REPORT

Bottom Trawl Surveys In The Bulgarian Black Sea Area Spring 2019

Agricultural Academy
Institute of Fish Resources (IFR, Varna)
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The present study was conducted by a team of specialists from the Institute of Fishery Resources (IFR) – Varna, Agricultural Academy, under contract № /D-156/16.05.2018г with the National Agency for Fisheries and Aquaculture (NAFA) - Burgas, for turbot stock assessment in the Bulgarian Black Sea waters during the spring period of 2019.

The study was conducted owing to the financial support of the European Commission in compliance with Council Regulation No. 199/2008 and Commission Decision 2010/93/EU, aimed to help the member states for creating a common frame for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

The study was performed in the period 11 - 20 May 2019 in the Bulgarian Black Sea waters on board of the "EGEO 2" fishing vessel.

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BOTTOM TRAWL SURVEY FOR TURBOT STOCK ASSESMENT IN BULGARIAN BLACK SEA SECTOR DURING SPRING SEASON OF 2019

1. Results from the National Bottom Trawl Surveys in May 2019

During 11 - 20 May 2019, within the frames of the National Programme for Fisheries Data Collection, the research team from IFR - Varna has conducted a demersal trawl survey with the fishing ship "EGEO 2" in the Bulgarian Black Sea waters - between Durankulak and Ahtopol, within the 100-meter isobath.

The filed survey has included the following main activities:

- Bottom trawl sampling;
- Qualitative and quantitative analysis of the catches, identification of biological diversity, biometric measurements;
- Collection of otoliths for turbot age determination;
- Sampling and analysis of stomach contents for identification of quantity and composition of the consumed food.

Through the filed survey and laboratory analysis, a dataset has been prepared, allowing assessment of the relative biomass and abundance of the reference species *Scophthalmus maximus* in Bulgarian Black Sea waters. The current report is focused on the estimation of turbot biomass indexes and density by depth strata and includes study on length/weight, age and sex structure of the turbot population.

This document contains a series of tables and figures that represent the distribution of relative abundance and analysis of turbot population - size/age and sex structure, estimation of the L-W relationship, calculations of growth rate and biological

parameters, based on *Von Bertalanffy* equations and examination of turbot diet composition.

1.1. Fishing vessel and fishing gear

The trawl surveys were conducted on board the fishing ship "EGEO 2" (picture 1) with the following parameters:

- Fishing vessel - TAKA;
- Fishing vessel length -17 m;
- Maximum width - 6 m;
- The fishing vessel year of built - 2007;
- Engine power - 530 kW;
- Maximum tonnage - 300 t;
- Net tonnage – 140 t;
- Speed – 9.5 Nd;
- Crew - 3 people;
- Research team - 3 people.

Picture 1. *Fishing ship*

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During the studies, a fishing bottom trawl 22/27-34 was applied (picture 2), with following functional and technical parameters:

- Trawl vertical opening - 2 m;
- Horizontal opening between the otter boards - 9 m;
- Effective part of wing spread - 13 m;
- Trawling speed - 2.2 - 2.6 Nd;
- Trawling duration - 60 min.
- Mesh size - 400 mm.

Picture 2. *Bottom trawl 22 / 27-34.*

2. Material and methods

The target species of the demersal survey was turbot (*Scophthalmus maximus*), and the by-catch species - the spiny dogfish (*Squalus acanthias),* the thornback ray (*Raja clavata*) and the European flounder (*Platichthys flesus*) were also measured and analysed.

The methodology and techniques, used for data collection, verification, processing and analysis and for complete turbot stock assessment were following the generally applied methodology in the Bulgarian Black Sea zone.

The field data were collected by standard techniques - bottom trawl that remained constant through the surveys. The GPS system of the ship was connected to NAFA satellite system for monitoring of the fishing vessels (VMS) and the ship location was strictly controlled during the trawling.

2.1 Information collected through the bottom trawling

- Depth - measured with the echo-sounder;
- GPS coordinates of the trawling - starting and end points;
- Trawling duration;
- Abundance of fish species in the trawl;
- Weight of the total catch in the trawl;
- Absolute and standard length; weight of collected specimens;
- Collection of otoliths for age determination;
- Sex identification;
- By-catch species composition;
- Turbot stomachs for stomach content analysis;

For turbot biomass calculations, data for catch per unit effort (CPUE) (kg/h) and catch per unit area (CPUA) (kg/km^2) were used.

The results are presented in the form of maps and tables that include data for:

- Catch per unit effort (kg/trawl)
- Catch per unit area (t/km^2);
- Abundance index (individual/km^2);
- Limits of variation of catches pet unit area;
- Total biomass (t.) and abundance (ind).

2.2. Sampling scheme

To establish the abundance and biomass of the reference species *S. maximus* off the Bulgarian Black Sea coast, a standard methodology for stratified sampling (Gulland,

1966; Sparre, Venema, 1998; Sabatella, Franquesa, 2004) was applied. The zones, where trawling was performed, are presented in Figure 1.

The surveyed region was divided into four strata, depending on the depth – Stratum 1 (15 - 35 m), Stratum 2 (35 - 50 m), Stratum 3 (50 - 75 m) and Stratum 4 (75 - 100 m). For assessment of turbot abundance and biomass, the surveyed territory was divided into 143 squares, each of them with sides 5 x 5 Nm, area 25 Nm^2 (or 85.8569 m^2). The sampling was carried out at 40 randomly chosen fields (rectangles), situated at depth between 15-100 m. Each rectangle is with sides 5'Lat × 5'Long, while the total area is 62.58 km^2 (measured by GIS). Each field was marked with letters and digits for better distinction.

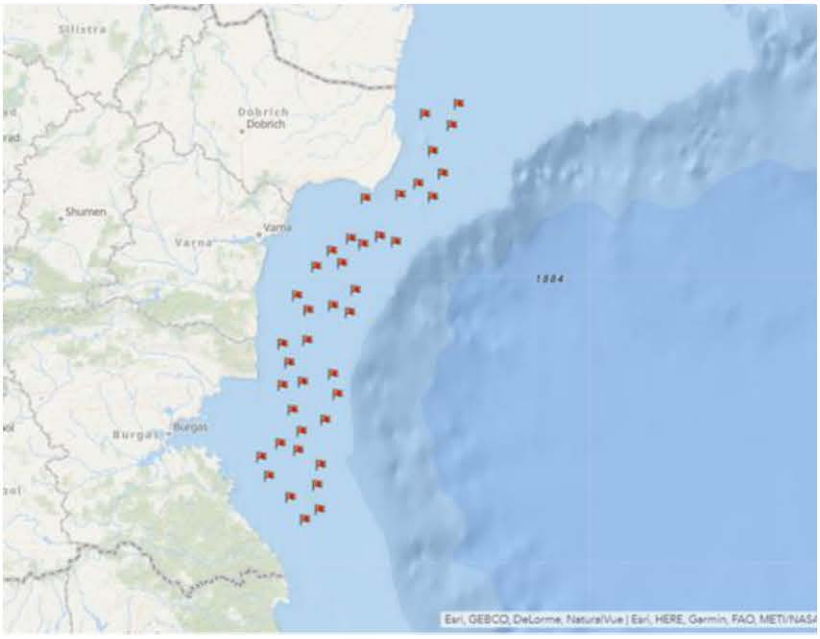

Fig. 1. Map of the surveyed sectors, V/2019

The seabed area covered during a single haul represents a basic measurement unit, considered representative, as turbots do not aggregate in dense assemblages (Martino, Karapetkova, 1957).

The duration of each hauls was 60 min. at trawling speed of 2.5 knots.

On the ship board, the absolute and standard length, as well as the individual weight of each specimen were measured in order to determine the size and weight

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structure of the turbot stock and to estimate the share of specimens with length below the allowable fishing length in the catches.

2.3. Laboratory analyses

After collecting the samples on shipboard, the age, maturity of the reproductive system and stomach content composition were determined in laboratory.

The turbot age was established by otoliths reading under binocular microscope. To identify the food composition, a total of 52 stomachs were collected in spring 2019. The stomach content analysis included identification of the taxonomic composition and total number of food components, weight and frequency of occurrence of each food component. The index of relative importance (IRI) was used to determine the significance of each food component in the trophic spectrum (Pinkas et.al., 1971):

$$IRI = (C_N + C_W) * F,$$

C_N - percentage share of the food item *i* in total number; C_W - percentage share of the food item *i* in the total weight; F – frequency of occurrence.

IRI expressed as a percentage was calculated by the equation (Cortes, 1997):

$$\%IRI_i = \frac{100 * IRI_i}{\sum_{i}^{n} IRI_i}$$

n – total number of the taxonomic categories at a given taxonomic level

2.4. Statistical methods

Swept areas method

To determine the relative biomass of the reference species *S. maximus*, the "swept area method" was applied. According to this method, trawl sweeps a well-defined path, the area of which is the length of the path times the width of the trawl, called the "swept area" or the "effective path swept", thus the swept area can be estimated from equation:

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$$a = D*hr*X2,\ D = V*t$$

V - is the velocity of the trawl over the ground when trawling, t - the time spent trawling, hr - the length of the head-rope. X2 is that fraction of the head-rope length, hr, which is equal to the width of the path swept by the trawl, the "wing spread", hr*X2, D-distance covered.

