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

**Institute of Fisheries and Aquaculture, Plovdiv**

**Agricultural Academy, Sofia**

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**2018**

## **Working group from IFA, Plovdiv**



**Prof. Tania Hubenova, PhD;**

**Prof. Angel Zaikov, PhD;**

**Assoc. Prof. Angelina Ivanova, PhD;**

**Georgi Rusenov, PhD**

**Assis. Prof. Vasilka Krasteva**

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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 third 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. Characteristics of the age structure.

### **2. Material and methods**

#### **2.1. Collection of biological data from landings**

The biological data collection is performed in the second 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 and Kavarna ports) are used for biological data collection.

### 2.1.2. Vessels for sample collection

Biological data is collected from 8 vessels from Varna port and 2 vessels from Kavarna port, listed in Table 1.

**Table 1. Ports and vessels used for monitoring and biological data collection from landings of turbot in the third quarter of 2018.**

№	Ships
<b>Port Varna</b>	
1.	Ival/Vn8194
2.	rk5/Vn8186
3.	Hermes3/Vn4926
4.	Sigma/Vn7180
5.	Vn8535
6.	Bumerang/Vn8250
7.	Vn8112
8.	Elekta
<b>Port Kavarna</b>	
9.	Vn4601
10.	Ivana/Vn6231

### 2.1.3. Number of collected samples

The biological data is collected from 11 turbot landings from vessels at the ports Varna and Kavarna.

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#### 2.1.4. Number of measured turbot

The total number of fish used for biological data collection is 247.

#### 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.	Ival/Vn8194			55-60
2.	rk5/Vn8186	43°22'12" N	28°31'48" E	62
3.	Hermes3/Vn4926	43°11'15" N	28°20'00" E	60-66
4.	Sigma/Vn7180			64-65
5.	Vn8535			60
6.	Bumerang/Vn8250			
7.	Vn8112			
8.	Elekta			
9.	Vn4601	43°16'08" N	28°23'23" E	
10.	Ivana/Vn6231	43°06'00" N	28°15'36" E	

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

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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.



#### **2.1.7. Characteristics of the reproductive biology of turbot**

In the third 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 third 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 36 female specimens and 14 male

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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):

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

$W_G$  – weight of the gonads, g;

$BW$  – body weight, g;

- **Determination of the maturity stage of the reproductive organs in relation to the season at the time of the study**

The organs are removed and fixed in formaldehyde for further processing in order to establish the maturity of the ovaries and the testes. Paraffin sections were prepared for determination of the stage of maturity.

- **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 247. The number of fish caught from each vessel is presented in **Fig. 1**. An average of 22 fish were caught from each ship or 48.49 kg/ship. The maximum catch for a ship was 111 fish (243.48 kg) and the minimum - 6 fish (11.80 kg).

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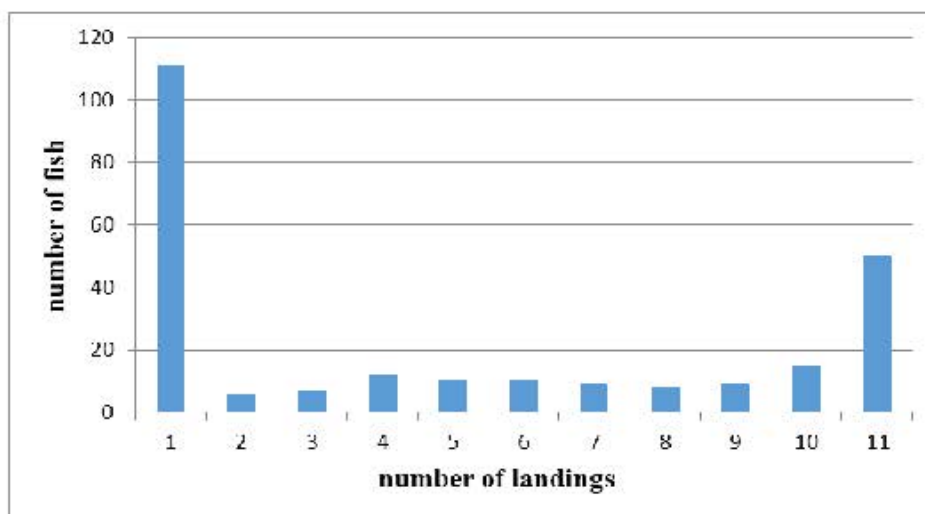




