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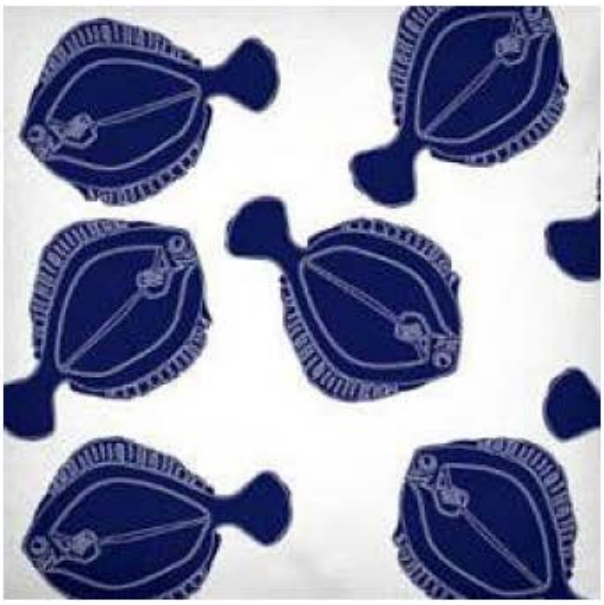

BIOLOGICAL MONITORING OF TURBOT (SCOPHTHALMUS MAXIMUS) LANDINGS AT THE BULGARIAN BLACK SEA IN THE FOURTH QUARTER OF 2019

Institute of Fisheries and Aquaculture, Plovdiv

Agricultural Academy, Sofia

2019

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Проект № BG14MFOP001-3.003-0001-C01, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 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 the turbot catches at the Bulgarian Black Sea is to collect biological data which will be used for analysis of the catches and for the development of database for tracking the changes in their structure over the years.

The collection of biological samples, from landings of turbot, during the fourth quarter of 2019, included the following main objectives:

1. Collecting data for landing ports, vessels selected for sampling, number of collected samples, number of studied specimens, geographical data for the catches;
2. Determination of size-weight structure of the landings of turbot;
3. Characteristics of the reproductive biology of turbot.
4. Determination of the age ratio of the turbot landings

2. Material and methods

2.1. Collection of biological data from landings

The biological data collection is performed in the fourth quarter of 2019 at the Bulgarian Black Sea coastal zone.

2.1.1. Ports for collection of biological data

Ports where landings of turbot are permitted (Varna, Balchik, Nesebar and Tsarevo ports) are used for biological data collection.

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2.1.2. Vessels for sample collection

Biological data is collected from landings from 11 vessels – 7 from Varna, 1 from Balchik, 2 from Nesebar и 1 from Tsarevo, listed in **Table 1**.

Table 1. Ports and vessels used for monitoring and biological data collection from landings of turbot in the fourth quarter of 2019.

№	Ships
Port Varna	
1.	Hermes 3/Vn 4926
2.	Sigma/Vn 7180
3.	Horizont/Vn 7346
4.	Ereo2
5.	Vn 422
6.	Bumerang/Vn 8250
7.	Diana/Vn 7669
Port Balchik	
8.	RK5/Vn 8186
Port Nesebar	
9.	Elekta/Vn 8046
10.	Trigona/Vn 8579
Port Tsarevo	
11.	Pm199

2.1.3. Number of collected samples

The biological data is collected from 11 turbot landings from vessels at the ports Varna, Balchik, Nesebar and Tsarevo.

2.1.4. Number of measured turbots

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The total number of fish used for biological data collection is 383, with required minimum of 300 specimens under contract № 160/25.05.2018 with EAFA, Burgas.

2.1.5. Geographical data of the turbot catch locations

The coordinates and depth of the catch locations for each ship are shown in **Table 2.**

Table 2.Coordinates and depth of the turbot catch locations.

№	Ship	Coordinates of catch locations		Depth of catch locations (m)
		latitude	longitude	
1.	Hermes 3/Вн 4926	43°43'10"	28°57'52"	65
2.	Sigma/Vn 7180	43°23'29"	29°10'06"	60
3.	Horizont/Vn 7346	43°16'30"	28°17'40"	60
4.	Ereo2	43°31'37"	29°08'59"	50-60
5.	Vn 422	43°23'02"	28°18'08"	55
6.	Diana/Vn 7669	43°35'35"	28°46'54"	60-65
7.	Bumerang/Vn 8250	43°18'49"	28°39'23"	60-65
8.	RK5/Vn 8186	42°34'32"	28°46'40"	60
9.	Elekta/Vn 8046	42°50'32"	28°07'55"	60-65
10.	Trigona/Vn 8579	42°25'47"	28°25'24"	50
11.	Pm 199	42°31'41"	27°49'01"	40-50

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

The measurements of the fish are made on board of the ships, immediately after docking at the port, on fresh ice-cooled subjects. The weight measurements are done with a precision of 0.1 g and the measurements of the total and standard lengths – with a precision of 0.1 cm.