To calculate turbot biomass, the catch per unit area (CPUA) was used:

$$\frac{C_{w/t}}{a/t} = \frac{Cw}{a} kg/km^2$$

Cw/t – catch in units of weight per trawling hour, a/t – area swept per trawling hour.

The biomass for each stratum was obtained from equation:

$$B = \left(\overline{C_{w/a}}\right) * A$$

$\overline{C_{w/a}}$ - mean catch per unit of area for all trawl sweeps in the stratum, A – stratum area.

The variance of biomass estimated for each stratum is:

$$VAR(B) = A^2 * \frac{1}{n} * \frac{1}{n-1} * \sum_{i=1}^{n} \left[Ca(i) - \overline{Ca}\right]^2$$

The total area of the surveyed region is equal to the sum of the areas of every stratum:

$$A = A1+A2+A3$$

The mean catch for the entire survey area was obtained from equation:

$$\overline{Ca}(A) = \frac{Ca1 * A1 + Ca2 * A2 + Ca3 * A3}{A}$$

Ca1- catch per unit area in stratum 1; A1 – stratum 1 area, etc.; A – total water area.

The total biomass in the survey area is estimated by equation:

$$B = \overline{Ca}(A) * A$$

$\overline{Ca}(A)$- mean weighted catch for the entire surveyed water area, A – total area surveyed.

Maximum sustainable yield

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Gulland's formula for virgin stock is:

$$MSY = 0.5*M*Bv$$

M – coefficient of natural mortality, Bv- biomass of virgin stock.

A generalized version of Gulland was proposed by Cadima (in Troadec, 1971) for exploited fish stocks for which only limited data are available for stock assessment:

$$MSY = 0.5 * Z * \overline{B}$$

$\overline{B}$ - mean annual biomass, Z – total mortality.

Because Z = F + M and Y = F * $\overline{B}$, Cadima suggested that in the absence of data for Z, the equation can be rewritten:

$$MSY = 0.5 * (y + M * \overline{B})$$

y – total catch in one year, $\overline{B}$ - mean biomass in the same year.

TAC - total allowable catch, Prediction models

***Beverton and Holt yield per recruit model* (1957):**

$$Y/R = F*\exp[-M*(Tc-Tr)]*W_{\infty} * \left[\frac{1}{Z} - \frac{3S}{Z+K} + \frac{3S^2}{Z+2K} - \frac{S^3}{Z+3K}\right]$$

S = exp [-K (Tc – t_0)], K = von Bertalanffy growth parameter, t0 = von Bertalanffy growth parameter, Tc = age at first capture, Tr = age at recruitment, W$_{\infty}$ = asymptotic body weight, F = fishing mortality, M = natural mortality, Z = F + M, total mortality.

To evaluate the exploitation ratio, the formulae of ***Pauly (1983)*** was used: E = F / Z; E - exploitation ratio, F - fishing mortality, Z - total mortality;

***Jones' Length-Based Cohort Analysis* (1981)**

Jones' length-based cohort analysis:

$$\exp\left(\frac{M}{2} * \Delta t\right) = \exp\left[\frac{M}{2} * \frac{1}{K} * \ln\left(\frac{L\infty - L1}{L\infty - L2}\right)\right] = \exp\left[\ln\left(\frac{L\infty - L1}{L\infty - L2}\right)^{M/2K}\right] = \left[\frac{L\infty - L1}{L\infty - L2}\right]^{M/2K}$$

Age and growth

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For the estimation of turbot growth rate, the von Bertalanffy growth function (1938) was applied, (according to Sparre, Venema, 1998):

$$L_t = L_\infty \left\{1 - \exp\left[-k\left(t - t_0\right)\right]\right\}$$

$$W_t = W_\infty \left\{1 - \exp\left[-k\left(t - t_0\right)\right]\right\}^n$$

L_t, W_t are the length or weight of the fish at age **t** years; L∞, W∞ - asymptotic length or weight; k – curvature parameter; t_o - the initial condition parameter.

The length – weight relationship is obtained by the following equation:

$$W_t = qL_t^n$$

q-constant in length-weight relationship; n - constant in length-weight relationship.

Natural mortality (M)

Pauly's empirical formula (1979, 1980) was applied:

$$\log M = -0.0066 - 0.279 * \log L_\infty + 0.6543 * \log k + 0.4634 * \log T^\circ C$$

$$\log \mathrm{M} = -0.2107 - 0.0824 * \log \mathrm{W}_\infty + 0.6757 * \log \mathrm{k} + 0.4687 * \log \mathrm{T^\circ C}$$

L∞, W∞ and k – parameters in von Bertalanffy's equation; TºC - the annual average temperature of the seawater in the horizons of habitation and reproduction of the species.

***Method of Richter si Efanov* (1976)**

$$M = \frac{1.521}{(t_{mat.50\%})^{0.720}} - 0.155$$

t_{mat} – age at first maturation.

Stock exploitation (E)

is determined by Pauly (1983): E = F/Z,
where Z - total mortality, and F - fishing mortality.

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3. Results

3.1. Population number and biomass

During the demersal trawl survey in V/2019, the following activities were carried out:

- 40 hauls with a bottom trawl, with duration of 60 minutes for each trawl at depths between 15 m and 100 m, covering entirely the continental shelf of the Bulgarian Black Sea zone, between Durankulak and Ahtopol.

- for each haul, a qualitative and quantitative analysis of the catch was accomplished, including biometric measurements of 93 turbot specimens, 4 ind. spiny dogfish, 29 specimens of European flounder and 27 specimens thornback ray (*Raja clavata*) (Picture 3,4 and 5).

Picture 3. *Bottom trawling yield*

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Picture 4. *Yield of turbot (Scophthalmus maximus) and associated species Merlangius merlangus (whiting), Platichthys flesus (European flounder), Raja clavata (thornback ray),* spiny dogfish *(Squalus acanthias) and Acipenseridae (sturgeons).*

Constant presence of *S. maximus* was established in almost all bottom trawls at a depth 75-100 m with yield - at least 1-7 individuals per haul (where catch ≠ 0).

At a depth between 15-50 m and 50-75 m, the average turbot catches were comparable. At eight fields, a high yield was obtained, with ranges between 10.01 to 18.89 kg/trawl.

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Four specimens of dogfish (*Sq. acanthias*) were captured during the survey, with size and weight that varied from -71 см/1.48 kg to 143 см/14.70 kg.

The main bycatch species included sprat (*Sprattus sprattus*), whiting (*Merlangius merlangus euxinus*) (Picture 5), European flounder (*Platichthys flesus luscus - 29 sp.*) and thornback ray (*Raja clavata*). Other bycatch species were black scorpionfish (*Scopaena porcus*), black mussel (*Mytilus galloprovincialis*), *sturgeons* (Acipenseridae) and prawn (*Crangon crangon*).

Picture 5. *Conducting biometric measurements and sampling for study of the stomach contents.*

Large amounts of marine litter were not found during the current survey.

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Comments on the biomass of *Scophthalmus maximus* in the Bulgarian waters by strata

Trawling at a depth of up to 30 m covered only three stations, and due to their small number, they were grouped together with the stations, preformed up to 50 m, thus the statistical analysis was conducted for the stratum 15 - 50 m. The biomass of the three shallow stations (at a depth < 30 m) reached respectively 0.0 kg/km^2, 2.324 kg/km^2 and 30.052 kg/km^2, with abundance - 0 ind/km^2, 17 ind/km^2 and 33 ind/km^2. At these stations, the highest yield was found off the Shkorpilovtsi, while in front of the Varna and under cape Kaliakra, the turbot biomass attained low levels.

The average value of the relative turbot biomass varied within a narrow range of 15-50 and 50-75 m, and the highest biomass was detected in the stratum 75-100 m - 0.140 t/km^2, while the highest average abundance was found again in the same stratum - 59 ind/km^2 (Table 1, Fig 2 and 3).

The information about the yields by stratum is given below:

Stratum 15 - 50 m

The relative turbot biomass varied between 0 and 161.054 kg/km^2, 50.091 kg/km^2 on average (Table 1, Fig. 2). The abundance indices varied between 0 and 50 individuals/km^2, on average - 24 ind/km^2 (Table 2).

Stratum 50 -75 m

The relative turbot biomass fluctuated between 0 and 185.405 kg/km^2, 60.505 kg/km^2 on average (Table 1, Fig. 2 and 3). The abundance indices varied between 0 and 100 ind/km^2, with average value of 39 ind/km^2 (Table 2, Fig. 2 and 4).

Stratum 75 - 100 m

In this stratum, the average relative biomass 140.286 kg/km^2 (varied from 7.97 to 306.5 kg/km2) was three times higher than the starts 15-50 and 50-75 m (Table 1, Fig. 2 and 4), with average abundance - 58 ind/km^2 (Table 2).