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**Fig. 1. Number of fish landings at ports.**

### 3.2 Weight structure of the fish catches

The average weight of the measured specimens is 2.16 kg, the maximum measured weight is 5.60 kg and the minimum measured weight is 1.33 kg.

In **Figure 2** is presented the percentage distribution of the fish weight. It can be observed that 134 specimens, or 54% of the total number of individuals, have weight up to 2 kg, and 87 specimens, or 35%, are fish with weight from 2 kg to 3 kg. Therefore, in the landings of the monitored ports, 89% of all turbot weigh up to 3 kg within the study period. The weight group of 3 kg to 4 kg is represented by 9% and that of over 4 kg is represented by 2% of the total number of the studied fish.

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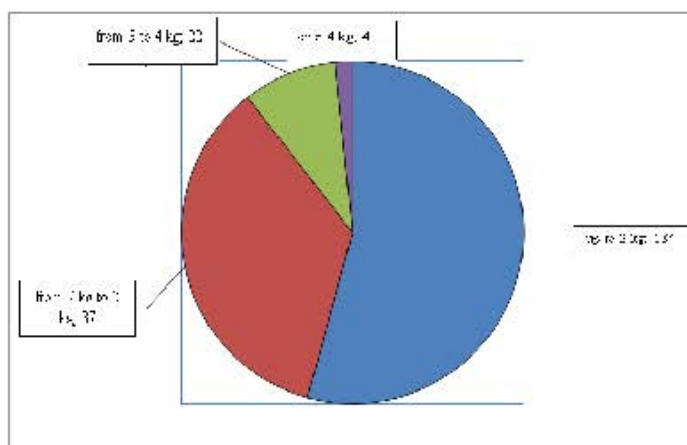
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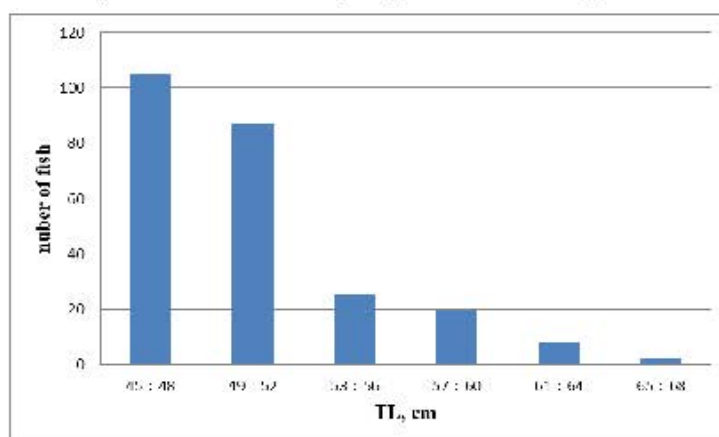
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**Fig. 2. Distribution of landings according to the weight of the measured fish.**

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

The average total length of the measured fish is 50.15 cm, the maximum is 68.00 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).**

