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**BIOLOGICAL MONITORING OF TURBOT (*SCOPHTHALMUS
MAXIMUS*) LANDINGS AT THE BULGARIAN BLACK SEA IN THE
FOURTH QUARTER OF 2018**

Institute of Fisheries and Aquaculture, Plovdiv

Agricultural Academy, Sofia

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Проектно предложение № BG14MFP001-3.003-0001, „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.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.



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2018

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4. Conclusions and recommendations

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 2018, 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 2018 at the Bulgarian Black Sea coastal zone.

2.1.1. Ports for collection of biological data

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

2.1.2. Vessels for sample collection

Biological data is collected from landings from 17 vessels – 8 from Varna, 4 from Kavarna, 2 from Balchik, 1 from Tsarevo, 2 from Pomorie and 1 from Sozopol, 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 2018.

№	Ships
Port Varna	
1	Bumerang/Vn8250
2	Dani/Bl2116
3	Vn8535
4	Skaimen/Vn4377
5	Viking/Vn8406
6	Diana/Vn7669
7	Sv. Anna/Vn8265
8	Trayana/Vn4320
Port Kavarna	
9	Hishtnik
10	Sv. Nikolai
11	Paldin
12	Ivana
Port Balchik	
13	Korsar2/Vn7643
14	Libra/Vn8311
Port Tsarevo	
15	Elis/Bch5322

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Port Pomorie	
16	Barbun/Vn7979
17	Elis/Bch5322
Port Sozopol	
18	Valkobor/Bs2330

2.1.3. Number of collected samples

The biological data is collected from 18 turbot landings from vessels at the ports Varna, Kavarna, Balchik, Tsarevo, Pomorie and Sozopol.

2.1.4. Number of measured turbots

The total number of fish used for biological data collection is 413.

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.	Bumerang/Vn 8250	43°23'29"	29°10'06"	55-60
2.	Dani/Bl 2116	43°22'12"	28°31'48"	62
3.	Vn 8535	43°11'15"	28°20'00"	60-66
4.	Skaimen/Vn 4377	43°31'37"	29°08'59"	64-65
5.	Viking/Vn 8406	43°15'18"	28°09'64"	60
6.	Diana/Vn 7669	43°21'27"	28°25'24"	50-60
7.	Sv. Anna1/Vn 8265	43°18'49"	28°39'08"	60
8.	Trayana/Vn 4320	43°23'50"	28°40'58"	60
9.	Hishtnik	43°16'08"	28°23'23"	50
10.	Sv. Nikolai	43°06'00"	28°15'36"	50-60
11.	Paldin	43°36'27"	28°47'83"	60

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12.	Ivana	43°41'30"	28°55'00"	50
13.	Korsar2/Vn 7643	43°41'53"	28°55'47"	50-60
14.	Libra/Vn 8311	43°39'15"	29°04'12"	55
15.	Elis/Bch 5322	43°31'37"	29°08'59"	60
16.	Barbun/Vn 7979	43°18'29"	29°12'40"	65-70
17.	Elis/Bch 5322	43°23'29"	29°10'06"	70
18.	Valkobor/Bs 2330	43°22'02"	29°18'08"	60

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 2018, 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 2018 is determined. The ratio between female and male individuals is presented.

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

The gonadosomatic index (GSI, %) is determined based on 32 female specimens and 18 male specimens. 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):

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

W_G – weight of the gonads, g;

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

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3.1. Number of fish caught

The total number of fish, used for biological data collection, is 413. The number of fish caught from each vessel is presented in Fig. 1. An average of 23 fish was caught from each ship or 69.53 kg/ship. The maximum catch for a ship was 70 fish (203.10 kg) and the minimum - 3 fish (9.00 kg).