Table 1

Turbot biomass by strata, May 2019

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15 - 50 м		50 – 75 м		75-100 м	
No. station	**t/км^2**	**No. station**	**t/км^2**	**No. station**	**t/км^2**
1	0.161	**2**	0.000	**5**	0.008
9	0.002	**3**	0.021	**6**	0.205
12	0.076	**4**	0.000	**7**	0.251
13	0.059	**8**	0.000	**10**	0.307
14	0.113	**11**	0.185	**16**	0.198
15	0.042	**18**	0.000	**17**	0.247
19	0.000	**22**	0.290	**35**	0.104
20	0.030	**25**	0.000	**36**	0.073
21	0.000	**27**	0.049	**37**	0.166
23	0.021	**28**	0.019	**38**	0.024
24	0.000	**29**	0.090	**39**	0.071
26	0.097	**34**	0.072	**40**	0.030
30	0.000				
31	0.057				
32	0.027				
33	0.115				
Total	**0.801**		**0.726**		**1.683**
Average	**0.050**		**0.061**		**0.140**
Variance	0.00250		0.0083		0.0103
Standard deviation	0.05001		0.0909		0.1015
Relative standard deviation	0.99838		1.5031		0.7238
Standard error	0.01250		0.0252		0.0338

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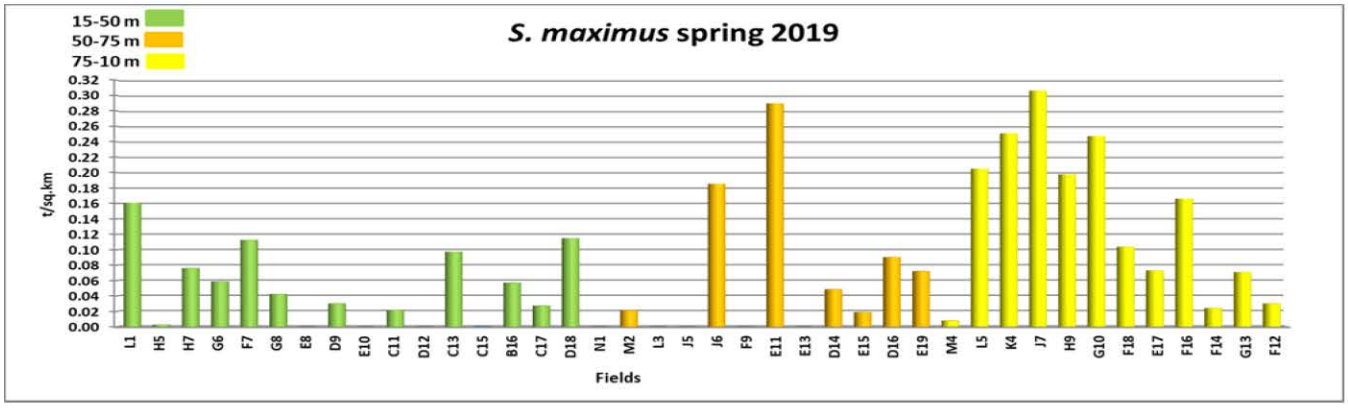

Fig. 2. Relative biomass (t/km^2) of S. maximus by strata off the Bulgarian Black Sea coast, May 2019.

Table 2 represents detailed data about turbot abundance by strata in May 2019.

Table 2

Abundance of *S. maximus* by strata May 2019.

15 - 50 м		*50 – 75 м*		*75-100 м*	
No. station	***No. Ind./km2***	***No. station***	***No. Ind./km2***	***No. station***	***No. Ind./km2***
1	50	**2**	100	**5**	17
9	17	**3**	66	**6**	83
12	17	**4**	66	**7**	100
13	17	**8**	0	**10**	100
14	50	**11**	17	**16**	83
15	17	**18**	17	**17**	116
19	0	**22**	0	**35**	33
20	33	**25**	17	**36**	17
21	0	**27**	17	**37**	66
23	50	**28**	83	**38**	17
24	0	**29**	66	**39**	50
26	33	**34**	17	**40**	17
30	17				

31	17				
32	17				
33	50				
Total	**382**	**Total**	**465**	**Total**	**697**
Average	**24**	**Average**	**39**	**Average**	**58**
Variance	12.945		28.852		22.544
Standard deviation	3.598		5.371		4.748
Relative standard deviation	0.151		0.139		0.082
Standard error	0.184		0.249		0.180

3.2. Catch per unit effort (CPUE)

Catches from a total of 40 trawls were distributed as follows:

- 5 hauls (12.5 % of total no. hauls), catch 0 кг.;
- 19 hauls (47.5 %), catch 0.1 – 4.99 kg per haul;
- 9 hauls (22.5 %), catch 5.0 – 9.99 kg per haul;
- 7 hauls (17.5 %), catch 10.0 – 18.99 kg per haul;

Stratum < 30 м; 3 hauls:

- 3 hauls, catch 0.1 - 4.99 kg per haul;

Stratum 31 – 50 м; 13 hauls:

- 2 hauls, catch - 0 кг на трал;
- 7 hauls, catch - 0.1 - 4.99 kg per haul;
- 4 hauls, catch - 5.0 - 9.99 kg per haul;

Stratum 50 – 75 м; 12 hauls:

- 2 hauls, catch - 0 kg per haul;
- 5 hauls, catch 0.1 – 4.99 kg per haul;
- 3 hauls, catch 5.0 – 9.99 kg per haul;

- 2 hauls, catch 10.0 – 18.99 kg per haul;

Stratum 75 – 100 м; 12 hauls:

- 5 hauls, catch 0.1 – 4.99 kg per haul;
- 2 hauls, catch 5.0 – 9.99 kg per haul;
- 5 hauls, catch 10.0 – 18.46 kg per haul;

The CPUE distribution in May 2019 is shown in Table 3 and Fig. 4.

Table 3

The sampling stations, coordinates and CPUE (kg/trawl) in May 2019

№	Field	Starting coordinates		Depth (m)	Speed (Nm)	Trawling time (min) №	Catch turbot	
		ϕ	λ				N	Kg
1	L1	43.37.070	28.41.38	49-51	2.5	60	3	9.7
2	N1	43.39.050	28.51.450	58.5-63.5	2.5	60	6	18.89
3	M2	43.34.510	28.49.520	63.5-64.5	2.5	60	4	8.42
4	L3	43.29.112	28.43.725	63-67.5	2.5	60	4	11.45
5	M4	43.24.230	28.46.614	76.5-79.5	2.5	60	1	0.48
6	L5	43.19.320	28.43.900	81-82	2.5	60	5	12.35
7	K4	43.22.150	28.39.670	70-64	2.5	60	6	15.12
8	J5	43.19.800	28.34.378	57.5-61.7	2.5	60	0	0
9	H5	43.19.032	28.23.890	19.5-30.5	2.5	60	1	0.14
10	J7	43.09.680	28.33.000	84.1-74.5	2.5	60	6	18.46
11	J6	43.10.885	28.28.450	67.8-55.1	2.5	60	1	1.52
12	H7	43.09.315	28.23.480	52.6-41.2	2.5	60	1	4.58
13	G6	43.10.385	28.19.800	39-31	2.5	60	1	3.53
14	F7	43.07.695	28.13.980	31.5-35.5	2.5	60	3	6.79
15	G8	43.05.060	28.17.160	41.8-58	2.5	60	1	2.55
16	H9	42.59.280	28.21.125	76.6-80	2.5	60	5	11.91
17	G10	42.54.620	28.19.560	82.3-82	2.5	60	7	14.9
18	F9	42.56.050	28.14.500	62.4-47	2.5	60	1	4.66
19	E8	43.04.400	28.09.440	28.5-23.8	2.5	60	0	0
20	D9	42.58.252	28.03.890	27.3-31.3	2.5	60	2	1.81
21	E10	42.54.915	28.07.250	36.5-44.8	2.5	60	0	0
22	E11	42.48.400	28.07.033	49.7-63.5	2.5	60	0	0
23	C11	42.47.700	27.59.641	32.5-35	2.5	60	3	1.29
24	D12	42.43.640	28.01.563	39.5-43.5	2.5	60	0	0
25	E13	42.39.442	28.05.695	59.6-70	2.5	60	1	3.18

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26	C13	42.38.715	27.59.640	40.8-42.5	2.5	60	2	5.86
27	D14	42.33.420	28.02.550	55-60	2.5	60	1	3.41
28	E15	42.28.860	28.05.350	66.6-68	2.5	60	5	6.66
29	D16	42.24.690	28.04.090	62-50.7	2.5	60	4	8.92
30	C15	42.26.200	27.58.970	46.7-38.8	2.5	60	1	0.03
31	B16	42.23.180	27.53.298	36.3-36.8	2.5	60	1	3.44
32	C17	42.19.020	27.55.780	37.5-42.4	2.5	60	1	1.64
33	D18	42.14.410	28.02.030	50-53.5	2.5	60	3	6.91
34	E19	42.09.530	28.06.300	57.4-65	2.5	60	1	4.25
35	F18	42.11.790	28.10.670	75-80.6	2.5	60	2	6.25
36	E17	42.17.098	28.09.770	78.4-77.6	2.5	60	1	4.39
37	F16	42.21.646	28.10.804	82.5-83.5	2.5	60	4	10.01
38	F14	42.31.240	28.12.205	85.5-85	2.5	60	1	1.45
39	G13	42.36.800	28.15.650	89-89.5	2.5	60	3	4.26
40	F12	42.41.310	28.14.360	86-80.9	2.5	60	1	1.81

