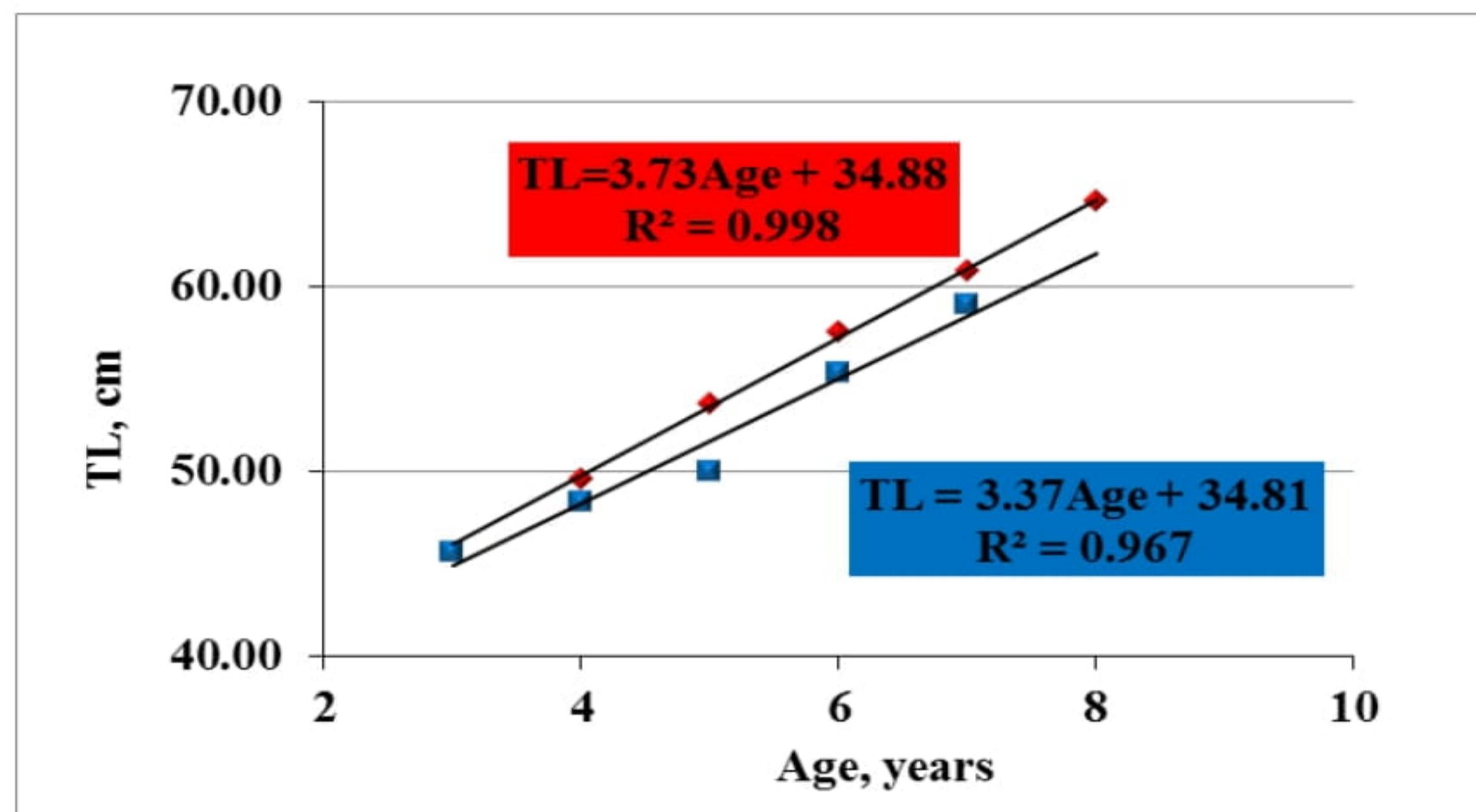
**Fig. 7. Correlation between total length and age of female fish in 2021,
n=57**



**Fig. 8. Correlation between total length and age of male fish in 2021,
n=43**



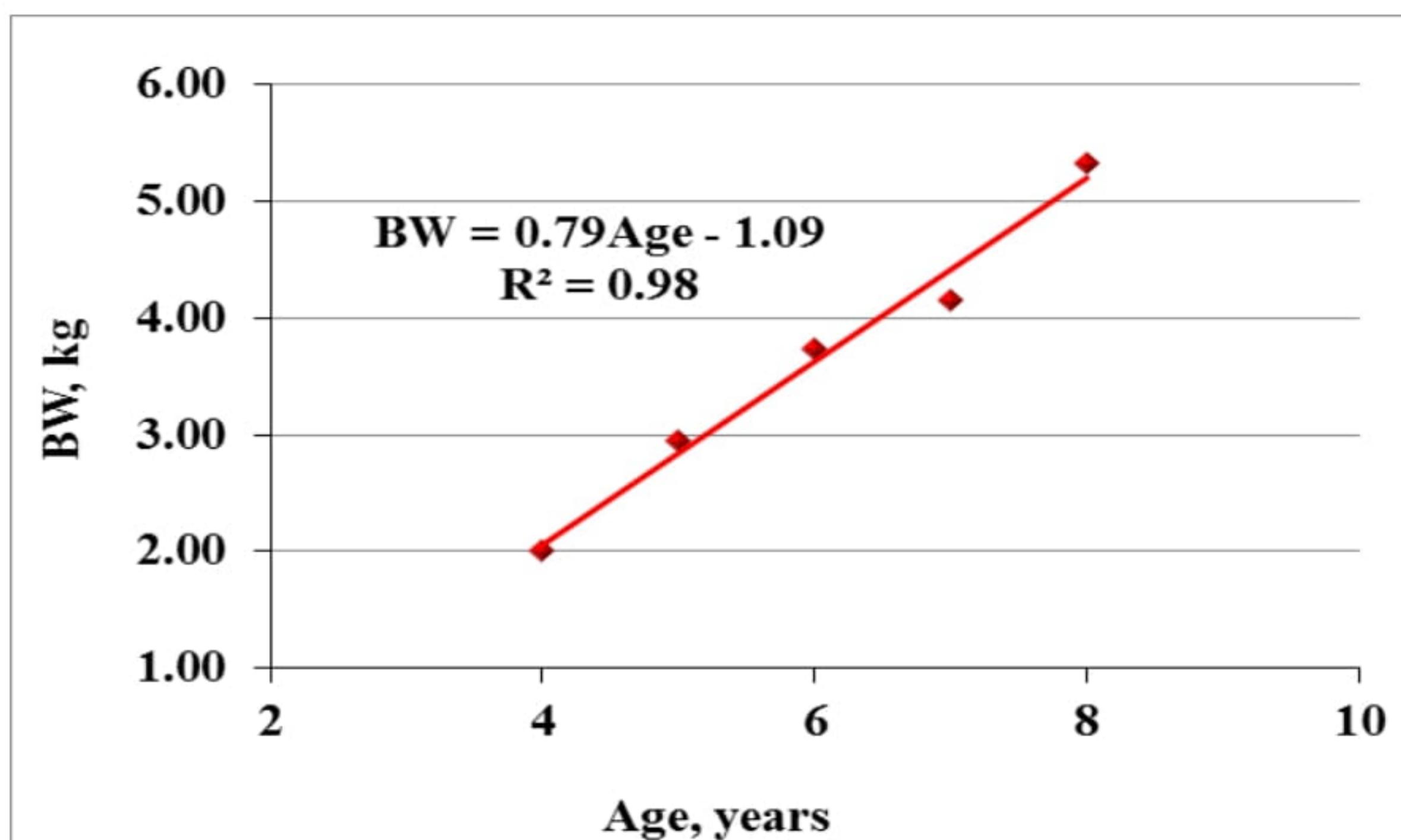
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**Fig. 9. Linear growth of turbot by age in 2021,
n=100**

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 (57 specimens) and in **Fig. 11** for male fish (43 specimens).



