

BIOLOGICAL MONITORING OF TURBOT (*PSETTA MAXIMA* L.) LANDINGS AT THE BULGARIAN BLACK SEA SHORE IN DECEMBER 2015

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Biological monitoring of turbot (*Psetta maxima* L.) landings at the Bulgarian Black Sea shore in December, 2015

1. Purpose

The purpose of the biological monitoring of turbot catches at the Bulgarian Black Sea shore was to build up a database for analysis of the catches structure over the years. The main tasks of the study included measurements of body weight, total and standard body length of turbot from landing operations in order to determine the size structure of catches and to analyse the results. Moreover also aims gathering information on other basic biological data about the species, mainly concerning reproduction, quality and quantity of meat and others.

2. Material and methods

2. 1. Collection of biological data from landing operations

The biological data collection was performed in December 2015 in the northern Bulgarian Black Sea coastal zone.

2.1.1. Ports for collection of biological data

From ports where landings of turbot are permitted, the Kavarna, Balchik and Varna ports were used for biological data collection.

2.1.2. Vessels for sample collections

Biological data were collected from 25 ships – 13 ships from the port of Kavarna, 7 ships from the port of Balchik and 5 ships from the port of Varna, all shown in Table 1.

Table 1. Ports and vessels used for monitoring and biological data collection during landings of turbot caught in December, 2015.

№	Port Kavarna
	ships
1	KB 5562 Gulliver
2	BH 4601
3	BH 4321 Gondola
4	BH 8190 Sveti Nikolay
5	BH 7180 Sigma



6	BH 4496 Amber
7	KB 6275 Delfin
8	KB 6241 Hera
9	BH 7041 Akula 1
10	KB 5642 Puldin
11	KB 6231 Ivana
12	KB 6262 Hishtnik
13	BH 8406 Viking
Port Balchik	
ships	
14	BH 2998
15	BH 8042 Elekta
16	BH 4040 Irina
17	BH 7643 Korsar 2
18	BH 3554 Sveti Georgi
19	BH 8311 Libra
20	BH 8250 Bumerang
Port Varna	
ships	
21	BH 4377 Skaymen
22	BH 3602 Sveti Martin
23	PK 5
24	BH 4003 Agi
25	BH 7669 Diana

2.1.3. Number of collected samples

The biological data were collected from 34 catches unloaded from the vessels on three ports – Kavarna, Balchik and Varna.

2.1.4. Number of measured turbot

The total number of fishes used for biological data collection was 500. The coordinates and the depth of places of catch for ships that landed on port Kavarna, Balchik and Varna are shown in Table 2.

Table 2. Coordinates and depth of turbot catch places

№	Ship	Coordinates of catch place		Depth of catch place
		latitude	longitude	
Port Kavarna				
1.	KB 5562 Gulliver	43.32333°	028.41957°	60
2.	BH 4601	43.15100°	028.81767°	62
3.	BH 4321 Gondola	43.07805°	028.20173°	66
4.	BH 8190 Sveti Nikolay	43.15849°	028.18896°	64-65
5.	BH 7180 Sigma	43.16665°	028.19300°	60
6.	BH 4496 Amber	43.32028°	028.31209°	60-62.5
7.	KB 6275 Delfin	43.11900°	028.11300°	73
8.	KB 6241 Hera	43.16665°	028.19300°	60
9.	BH 7041 Akula 1	43.31170°	028.39228°	67
10.	KB 5642 Puldin	43.28978°	028.34873°	62.5
11.	KB 6231 Ivana	43.28638°	028.35305°	63
12.	KB 6262 Hishtnik	43.33028°	028.31139°	65
13.	BH 8406 Viking	43.29527°	028.37305°	63
Port Balchik				
14.	BH 2998	43.36027°	028.55944°	60
15.	BH 8042 Elekta	43.76333°	030.11638°	66
16.	BH 4040 Irina	43.32954°	028.46868°	63
17.	BH 7643 Korsar 2	43.27888°	028.25111°	62
18.	BH 3554 Sveti Georgi	43.31667°	028.50555°	60
19.	BH 8311 Libra	43.25666°	028.58222°	62.5
20.	BH 8250 Bumerang	43.04776°	028.21195°	63
Port Varna				
21.	BH 4377 Skaymen	43.18861°	028.30583°	65
22.	BH 3602 Sveti Martin	43.40833°	028.37666°	64
23.	PK 5	43.61666°	028.88333°	61



24.	BH 4003 Agi	42.99170°	028.07576°	60
25.	BH 7669 Diana	43.06972°	028.32722°	62

2.1.5. Data processing

The measurements of fishes were made on the board of ship immediately after docking of ships at the port, on fresh ice-cooled subjects. The weight measurement was done with a precision of 0.1 g, while that of total and standard lengths – with a precision of 0.1 cm.



The data processing, graphs and tables were elaborated by means of statistical software. The primary measurement data are presented in an appendix to the report tables.

2.2. Other biological data

2.2.1. Carcass evolution

The carcass evolution was performed on 10 fishes from the both sexes selected randomly – 5 females and 5 males from the catches in December, 2015.



An individually measurement of the body weight, the weight of the head (without gills), the internal organs, gills, fins and carcass has been performed. Data are presented in absolute (g) and the relative values (% of body weight).

The absolute (g) and relative (% of body weight) values of the different rates of body yield - carcass yield, consumables yield and yield for the canning industry, separately for both sexes, are also calculated.

From the catches in March 2016 data for the above mentioned features are presented but only from 5 females, due to lack of a representative number of males in catches at that time.

2.2.2. Biochemical analysis of meat in both sexes

The biochemical composition of turbot meat (*Psetta maxima*), caught in the Black Sea by trawling with a bottom trawl in December 2015 and March 2016 was determined for the purposes of the investigation. Fish were divided in two groups according to their sex.

Samples for the analysis of the edible fish tissue were collected according to BSS 3419:1978 “Fish and fish products. Rules for sampling”.