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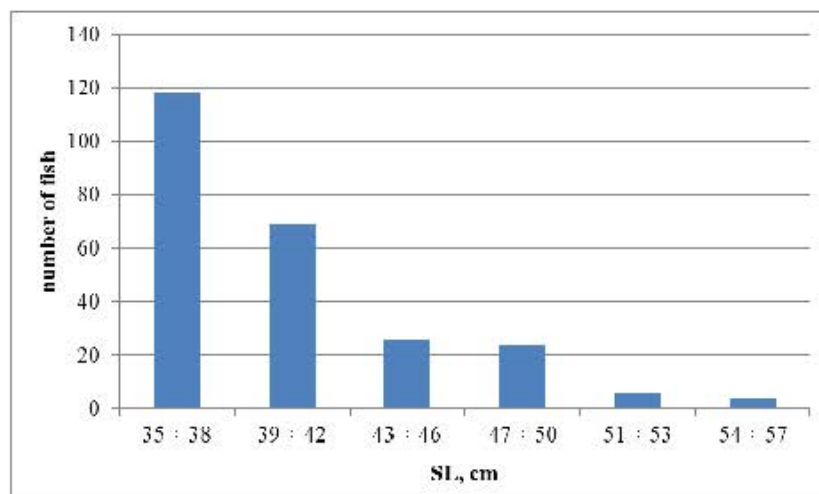


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From the distribution of the specimens by size groups (at 3 cm intervals), it is established that the most represented is the size group of 45-48 cm. This group represents 42.51% of the studied specimens, followed by the 49-52 cm – 35.22%. 77 specimens are with total length in the range of 45-52 cm (77.73%).

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.



**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 (47.77%), followed by the size group 39-42 cm (27.94%). 187 fish are with standard body lengths in the 35-42 cm range.

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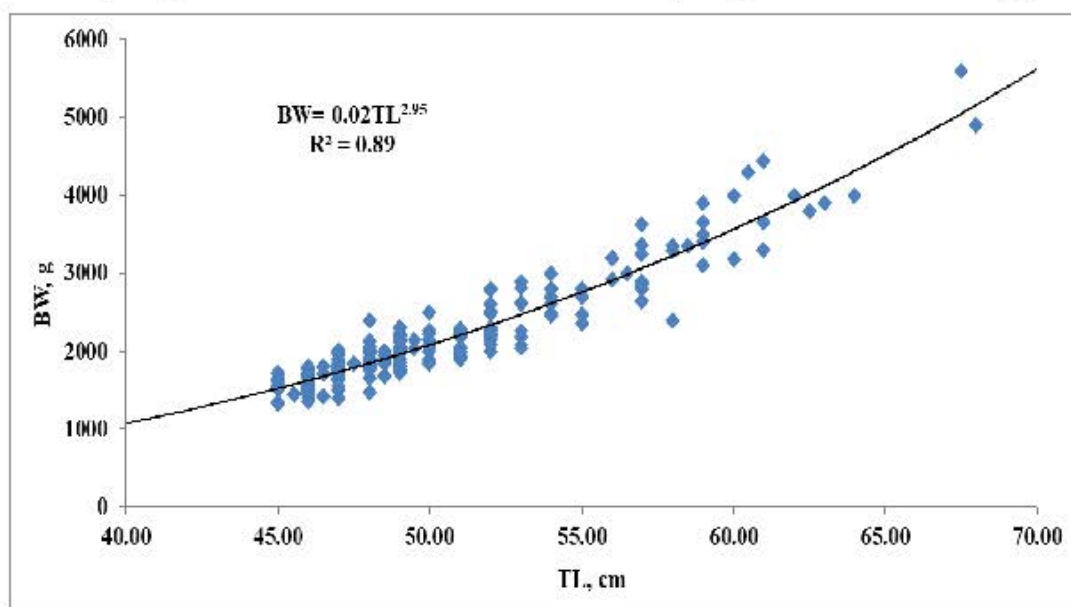
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From the results, it can be concluded that the total body length (TL, cm) of the measured fish ranged from 45.0-68.0 cm and the body weight from 1.33-5.60 kg (**Fig. 5**). The dominant group has a total body length from 45.0 cm to 48.0 cm and a body weight from 1.33-2.13 kg (45%).



**Fig. 5. Correlation between total body length (TL, cm) and weight (BW, g) of turbot (n=247).**

The correlation between the total body length and weight of the turbot landings is expressed with the equation:  $BW = 0.02TL^{2.95}$ .