**Fig. 10. Correlation between body weight (BW, kg) and age of female turbot in 2021,
n=57**

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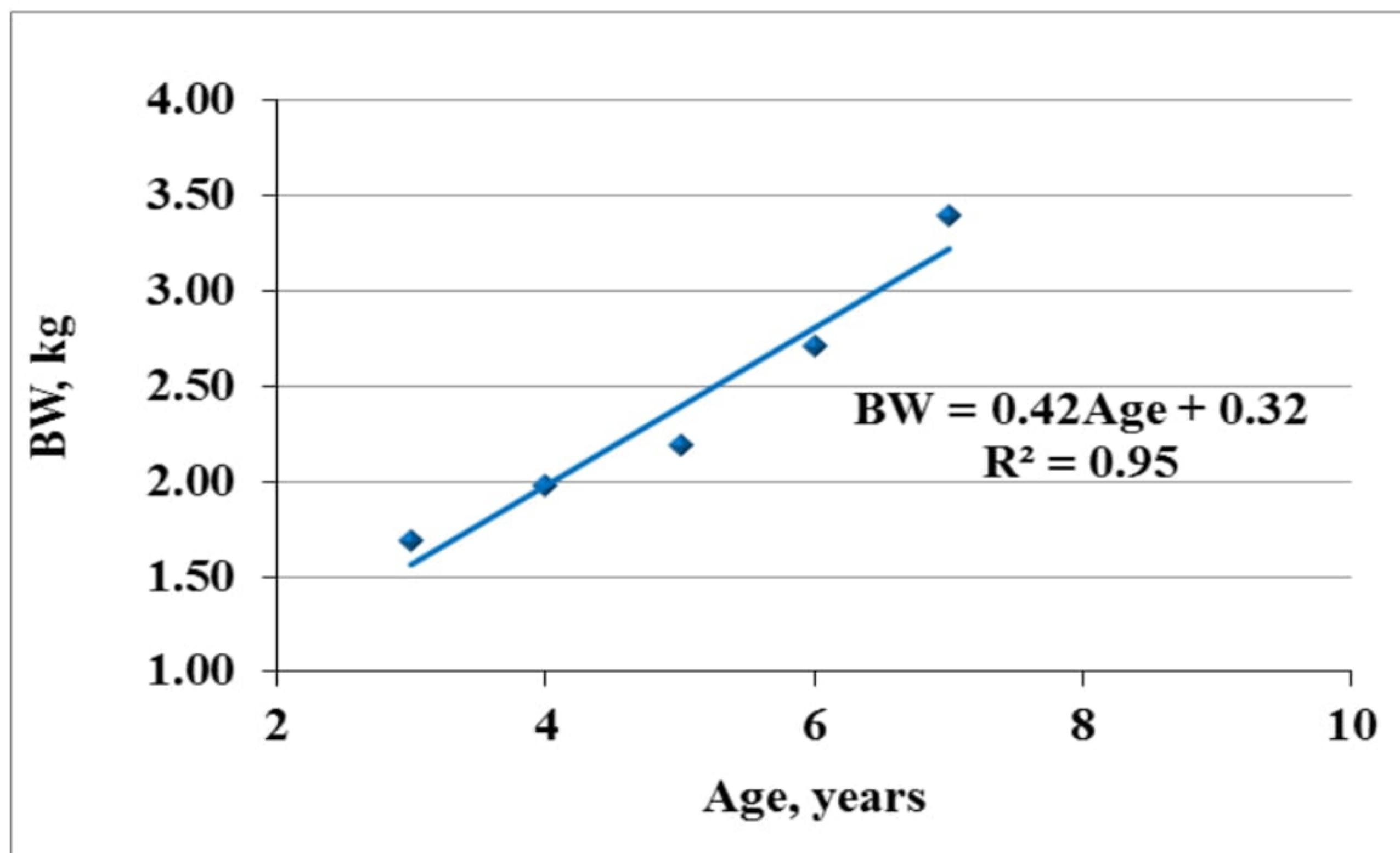


Fig. 11. Correlation between body weight (BW, kg) and age of female turbot in 2021,
n=43

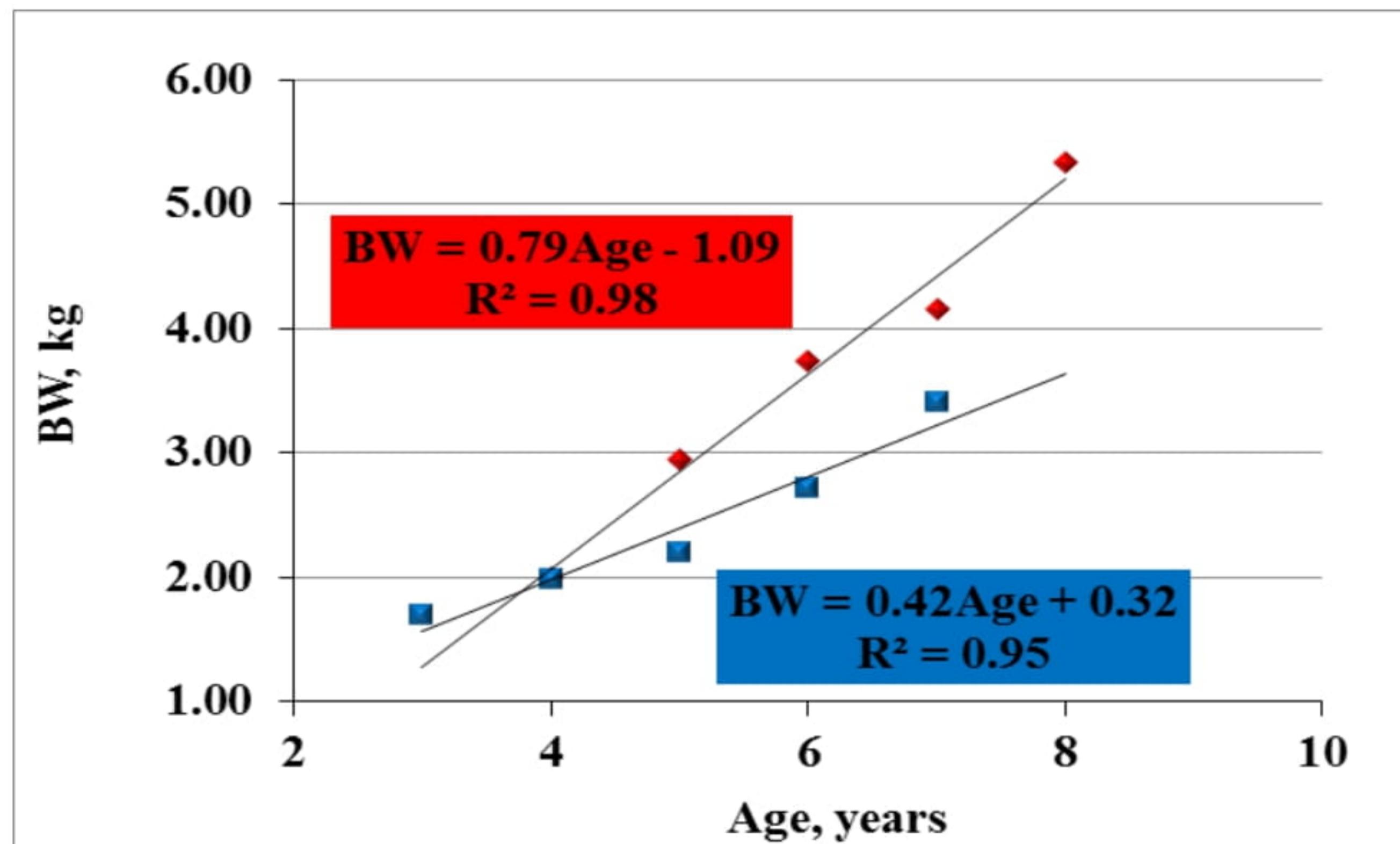


Fig. 12. Correlation between body weight and age of turbot in 2021,
n=100

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From **Fig.12** it can be seen that females above 2 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 57 specimens are female and 43 specimens are males. The percentage of females and males is 57% to 43% in favor of females.