The chemical meat composition was determined individually with respect to: water content (drying at 105° C, 24 h; Bulgarian State Standard – SR ISO 5984); protein content (Kjeldahl method; Bulgarian State Standard – SR ISO 5983 using a semi-automated DK 6 digester unit and UDK 132 distillation system, Velp Scientifica); fat content, % (by the method of Smidt-Boudzynski Ratzlaff); mineral content, % (by burning in a muffle furnace at 550° C, BSS – SR ISO 6496).

The energy content of turbot meat was estimated theoretically on the basis of the chemical composition using the following coefficients: 17 kJ.g⁻¹ for proteins and carbohydrates and 37.0 kJ.g⁻¹ for fat (Ordinance 23 /2001, Ministry of Health).

2.2.3. Gonadosomatic index (GSI,%)

The Gonadosomatic index (GSI,%) is determined during the autumn-winter period of sampling – December, 2015 based on 7 females and 13 males. In the spring catch - March, 2016 GSI is defined only on 10 females and 2 males. The determination is calculated as a percentage of the body weight for each gender separately, based on data from the weight measurements of body and sex organs in male and female fish.

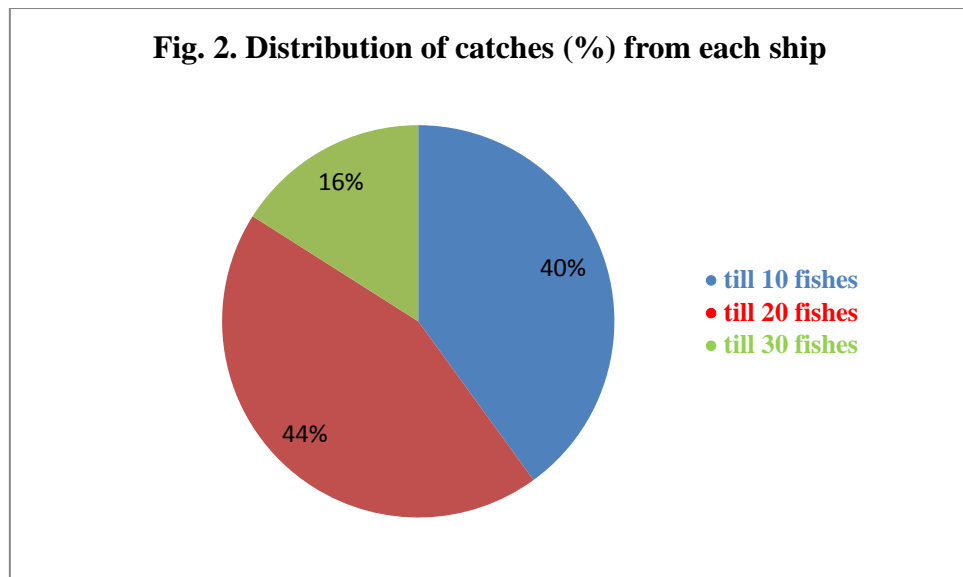
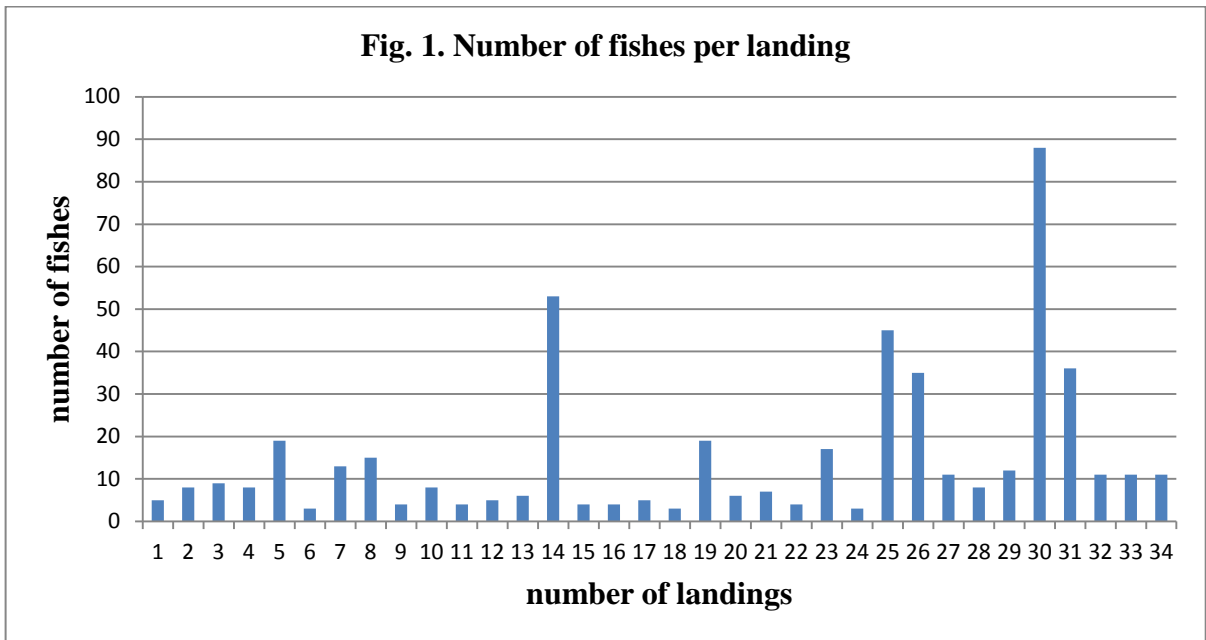
2.2.4. Fecundity

The fecundity was determined based on 10 females caught in March, 2016. Presented are data on the absolute (egg number/fish) and relative (egg number/kg fish body weight) fecundity.

3. Results

3.1. Number of fishes caught from each ship

The total number of fishes, used for biological data collection, was 500. The number of fishes caught from each vessel and their percentage distribution is presented on **Fig. 1** and **Fig. 2**. 15 turbot were caught from each ship on the average, with maximum number of 88 and minimum – 3 turbot. 10 vessels caught 5 to 10 fishes; 11 ships - 11 to 20 turbot. In single cases fishermen unloaded at the port more than 30 subjects.