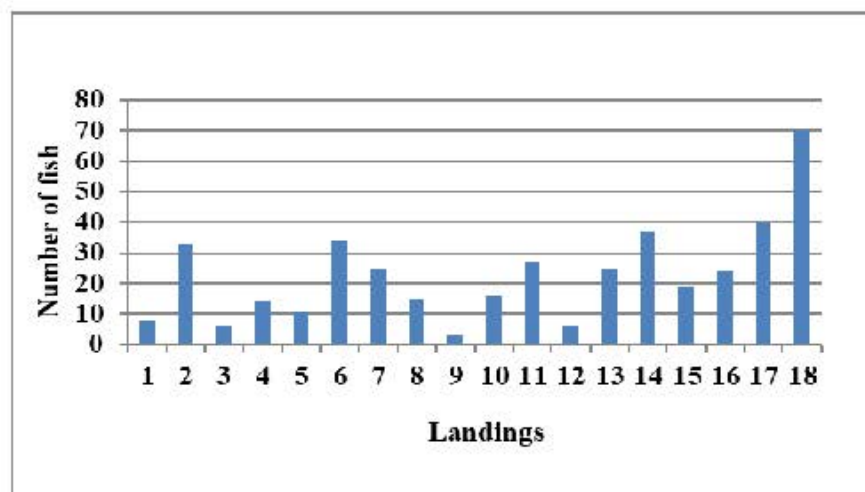


Fig. 1. Number of fish landings at ports.

3.2. Weight structure of the fish catches

The average weight of the measured specimens is 3.03 kg, the maximum measured weight is 6.80 kg and the minimum measured weight is 1.60 kg.

In Figure 2 is presented the percentage distribution of the fish weight. It can be observed that 50 specimens, or 12% of the total number of individuals, have weight up to 2 kg, and 196 individuals, or 47%, are fish with weight from 2 kg to 3 kg. Therefore, in the landings of the monitored ports, 73% of all turbot have weight from 2 to 4 kg within the study period. The weight group of 3 kg to 4 kg is represented by 26% and that of over 4 kg is represented by 15% of the total number of the studied fish.

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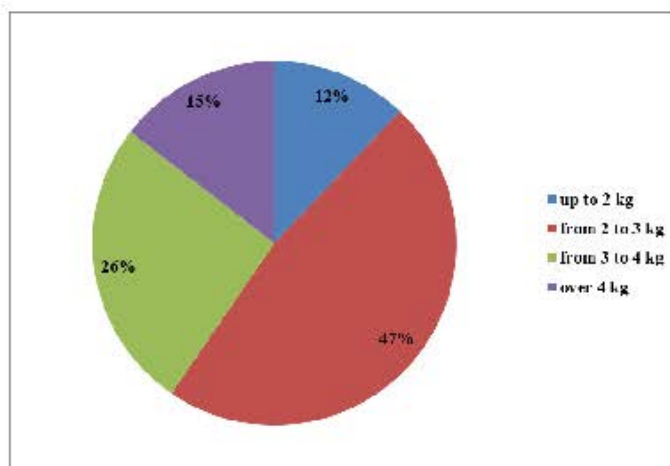


Fig. 2. Distribution of landings according to the weight of the measured fish.

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

The average total length of the measured fish is 54.03 cm, the maximum is 81.50 cm and the minimum - 45.10 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**.

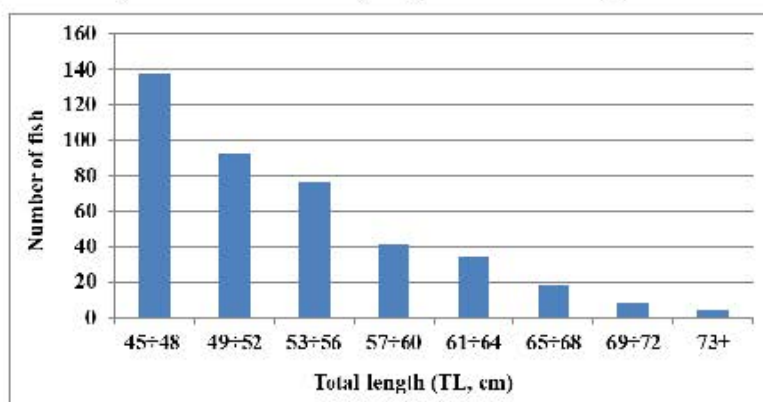


Fig. 3. Distribution of fish in different size groups (3 cm intervals) by total body lengths (TL, cm).

