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Size-weight structure of plain (*Psetta maxima*) in the Bulgarian Black Sea aquatoria

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Abstract

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Turbot (*Psetta maxima*(Linnaeus, 1758) is a demersal fish. It is widespread in all countries bordering the Black Sea. Turbot is one of the most valuable commercial fish species, with high demand and a corresponding high price. Higher catches are recorded in spring and autumn. In the Black Sea, it inhabits the coastal zone, particularly on sandy or muddy bottoms, and is found at depths of up to 100 m. It lives up to 10–12 years. It grows up to approximately 90 cm and reaches a weight of up to 15 kg. The breeding season is between April and June. Several local populations represent the black Sea turbot. The fish is not a highly migratory species, but it seasonally moves to coastal areas where it is introduced to spawn, feed, or winter (Hubenova et al., 2015).

The assessment of the collection of fish stocks for the Black Sea in recent years in the sector is carried out within the framework of the implementation of the scientific studies (Petrova et al., 2023; Lazarova et al., 2023), that Bulgaria is obliged to perform, according to the Work Plan for the collection, management and use of data „Fisheries“ for the purposes of scientific analysis and the implementation of the Common Fisheries Policy. The institutes responsible for and implementing this activity are the Institute of Fish Resources, Varna, the Agricultural Academy, Institute of Oceanology, Varna, BAS, and the Institute of Fisheries and Aquaculture, Plovdiv. The Institute of Fisheries and Aquaculture in Plovdiv has been monitoring turbot landings since 2014. Object of analysis of the size-weight characteristic, age, sex ratio, degree of maturity of the reproductive system, fertility, etc., of the specimens caught and landed.

The study spans the period from 2019 to 2022. Within the framework of the contracts with the Executive Agency of Fisheries and Aquaculture for monitoring, the Institute of Fisheries and Aquaculture's team registered 152 turbot landings. 3370 fish with an average size of 54.44 cm and an average weight of 2.88 kg were analyzed. Maximum production value of 9.75 kg and minimum of 1.40 kg. On the basis of the data presented in this way, we assume that a significant share of the catches consists of fish with a relatively low weight. Future studies may confirm or reject this suggestion.

The impact of size is essential in the direction of weight in the studied specimens. A very strong positive correlation was shown between length (TL) and turbinate weight (BW). The regression equation is: $W = 5{,}86 + 0{,}16\ TL$.

Keywords: turbot; *Psetta maxima*; Black Sea; landings; size structure

Introduction

Turbot (*Psetta maxima*) is a demersal species found throughout the shelf area of all Black Sea countries, at depths of up to 100 m, grouped in local shoals. The fish has a lifespan of 10-12 years and reaches lengths of up to 90 cm and weights of up to 15 kg (Karapetkova and Zhivkov, 2006). The spawning process occurs during the spring season, typically between April and June. The species inhabits sandy or muddy bottoms, as well as mussel beds or mixed species communities. The Black Sea turbot is represented by several local populations that migrate and mix in neighboring areas. The fish is not a

highly migratory species, but moves seasonally inshore and offshore, familiar with breeding, feeding, and wintering.

Turbot is one of the most important demersal fish in the Black Sea with high market demand and prices. In the spring and autumn period, a larger catch of turbot is registered. Basic tackle for turbot fishing in Bulgaria with gill nets. According to Art. 35 of the Fisheries and Aquaculture Act the use of bottom trawls and dredging has been prohibited since 1984. The minimum legal size of bottom nets used in turbot fishing is 400 mm (Article 11 of Commission Regulation 850/98 of Council), and the minimum permissible total landing length is 45 cm (Annex XII to Council Regulation 850/98 and Annex II to the LFA). No catch, retention on board, transboundary transfer, landing, first sale, and transport of turbot is permitted during the breeding period between 15 April and 15 June. Turbot quotas have been introduced in national waters since 2004 and in Community waters since 2008, according to Council regulations (EC, 2008–2013). From 2018 to 2023, a catch quota of 75 tons was not set for the country. For 2024, it was changed to 95 tons, due to the COVID-19 crisis and the war in Ukraine. Targeted turbot fishing in the Black Sea is carried out with bottom nets with a minimum girth pitch of 160 mm in the waters of Turkey (Tonay et al., 2015) and 180 mm in the waters of Georgia, the Russian Federation and Ukraine (Prodanov et al., 1997), as well as bottom trawls in the waters of Turkey with a minimum size of about 40 mm. Despite the measures taken to protect turbot populations, since 2008, we have observed a tendency towards a decrease in the estimated relative biomass of turbot in the Bulgarian Black Sea.