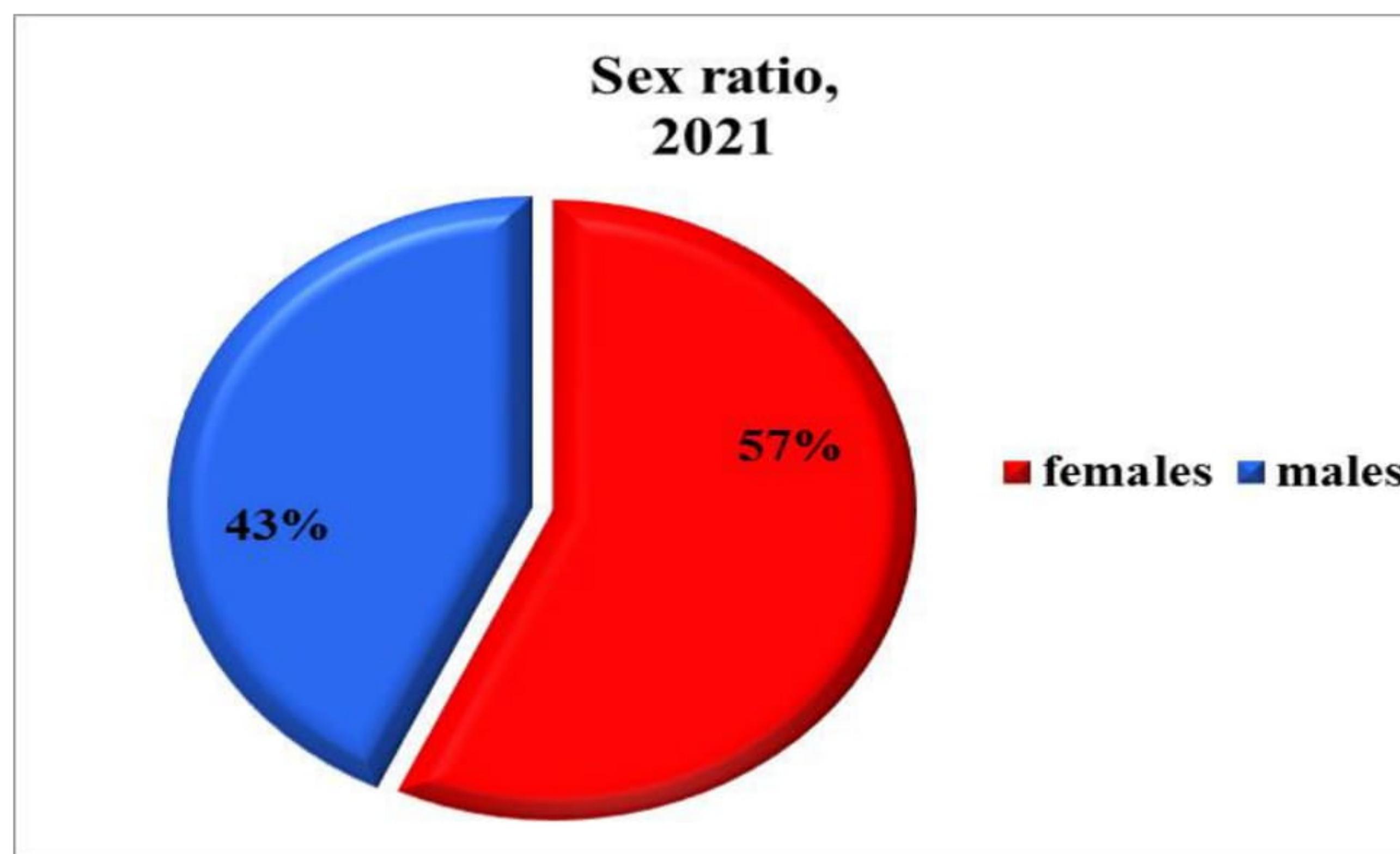


Fig. 13. Percentage distribution between female and male individuals in 2021, n=100

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.

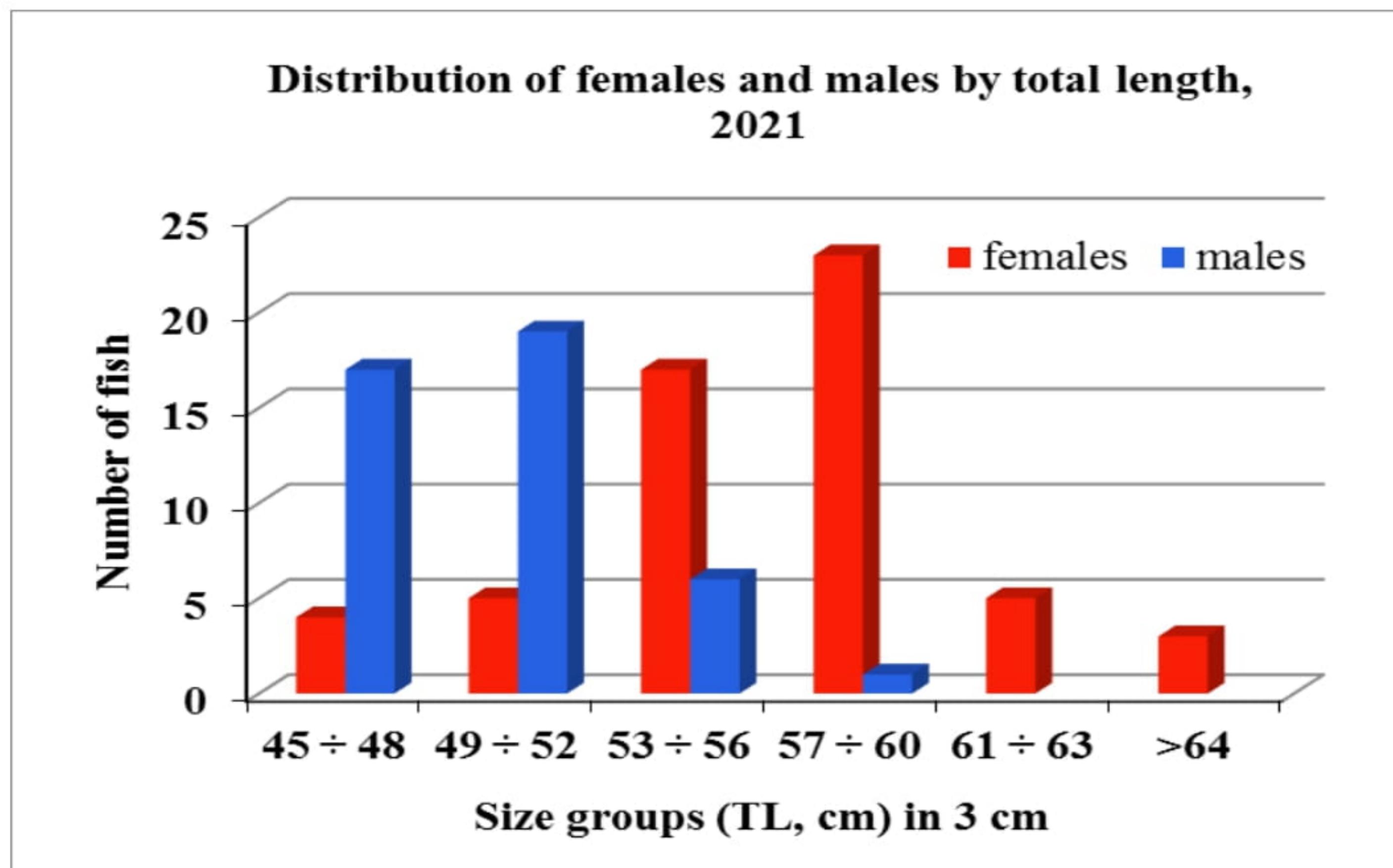
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**Fig. 14. Distribution of females and males by total length of the body (TL, cm), (n=100;
f=57, m=43)**

Males with a total body length of up to 60.00 cm predominate. At a length of more than 53.00 cm, the percentage of female individuals increases (**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	> 64
Number of male individuals	17	19	6	1	-	-
Number of female individuals	4	5	17	23	5	3
Ratio males/females	4.25:1	3.8:1	1:2.83	1:23	-	-

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**.