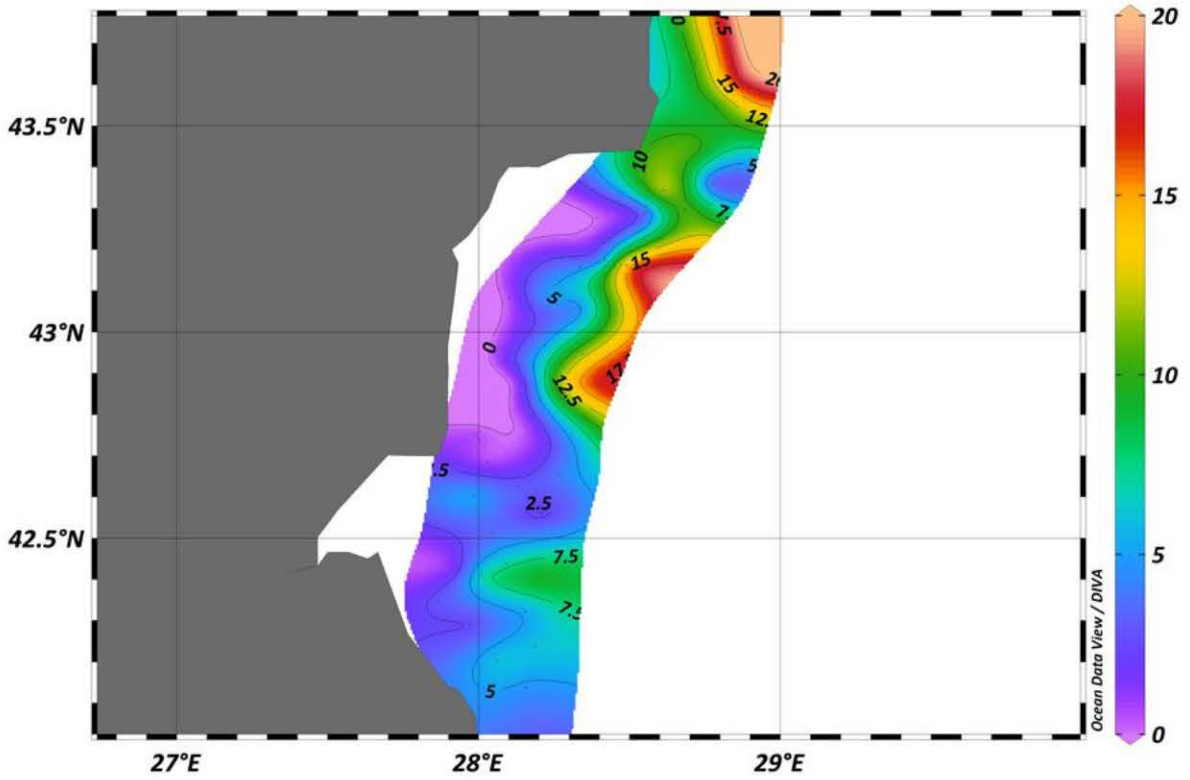

Fig. 3. *Distribution of catch per unit effort (CPUE)*

3.3. Catch per unit area (CPUA)

The turbot abundance and biomass per unit area are presented at Table 4 and Fig 2 and 4. and distribution of the relative biomass (kg/km2) and abundance (n/km2) of *S. maximus* in May, 2019 is presented at Fig.5.

High relative biomass, between 0.15 - 0.31 t/km^2 was established in four sectors of the Bulgarian Black Sea zone:

- in north direction, between Durankulak and Shabla, at a depth of 58.5-63.5 m (st. N1);
- in front of cape Kaliakra (st. L5 и K4), at a depth of 81-82 m and 70-64 m;
- off the central part of the coast, between Varna and near to the Kamchiya River mouth (st. J7, H9 and G10) at depths of 76-84.5 m; м.
- in south direction, between Sozopol and Primorsko (st. F16 and 82.5 m), (Fig.2 and 4).

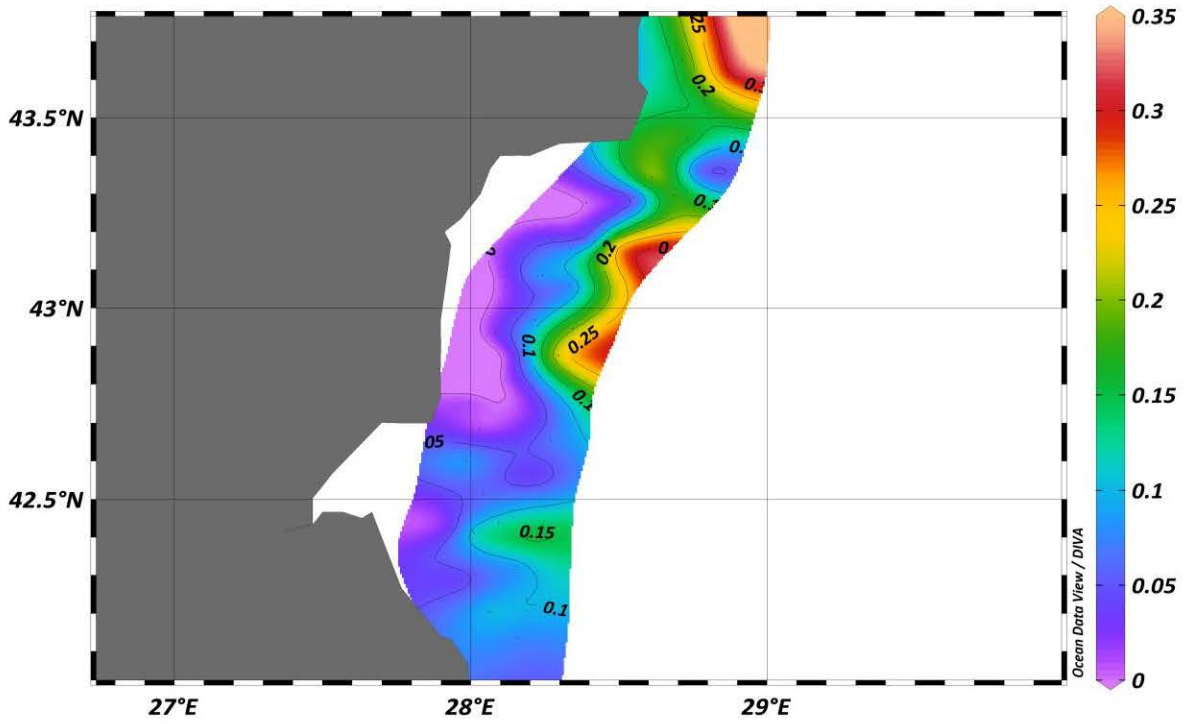

Fig. 4. Distribution of the relative biomass (t/km^2) of S. maximus in May 2019.

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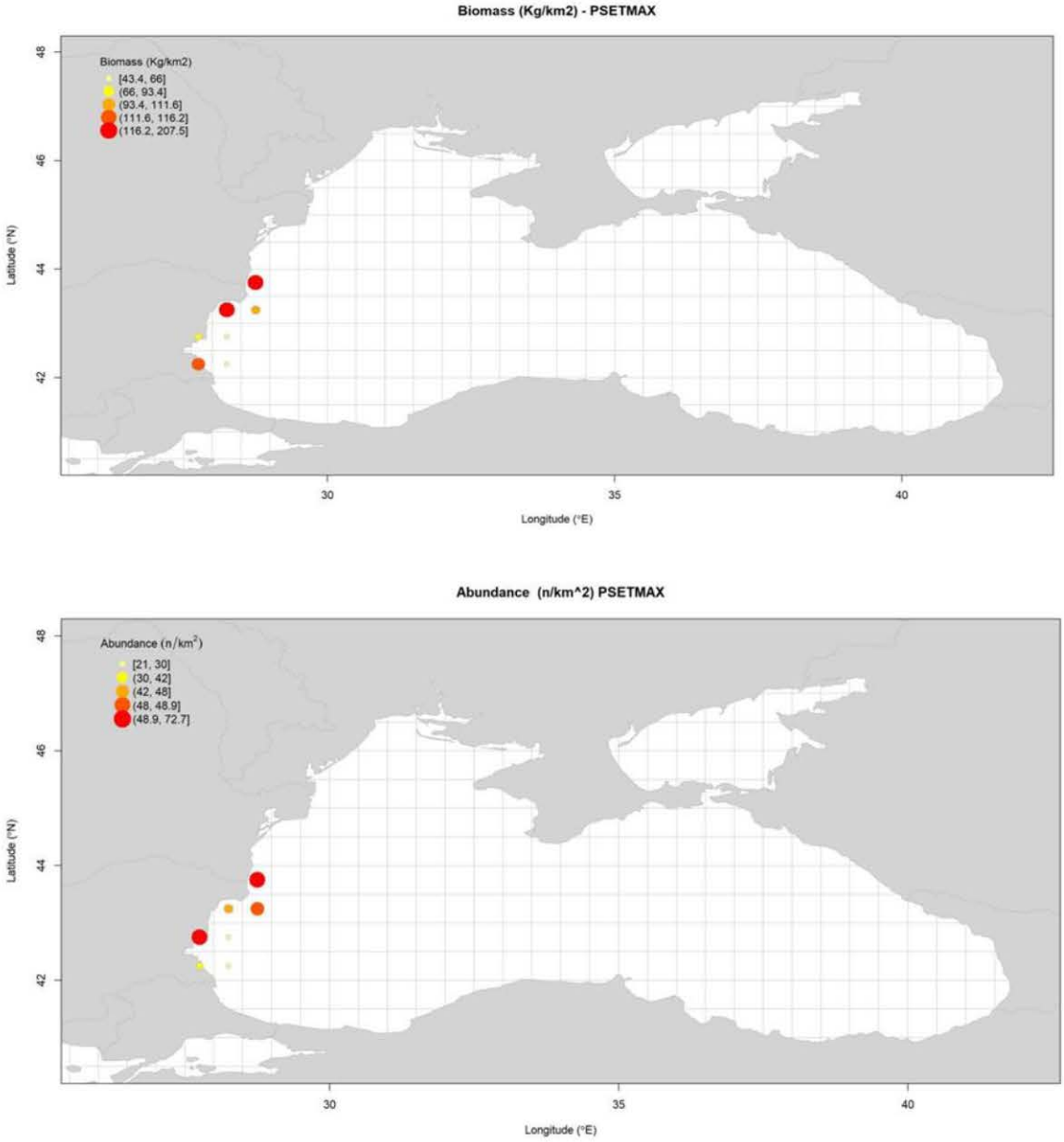

Fig. 5 Distribution of the relative biomass (kg / km2) and abundance (n / km2) of S. maximus in May, 2019.