3.2. Body weight structure of catches

The average, maximum and minimum weight from the turbot landings is shown on **Fig. 3**. The average weight of measured turbot was 2.50 kg, and the maximum-minimum range: 6.34-1.30 kg.

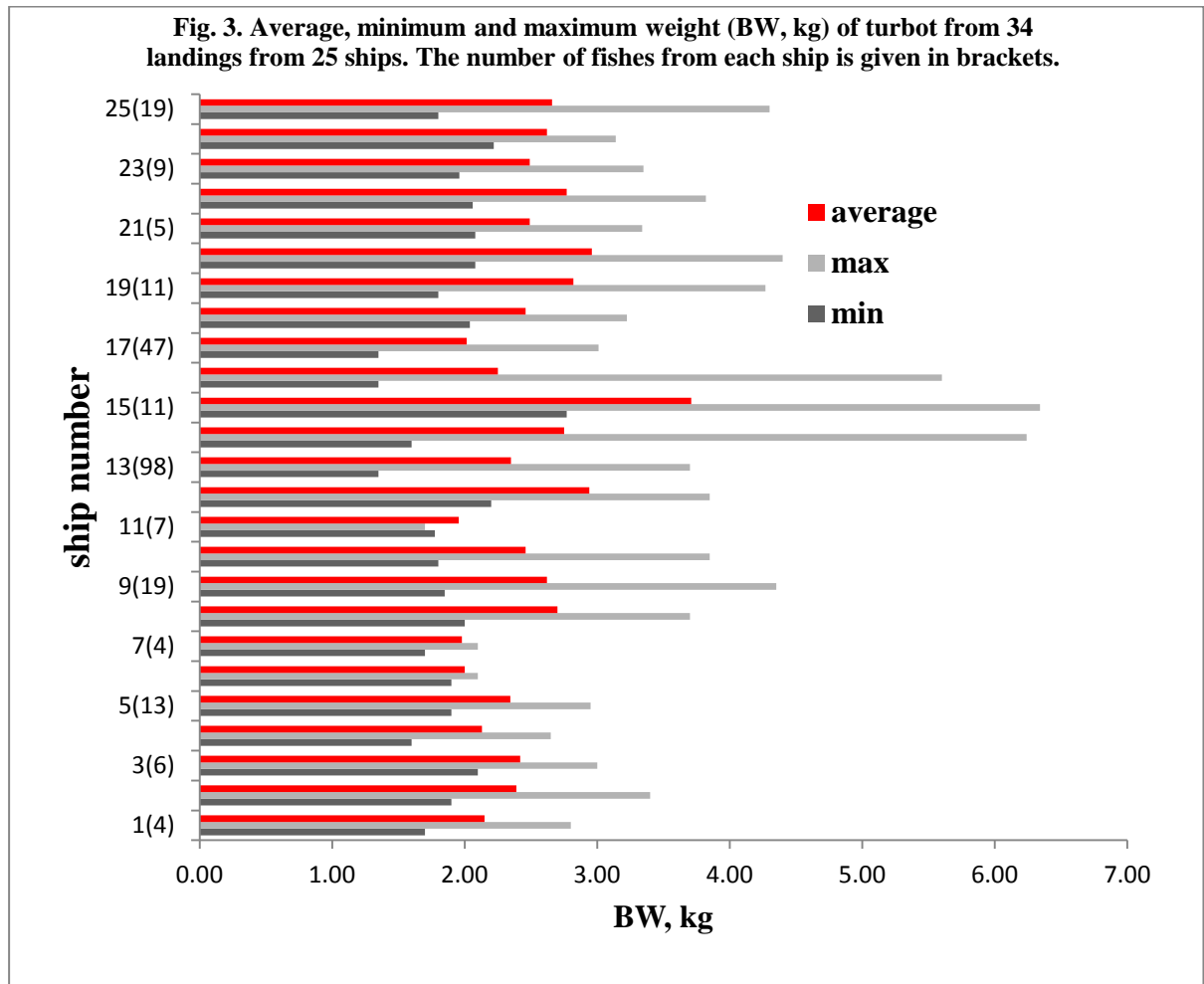
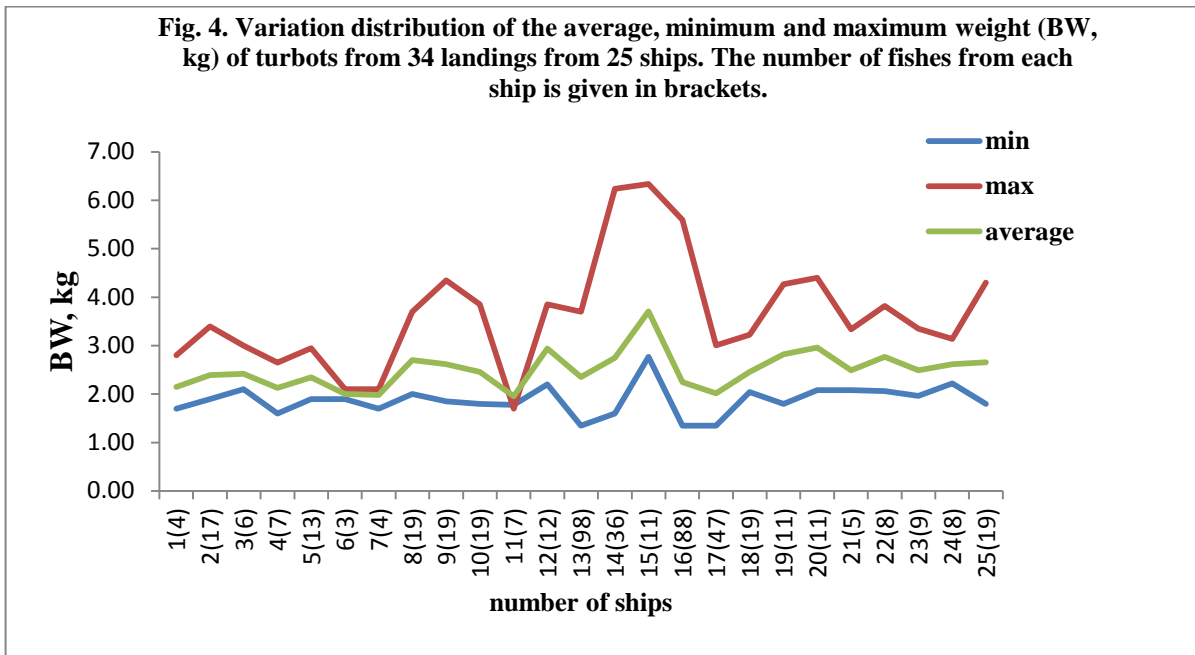
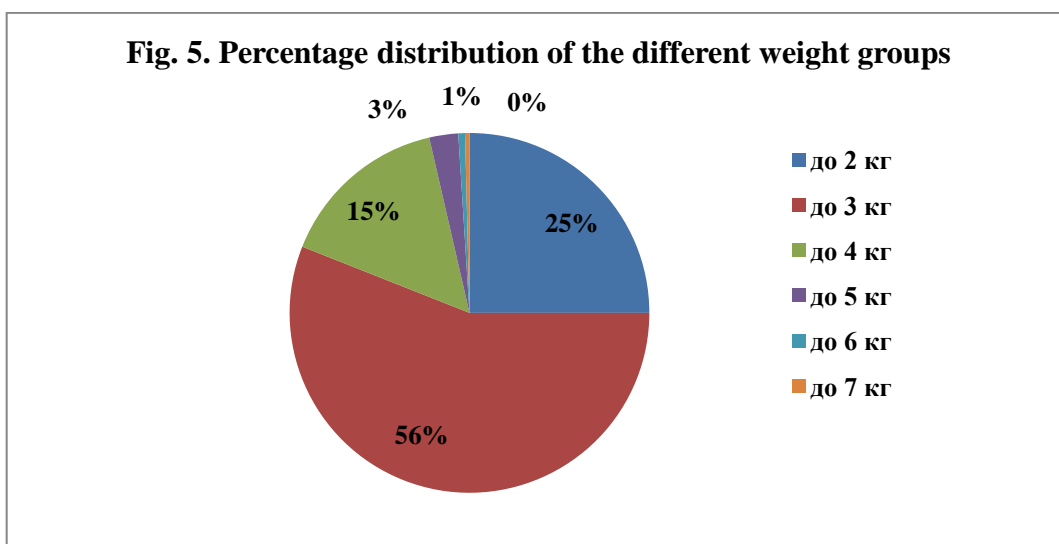