### **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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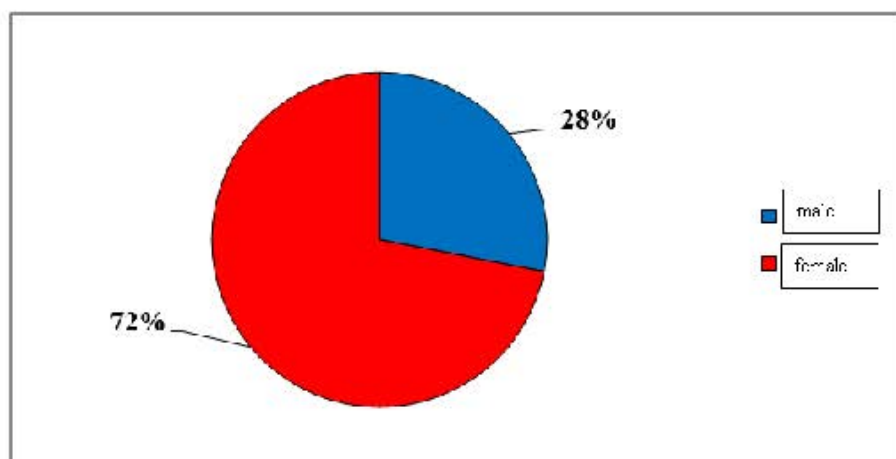




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**Fig. 6. Sex ratio of studied female and male specimens.**

From 50 specimens, 36 were female and 14 were male. The female to male ratio is 72:28% or 2.6:1

### 3.4.2. Gonadosomatic index (GSI,%)

The average weight of female fish, measured in August 2018, is 1.76 kg and is in the range 1.34-2.80 kg. The weight of the ovaries is between 0.011 kg and 0.042 kg, with an average value of 0.026 kg. The GSI, %, for female fish, caught in August 2018, has an average value of 1.45% (Table 3).

**Table 3. Body weight (BW, kg), total (TL, cm) and standard (SL, cm) body lengths, testes weight (WG, kg), GSI,% and age of female specimens in August 2018.**

Nº	BW, kg	TL, cm	SL, cm	WG, kg	GSI, %	Age
1	1.34	45.0	35.0	0.011	0.79	2
2	1.36	46.0	36.0	0.021	1.54	4
3	1.51	46.0	35.0	0.018	1.16	2

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4	1.53	45.0	35.0	0.018	1.16	3
5	1.54	45.0	35.0	0.018	1.17	3
6	1.54	46.0	36.0	0.018	1.18	3
7	1.55	46.0	36.5	0.027	1.72	3
8	1.56	45.0	35.0	0.020	1.25	2
9	1.56	46.0	35.5	0.021	1.32	4
10	1.60	46.0	35.0	0.019	1.18	3
11	1.61	45.0	36.0	0.017	1.06	3
12	1.62	45.0	35.0	0.023	1.44	5
13	1.65	46.0	35.0	0.030	1.81	3
14	1.66	45.0	35.0	0.024	1.42	3
15	1.68	48.5	36.0	0.028	1.65	3
16	1.70	46.0	36.0	0.019	1.09	3
17	1.70	46.0	36.0	0.028	1.63	3
18	1.71	45.0	35.0	0.025	1.46	4
19	1.72	46.5	37.5	0.032	1.85	4
20	1.72	46.0	36.0	0.024	1.40	3
21	1.75	47.0	37.5	0.035	2.01	3
22	1.78	46.0	36.5	0.025	1.38	3
23	1.80	47.0	36.0	0.029	1.62	3
24	1.80	46.5	35.0	0.022	1.19	4
25	1.80	46.0	36.0	0.042	2.31	4
26	1.80	47.0	36.5	0.018	0.98	4
27	1.84	47.0	36.0	0.036	1.96	3
28	1.85	47.5	38.5	0.036	1.93	2
29	1.86	49.0	38.0	0.027	1.47	4
30	1.89	50.0	39.0	0.019	1.00	3
31	1.99	49.0	38.0	0.035	1.78	5
32	2.00	47.0	38.0	0.030	1.50	3
33	2.06	48.0	38.0	0.035	1.70	4