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Table 4

Turbot abundance and biomass observed in the Bulgarian waters in May 2019

No. Station	*Field*	*No. ind./km²*	*t/км²*
1	L1	50	0.161
2	N1	100	0.314
3	M2	66	0.140
4	L3	66	0.190
5	M4	17	0.008
6	L5	83	0.205
7	K4	100	0.251
8	J5	0	0.000
9	H5	17	0.002
10	J7	100	0.307
11	J6	17	0.025
12	H7	17	0.076
13	G6	17	0.059
14	F7	50	0.113
15	G8	17	0.042
16	H9	83	0.198
17	G10	116	0.247
18	F9	17	0.077
19	E8	0	0.000
20	D9	33	0.030
21	E10	0	0.000
22	E11	0	0.000
23	C11	50	0.021
24	D12	0	0.000
25	E13	17	0.053
26	C13	33	0.097
27	D14	17	0.057
28	E15	83	0.111
29	D16	66	0.148

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30	C15	17	0.000
31	B16	17	0.057
32	C17	17	0.027
33	D18	50	0.115
34	E19	17	0.071
35	F18	33	0.104
36	E17	17	0.073
37	F16	66	0.166
38	F14	17	0.024
39	G13	50	0.071
40	F12	17	0.030
Total		1544	3.670
	Average	38.60308	0.092
	Total in the Bulgarian area	**447 436 Ind.**	**1063.36 tonnes**

	№ ind./км²	*t/км²*
Variance	1079.906	0.007599
Standard deviation	32.86192	0.087175
Relative standard deviation	0.851277	0.950212
Standard error	5.195925	0.013784

The calculated turbot biomass in the Bulgarian Black Sea waters amounted to **1063.36 tons**, by abundance – **447 436** individuals (Table 4).

3.4. Size structure

The information about the size structure of turbot population was based on biometric measurements of 93 turbot specimens, and included data on the absolute and standard length, and individual weight (pic.4).

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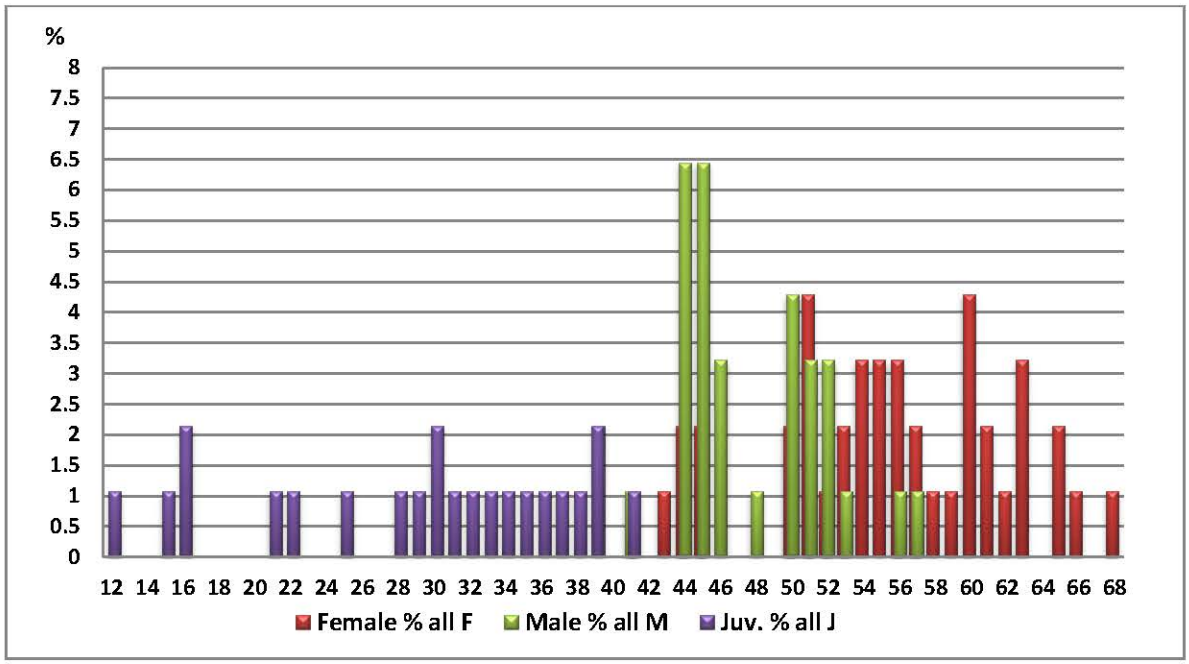

Fig. 6. Length structure of S. maximus.

The absolute length of the measured individuals varied between 12.50 and 68.50 cm, by weight - between 30 and 5510 g. The total turbot catches reached 221.02 kg. Distribution of the length classes was as follows: eight individuals were of sizes between 12.5-28 cm (8.60 %),13 individuals - between 29-39 cm (13.98 %), 29 - in the range between 40-50 cm (31.18 %) 35 individuals - between 51-61 cm (37.63 %) and 8 individuals - between 62-68.5 cm (8.60 %) (Fig. 6).

Sexually mature individuals dominated in the total catch - 76.34 % (71 specimens), while juveniles (< 45 cm) were presented by 22 specimens and formed 23.66 %. With a percent share of 44.09 % (41 specimens), the females outnumbered the males - 32.26 % (30 specimens).

The size structure was analysed in compliance with the national regulations, setting out the minimum permissible length of the individuals for fishing purpose. Thus, the individuals with absolute length under 45 cm were marked as undersized, and those with

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length > 45 cm - as standard.

Fig. 7 shows the total turbot abundance (ind/km^2) and the distribution of the ratio between the undersized individuals and those of standard length.

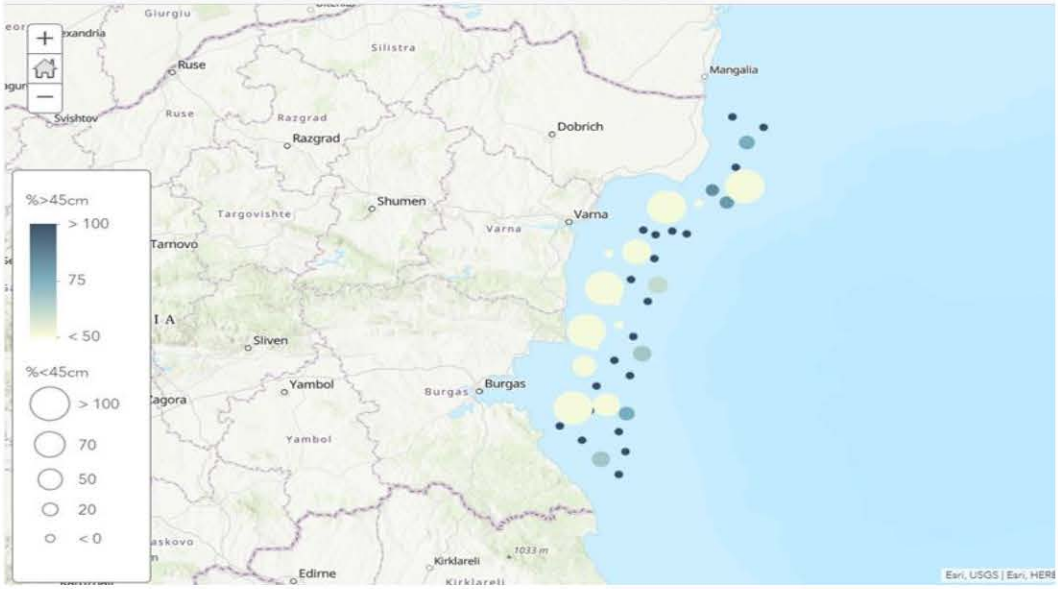

Fig. 7. Distribution of the S. maximus abundance (ind/km^2) and ratio between the undersized individuals and those with standard length.

The relative turbot biomass by size classes is given in Fig. 8, presenting high biomass for two size classes - those of 51-61 cm.