Fig. 4 presents the distribution of average, minimum and maximum weights of measured fishes. The average turbot weight from the different catches varied between 1.87 and 3.71 kg; maximum weight – between 6.34 and 2.10 kg, and minimum ones - between 2.77 and 1.30 kg.



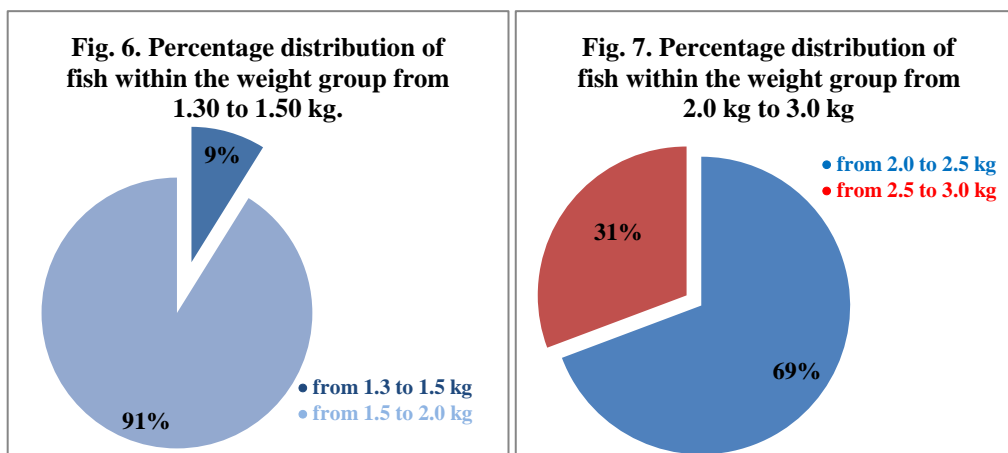
On **Fig. 5** is shown the percentage distribution of the different weight groups for all 500 investigated turbot. The highest share has the weight group from 2.0 to 3.0 kg – 56%, followed by the weight group from 1.3 to 2.0 kg – 25%. The share of the weight group between 3.0 and 4.0 kg is 15%, that of the group from 4.0 to 5.0 kg - 3%, and that of the weight group from 5.0 to 6.0 kg is only 1%. Only two fishes from all 500 investigated have body weight between 6 and 7 kg.



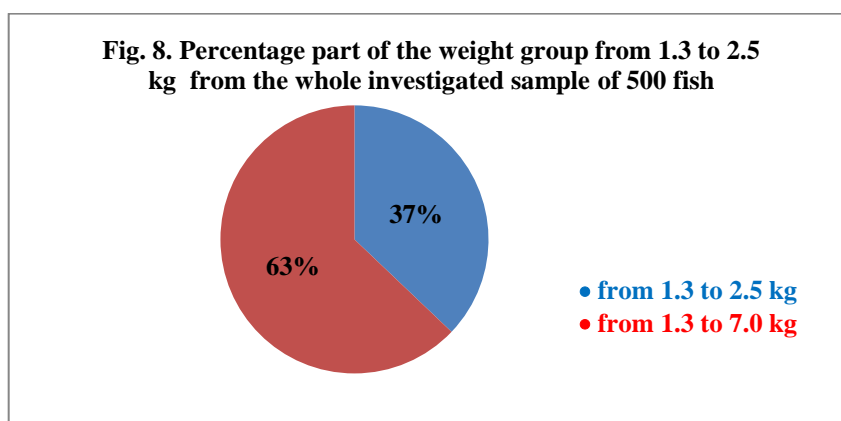
When the first weight group (from 1.30 to 2 kg) is divided into two subgroups - from 1.30 to 1.50 kg and from 1.50 to 2.00 kg, it becomes obvious that only 9% of turbot weigh from 1.30 to 1.50 kg, while those weighing between 1.50 and 2.00 kg are 91% (**Fig. 6**).