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2.1.7. Characteristics of the reproductive biology of turbot

In the fourth quarter of 2019, based on samples of reproductive organs of 50 specimens, the gonadosomatic index, fecundity and maturation of sex organs was determined. From the same specimens, otoliths were collected for determination of fish age. Correlations between the following parameters were established:

- **Sex ratio**

The sex of 50 turbot caught in the fourth quarter of 2019 is determined. The ratio between female and male individuals is presented.

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

The gonadosomatic index (GSI, %) is determined based on 19 female specimens and 31 male specimens caught in December 2019. GSI is calculated as % of weight for each sex, using the data for body weight and the gonads of female and male fish, applying Wootton formula (1998):

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

W_G – weight of the gonads, g;

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BW – body weight, g;

- **Determination of fish age**

The age of the fish was determined by counting the concentric circles (zones) of the otoliths, corresponding to the periods of growth. The otoliths were removed through the gills of the fish without opening the skull, carefully separating each pair without breaking. The otoliths were cleaned and stored until observation, which was performed using a stereomicroscope with appropriate magnification and light.

3. Results

3.1. Number of fish caught

The total number of fish, used for biological data collection, is 383. The number of fish caught from each vessel is presented in **Fig. 1**. An average of 35 fish were caught from each ship or 98 kg/ship. The maximum catch for a ship was 101 fish (323.70 kg) and the minimum - 6 fish (15.40 kg).

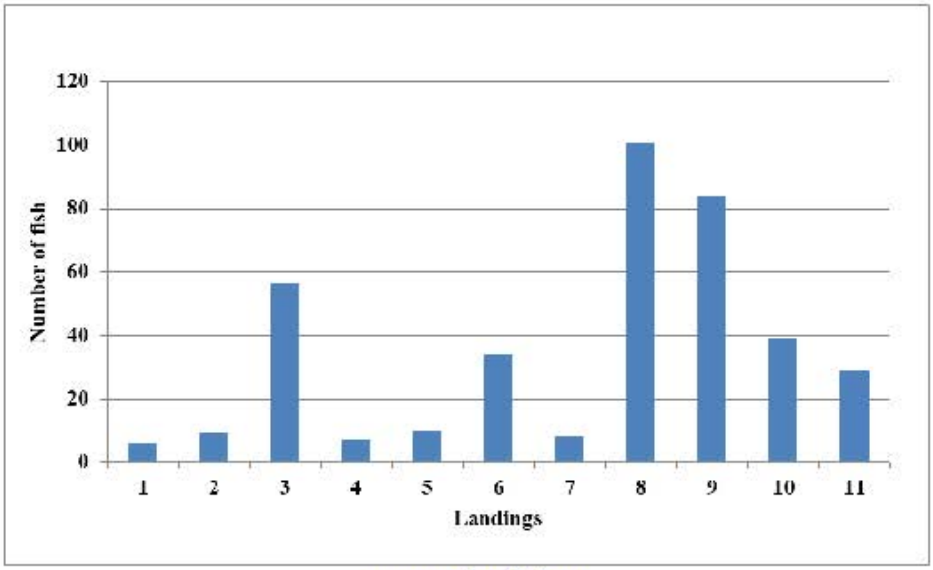

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Fig. 1. Number of fish landings at ports.

3.2. Weight structure of the fish catches

The average weight of the measured specimens is 2.83 kg, the maximum measured weight is 6.00 kg and the minimum measured weigh is 1.55 kg.

In **Figure 2** is presented the percentage distribution of the fish weight. It can be observed that 68 specimens, or 18% of the total number of individuals, have weight up to 2 kg, and 184 individuals, or 48%, are fish with weight from 2 kg to 3 kg. Therefore, in the landings of the monitored ports, 66% of all turbots weigh up to 3 kg within the study period. The weight group of 3 kg to 4 kg is represented by 23% and that of over 4 kg is represented by 11% of the total number of the studied fish.