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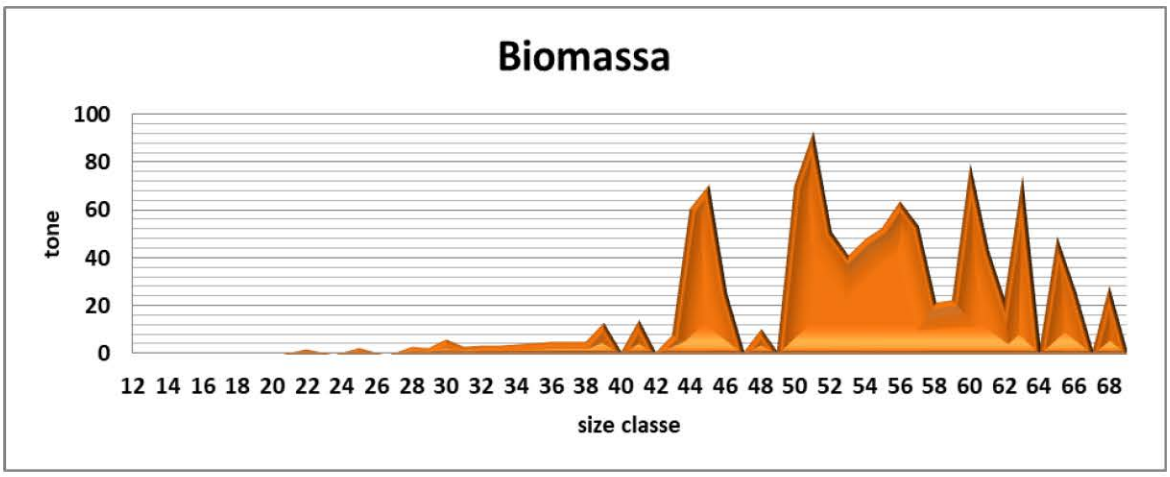

Fig. 8. Biomass by mean size classes of S. maximus.

3.5. Age structure

The turbot age composition was determined through analysis of 71 pairs of otoliths. The age structure included 1 - to 9 - years classes, with domination of the 4 (21.51 %) and 5 (21.51 %) years (43.01 % in total), followed by 6 - year class – 16.13 % (Fig. 9).

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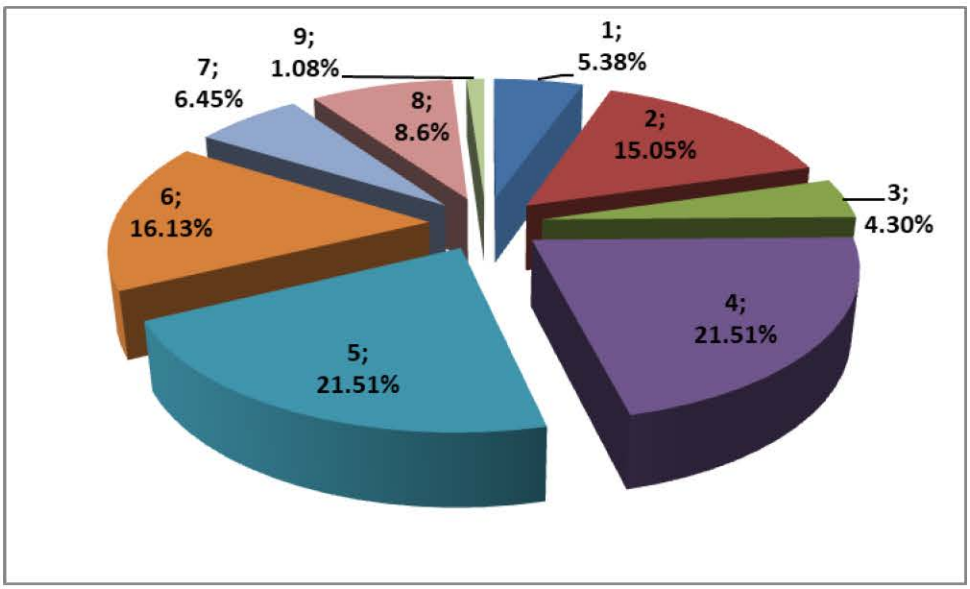

Fig. 9. Age structure of turbot in May 2019.

In the spring season of 2019, the share of the replenishment of 2 - year class reached 15.05 %. It should be noted, that during the V/2016, the portion of 1 - and 2 - year classes attained 25.77 %, then in spring of 2017, the percent share of the group was almost half (13.25%) in comparison with 2016, then during the spring survey in 2018, this share comprised very low level of 3.17 % of all age classes. Thus, data in spring 2019 about the share of replenishment in the turbot age structure were closer to those from the spring season of 2016.

Although having small frequency of occurrence, specimens from 7 - to 9 - years classes were registered in the yield.

The spatial distribution of *S. maximus* by age classes in the surveyed area is shown in Fig.10.

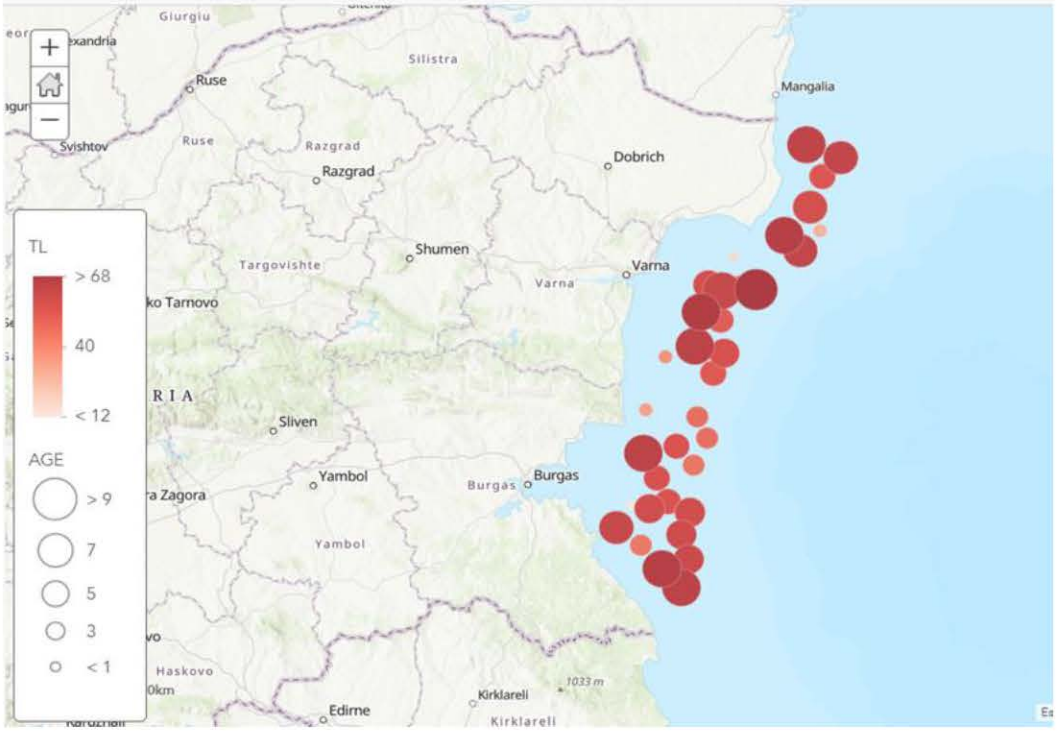

Fig. 10. Spatial distribution and age structure of S. maximus in May 2019.

3.6. Biological parameters of *S. maximus*

To estimate the turbot growth rate, the data about the average length and weight by age groups for the two sexes were combined. The parameters k, $L\infty$ and t_0 are estimated.

The calculated values of the parameters in *von Bertalanffy's* and L-W equation were as follows:

a = 0.0355
b = 2.84
q = -1.4495
$L\infty$ = 72.11
k = 0.351
to = -0.36

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The equation, representing the length-weight relationship, based on the spring survey data is shown in Fig.11.

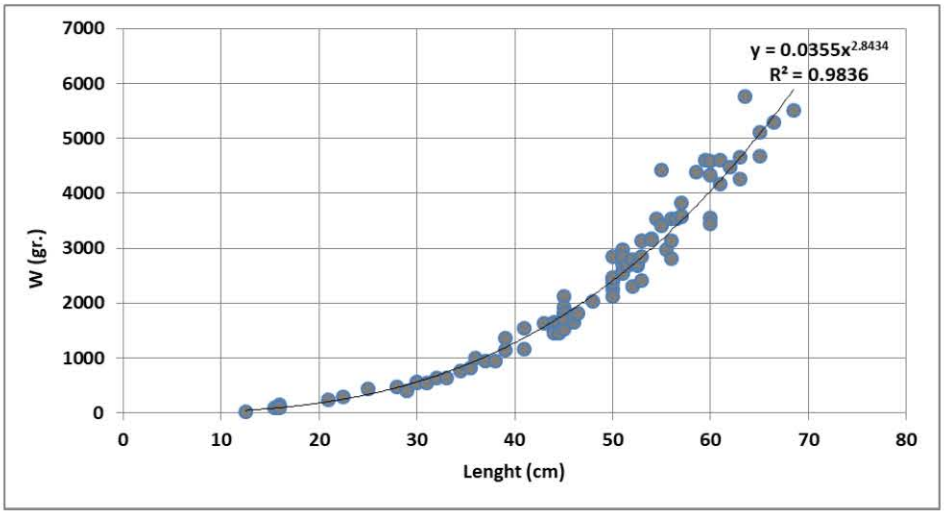

Fig. 11. S. maximus: Length-weight relationships in May 2019.