The division of the second weight group - from 2.00 to 3.00 kg into two subgroups - from 2.00 to 2.50 kg and from 2.50 to 3.00 kg, demonstrates that the major part of fishes (69%) weight between 2.00 and 2.50 kg (**Fig. 7**).



When summing up the results from the two **Figures (6 and 7)** it becomes clear that the fishes weighting from 1.3 to 2.5 kg have a share of 37% from all investigated 500 fishes (**Fig. 8**).



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

The average, minimum and maximum total body length (TL, cm) of turbot from the landings are presented on **Fig. 9**. The average total length of measured fishes is 51.02 cm, the maximum is 71.50 cm, while the minimum – 45.00 cm.

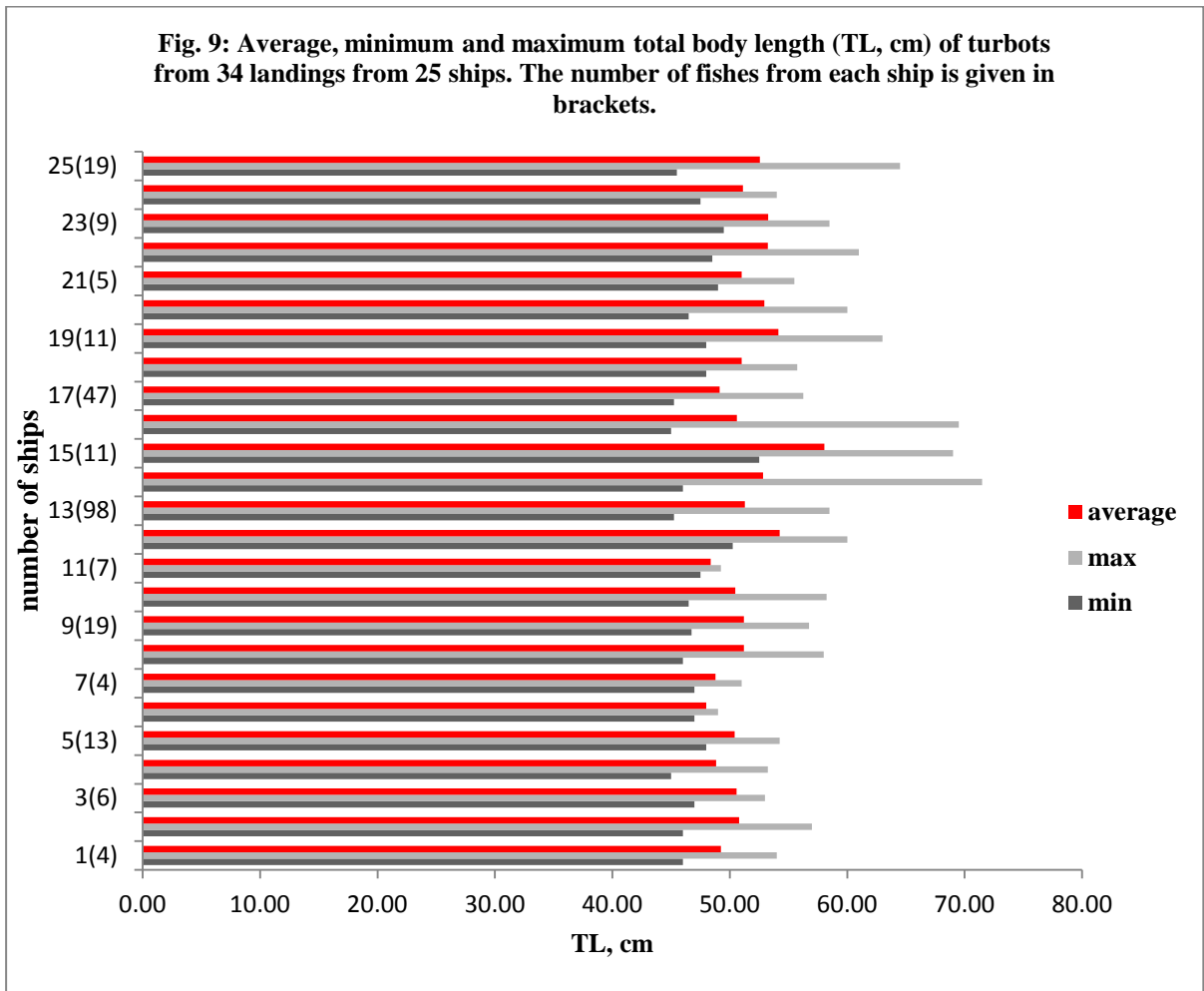
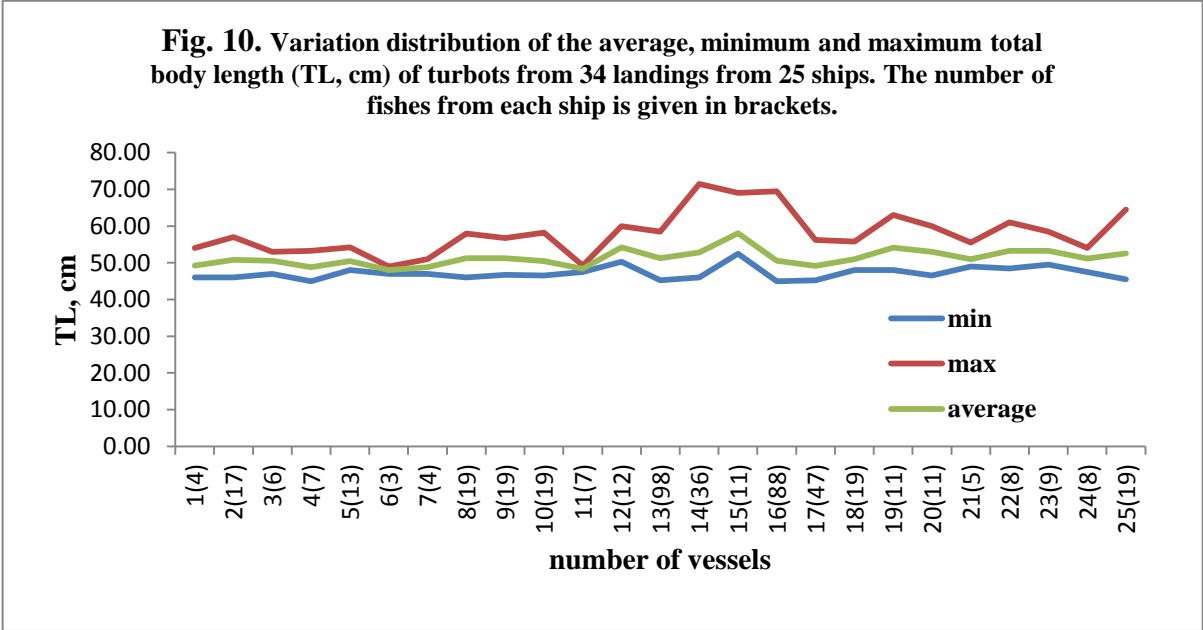
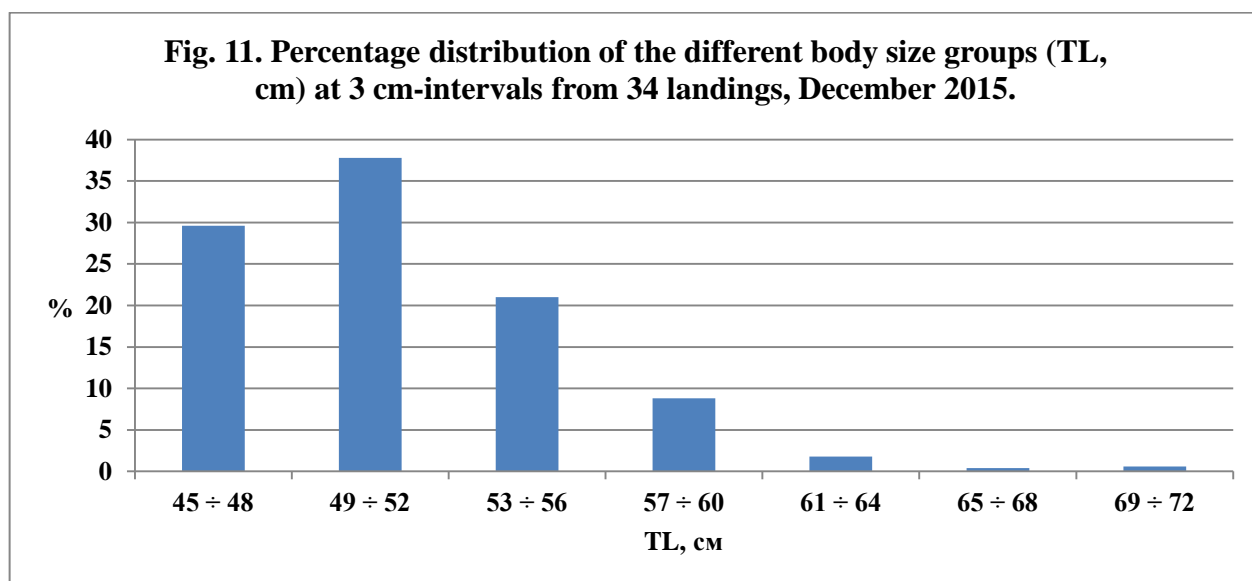