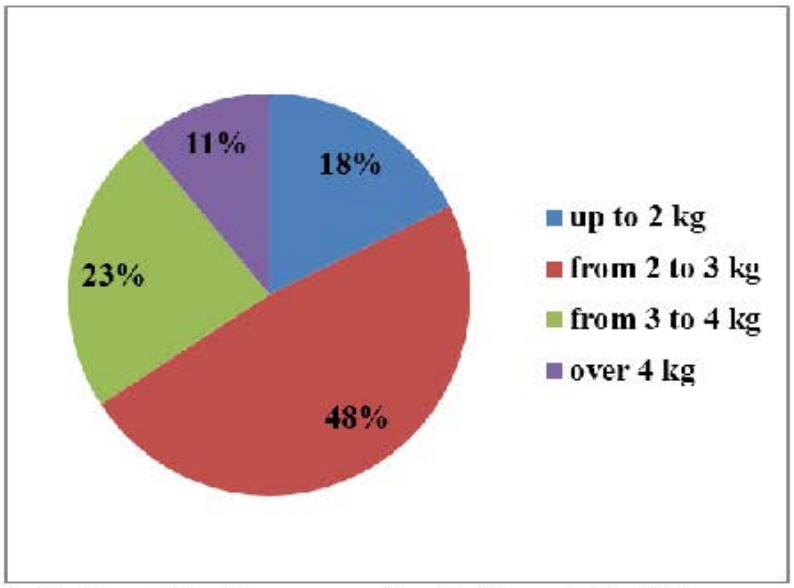

Fig. 2.Distribution of landings according to the weight of the measured fish.

3.3. Body size structure (total and standard body lengths) of turbot catches

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The average total length of the measured fish is 54.30 cm, the maximum is 70.00 cm and the minimum - 45.50 cm. The dynamics of the distribution of the values of the total length (TL, cm) of the measured specimens (at 3.0 cm intervals) is presented in **Figure 3**.

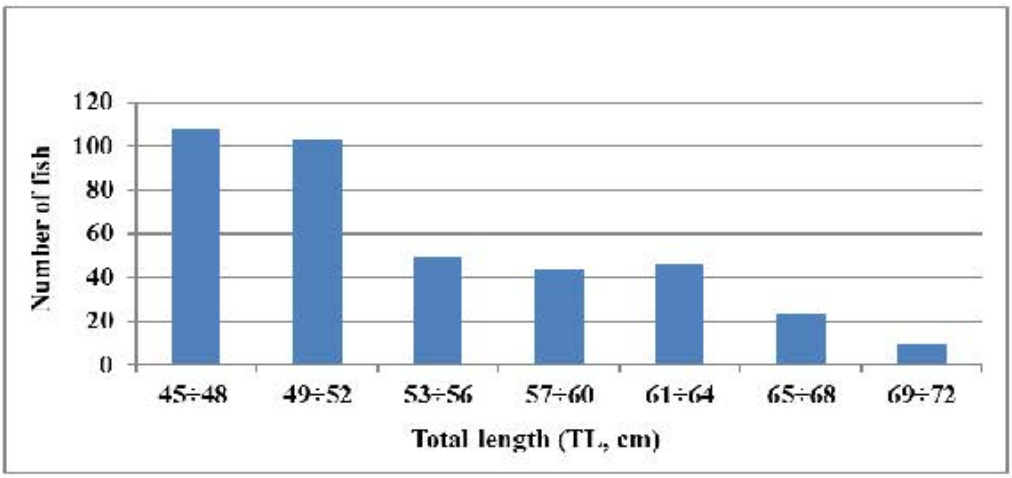

Fig. 3. Distribution of fish in different size groups (3 cm intervals) by total body lengths (TL, cm).

From the distribution of the specimens by size groups (at 3 cm intervals), it is established that the most represented is the size group of 45-48 cm. This group represents 55% (211 fish) of the studied specimens, followed by the 53-56 cm, 57-60 cm and 61-64 cm groups – 18%.

The dynamics of distribution of the average standard length (SL, cm) of the measured specimens is presented in **Figure 4**. The average value of the standard body length (SL, cm) is 42.56 cm. The maximum measured standard length is 56.00 cm and the minimum measured standard length - 35.00 cm.