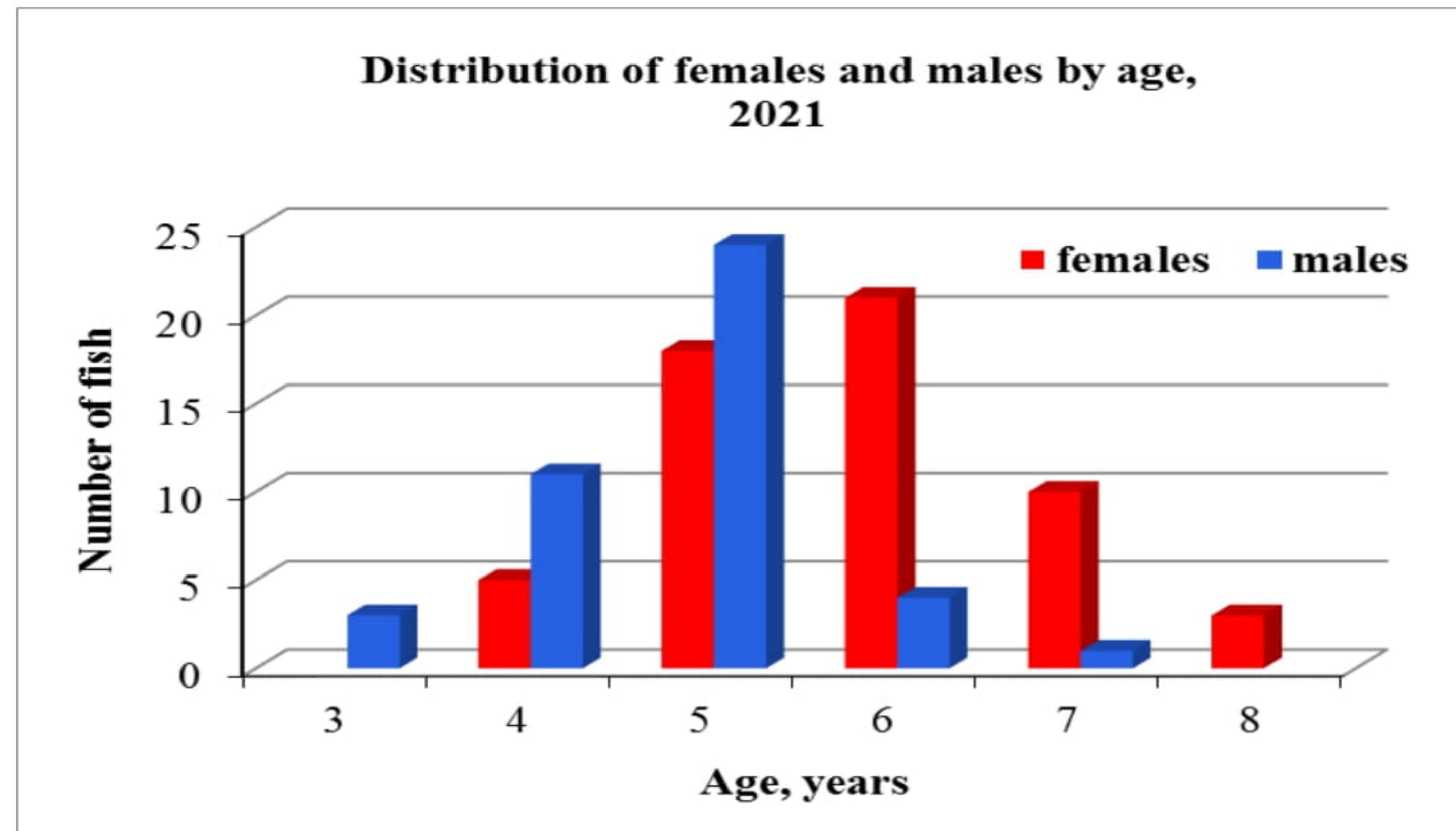
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**Fig. 15. Distribution of females and males in relation to age
(n=100; f=54, m=46)**

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	8
Number of male individuals	3	11	24	4	1	-
Number of female individuals	-	5	18	21	10	3
Ratio males/females	-	2.2:1	1.33:1	1:5.25	1:10	-

The results show that 4 and 5 year-old turbot predominate in males and 6 and 7 year-old fish - in females.



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3.5.4. Gonadosomatic index (GSI, %)

Gonadosomatic index – second quarter of 2021

The average weight of male fish in the first half of April 2021 is 2.09 kg and it is in the range 1.64-3.00 kg. The weight of the gonads is between 5.00 g and 35.00 g, with an average value of 17.90 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 2021

First half of April 2021						
Nº	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	1.74	45.50	34.00	11.18	0.64	3
2	2.25	50.00	38.00	15.00	0.67	5
3	2.35	52.50	40.50	5.00	0.21	5
4	2.45	53.00	41.00	20.00	0.82	5
5	1.90	50.00	39.50	15.00	0.79	4
6	1.78	48.50	37.00	15.00	0.84	4
7	1.80	49.00	37.50	15.00	0.83	5
8	2.22	51.00	39.00	10.00	0.45	5
9	2.16	47.50	37.00	20.00	0.93	5
10	1.80	48.00	38.00	15.00	0.83	5
11	2.00	48.50	37.00	20.00	1.00	5
12	3.00	56.00	43.00	35.00	1.17	6
13	1.97	50.00	38.00	25.00	1.27	5
14	2.32	51.00	39.00	30.00	1.29	5
15	1.64	45.50	35.00	15.00	0.91	3
16	1.69	46.00	36.00	15.00	0.89	3
17	2.22	48.50	38.00	15.00	0.68	5
18	2.18	50.00	37.50	35.00	1.61	5
19	2.30	52.00	39.00	25.00	1.09	5

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20	2.33	51.00	39.00	20.00	0.86	5
21	2.25	51.00	39.50	20.00	0.89	5
22	1.85	55.50	43.00	15.00	0.81	6
23	2.16	47.00	37.00	15.00	0.69	5
24	1.96	48.00	37.50	10.00	0.51	4
25	1.95	47.00	35.00	15.00	0.77	5
26	2.05	48.00	37.00	5.00	0.24	5
27	2.12	49.50	39.00	15.00	0.71	5
28	2.19	52.00	39.50	30.00	1.37	5
ave	2.09	49.70	38.23	17.90	0.85	5
min	1.64	45.50	34.00	5.00	0.21	3
max	3.00	56.00	43.00	35.00	1.61	6

The GSI values, % for male fish in the first half of April 2021 are in the range of 0.21% and 1.61%, with an average of 0.85%.

The average weight of female fish in the first half of April 2021 is 3.63 kg and it is in the range of 1.82-5.49 kg. The weight of the ovary is between 15.00 g and 870.00 g, with an average value of 431.07 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 2021

First half of April 2021						
Nº	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	5.49	65.00	49.50	540.00	9.84	8
2	4.50	56.50	43.00	770.00	17.11	5
3	4.20	56.00	44.00	565.00	13.45	6
4	2.40	54.00	41.00	180.00	7.50	5
5	4.50	60.50	47.00	685.00	15.22	7

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6	4.50	58.50	46.00	745.00	16.56	6
7	2.10	49.50	37.50	185.00	8.81	5
8	3.75	58.00	45.00	570.00	15.20	6
9	4.40	58.00	45.00	675.00	15.34	6
10	3.85	57.00	45.00	555.00	14.42	6
11	4.25	58.00	46.00	540.00	12.71	6
12	5.10	64.00	50.00	870.00	17.06	8
13	2.25	53.00	40.00	15.00	0.67	5
14	2.00	48.50	38.00	80.00	4.00	4
15	3.46	56.00	44.00	290.00	8.38	6
16	3.95	57.50	45.50	73.60	1.86	6
17	5.40	65.00	52.00	790.00	14.63	8
18	4.23	60.00	46.00	515.00	12.17	7
19	3.65	58.00	45.00	515.00	14.11	6
20	1.82	48.50	38.00	50.00	2.75	4
21	2.02	47.50	37.00	165.00	8.17	5
22	2.04	49.00	37.50	110.00	5.39	5
ave	3.63	56.27	43.73	431.07	10.70	6
min	1.82	47.50	37.00	15.00	0.67	4
max	5.49	65.00	52.00	870.00	17.11	8

GSI values,% for female fish in the first half of April 2021 are in the range between 0.67% and 17.11%, with an average of 10.70%.

Gonadosomatic index – December 2021

The average weight of male fish in December 2021 is 2.33 kg and it is in the range of 1.80-3.40 kg. The weight of the gonads is between 5.00 g and 25.00 g, with an average value of 16.12 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 males in December 2021

December 2021						
Nº	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	2.20	53.00	39.00	5.00	0.23	5
2	2.80	54.00	42.00	15.00	0.54	6
3	3.20	56.00	44.00	15.00	0.47	6
4	2.30	48.00	37.00	15.00	0.65	4
5	1.80	47.00	37.00	25.00	1.39	4
6	2.10	49.00	39.00	25.00	1.19	4
7	2.40	52.00	40.00	20.00	0.83	5
8	2.00	49.00	38.00	15.00	0.75	4
9	3.40	59.00	46.00	20.00	0.59	7
10	2.10	48.00	37.00	18.03	0.86	4
11	2.00	49.00	38.00	19.00	0.95	4
12	2.30	49.00	37.00	19.21	0.84	5
13	2.00	48.00	36.00	9.96	0.50	4
14	1.80	47.00	36.50	14.07	0.78	4
15	2.50	49.00	38.00	6.47	0.26	5
ave	2.33	50.47	38.97	16.12	0.72	5
min	1.80	47.00	36.00	5.00	0.23	4
max	3.40	59.00	46.00	25.00	1.39	7

GSI values,% for male fish in December 2021 are in the range of 0.23% and 1.39%, with an average value of 0.72%.

The average weight of female fish in December 2021 is 3.40 kg and it is in the range of 2.00-4.60 kg. Ovarian weight is between 33.77 g and 175.00 g, with an average value of 92.59 g (**Table 9**).