Fig. 10 presents the distribution of average, minimum and maximum total body length of all measured fishes. The average total length of fishes varied from 58.05 and 46.95 cm; the maximum between 71.50 and 49.00 cm, and the minimum between 52.50 and 45.00 cm.



The percentage distribution of the different size groups (at 3 cm-intervals) showed that three size groups are most frequently presented: 45-48 cm; 49-52 cm and 52-55 cm (**Fig. 11**).

The biggest is the group of turbot with total body length (TL, cm) within the range 49-52 cm – 37.8 % (189 ind.), followed with an insignificant difference by the 45-48 cm-group (29.6%, 148 ind.), and 53-56 cm-group (21%). Turbot with total body length from 45 to 56 cm comprised 88.4% (442 ind.) of all investigated 500 individuals. Fishes with a total body length of 45 cm, which is the minimum allowed length for catch, are only 1.6% (8 ind.) of all turbot, but with a total length similar to that ranging from 45 to 48 cm are a quarter of all 500 fishes.



3.4. Carcass evaluation

Investigation on the percentage and edible/non-edible body parts ratio of turbot from autumn catch December, 2015.

The weight of the edible and non-edible body parts of studied turbot groups (female and male) from the 2015 autumn catch, given in both absolute (g) and relative values (% from body weight), are presented in **Table 3**.

The data demonstrated that females' body weight varied from 1650 to 2570 g (average weight 2214 g). The male's body weight varied within the range 1820 - 2400 g (average weight 2008 g).

The relative part of head's weight from the whole body weight in females varied from 14.0% to 17.0% (average 15.0%). For male fish, the values are within the range 13.3-17.1% (15.2% on the average).

The relative carcass's weight in females varied from 65.3% to 80.6% (average value 71.5%), and respective values in males are in the range from 67.5 to 69.4% (68.3% on the average). The relative

viscera's weight in females is between 8.0 and 14.0% (9.7% on the average). The relative values of viscera in males are lower – in average 7.8 % ranging from 5.6% to 9.6%.

Table 3. Average, absolute and relative values of different edible/non-edible body parts in turbot, caught in the autumn 2015.