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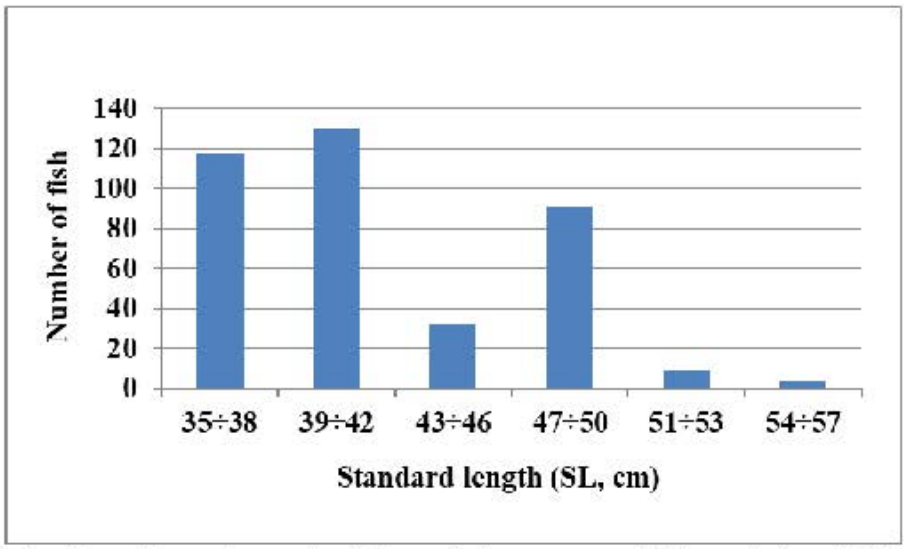

Fig. 4. Distribution of specimens in different size groups (at 3 cm intervals) by standard body length (SL, cm).

From the distribution of the specimens by size groups (at 3.0 cm) by standard lengths, it is established that the most frequently encountered is the size 35-38 cm. The largest groups are those of specimens with standard body length (SL, cm) in the range of 35-38 cm (31%) and 39-42 cm (34%). 91 fish are with standard body lengths in the 47-50 cm range are (24%).

From the results, it can be concluded that the total body length (TL, cm) of the measured fish ranged from 46.0-72.0 cm and the body weight from 1.70-6.30 kg (**Fig.** 5). The dominant group has a total body length from 49 cm to 52 cm and a body weight from 2.00 to 2.55 kg.

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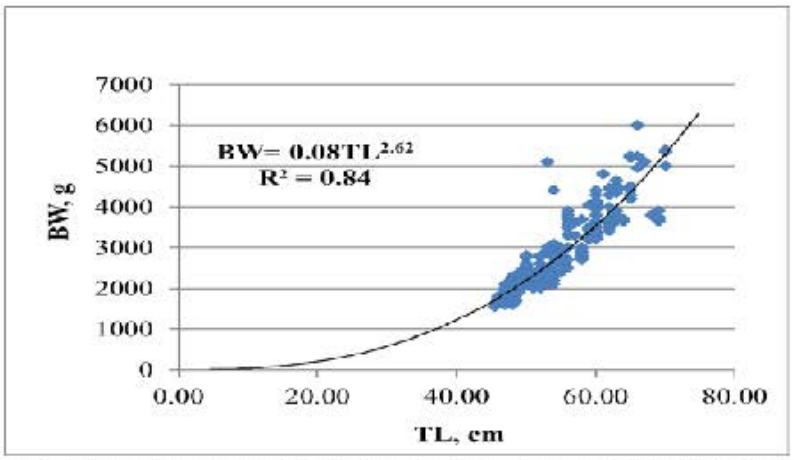

Fig. 5. Correlation between total body length (TL, cm) and weight (BW, g) of turbot (n=383).

The correlation between the total body length and weight of the turbot landings is expressed with the equation: $BW = 0.02TL^{2.93}$.

3.4. Characteristics of the reproductive biology of turbot

3.4.1. Sex ratio

The percentage distribution of the sex ratio of turbot is shown in **Fig. 6**.

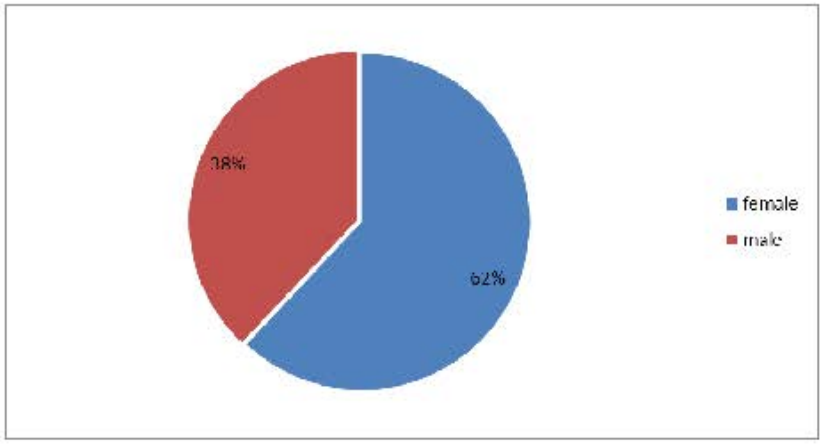

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Fig. 6. Sex ratio of studied female and male specimens.

From 50 specimens, 19 were female and 31 were male. The female to male ratio is 38:62% or 1: 1.7.