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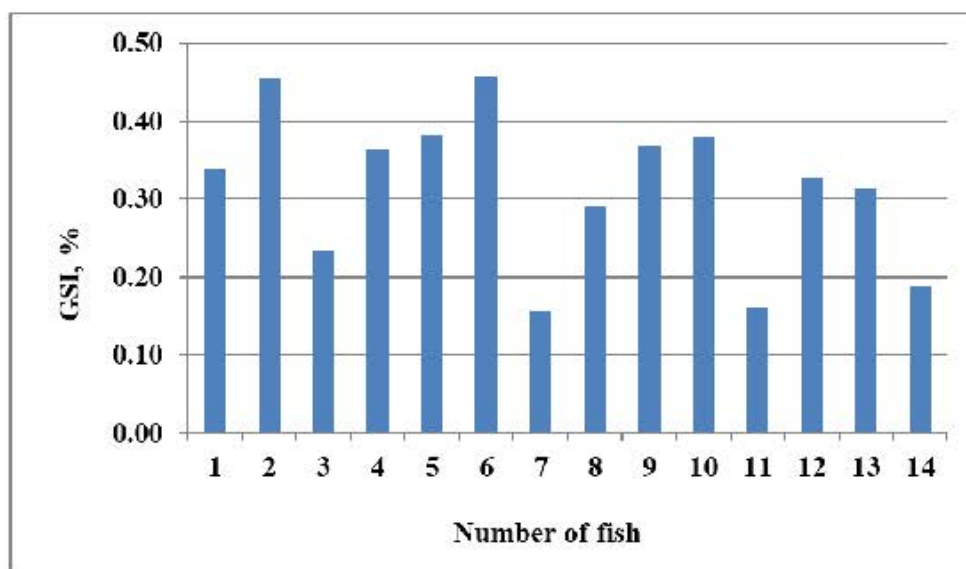


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34	2.13	48.0	38.0	0.020	0.94	3
35	2.26	52.0	41.0	0.041	1.82	5
36	2.80	52.0	40.0	0.035	1.25	3
<b>min</b>	<b>1.34</b>	<b>45.0</b>	<b>35.0</b>	<b>0.011</b>	<b>0.79</b>	<b>2</b>
<b>max</b>	<b>2.80</b>	<b>52.0</b>	<b>41.0</b>	<b>0.042</b>	<b>2.31</b>	<b>5</b>
<b>average</b>	<b>1.76</b>	<b>46.8</b>	<b>36.5</b>	<b>0.026</b>	<b>1.45</b>	<b>3</b>

The GSI, % for male fish, caught in August 2018, has an average value of 0.31% (Fig. 7).



**Fig. 7. GSI (%) values for male specimens in August 2018 (n = 14).**

The maximum and minimum values of GSI, %, in males in August 2018, are respectively 0.16% and 0.46%.

In **Table 4** the GSI values, % and turbot age in May and August 2018 are presented.

**Table 4. Relation between GSI, % values and turbot age.**

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Age, years	Gonadosomatic index, %		
	Female fish		Male fish
	May (32 specimens)	August (36 specimens)	August (14 specimens)
2	-	1.28	0.26
3	8.03	1.41	0.33
4	10.57	1.54	0.29
5	16.50	1.68	0.31
6	8.16	—	—
7	6.91	—	—
8	6.74	—	—
10	10.95	—	—

The average GSI, % for female fish, is on average 8 times lower in August compared to May, which is distinctive 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 II-III stage of maturity is reached. The major part of the ovaries contained previtelogenic follicles and in the testes - the spermatids.