The period from 2019 to 2022 coincided with the COVID-19 crisis in Bulgaria. The idea of creating a database is that it will be evaluated every year, and the results will be used for comparison with the next period. During this period, the Institute of Fisheries and Aquaculture in Plovdiv carried out seasonal and annual assessments of the biomass and age of turbot (*Psetta maxima*) stocks, along with established monitoring of the legally designated ports. An analysis was conducted of 3,370 pieces of turbot to determine the size-weight characteristics of the catch.

The present study aims to investigate turbot catches along the Bulgarian Black Sea coast and establish a database to track the catch structure for the period 2019–2022, at a set quota of 75 tons. The main tasks of the study included measuring body weight and the total length of the turbots from unloading, as well as analyzing the results.

Materials and Methods

Data for the period 2019-2022 are presented on unloading in the Bulgarian waters of the Black Sea, with a designated quota of 75 tons of turbot catch. Biological data were collected from ports where turbot unloading is permitted, including the ports of Shabla, Kavarna, Balchik, Varna, Byala, Nesebar, Pomorie, Sozopol, and Tsarevo. The data were collected from 152 unloading events from ships complying with the turbot catch requirements during the selected period. The total number of fish used for biological data collection was 3370. Catches were made in the Black Sea waters between 42°05′ and 43°45′ north latitude and 28°09′ and 29°18′ east longitude. The depth of the fishing locations ranged from 25 to 100 meters. Fish measurements were taken on board the ships immediately after landing on fresh, ice-cooled objects. Weight measurements were performed with an accuracy of 1 gram, and total lengths were measured with an accuracy of 0.1 centimeters. Data processing, graphs, and tables were developed using statistical software.

Using correlation-regression analysis, we examined the relationship between weight and time. Through the regression equation, we determined the changes in weight as a function of turbot size:

$$y = a + b\,x,$$

where:

y – weight, kg;

x – size, cm;

a, b – coefficients of the equation.

Weight is the dependent variable (y), while the size (x) of the turbot is the independent variable. Correlation-regression analysis and covariance measurement were performed using Microsoft Excel functions: Correlation, Regression, and Covariance.

Results and Discussion

The analysis of the turbot catch structure aims to demonstrate compliance with the European Commission's regulations. The results directly influence the determination of the turbot quota for the respective year. Objects of study are: the number of fish caught by each vessel, the weight structure, and the size structure of the catch.

Number of Fish Caught by Each Vessel

In compliance with the agreement with the Institute of Fisheries and Aquaculture, Plovdiv tracks the dynamics of turbot catches from 2019 to 2022. During this period, 152 unloadings were observed, and 3370 fish were measured. An average of 22 turbot fish was caught per vessel, with a maximum of 101 and a minimum of 2 fish recorded per vessel. Table 1 presents the percentage distribution of catches by vessels for the period 2019–2022.

Ninety-four vessels, or 62% of all 152 registered unload-

Table 1. Percentage distribution of catches by vessels, for the period 2019–2022

fishes	vessels
less than 20	94
21 to 50	51
more than 50	7

Source: Compiled by Authors

ings, caught up to 20 fish, fifty-one vessels (33%) caught between 21 and 50 fish, and only seven vessels (5%) caught more than 50 fish. Catches of fewer than 5 turbots were recorded in six cases. The most common turbot unloadings range between 10 and 20 fish, observed in 43% of the representative sample.

Weight Structure of the Catch

The weight structure of the catch for the period 2019–2022 is presented in Table 2. A total of 3370 fish are distributed into four weight groups, corresponding to size groups defined in the regulatory framework for the fishing log order. Table 2 provides information on the weight structure of the catch for 2019–2022.

Table 2. Weight structure of the catch, 2019–2022

kg per fish	numbers of fishes	percentage of all
less than 2.1 kg	957	28%
2.2 kg to 3.3 kg	1628	48%
3.4 kg to 5 kg	563	17%
more than 5.1 kg	222	7%

Source: Compiled by Authors

The average weight of turbot is 2.88 kg, and the weight of the fish ranges from 1.40 to 9.75 kg. The percentage distribution of the different weight groups shows that the highest share is in the weight group from 2.2 to 3.3 kg (48%), followed by the group weighing up to 2.1 kg (28%). The share of the weight group from 3.4 to 5.0 kg is 17% of the statistical population. In comparison, turbot over 5 kg accounts for 7% or 222 individuals. Table 2 shows that turbot weighing between 1.4 and 3.3 kg constitute 76% or 2585 fish of the representative sample.

Size Structure of the Catch

The measured 3370 fish are divided into four weight groups based on the Fishing Log Order. Table 3 illustrates the size structure of turbot, measured on board the vessels immediately after they dock at the designated ports during the period from 2019 to 2022. Table 3 presents the size structure of the catch for the period 2019–2022.