3.4.2. Gonadosomatic index (GSI,%)

The average weight of female fish, measured in December 2019, is 2.55 kg and is in the range 1.60-3.42 kg. The weight of the ovaries is between 44.30 g and 157.00 g, with an average value of 72.12 g (**Table 3**). The GSI, % , for female fish, caught in December 2019, has an average value of 2.83%.

Table 3. Body weight (BW, kg), total (TL, cm) and standard (SL, cm) body lengths, testes weight (WG, g), GSI,% and age of female specimens in December 2019.

№	BW, kg	TL, cm	SL, cm	W_G, g	GSI, %	Age
1	2.80	54.00	43.00	96.00	3.43	3
2	2.46	52.50	42.00	44.30	1.80	3
3	2.58	53.00	42.50	73.40	2.84	4
4	3.10	58.50	46.00	108.00	3.48	5
5	2.20	52.00	41.00	49.70	2.26	4
6	2.10	49.00	39.00	57.70	2.75	4
7	1.60	47.00	37.00	55.70	3.48	3
8	1.80	46.00	36.00	54.90	3.05	3
9	2.10	50.00	40.00	51.80	2.47	3
10	3.40	62.00	50.00	101.70	2.99	5
11	3.10	58.00	45.50	52.30	1.69	5
12	2.30	54.00	43.00	52.60	2.29	4
13	2.10	50.00	39.50	54.80	2.61	4
14	2.47	52.50	42.00	53.00	2.15	5
15	2.76	54.00	42.00	157.00	5.69	5
16	2.70	56.00	43.50	125.90	4.66	5
17	2.23	52.50	42.00	47.50	2.13	4
18	3.42	59.50	47.00	82.50	2.41	6
19	3.15	56.50	46.50	51.50	1.63	5
min	**1.60**	**46.00**	**36.00**	**44.30**	**1.63**	**3**
max	**3.42**	**62.00**	**50.00**	**157.00**	**5.69**	**6**

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average	2.55	53.53	42.50	72.12	2.83	4

The GSI, % for male fish, caught in December 2019, has an average value of 1.01%. The maximum and minimum values are respectively 0.15% and 1.83%.

The average GSI,% for female fish is significantly lower in December compared to May, which is specific characteristic of the ovaries after the breeding season.

3.4.3. Determination of the maturity stage of the gonads

In December, in the ovaries and testes of the studied specimens III stage of maturity is reached. The major part of the ovaries contained previtelogenic follicles and in the testes - the spermatids.

3.5. Age

In order to determine the age ratio of turbot landings, in December 2019, 50 pairs of otoliths were examined. The age structure of the 19 studied female specimens ranged from 3 to 6 years of age.

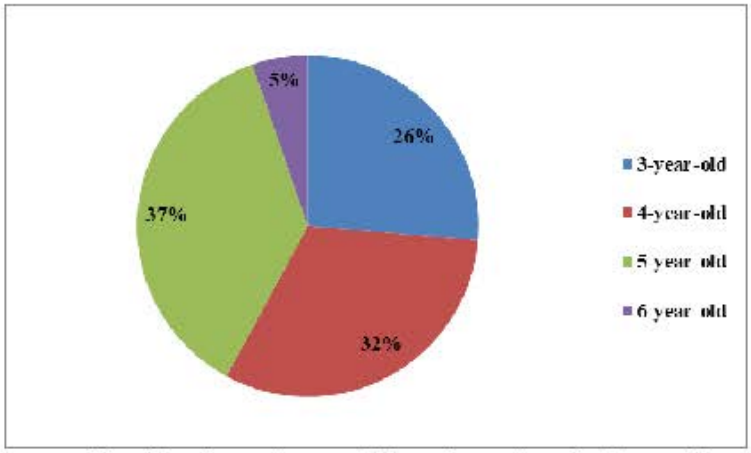

Fig. 7. Percentage distribution of age of female turbot in December 2019 (n=19).

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The age ratio of the 31 studied male turbot included 3, 4, 5 and 6-year-old specimens, with predominantly established specimens at 3 and 4 years of age (**Figure 8**). The percentage of male individuals at this age is around 68%, followed by 5-year-old specimens - 19% and 6-year-old - 13% of the total number of fish studied.