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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 2021

December 2021						
Nº	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	2.00	52.00	40.00	40.00	2.00	4
2	3.50	57.00	45.00	50.00	1.43	6
3	3.60	60.00	48.00	90.00	2.50	7
4	3.50	56.00	44.00	80.00	2.29	6
5	4.20	61.00	49.00	120.00	2.86	7
6	3.50	58.00	46.00	45.00	1.29	6
7	4.30	60.00	48.00	100.00	2.33	7
8	3.60	55.00	44.00	95.00	2.64	5
9	3.20	55.00	41.00	45.00	1.41	5
10	2.90	55.00	42.00	60.00	2.07	5
11	2.90	55.00	42.00	105.00	3.62	5
12	3.20	56.00	43.00	90.00	2.81	5
13	3.70	59.00	45.00	160.00	4.32	6
14	3.40	57.00	45.00	105.00	3.09	6
15	3.50	60.00	46.00	155.00	4.43	7
16	3.90	61.00	49.00	175.00	4.49	7
17	3.20	57.00	44.00	80.00	2.50	6
18	2.60	52.50	41.00	50.00	1.92	5
19	3.50	55.00	43.00	50.00	1.43	5
20	3.40	55.00	43.00	80.00	2.35	5
21	2.20	51.00	40.00	94.11	4.28	4
22	4.60	62.00	50.00	99.65	2.17	7
23	3.20	57.00	45.00	99.11	3.10	6
24	3.30	59.00	47.00	102.67	3.11	6
25	3.70	59.00	47.00	80.26	2.17	6
26	3.40	55.00	43.00	88.06	2.59	5
27	4.40	61.00	49.00	165.00	3.75	7
28	3.50	57.00	45.00	142.20	4.06	6

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29	3.30	55.00	43.00	63.17	1.91	5
30	2.60	53.00	41.00	52.42	2.02	5
31	4.30	59.00	47.00	123.26	2.87	6
32	3.50	57.00	45.00	147.39	4.21	6
33	2.00	48.00	36.00	33.77	1.69	4
34	4.40	63.00	50.00	91.75	2.09	7
35	3.10	55.00	41.50	82.68	2.67	5
ave	3.40	56.79	44.50	92.59	2.70	6
min	2.00	48.00	36.00	33.77	1.29	4
max	4.60	63.00	50.00	175.00	4.49	7

GSI values,% for female fish in December 2021 are in the range between 1.29% and 4.49%, with an average of 2.70%.

Table 10 presents the average values of the gonadosomatic index (GSI, %) for female turbot in 2021.

Table 10. Average values of gonadosomatic index (GSI, %), female turbot 2021.

Month GSI, %	Second quarter	Fourth quarter
average	10.70	2.70
min	0.67	1.29
max	17.11	4.49

Table 11 presents the average values of the gonadosomatic index (GSI, %) for male turbot in 2021.

Table 11. Average values of gonadosomatic index (GSI, %), male turbot 2021.

Month GSI, %	Second quarter	Fourth quarter
average	0.85	0.72
min	0.21	0.23
max	1.61	1.39



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3.5.5. Fecundity of female fish

The female fish (22 specimens), caught and purchased in the first half of April 2021, based on which fertility is determined, have an average body weight of 3.63 kg. The average total body length is 56.27 cm and the average age is 6 years (**Fig. 16**).

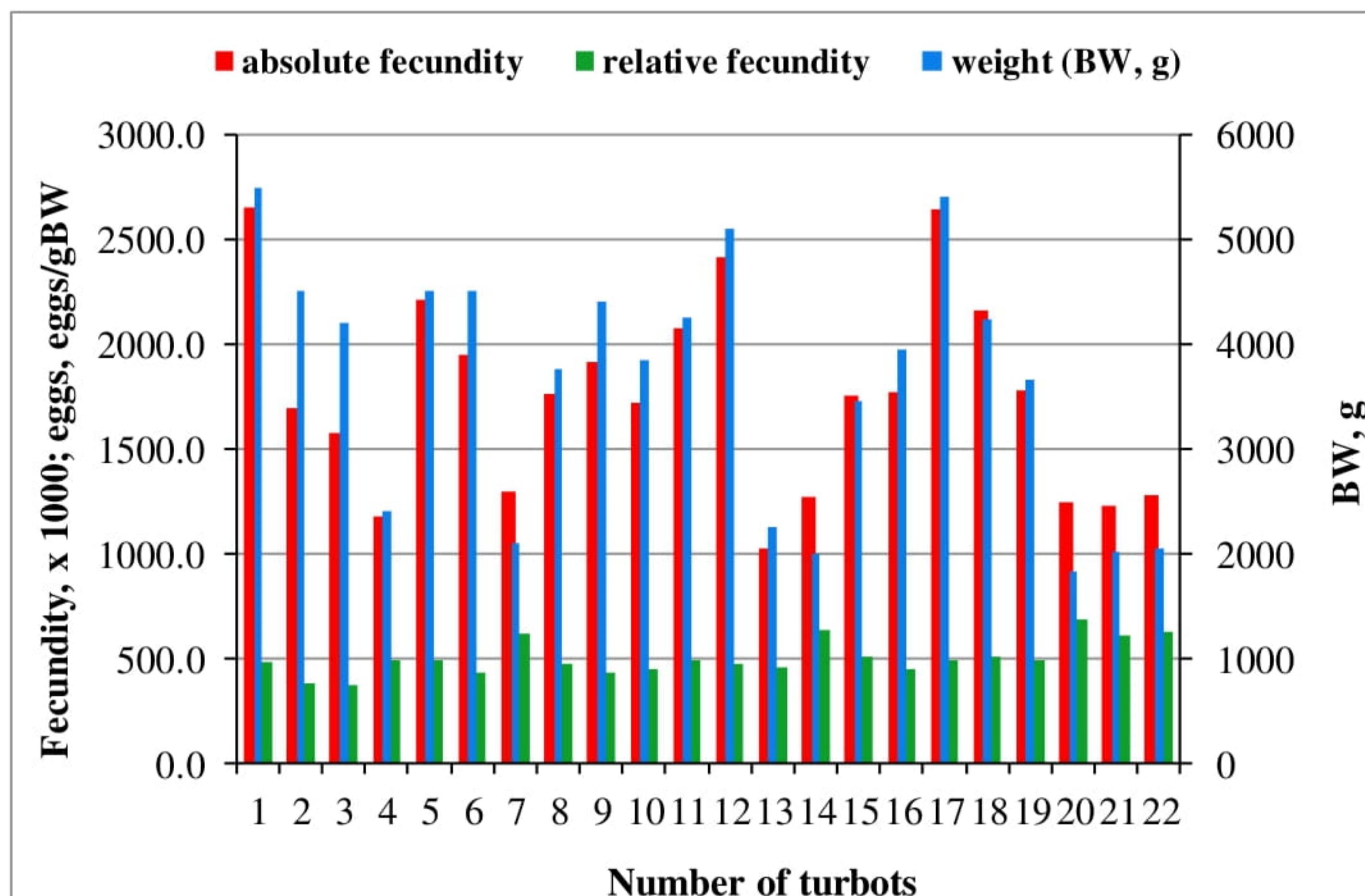


Fig. 16. Absolute and relative fecundity of female turbots in the first half of April 2021

The absolute fecundity of female turbots caught and purchased in the first half of April 2021 is 1 753 427.7 eggs, and the relative fecundity – 501 152.2 eggs (**Table 12**).



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Table 12. Values of absolute and relative fecundity of turbot in the first half of April 2021

Parameter	Average values
Number of female fish	22
Total body length, TL (cm)	56.27
Body weight, BW (g)	3 630
Absolute fecundity, number of eggs/ind	1 753 427.7
Relative fecundity, number of eggs/BW, g	501 152.2
Age, years	6

The female fish (30 individuals), caught during a trawl survey in the period 9-19 May 2021, of which fecundity is determined, have an average body weight of 3.31 kg. The average total body length is 53.55 cm and the average age is 6 years (**Fig 17**).