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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 33% of the studied specimens, followed by the 49-52 cm – 23%. Specimens, with total length in the range of 45-52, are 231 representing 56% of all studied fish.

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 43.66 cm. The maximum measured standard length is 68.50 cm and the minimum measured standard length - 34.00 cm.

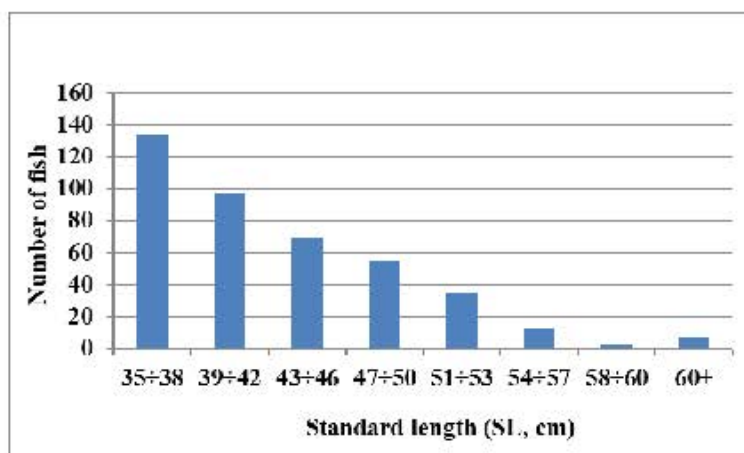


Fig. 4. Distribution of specimens in different size groups (at 3 cm intervals) by standard body length (SL, cm).

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 size group is in the range of 35-38 cm (32%), followed by the group of 39-42 cm (23%). 231 fish are with standard body lengths in the 35-42 cm range.

From the results, it can be concluded that the total body length (TL, cm) of the measured fish ranged from 45.10-81.50 cm and the body weight from 1.60-6.80 kg (**Fig. 5**). The dominant

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group has a total body length from 45 cm to 48 cm and a body weight from 1.33 to 2.13 kg (45%).

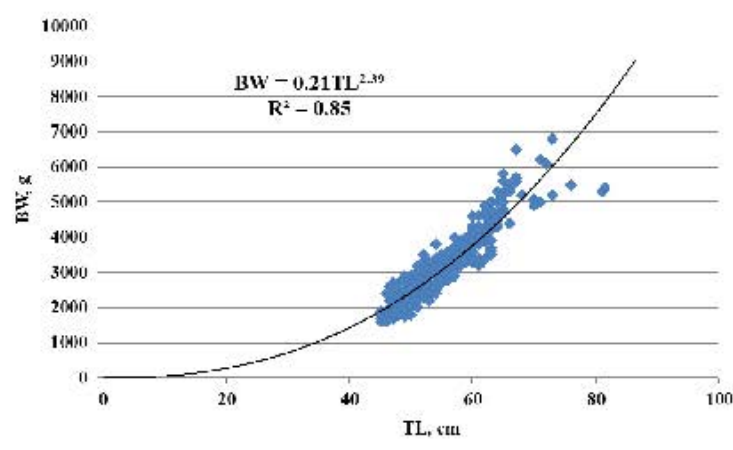


Fig. 5. Correlation between total body length (TL, cm) and weight (BW, g) of turbot (n=413).

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.

From 50 specimens, 32 were female and 18 were male. The female to male ratio is 64:36% or 1.8: 1.