The coefficient of natural mortality (M) was calculated according to Pauly's formula (1980), describing the natural mortality as a function of k, L∞, W∞ and water temperature at the bottom layer.

$L_\infty = L_{t\ max}/0.95$

$k = 1/(t_2-t_1) * \ln(L_\infty-L_1)/(L_\infty-L_2)$

$\log(-t_0) = -0.3922 - 0.2752*\log L_\infty - 1.038*\log k$

$\ln M=-0.0152-0.279\ln L_\infty+0.6543\ln k+0.463\ln t_0$

Considering, that the water temperature was 8-10 °C during the study, the coefficient of natural mortality (M) for both sexes was equal to 0.33.

Fulton's condition factor (K)

This factor is used as a proxy for the "physiological condition" of individuals. The collected data show that the Fulton coefficient varies in small bounds with changes in size and age of turbot (Fig. 12).

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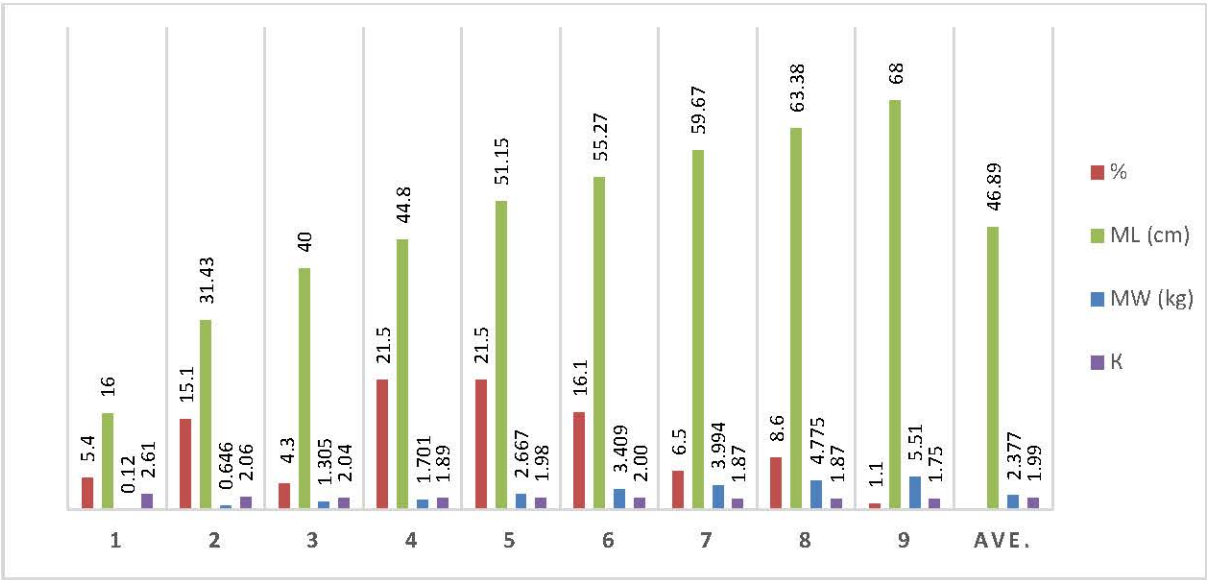

Fig. 12. Relationship between length, age, average size and weight of turbot and coefficient of Fulton by age.

3.7. Sex structure

Sex ratio

The results of the turbot sex structure analysis in spring 2019 are shown in Fig.13. The total share of sexually immature individuals formed 23.66 % of the total yield, the female individuals formed 44.09 %, and the share of males was 32.26 %.

From a total of 40 fields, studied off the Bulgarian coast in May 2019, female specimens were not identified in 14 fields, in 24 fields - males were not estimated, and in 5 field - only young forms were found, while adult specimens were absent (Fig.13).

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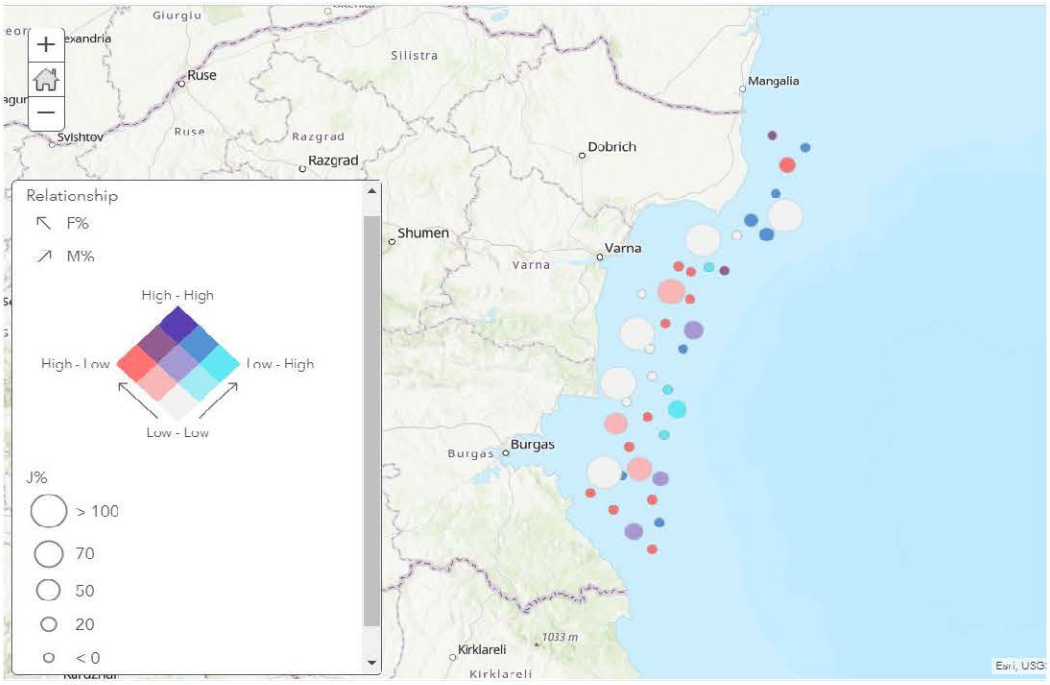

Fig.13. Sex structure of S. maximus in May 2019: distribution by stations (female, male and juvenile specimens are indicated by: coral, blue and white).

Male specimens were found over the depths of 55 to 85 m., and the female specimens were observed from 30 to 78 m deep. The juveniles were concentrated in the section c. Kaliakra (76.5-79.5 m), in front of Varna (19.5-30.5m) and between Byala - Sozopol they were observed at different depths (27.3-46 m). The females were established mainly in the regions Shabla – c. Kaliakra, between Varna - Kamchia and Ahtopol, while high concentrations of males were detected in the region of Byala - Sozopol.

The average weight of females was 3530.24 g, with average length TL = 52.69 cm and standard length SL = 36.99 cm. The maximum weight of females reached 5510 g, besides the minimum weight was 1640 g.

Among females, the dominant classes were - 50 to 57 cm and 60 to 63 cm, and these size groups have formed 69.23 % of all studied females (Fig. 14).

For the length classes over > 58 cm (up to 68.5 cm), all specimens were only females, comprising 39.02 % of the total abundance.

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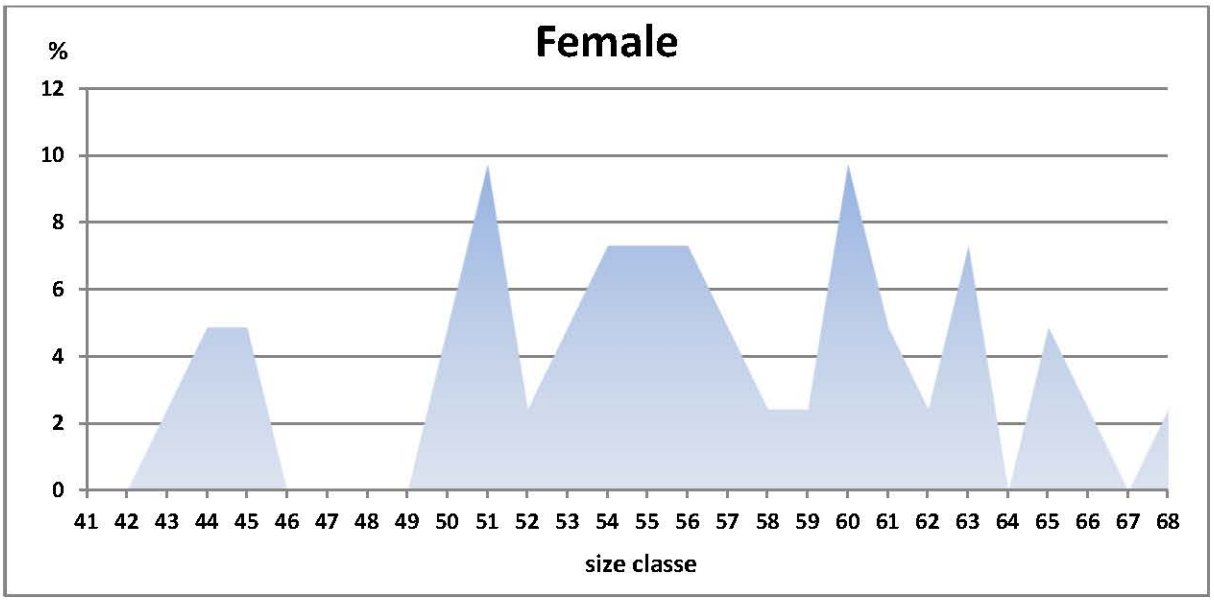

Fig.14. Females' specimens: Percentage distribution by length classes.