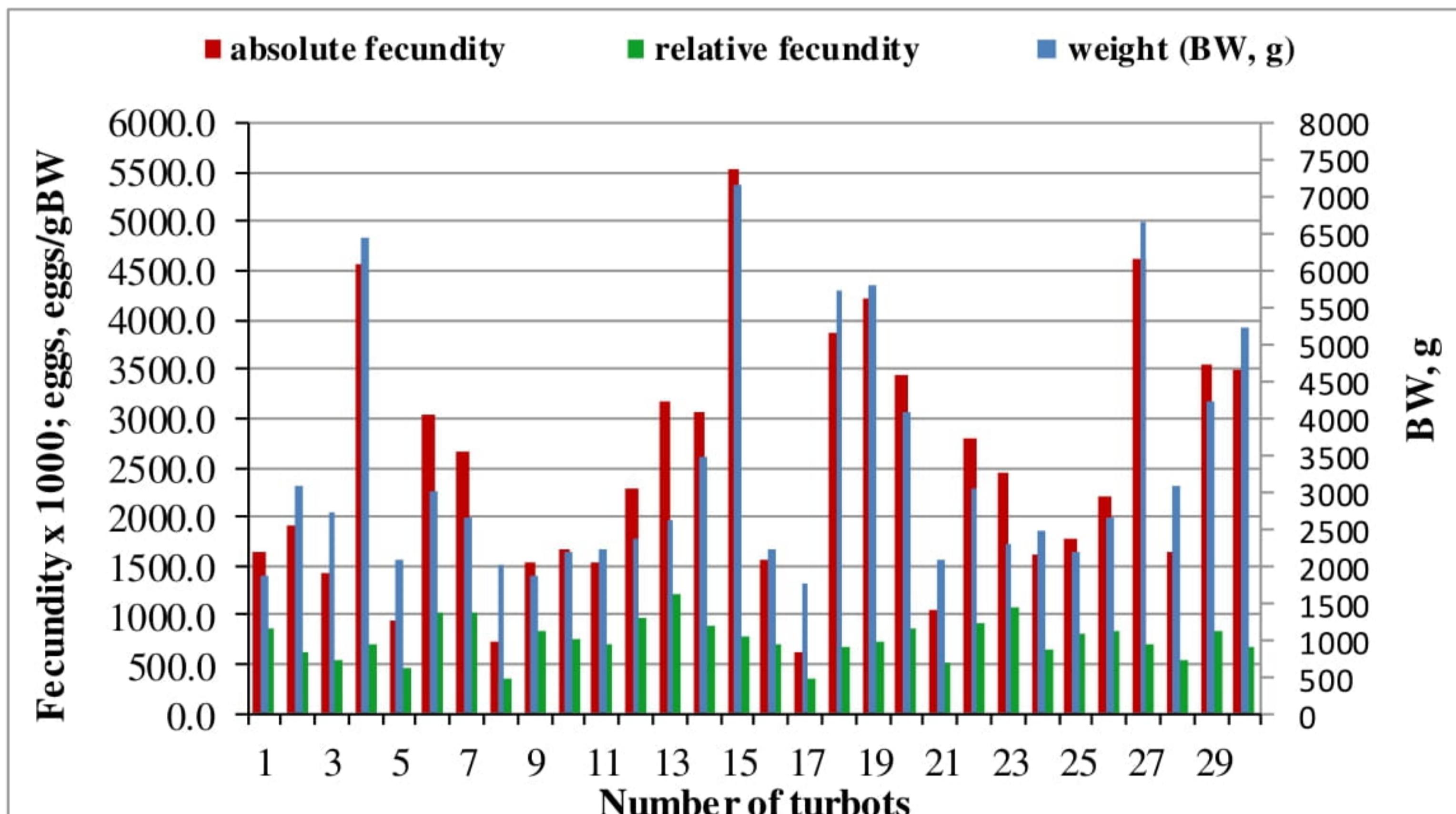


Fig. 17. Absolute and relative fecundity of female turbots, 9-19 May 2021



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The absolute fecundity of female turbots caught in May 2021 is 2 487 522.1 eggs, and the relative fecundity - 749 920.4 eggs (**Table 13**).

Table 13. Values of absolute and relative fecundity of turbot, May 2021

Parameter	Average values
Number of female fish	30
Total body length, TL (cm)	53.55
Body weight, BW (g)	3 310
Absolute fecundity, number of eggs/ind	2 487 522.1
Relative fecundity, number of eggs/BW, g	749 920.4
Age, years	6

The established fecundity of turbot in the first half of April is 734 094 eggs/individual lower than those found in the period 9-19 May. It is due to the fact that in the first samples the process of reproduction did not occur, while in the second samples turbot is in the breeding season.

The established fecundity of 1 753 427.7 eggs/individual is 646 572.3 eggs/individual lower than those established by Aydin *et al.* 2019, who report an absolute fecundity of 2 400 000 eggs/individual. 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 575 572 eggs/individual higher than those found in the present study. The correlation between absolute fecundity and total body length, with fecundity increasing with the increasing body length, is presented in **Fig. 18**.



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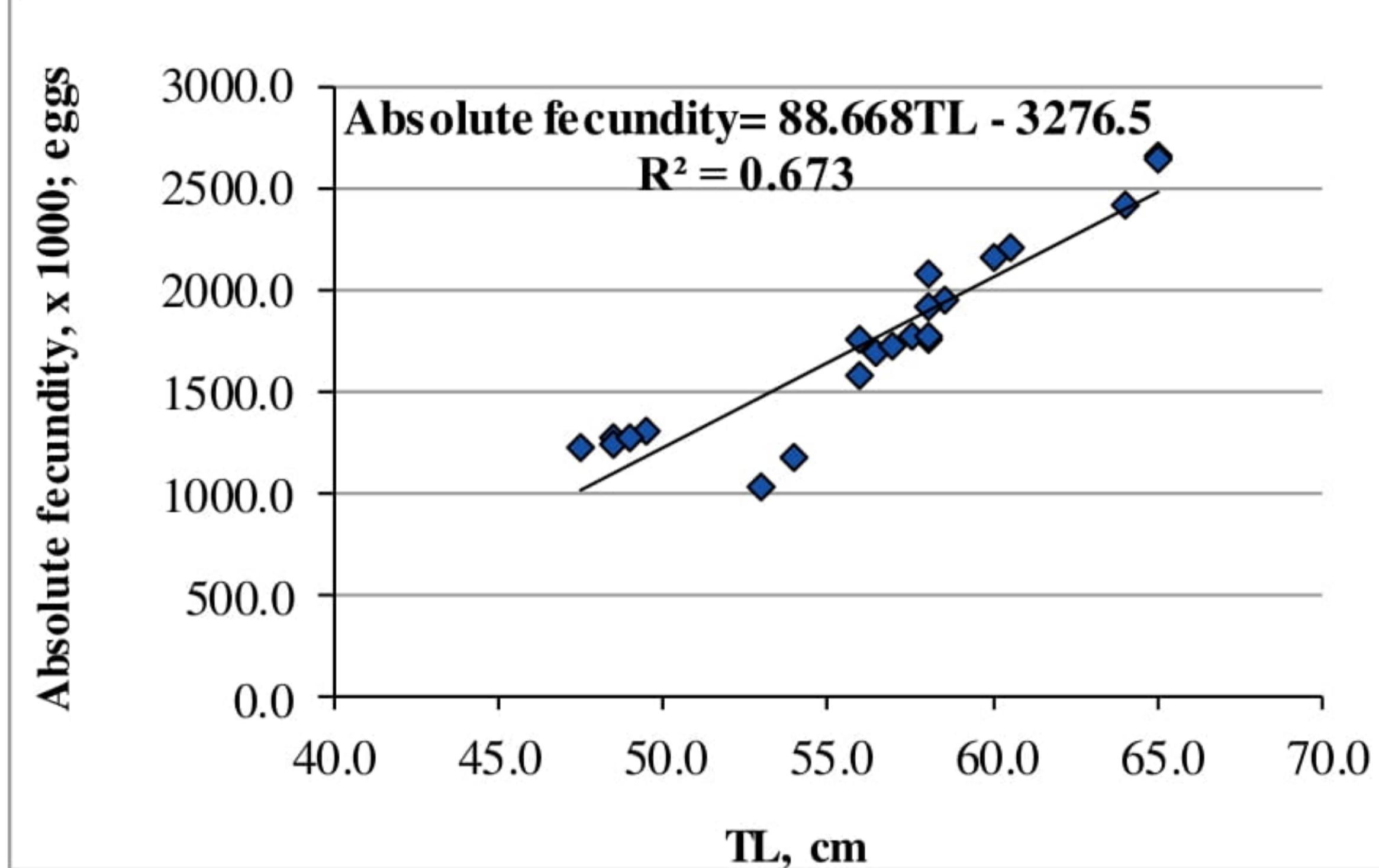


Fig. 18. Correlation between absolute fecundity and total length of female turbots in the first half of April 2021

The correlation between absolute fecundity and body weight of female turbots is presented in **Fig. 19**.