### 3.4.4. Age

In order to determine the age ratio of turbot landings, in August 2018, 50 pairs of otoliths were examined. The age structure of the 36 studied female specimens ranged from 2 to 5 years of age,

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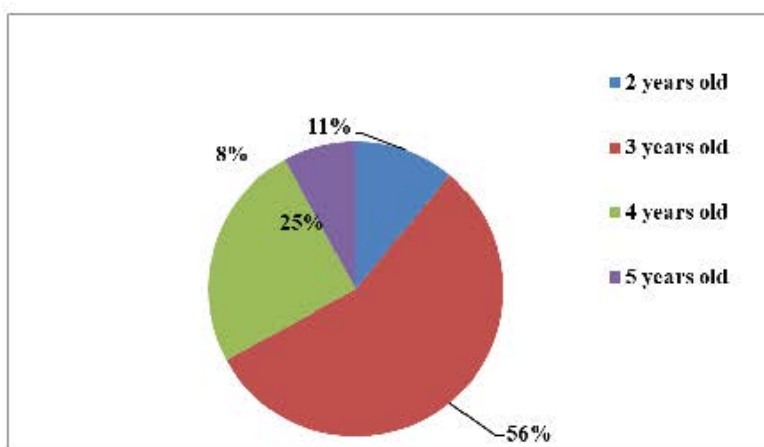
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with 3 and 4-year-old fish being predominant (**Fig. 8**). They form 81% of the total number of studied fish. Most of the fish are 3-year-old – 56%, followed by 4-year-old specimens – 25%.



**Fig. 8. Percentage distribution of age of female turbot in August 2019 (n=36).**

The age ratio of the 14 studied male turbot included 2, 3, 4 and 5-year-old specimens, with 3-year-old specimens being predominant (Figure 9). The percentage of male specimens at this age is around 50%, followed by 5-year-old specimens - 29% and 2-year-old - 14% of the total number of fish studied.

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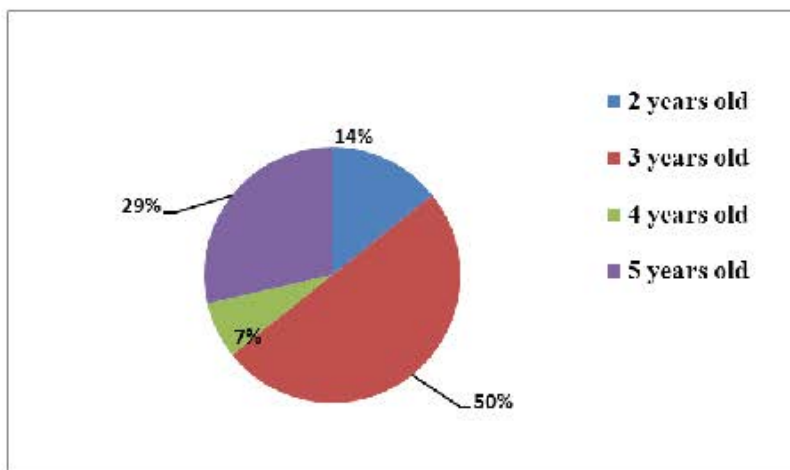
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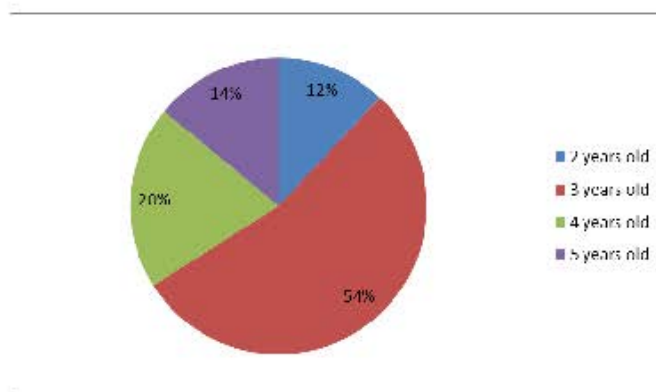


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**Fig. 9. Percentage distribution of age of male turbot specimens in August 2018 (n=14).**

The analysis of the results established that the percentage of specimens (female and male) of 3 and 4 years of age is around 75%. 5-year-old fish are 14% and the at 2-year-old represent 2% of the total number of studied specimens (Fig. 10).