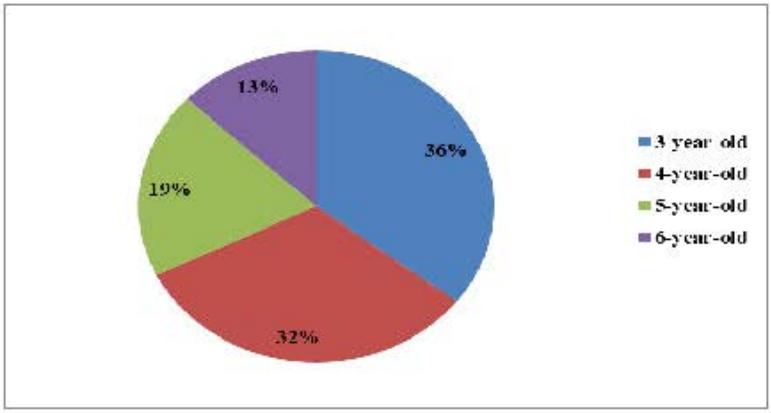

Fig. 8. Percentage distribution of age of male turbot specimens in December 2019 (n=18).

The analysis of the results established that the percentage of specimens (female and male) of 3 and 4 years of age is around 64%. Fish at 5 years of age are 26% and those at 6 years of age represent 10% of the total number of studied specimens (**Fig. 9**).

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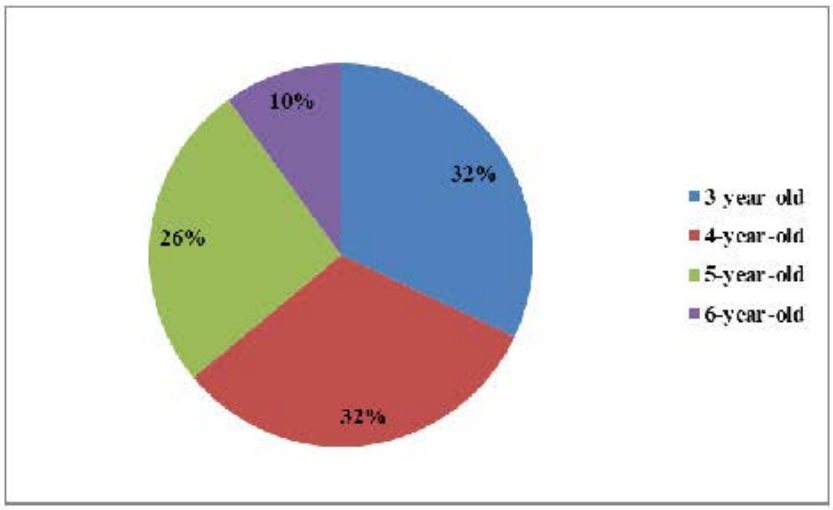

Fig. 9. Percentage distribution of age of turbot (n=50).

Based on the average values, the correlation between the linear growth and the age of turbot, caught in December 2019, is presented in **Fig. 10**, **Fig. 11 and Fig. 12**.

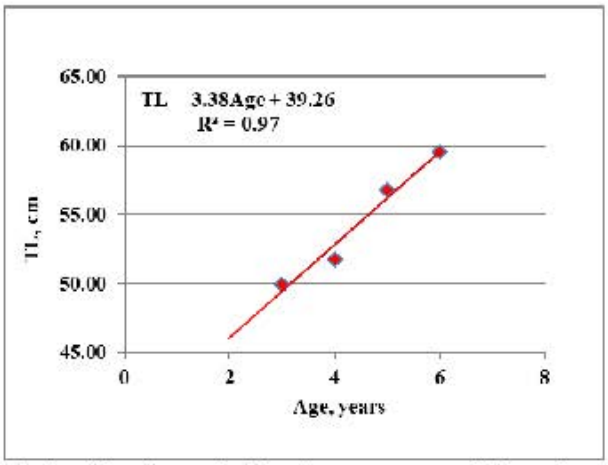

Fig. 10. Correlation between total length (TL, cm) and age (years) of female turbot (n=19).

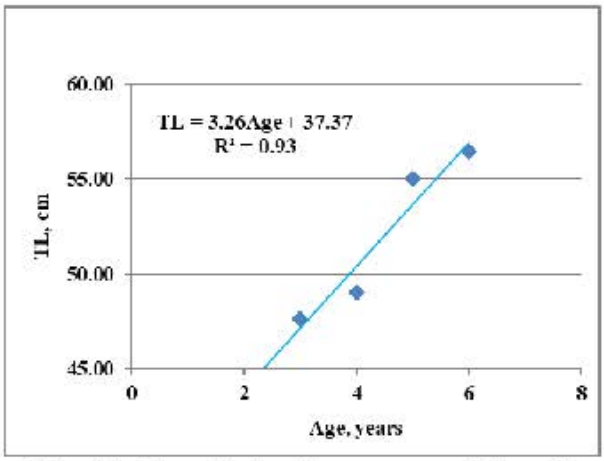

Fig. 11. Correlation between total length (TL, cm) and age (years) of male turbot (n=31).