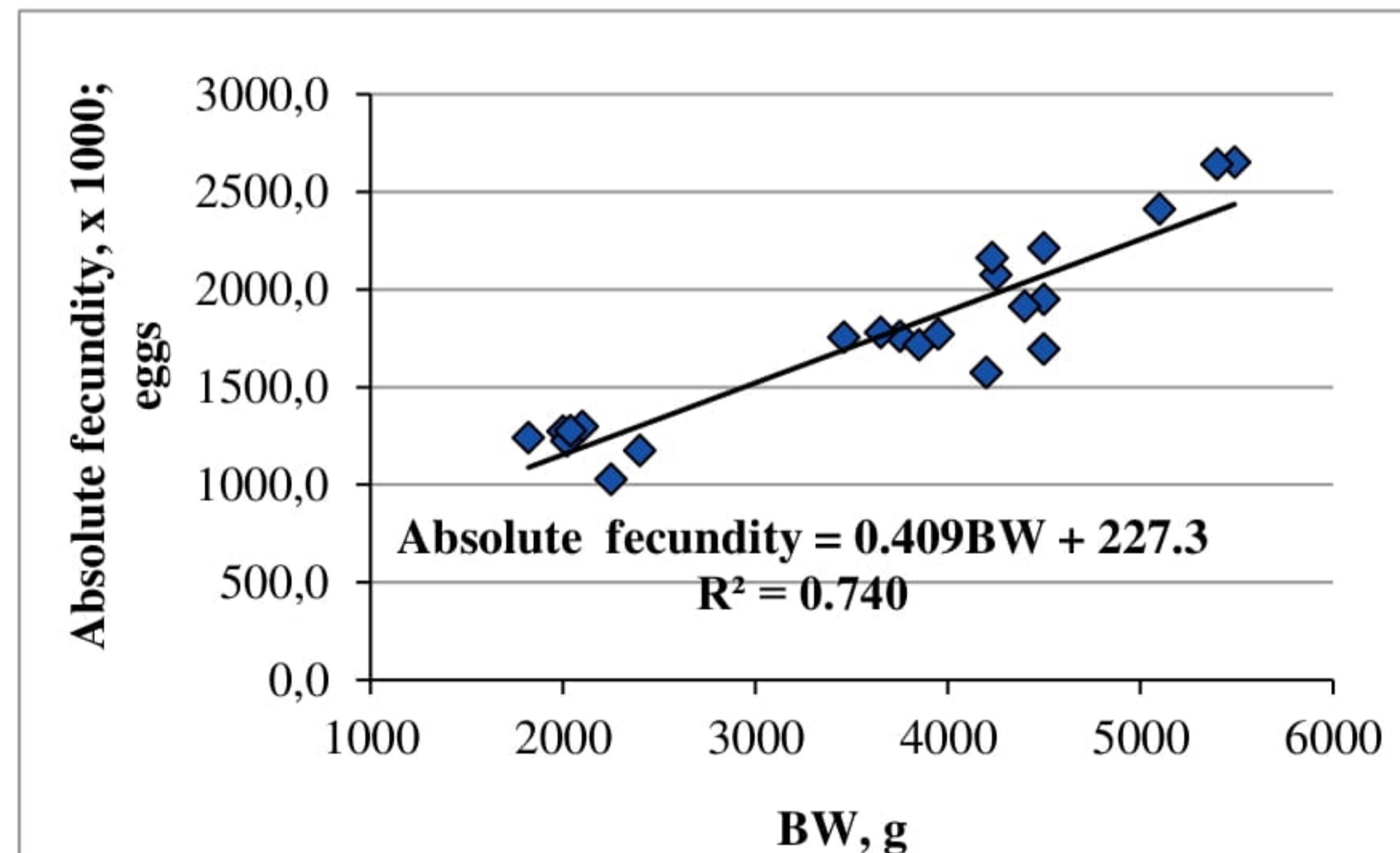


Fig. 19. Correlation between absolute fecundity and body weight of female fish in the first half of April 2021

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

The correlation between absolute fecundity and age of female turbots in April 2021 is presented in **Fig. 20**.

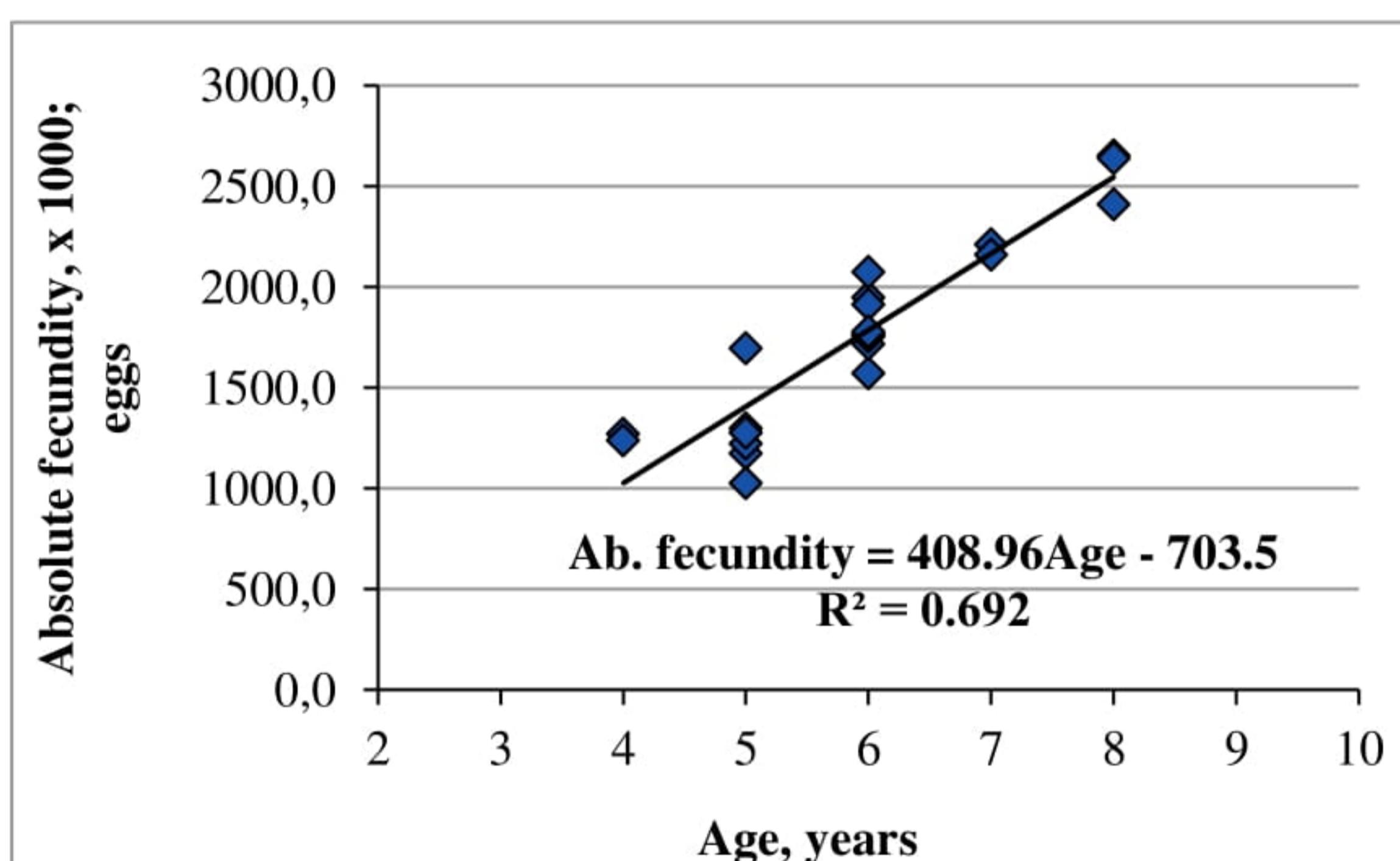


Fig. 20. Correlation between absolute fecundity and age of female turbots, in the first half of April 2021

3.5.6. Degree of maturity of the reproductive organs

During 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 vitelogenic oocytes of different size, and the ovary is in III-IV degree of maturity. In the ovary of the studied female individuals in May IV-V degree is reached. During the reproductive period, several phases of oocyte development are observed in the ovary, which is a reflection of the group-portion nature of their release. Five structural elements are identified - empty follicular sheaths of ovulated oocytes, individual atretic oocytes,



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oocytes of definite size, completed vitellogenesis and ready for ovulation and smaller vitelogenic oocytes forming the next ovulation wave.