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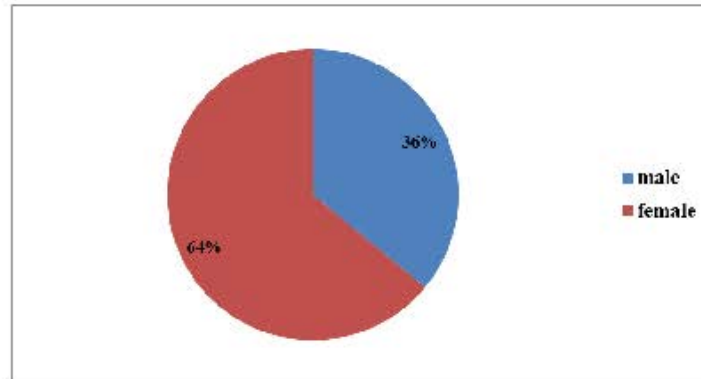


Fig. 6. Sex ratio of studied female and male specimens.

3.4.2. Gonadosomatic index (GSI,%)

The average weight of female fish, measured in December 2018, is 2.88 kg and is in the range 1.60-5.20 kg. The weight of the ovaries is between 11.50 g and 224.10 g, with an average value of 57.95 g (Table 3). The GSI, %, for female fish, caught in December, has an average value of 1.88%. The average value of GSI,% for female fish is 5 times lower in December compared to May, which is specific characteristic of the ovaries during the winter.

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 2018.

№	BW, kg	TL, cm	SL, cm	W _G , g	GSI, %	Age
1	1.60	45.00	35.00	35.20	2.20	3
2	1.80	46.00	36.00	18.20	1.01	4
3	1.90	46.00	36.00	26.00	1.37	4
4	1.75	46.00	36.00	24.20	1.38	3
5	1.80	47.00	37.00	11.50	0.64	4
6	1.90	48.00	38.00	27.40	1.44	4
7	2.00	48.00	38.00	22.00	1.10	4
8	2.15	49.00	39.00	38.20	1.78	4
9	2.25	50.00	39.00	40.20	1.79	4
10	2.70	51.00	41.00	39.00	1.44	4

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11	2.60	52.00	42.00	76.80	2.95	5
12	2.30	52.00	40.00	48.60	2.11	4
13	2.30	52.00	40.50	36.80	1.60	5
14	2.10	52.00	41.50	50.80	2.42	5
15	2.70	53.00	42.00	47.00	1.74	5
16	2.95	54.00	42.00	64.70	2.19	5
17	2.90	54.00	42.00	78.00	2.69	5
18	3.00	54.00	43.00	63.30	2.11	5
19	3.30	55.50	44.00	38.70	1.17	5
20	3.10	56.00	45.00	29.40	0.95	5
21	3.60	56.00	46.00	76.00	2.11	6
22	3.50	56.00	46.00	75.30	2.15	6
23	3.69	56.00	45.50	67.50	1.83	6
24	2.80	56.50	44.50	50.50	1.80	5
25	3.40	57.50	44.50	59.80	1.76	6
26	3.10	58.00	46.00	30.70	0.99	6
27	3.25	58.50	46.00	50.90	1.57	6
28	3.90	59.00	48.00	68.20	1.75	6
29	4.00	61.00	50.00	100.50	2.51	7
30	3.90	62.00	52.00	50.10	1.28	7
31	4.70	63.50	50.00	224.10	4.77	7
32	5.20	64.00	51.00	184.70	3.55	7
min	1.60	45.00	35.00	11.50	0.64	3
max	5.20	64.00	52.00	224.10	4.77	7
average	2.88	53.70	42.70	57.95	1.88	5

The GSI, % for male fish, caught in December 2018, has an average value of 0.85%. The maximum and minimum values are respectively 0.37% and 1.33%.

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 previtellogenic follicles and in the testes - the spermatids.

3.5. Age

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In order to determine the age ratio of turbot landings, in December 2018, 50 pairs of otoliths were examined. The age structure of the 32 studied female specimens ranged from 3 to 7 years of age, with specimens at 4 and 5 years of age being dominant (Fig. 7). They make up for 59% of the total number of fish studied. Most fish are 5-year-old - 31%, followed by 4-year-old specimens - 28%.