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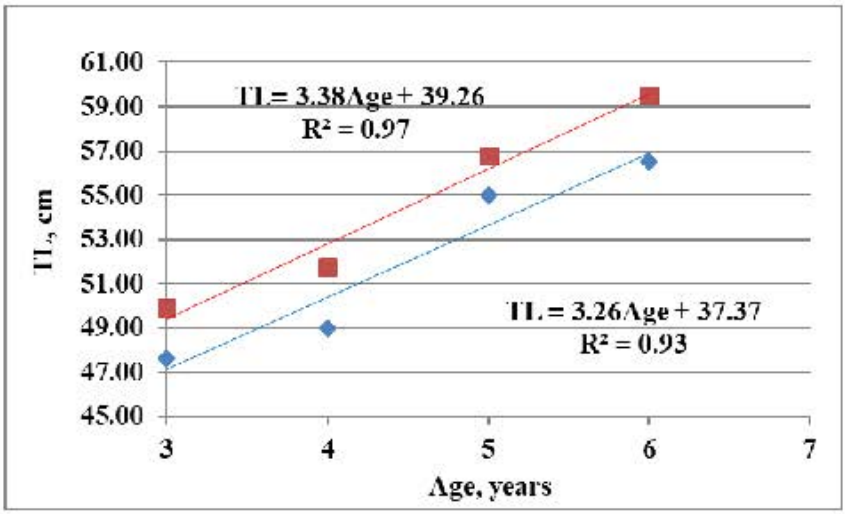

Fig. 12. Correlation between total body length (TL, cm) and age (years) of female and male specimens.

The weight gain of turbot, in relation to age and sex is presented in **Fig. 13**, **Fig. 14** and **Fig. 15**.

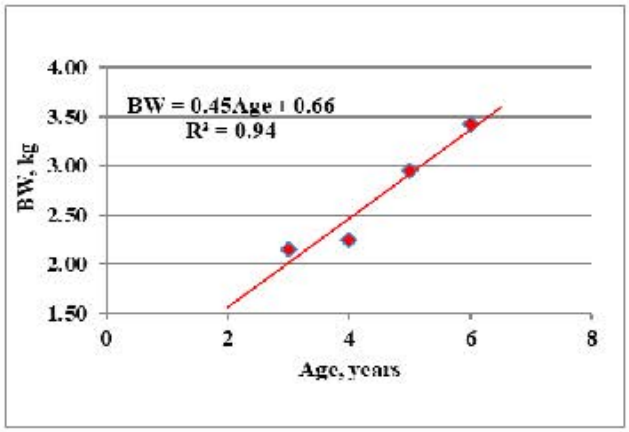

Fig 13. Correlation between weight (BW, kg) and age (years) of female turbot (n=19).

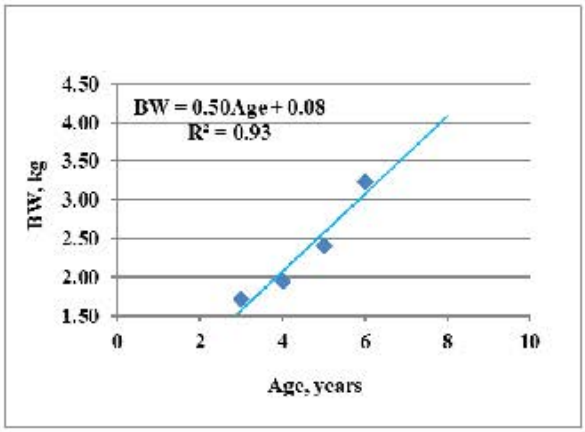

Fig. 14. Correlation between weight (BW, kg) and age (years) of male turbot (n=31).

The weight gain of turbot in correlation to age, based on mean values, is presented in **Fig. 15.**

Проект № BG14MFOP001-3.003-0001-C01, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.", финансиран от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