Sex	№	Body weight, g	Head's weight (without gills), g/%	Carcass's Weight, g/%	Viscera's (total) weight, g/%	Gill's weight, g/%	Fins' weight, g/%
Females, n=5	1	2080	311.0	1390	198.8	47.6	112.3
			15.0	66.8	9.60	2.30	5.40
	2	2420	372.5	1665	204.8	42.4	111.1
			17.0	80.6	14.0	2.3	6.5
	3	2570	410.6	1950	339.1	55.7	158.1
			16.0	75.9	13.2	2.2	6.2
4	2350	335.4	1535	189.1	41.1	108.7	
		14.3	65.3	8.0	1.7	4.6	
5	1650	231.5	1135	144.5	33.0	91.5	
		14.0	68.8	8.8	2.0	5.5	
x	2214	332.2	1535.0	215.3	43.9	116.3	
		15.0	71.5	9.7	2.0	5.3	
Males, n=5	1	1980	305.8	1375.0	145.4	33.6	103.0
			15.4	69.4	7.3	1.7	5.2
	2	1830	292.2	1235.0	127.4	40.9	94.3
			16.0	67.5	7.0	2.2	5.2
	3	1820	266.3	1250.0	164.8	31.1	84.9
			14.6	68.7	9.1	1.7	4.7
4	2010	344.3	1380.0	113.1	37.8	107.6	
		17.1	68.7	5.6	1.9	5.4	
5	2400	318.7	1622.0	230.0	47.4	146.2	
		13.3	67.6	9.6	2.0	6.1	
x	2008	305.5	1372.4	156.1	38.2	107.2	
		15.2	68.3	7.8	1.9	5.3	

The absolute and relative values of females and males carcass's yields are shown in Tables 4-5. In females the individual varied from 86.8 to 92.0% (average value 90.3%). In males the values are higher - 90.4-94.4% (92.2% on the average). The consumable yield values are lower than the carcass' yield values. These values ranged within 88.2-90.2% in females (average 88.3%), and within 88.4-92.5% (average 90.3 %) in males.

Table 4. Absolute (g) and relative values (%) of the different yields in turbot, caught in autumn 2015.

Sex	Body weight, g	Rate of yield (g/% of body weight)		
		Carcass' yield	Consumable yield	Yield for canning industry
Females n=5	2080	1881.2	1833.6	1570.2
		90.4	88.2	75.5
	2420	2215.2	2172.8	1842.7
		91.5	89.8	76.1
	2570	2230.9	2175.2	1820.3
		86.8	84.6	70.8

	2350	2160.9	2119.8	1825.5
		92.0	90.2	77.7
	1650	1505.5	1472.5	1274.0
		91.2	89.2	77.2
Males n=5	1980	1834.6	1801.0	1528.8
		92.7	91.0	77.2
	1830	1702.6	1661.7	1410.4
		93.0	90.8	77.1
	1820	1655.2	1624.1	1388.9
		90.9	89.2	76.3
	2010	1896.9	1859.1	1552.6
94.4		92.5	77.2	
2400	2170	2122.6	1851.3	
	90.4	88.4	77.1	

Table 5. Total absolute (g) and relative values (%) of the different yields in turbot, caught in autumn 2015.

Sex	Body weight, g	Rate of yield (g/% of body weight)		
		Carcass' yield	Consumable yield	Yield for canning industry
Females, n=5	2214	1998.7	1954.8	1666.5
		90.3	88.3	75.3
Males, n=5	2008	1851.9	1813.7	1546.4
		92.2	90.3	77.0

Investigation on the percentage and edible/non-edible body parts ratio of female turbot from spring catch, 2016.

An individually measuring of a sample of 10 females from spring catch (March, 2016) is performed. The choice of the fishes is done randomly. Males are not studied for lack of a representative number of individuals. The weight of the edible and non-edible body parts of the studied group females, expressed as an average absolute (g) and relative values (% of the body weight) are shown in **Table 6**.

The data showed body weights varying from 2550 g to 2695 g (2633 g average weight). The relative part of the head varies from 11.0% to 17.3%, with mean value of 14.7%. The relative part of the carcass is between 60.7% and 66.7% (64.0% on the average). The relative weight of viscera ranged between 10.6-16.4 %, (12.9 % on the average).

Table 6. Average, absolute and relative values of different edible/non-edible body parts in female turbot, caught in spring 2016.

Sex Females, n=5	Body weight, g	Head's weight (without gills), g/%	Carcass's Weight, g/%	Viscera's (total) weight, g/%	Gill's weight, g/%	Fins' weight, g/%
1	2550	400	1570	352.5	45	105
		15.7	61.6	13.8	1.8	4.1
2	2640	390.4	1710	305.9	43.3	116.8

		14.8	64.8	11.6	1.6	4.4
3	2595	286.7	1575	424.5	45.2	110.1
		11.0	60.7	16.4	1.7	4.2
4	2685	396	1790	283.3	48.9	119.5
		14.7	66.7	10.6	1.8	4.5
5	2695	467.2	1785	326.5	55.4	126.4
		17.3	66.2	12.1	2.1	4.7
x	2633	388.1	1686.0	338.5	47.6	115.6
		14.7	64.0	12.9	1.8	4.38

The absolute and relative body yields in females from the spring catch are shown in **Table 7**. The relative values of carcass's yields in studied females are between 83.6-89.4%, with average value of 87.1%. The relative values of the consumable yield are lower than the carcass' yield and varied between 81.9 and 87.63% (85.3% on the average).

Table 7. Average absolute (g) and relative values (%) of the different yields in female turbot, caught in spring 2016.

Sex		Body weight, g	Rate of yield (g/% of body weight)		
			Carcass' yield	Consumable yield	Yield for canning industry
Females, n=5	1	2550	2197.5	2152.5	1797.5
			86.2	84.4	70.5
	2	2640	2334.1	2290.8	1943.7
			88.4	86.77	73.63
	3	2595	2170.5	2125.3	1883.8
			83.6	81.9	72.59
	4	2685	2401.7	2352.8	2005.7
89.4			87.63	74.7	
5	2695	2368.5	2313.1	1901.3	
		87.9	85.8	70.6	
x	2633	2294.5	2246.9	1906.4	
		87.1	85.3	72.4	

3.5. Biochemical analysis of turbot meat

The values reflecting the content of water, proteins, fats and minerals in the meat of females and males turbot are shown in **Table 8**.