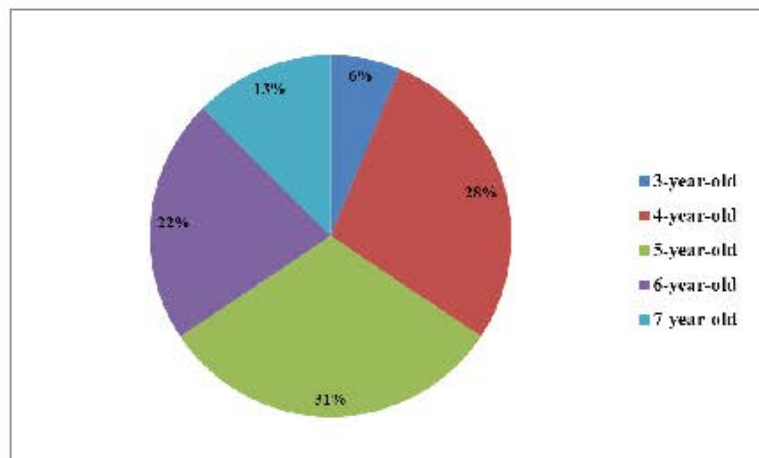


Fig. 7. Percentage distribution of age of female turbot in December 2018 (n=32).

The age ratio of the 18 studied male turbot included 3, 4, 5, 6 and 7-year-old specimens, with 4-year-old being dominant (Figure 8). The percentage of male individuals at this age is around 44%, followed by 3-year-old specimens - 22% and 5-year-old - 17% of the total number of fish studied.

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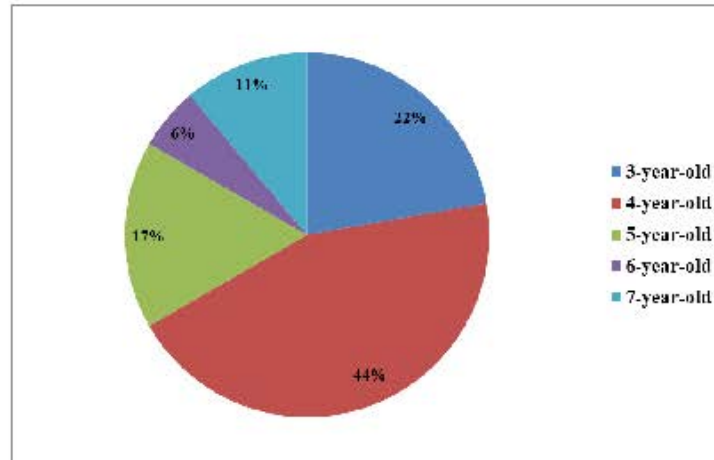


Fig. 8. Percentage distribution of age of male turbot specimens in December 2018 (n=18).

The analysis of the results established that the percentage of specimens (female and male) at 4 and 5 years of age is 60%. 6-year-old fish are 16% and the 3 and 7-year-old specimens represent 24% of the total number of studied fish (Fig. 9).

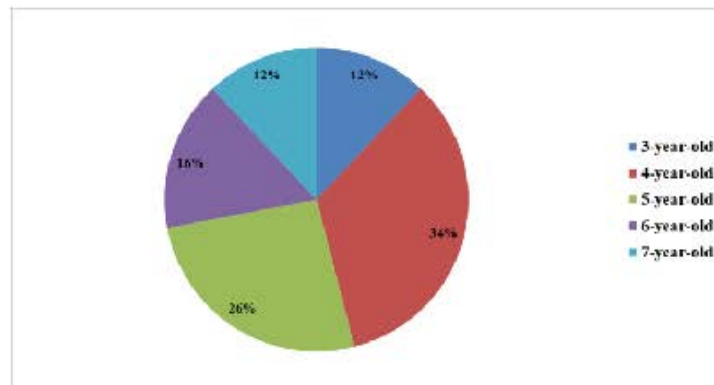


Fig. 9. Percentage distribution of age of turbot (n=50).