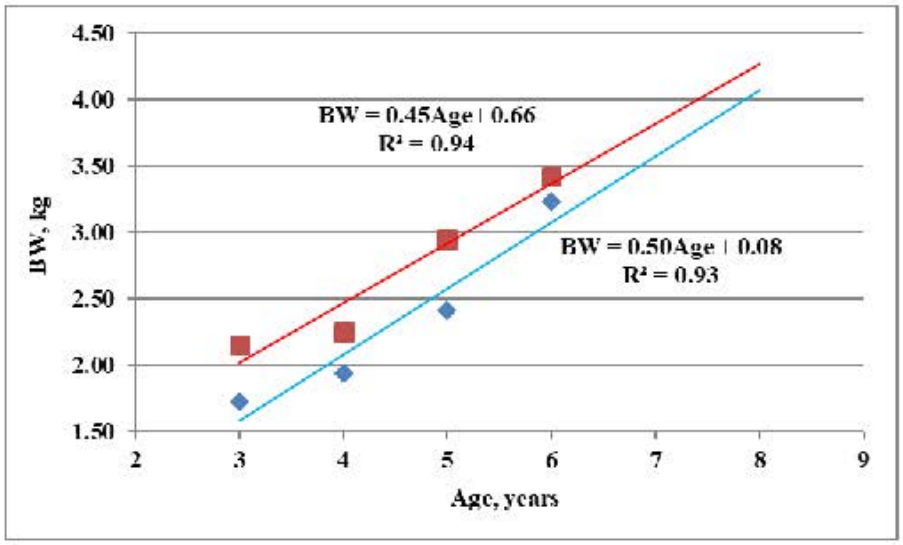

Fig. 15. Weight gain of female and male specimens in relation to age

From the presented figures it can be observed that female fish gain weight faster with age compared to male fish.

4. Conclusions and recommendations

Based on the results of the biological monitoring of turbot landings, carried out at the Bulgarian Black Sea coast in the fourth quarter of 2019, we can make the following conclusions and suggest the following recommendations:

1. During the study period in 2019, the landings from the fishing ships have an average value of 35 specimens of turbot and an average of 98 kg per day. The maximum number of fish from the landings of the monitored ports is 101 fish and the minimum is 6 fish.
2. From a total of 11 landings of the monitored ports, 383 specimens are measured with an average weight of 2.83 kg, an average total body length of 54.30 cm and an average standard body length of 42.56 cm.
3. The maximum measured weight is 6.00 kg and the minimum measured - 1.55 kg.

Проект № BG14MFOP001-3.003-0001-C01, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансиран от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

4. The maximum measured total length is 70.00 cm and standard length - 56.00 cm. The minimum measured total length and standart length are respectively 45.50 cm and 35.50 cm.
5. 68 specimens, or 18% of the total number of fish, have weight up to 2 kg and 184 specimens, or 48% of all studied fish, have weight from 2 kg to 3 kg. 89 specimens, or 23% of all studied fish, have weight from 3 kg to 4 kg. Specimens with weight over 4 kg are 11% of all measured fish. Therefore, from the landings of the monitored ports, around 90% of all turbots weigh up to 4 kg during the carried out monitoring.
6. From the distribution of the fish by size groups (at 3 cm) by total length, it is established that the largest size groups are those of 44-48 cm and 49-52. These groups represent 55% (211 fish) of all studied specimens, followed by the groups of 53-56 cm, 57-60 cm and 61-64 cm – 36%.
7. The average value of the standard body length (SL, cm) is 42.56 cm. The maximum standard length measured is 56.00 cm and the minimum measured - 35.00 cm. From the distribution of the fish by size groups (at 3 cm) by standard length, it is established that the largest size groups are those of 35-38 cm (31%) and 39-42 cm (34%). The specimens with standard body length in the range of 47-50 cm are 91 (24%).
8. The correlation between the size and the weight structure of the turbot landings is described with the equation: $BW = 0.02TL^{2.93}$.
9. The average weight of female fish, measured in December 2019, is 2.55 kg and is in the range of 1.60-3.42 kg and the weight of the ovaries is between 44.30 g and 157.00 g, with an average value of 72.12 g. The gonadosomatic index (GSI, %) of female fish, caught in December 2019, has an average value of 2.83%.
10. The gonadosomatic index (GSI, %) of male fish, caught in December 2019, has an average value of 1.02%.

Проект № BG14MFOP001-3.003-0001-C01, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансиран от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

11. The age structure of the 19 female specimens studied included fish from 3 to 6 years of age, with specimens at 4 years of age being predominant. The ratio between female and male fish is 36:62% or 1:1.7.
12. The age ratio of the 31 male turbot specimens studied included 3, 4, 5, and 6-year-old individuals, with specimens at the age of 3 and 4 years being predominant. The percentage of male specimens at this age is about 68%, followed by those at 5 years of age with 19% and at 6 years of age with 13% of the total number of the studied fish. The analysis of the results showed that the percentage of individuals (female and male) age 3 and 4 years is around 64%. Fish at 5 years of age are 26% and those at 6 years of age represent 10%. Female fish grow faster with age compared to male fish.
13. Яйчникът на изследваните индивиди през месец декември се намира във III степен на зрялост, характерна за зимния период. In December, the ovaries of the studied specimens is in the III stage of maturity, which is specific for the winter period.

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