The data showed that water is the main component of the biochemical meat composition of all studied turbot groups. The evaluation of this parameter is necessary as it is important for the organoleptic properties of the meat. The amount of water in the meat of the turbot from the autumn sampling has averaged 80.64% for females and 80.56% for males. The reported values for this parameter from the spring samples in female turbot are similar - 80.68% against those of the autumn samples, and the difference between the values is less than 1%.

The mean values of the proteins are 16.83% in females and 16.50% in males during the autumn-winter season. This indicator also does not count difference with spring probes in females for which the protein content has an average value of 16.87%.

The meat fat content of from the studied groups varied with in an arrow range from 1.70% (females, March 2016) to 2.16% (males, December 2015). On the basis of the results from the analysis and the classification of Kyosev and Dragoev (2009), the turbot from studied catches could be classified as lean fish (fat content < 2%).

The mineral content of turbot meat ranged within 0.74-0.79%. Energy values of turbot meat from studied groups were from 349.66 kJ.100g⁻¹ to 360.49 kJ.100g⁻¹.

Table 8. Chemical composition and energy value of turbot meat, n=5

Seasons	Water,%	Protein,%	Fat,%	Ash,%	Energy (total), kJ.100 g ⁻¹
Autumn 2015					
females	80.64	16.83	1.80	0.74	352.56
males	80.56	16.50	2.16	0.79	360.49
Spring 2016					
females	80.68	16.87	1.70	0.78	349.66

3.6. Gonadosomatic index (GSI,%)

The gonadosomatic index (GSI,%) in females caught in December, 2015 (n=7) is with an average value of 2.97%, as maximum and minimum recorded values are respectively 2.97% and 1.36%. The gonadosomatic index (GSI,%) in females caught in spring 2016 (n=10) is 5.25% on the average, with maximum and minimum values 7.44 and 2.58%, respectively. It is clear that the rate of the ovary as part of the whole body has increased almost 2.5 times within three months, which testifies to actively occurring vitellogenesis in the egg follicles.

The GSI,% in males caught in autumn is 1.09 % on the average, with maximum and minimum values 1.47 and 0.56%, respectively. The average GSI,% in males caught in spring is 1.04 %, with maximum/minimum values 1.48 and 0.60%. Due to the small number of investigated male turbot (n = 2) in March 2016 the results for GSI,% are not representative.

3.7. Fecundity

The fertility is investigated on 10 females in March, 2016. It was not possible to study this parameter in females caught in December 2015 due to a very early stage of development of egg follicles in the ovary and the impossibility of their differentiation. The achieved results are presented in **Table 9**.

Table 9. Absolute and relative fecundity in female turbot

Parameter	Mean values
Number of females, n=10	10
Total length, TL (cm)	52.02
Body weight, BW (g)	2500
Absolute fecundity ($\times 10^3$), egg number/female	3928
Relative fecundity ($\times 10^3$), egg number/kg body weight	207

In females with an average body weight of 2500 g, the average absolute fecundity is 3.928 million eggs/female, and the average relative fecundity is 207 000 eggs/ kg body weight. According to Zengin (2000) and Hara (2001) the relative fertility in turbot varies between 400,000 and 500,000 eggs/kg body weight. The reported in this study values on the absolute fertility are significantly lower, which can be explained by the lower weight of the investigated females, but which in turn is within the average weights obtained on the basis of the 500 investigated individuals. In this regard, further studies are needed and that during the active reproductive period of turbot.

Conclusions and recommendations

On the basis of results from the biological monitoring of turbot landings at the Bulgarian Black Sea shore in December 2015, the following conclusions and recommendations could be made:

1. During the autumn-winter period of 2015 fishing ships caught per day in Bulgarian waters of the Black Sea on average 15 turbot.
2. From a total of 34 turbot landings in the monitored ports 500 fishes with an average body weight of 2.50 kg and an average total body length of 51.13 cm are measured. The maximum measured weight is 6.34 kg, and the minimum 1.30 kg.
3. The fishes with a body weight of 1.30 to 3.00 kg constitute 81.6% of all measured 500 turbot.
4. With the highest percentage of participation is presented the weight group from 2.00 to 3.00 kg - 56%, which represents more than the half of measured individuals. The weight group from 1.3 kg to 2.0 kg is 25% of the whole investigated sample. Therefore every second fish is between 2 and 3 kg, and every fourth turbot weights between 1.30 and 2.00 kg. In 15% of the cases the fishes are weighing between 3.0 and 4.0 kg, while the other weight groups are with negligible small number of fishes.

5. The average total body length (TL, cm) of measured fishes is 51.13 cm, with maximal and minimal values of 71.50 cm and 45.00 cm, respectively.
6. The most numerous are three of all size groups: 45-48 cm; 49-52 cm and 53-56 cm, corresponding to 29.6%, 37.8% and 21% of the whole sample of 500 fishes respectively. Fishes with a total body length within the range 45-56 cm comprised 88.4% of all measured individuals, whereas those within the range 49-56 cm - 60%. Fishes with a total length of 45 cm, which is the minimum allowed for catch are only 1.6%, but those with length in the near range of 45-48 cm comprised one quarter of the whole sample of 500 ind.
7. Established is a higher water content (80.64-80.56%) and lower lipid content (1.8-2.16%) in the turbot's meat in autumn-winter period (December, 2015). There are no differences in the studied parameters between the autumn (December) and spring (March) values in females.
8. The gonadosomatic index (GSI,%) in females caught in December, 2015 is with an average value of 0.20%, and those caught in March 2016, has an average value for the GSI% of 0.52%, ie. e. there is an increase of almost 2.5 times within three months.
9. In females with an average body weight of 2500 g, the average absolute fecundity is 3.928 million eggs/female, and the average relative fecundity is 207 000 eggs/ kg body weight. The lower fecundity can be explained by the lower weight of the investigated females, but which in turn is within the average weights obtained on the basis of the 500 investigated individuals.
10. It is recommended the biological monitoring on turbot catch from the Bulgarian Black Sea coast to continue in the future aiming the creation of a more complete and objective picture of the catches' structure over the years, which is an indicator of population structure of the species too. It is advisable to cover the spring catches too, that are much more massive than the autumn. This will enable a comparative analysis of the data from the two periods.