**Fig. 10. Percentage distribution of age of turbot (n=50).**

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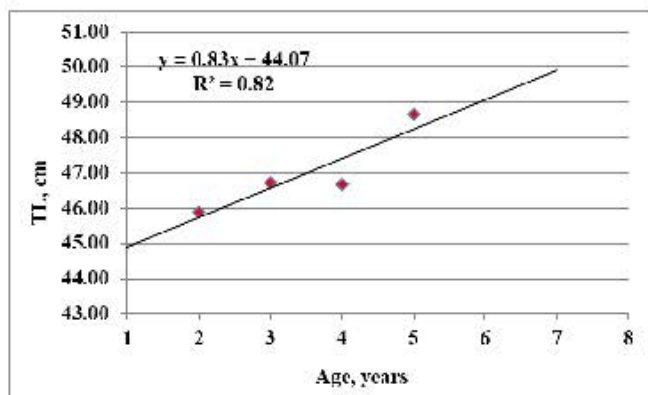
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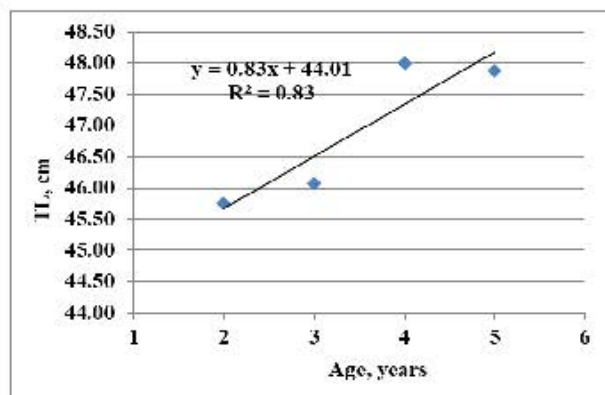
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Based on the average values, the correlation between the linear growth and the age of turbot, caught in August 2018, is presented in Fig. 11 and Fig. 12.