Based on the average values, the correlation between the linear growth and the age of turbot, caught in December 2018, is presented in Fig. 10 and Fig. 1.

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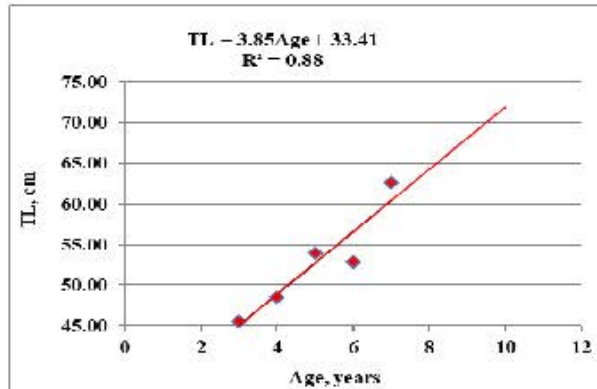


Fig. 10. Correlation between total length (TL, cm) and age (years) of female turbot (n=32).

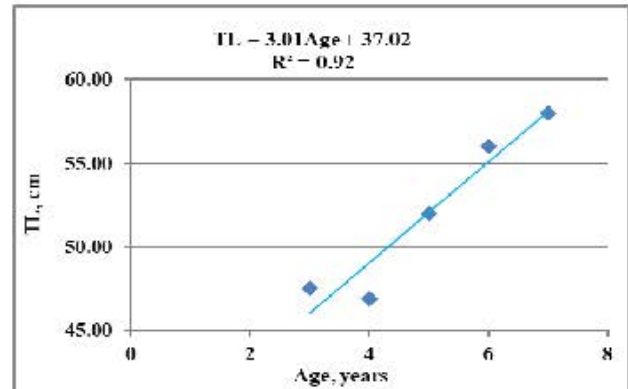


Fig. 11. Correlation between total length (TL, cm) and age (years) of male turbot (n=18).

The weight gain of turbot, in relation to age and sex is presented in Fig. 12, Fig. 13 and Fig. 14.

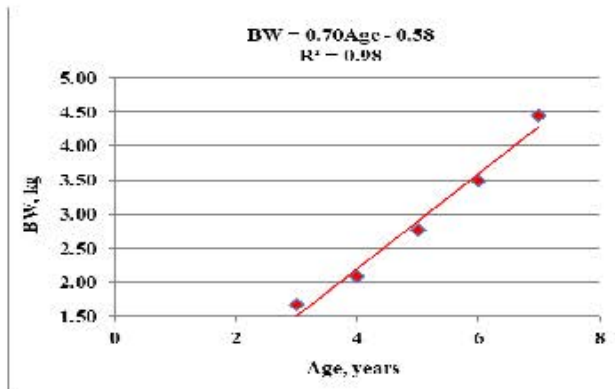


Fig 12. Correlation between weight (BW, kg) and age (years) of female turbot (n=32)

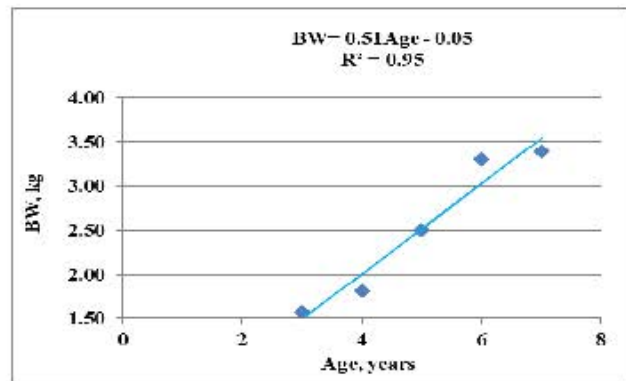


Fig. 13. Correlation between weight (BW, kg) and age (years) of male turbot (n=18).