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 2021, of all 100 fish studied for stomach content, 38 had a full stomach and 62 had an empty stomach (**Table 14**). The average value of ISF,% for 2021 is 1.11%. In the second quarter, most of the 50 fish studied have an empty stomach (34 fish or 68%), due to the breeding season. In the fourth quarter of the 50 fish studied, 22 had a full stomach (44%), which corresponds to the preparation for the next period of reproduction and accumulation of food reserves.

In the second and fourth quarters of 2021, *Merlangius merlangus* has the highest value of the index of relative importance, respectively IRI = 1087.41 and IRI = 4083.67.

According to the index of relative importance (IRI,%) in the second and fourth quarters of 2021 *M. merlangus* has a dominant share in the composition of the food spectrum, of all successfully identified taxa, respectively 44.83% and 29.34%.

Table 14. Index of stomach fullness (ISF, %) of turbots with full stomachs in 2021.

Nº	BW, g	TL, cm	Full stomach, g	Empty stomach, g	FW, g	ISF, %
1	4200	56.0	50.30	35.60	14.70	0.35
2	2250	50.0	45.00	23.70	21.30	0.95
3	2350	52.5	25.00	23.70	1.30	0.06
4	2450	53.0	50.00	39.00	11.00	0.45
5	1900	50.0	70.00	44.00	26.00	1.37
6	4500	58.5	63.70	34.90	28.80	0.64
7	2100	49.5	40.00	24.80	15.20	0.72

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8	2000	48.5	24.10	12.00	12.10	0.61
9	3950	57.5	72.60	47.60	25.00	0.63
10	3000	56.0	45.00	28.40	16.60	0.55
11	1820	48.5	51.50	19.70	31.80	1.75
12	2180	50.0	27.7	16.80	10.90	0.50
13	2330	51.0	32.80	25.40	7.40	0.32
14	2160	47.0	118.50	44.80	73.70	3.41
15	2120	49.5	25.00	20.00	5.00	0.24
16	2190	52.0	85.00	25.00	60.00	2.74
17	2200	53.00	55.00	30.00	25.00	1.14
18	2000	52.00	45.00	40.00	5.00	0.25
19	3500	57.00	90.00	75.00	15.00	0.43
20	4300	60.00	170.00	120.00	50.00	1.16
21	3200	55.00	100.00	80.00	20.00	0.63
22	2900	55.0	105.00	85.00	20.00	0.69
23	3400	57.00	160.00	105.00	55.00	1.62
24	2600	52.50	105.00	90.00	15.00	0.58
25	2400	52.00	105.00	90.00	15.00	0.63
26	3300	59.00	90.29	59.39	30.90	0.94
27	3700	59.00	120.05	61.29	58.76	1.59
28	3400	55.00	83.83	52.81	31.02	0.91
29	4400	61.00	181.96	74.87	107.09	2.43
30	3300	55.00	97.42	60.45	36.97	1.12
31	2100	48.00	64.00	36.26	27.74	1.32
32	2600	53.00	85.10	54.55	30.55	1.18
33	3500	57.00	104.30	64.10	40.20	1.15
34	2300	49.00	107.40	41.43	65.97	2.87
35	1800	47.00	44.31	31.66	12.65	0.70
36	2000	48.00	73.50	37.24	36.26	1.81
37	4400	63.00	210.56	92.87	117.69	2.67

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38	2500	49.00	82.66	56.72	25.94	1.04
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4. Conclusions and recommendations

Based on the results of the biological monitoring of turbot landings at the Bulgarian Black Sea coast in 2021, the following conclusions and recommendations can be made:

1. Fishing vessels unload an average of 24 turbots per vessel. The maximum catch is 99 fish and the minimum is 2 fish.
2. From a total of 39 landings at the monitored ports - Shabla, Kavarna, Balchik, Varna, Byala, Nesebar, Pomorie, Sozopol and Tsarevo 928 turbots are measured with an average weight of 3.00 kg and an average total body length of 55.56 cm.
3. The maximum measured weight is 9.75 kg and the minimum - 1.60 kg.
4. The maximum measured values for the total body length are 78.00 cm, and the minimum - 45.50 cm.
5. From the 928 turbots, 192 (21%) weigh up to 2 kg. Fish weighing from 2 to 3 kg make up 44% of the measured specimens (412 specimens). The weight group from 3 kg to 4 kg is represented by 175 specimens. or 19% of the representative sample. Turbots weighing from 4 kg to 5 kg represent 9% or 86 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 5 kg - 7% or 63 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. Turbots with total body length (TL, cm) in the range of 49-52 cm represent 25.86% of the landings, followed by the groups 53-56 cm (22.31%) and 57-60 cm (16.81%). The individuals with total body length in the range of 45-48 cm are 124 specimens, which represents 13.36% of

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all measured specimens. Fish with a total body length between 61 and 68 cm are 154 specimens or 16.59% of all measured fish. Fish over 69 cm are 47 specimens or 5.06%.

7. From the distribution of individuals by size groups by standard length (SL, cm) it is established that the group 40-43 cm is most widely represented (264 specimens - 28.45%). It is followed by the groups 36-39 cm (258 specimens - 27.80%) and 44-47 cm (178 specimens - 19.18%). Individuals with a standard body length in the range of 48-51 cm are 112 specimens, which represents 12.07% of all measured specimens. Fish with standard body length in the groups 52-55 cm and 32-35 cm are 5.17% and 3.77%, respectively. Last, with the lowest percentage are turbots with a standard body length greater than 56 cm - 33 specimens or 3.56%.
8. The rcorrelation between the size and weight of turbot is clearly expressed and it is described by the equation: $BW = 0.02TL^{2.93}$.
9. The percentage of females and males is 57% to 43% in favor of females.
10. The age composition of the studied 100 specimens of turbot in 2021 includes from 3 to 8-year-old individuals, with five (42%) and six (25%) year-old fish predominating. In total, they represent 67% of the total number of studied specimens. The percentage of turbot aged 4 and 7 years is 16% and 11%, respectively. The lowest percentage is of fish at 3 years and 8 years of age, respectively, with 3 specimens or 3% of the age composition.
11. Males with a total body length of up to 60.00 cm predominate. At lengths over 53.00 cm the percentage of female individuals increases.
12. In males, 4 and 5 year-old turbot predominate, and in females 6 and 7 year-old fish.
13. The average weight of male fish in the first half of April 2021 is 2.09 kg and it is in the range of 1.64-3.00 kg. The weight of the gonads is between 5.00 g and 35.00 g, with an average value of 17.90 g. The GSI,% values for male fish in the first half of April 2021 are in the range of 0.21% and 1.61%, with an average value of 0.85%.

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14. The average weight of female fish in the first half of April 2021 is 3.63 kg and it is in the range of 1.82-5.49 kg. The weight of the ovary is between 15.00 g and 870.00 g, the average value is 431.07 g. GSI,% values for female fish in the first half of April 2021 range between 0.67% and 17.11%, with an average of 10.70%.
15. The average weight of male fish in December 2021 is 2.33 kg and it is in the range of 1.80-3.40 kg. The weight of the gonads is between 5.00 g and 25.00 g, with an average value of 16.12 g. GSI,% values for male fish in December 2021 are in the range of 0.23% and 1.39%, with an average of 0.72%.
16. The average weight of female fish in December 2021 is 3.40 kg and it is in the range of 2.00-4.60 kg. The weight of the ovary is between 33.77 g and 175.00 g, the average value is 92.59 g. GSI,% values for female fish in December 2021 range between 1.29% and 4.49%, with an average value of 2.70%.
17. It is established that the absolute fecundity of female turbots caught and purchased in the first half of April 2021 is 1 753 427.7 eggs, and the relative fecundity – 501 152.2 eggs
18. It is established that the absolute fecundity of female turbots caught in May 2021 is 2 487 522.1 eggs, and the relative fecundity - 749 920.4 eggs
19. During 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 vitelogenic oocytes of different size, and the ovary is in III-IV degree of maturity. In the ovary of the studied female individuals in May IV-V degree is reached. During the reproductive period, several phases of oocyte development are observed in the ovary, which is a reflection of the group-portion nature of their release.

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20. 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.
21. For 2021, of all 100 fish studied for stomach content, 38 had a full stomach and 62 had an empty stomach. The average value of ISF,% for 2021 is 1.11%.
22. In the second and fourth quarters of 2021, *Merlangius merlangus* has the highest value of the index of relative importance, respectively IRI = 1087.41 and IRI = 4083.67.
23. According to the index of relative importance (IRI,%) in the second and fourth quarters of 2021 *M. merlangus* has a dominant share in the composition of the food spectrum, of all successfully identified taxa, respectively 44.83% and 29.34%.

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.

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