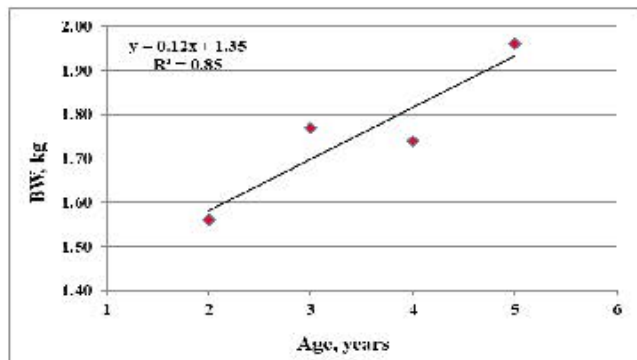


**Fig. 11. Correlation between total length (TL, cm) and age (years) of female turbot (n=36).**

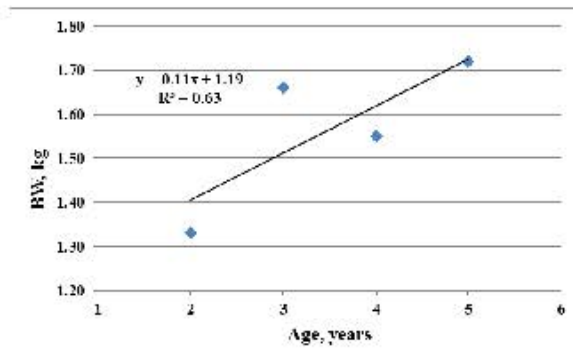


**Fig. 12. Correlation between total length (TL, cm) and age (years) of male turbot (n=14).**

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



**Fig 14. Correlation between weight (BW, kg) and age (years) of female turbot (n=36).**



**Fig. 15. Correlation between weight (BW, kg) and age (years) of male turbot (n=14).**

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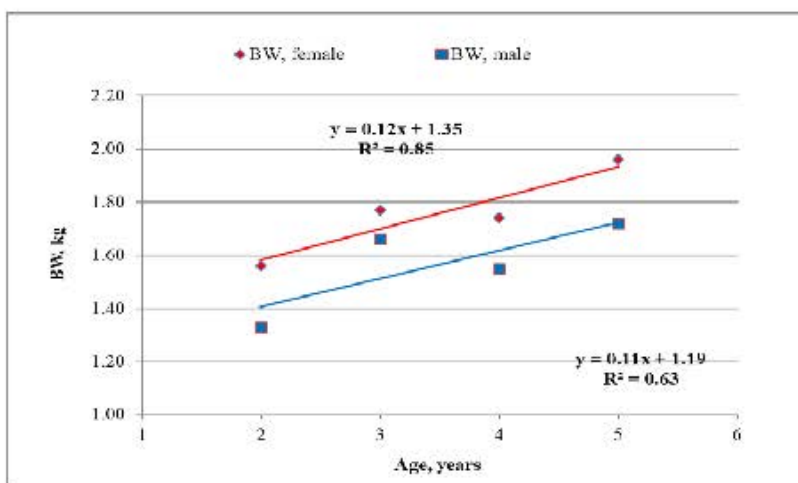
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The weight gain of turbot in correlation to age, based on mean values, is presented in **Fig. 16**.



**Fig. 16. Weight gain of female and male specimens in relation to age (n=50).**

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 third quarter of 2018, we can make the following conclusions and suggest the following recommendations:

1. In August 2018, the landings from the fishing ships have an average value of 17 specimens of turbot and an average of 36 kg per day. The maximum number of fish from the landings of the monitored ports is 50 fish and the minimum is 8 fish.

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2. From a total of 11 landings of the monitored ports, 247 specimens are measured with an average weight of 2.16 kg, an average total body length of 50.15 cm and an average standard body length of 40.08 cm.
3. The maximum measured weight is 5.60 kg and the minimum measured - 1.33 kg.
4. The maximum measured total length is 68.00 cm and standard length - 56.50 cm. The minimum measured total length and standard length are respectively 45.00 cm and 35.00 cm.
5. 134 specimens, or 54% of the total number of fish, have weight up to 2 kg and 87 specimens, or 35% of all studied fish, have weight from 2 kg to 3 kg. 22 specimens, or 9% of all studied fish, have weight from 3 kg to 4 kg. Specimens with weight over 4 kg are 2% of all measured fish. Therefore, from the landings of the monitored ports, around 89% of all turbot weigh up to 3 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 group is that of 45-48 cm. This group make up for 42.51% of all studied specimens, followed by the group of 49-52 cm – 35.22%.
7. Specimens with total body lengths in the 45-52 cm range are 192, representing 77.73% of all measured specimens.
8. The average value of the standard body length (SL, cm) is 40.08 cm. The maximum standard length measured is 56.00 cm and the minimum measured - 35.00 cm.
9. The correlation between the size and the weight structure of the turbot landings is described with the equation:  $BW = 0.02TL^{2.95}$ .
10. With age, female fish gain weight faster than male fish.
11. The age ratio of the caught specimens includes 2 to 6-year-old fish, with 3 and 4-year-old specimens being predominant.

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12. From the 50 turbot specimens examined, 36 are female and 14 are male. The percentage ratio of female to male fish is 72:28.
13. In August 2018, the gonadosomatic index (GSI, %) for female turbot has an average value of 1.45%, with maximum and minimum values of 2.31% and 0.79%, respectively.
14. The maximum and minimum values of the gonadosomal index in male specimen, in August 2018, are 0.16% and 0.46%, respectively.
15. The ovaries and testes of the studied specimens are in stage II-III of maturity.

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