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

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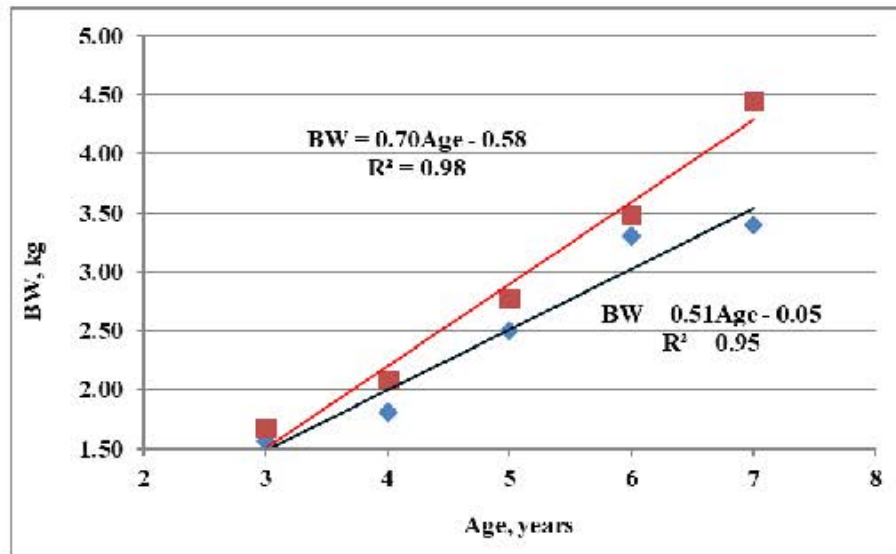


Fig. 14. Weight gain of female and male specimens in relation to age

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

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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 2018, 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 23 specimens of turbot and an average of 69.53 kg per day. The maximum number of fish from the landings of the monitored ports is 70 fish and the minimum is 3 fish.
2. From a total of 18 landings of the monitored ports, 413 specimens are measured with an average weight of 3.03 kg, an average total body length of 54.03 cm and an average standard body length of 43.66 cm.
3. The maximum measured weight is 6.80 kg and the minimum measured - 1.60 kg.
4. The maximum measured total length is 81.50 cm and standard length – 68.50 cm. The minimum measured total length and standard length are respectively 45.10 cm and 34.00 cm.
5. 50 specimens, or 12% of the total number of fish, have weight up to 2 kg and 196 specimens, or 47% of all studied fish, have weight from 2 kg to 3 kg. Therefore, from the landings of the monitored ports, around 73% of all turbot have weight from 2 to 4 kg during the carried out monitoring. The weight group of 3 to 4 kg make up for 26% and 15% - the 4 kg size group.
6. From the distribution of the fish by size groups (at 3 cm) by total length, it is established that the largest size group is the 45-48 cm. This group represent 33% of all studied specimens, followed by the group of 49-52 cm – 23%. 192 fish have 45-52 cm total body length, which is 77.73% of all measured specimens.
7. The average value of the standard body length (SL, cm) is 43.66 cm. The maximum standard length measured is 68.50 cm and the minimum measured - 34.00 cm.

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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. With age, female fish gain weight faster than male fish.
10. The age structure of the caught specimens include 3 to 7-year-old fish, with 4 and 5-year-old specimens being predominant.
11. From the 50 turbot studied specimens, 32 are female and 18 are male. The percentage ratio between female and male fish is 64:36.
12. In December 2018, the gonadosomatic index (GSI, %) for female turbot has an average value of 1.88%, with maximum and minimum values of 4.77% and 0.64%.
13. The maximum and minimum values of the gonadosomatic index for male specimens in December 2018 are respectively 1.33% and 0.37%, with an average value of 0.85%.
14. In December, the ovaries and testes of the studied specimens have reached III stage of maturity, which is specific characteristic for the winter period.

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