The data analysis reveals that the average size of turbot is 54.44 cm. The sizes of the measured individuals range

Table 3. Size structure of the catch, 2019–2022

length, cm	numbers of fishes	percentage of all
45.1–50.0 cm	1193	35.40%
50.1–60.0 cm	1558	46.23%
60.1–80.0 cm	606	17.98%
> 80.1 cm	13	0.39%

Source: Compiled by Authors

from 45.50 to 82.00 cm. The percentage distribution of the different size groups shows that the highest share is in the size group from 50.1 to 60.0 cm (46%), followed by the size group from 45.1 to 50.0 cm (36%). The share of the size group from 60.1 to 80.0 cm is 18% of the statistical population, while turbot over 80 cm accounts for 0.39% or 13 individuals. Table 3 indicates that turbot with sizes ranging from 45.1 to 60.0 cm constitute 82% or 2751 fish of the representative sample.

Correlation-Regression analysis

Using analysis of variance, we examine whether the influence of turbot size under given conditions is statistically significant. We employ hypothesis testing methodology. We formulate the null hypothesis – size does not influence weight, and the alternative hypothesis is that the effect of size on weight is significant. The results of the t-Test for testing the null hypothesis for dependent samples show that: $P(T<=t)$ two-tail < 0.05. Thus, we establish that $p < \alpha$. Therefore, the null hypothesis is rejected at a significance level of 0.05. Consequently, we prove that the effect of size is significant with respect to weight in the examined specimens.

To determine the strength of the relationship between the two variables, we use the Correlation function in MS Excel. When calculating the correlation dependency, we find the Pearson coefficient to be $r = 0.89$. Its value indicates a very strong positive correlation between the length and weight of turbot. Upon comparing the table of Pearson correlation coefficients (http://uni-sz.bg/StatExcel5/Correlations.htm), the obtained value falls within the following interval: $0.7 < 0.89 < 0.9$.

In the data analysis, we find that as the size (x) increases, the weight (y) of the turbot also increases. We verify this statement using the Covariance.s function in MS Excel (7.00). The positive covariance indicates that the two variables move in the same direction.

In processing the data using MS Excel Regression, we obtain a multiple regression coefficient of 0.96. The empirical regression line is of the form: $y = -5.86 + 0.16x$. Figure 1 presents the functional relationship between size and weight of turbot for the period 2019-2022. The coefficients of the equation are $a = -5.86$ and $b = 0.16$.

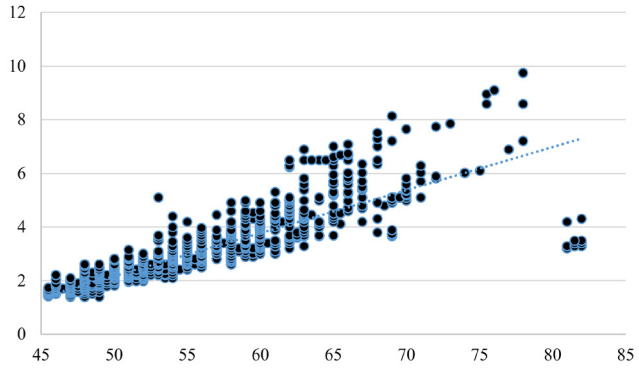

Fig. 1. Relationship between size and weight of turbot, n = 3370, 2019-2022

Source: Compiled by Authors

The regression equation is: y = –5.86 + 0.16, where:

- axis X: Length, cm;
- axis Y: Weight, kg;
- multiple regression coefficient: $R^2 = 0.79$;
- -5.86 and 0.16 – coefficients of the equation

The coefficient of determination is 0.79, indicating that the functional dependence is valid for 79% of the 3370 turbots for the period 2019–2022. The coefficient for statistical significance determines the significance of the regression equation.

Conclusions

The analysis of data obtained from 3,370 turbot, with an average weight of 2.88 kg and a total biomass of 9,697.32 kg, allows us to conclude that a significant portion of the catch consists of fish with relatively low weights. Future monitoring studies can either support or refute this proposition. According to EU legislation, the mesh size of turbot nets must be at least 400 mm, which prevents the capture of specimens that weigh below the minimum allowable size. The results of this study show that turbot ranging in size from 45.1 to 50.0 cm constitute one-third (36%), corresponding to weights up to 2 kg. We hypothesize that the low weight of turbot with body sizes around the minimum permissible (45 cm) may be due to the poorer physical condition of the fish during the study period, as confirmed by the results of biochemical analysis of turbot meat.

Analyses demonstrate the impact of size on weight. A strong positive correlation has been established between the length (TL) and weight (BW) of turbot. The regression equation is: W = -5.86 + 0.16TL.

The practical significance of the study and the obtained results correspond to the increased quota for turbot catch in 2024, which has been increased to 92 tons. We recommend reducing turbot catches off the Bulgarian coast during the pre-spawning period. Biological monitoring of turbot landings along the Bulgarian Black Sea coast contributes to a more comprehensive and objective understanding of the catch structure over the years.

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