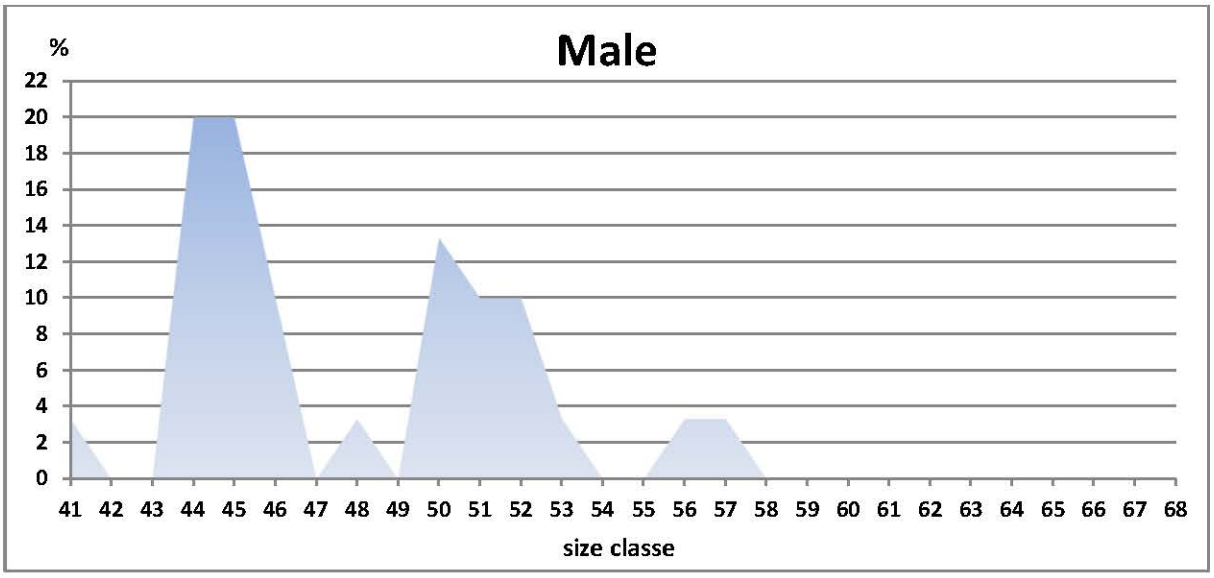

Fig.15. Male specimens: Percentage distribution by length classes.

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For males (Fig.15), the most significant proportion of total abundance – 53.33 % belonged to the length class 44 - 48 cm, followed by the size class 50-53 cm – 36.66 %.

The results demonstrate sexual dimorphism regarding the body length, with high presence of large size classes of females (Fig. 14 and 15).

3.8. Accompanying species

During the trawl survey, as a bycatch were collected four specimens of dogfish (*Squalus acanthias*), 27 specimens thornback ray (*Raja clavata*) and 29 individuals of European flounder (*Platichthys flesus*) (Table 5).

Table 5

Data on species composition and biological characteristics of the bycatch species

Bycatch species	N	Size (cm)			Weight (kg)		
		Min.	Max.	Ave.	Min.	Max.	Ave.
Squalus acanthias	4	71	143	109.75	1.48	14.7	7.405
Raja clavata	27	31	86	52.61	0.220	5.52	1.297
Platichthys flesus luscus	29	14.5	28	20.17	0.100	0.300	0.154

Map, showing the location of stations with above mentioned bycatch species is presented in Fig. 16. The species *Squalus acanthias* was mainly observed in the regions in Cape Kaliakra, Shabla, Kamchiya, and under the Cape Emine (63.5-85 m). Large number of *Pl. flesus* was caught in north direction - Duranculak – Shabla (58-63.5 м).

Thornback ray were observed in the vast area - from Shabla to Primorsko at depths 32 - 89 m.

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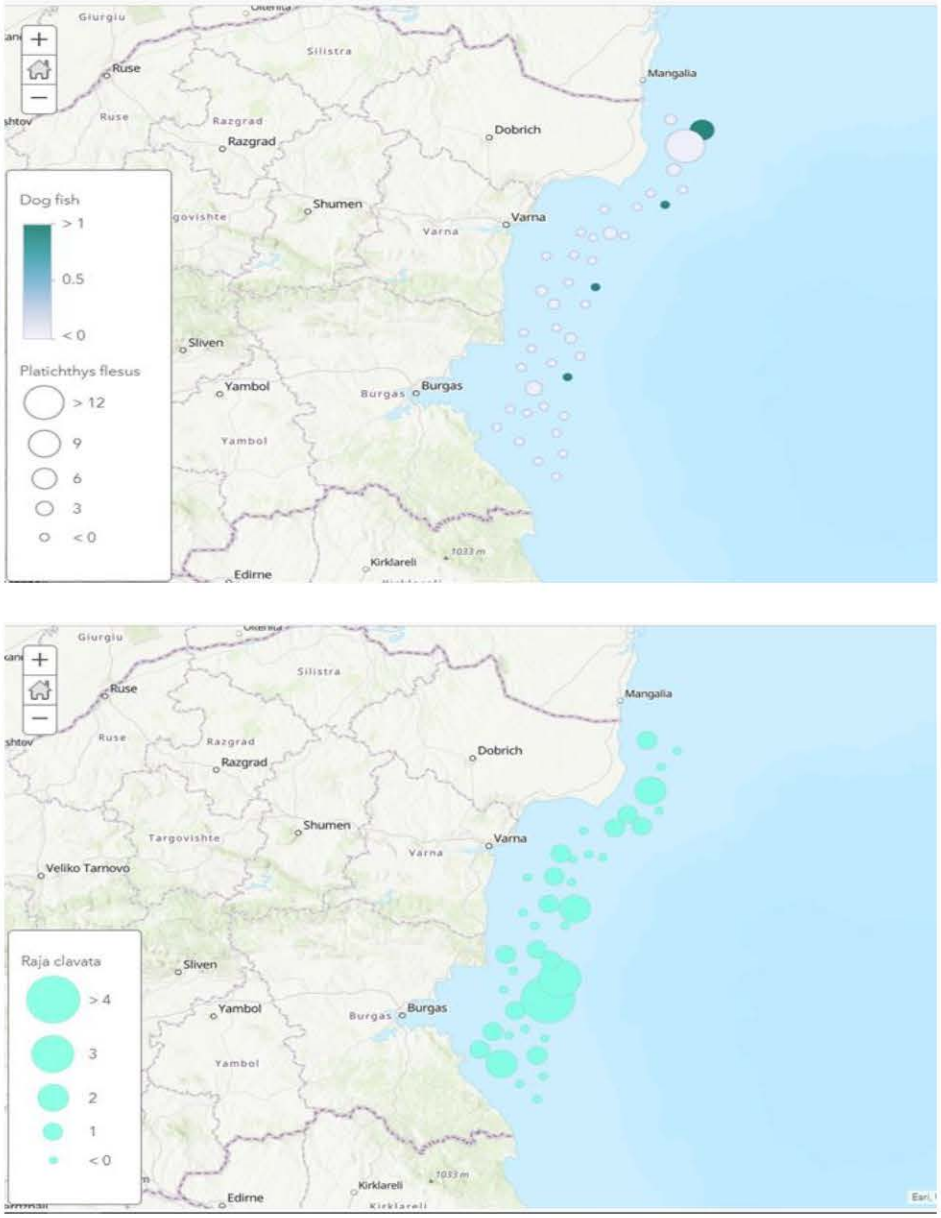

Fig. 16. *Location of stations with bycatch from spiny dogfish (S. acanthias, circles with blue colour), thornback ray (Pl. flesus, circles with white colour) and* flounder (*R. clavata, circles with green colour).*

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3.9. Food composition

In the spring season of 2019, a total of 52 stomachs were gathered to determine the dietary spectrum of turbot. The food components were found in 21.15 % of the examined specimens and 78.85 % were with empty stomachs.

Full description of the collected data and some statistical parameters are given in the table 6 and 7.

Table 6

Survey area, length and weight of specimens, the weight of stomachs (filled, empty), stomach contents and index of stomach fullness (ISF).

Зона	L (mm)	W (g)	St content /g/	ISF (% BW)
B16/1	60	3440	34	0.99
C17/1	43	1640	14.5	0.88
D14/1	55	3410	30	0.88
D16/1	45	1780	16	0.90
D16/2	41	1540	8.5	0.55
D16/3	48	2030	15	0.74
D18/2	45	1820	17.5	0.96
D18/3	65	4680	14	0.30
E13/1	54	3180	23	0.72
E15/4	50	2130	7.5	0.35
E15/5	54	3160	36.5	1.16
E17/1	58.5	4390	34.5	0.79
E19/1	63	4250	48	1.13
F7/3	66.5	5290	9	0.17
F9/1	63	4660	10.5	0.23
F12/1	46.5	1810	10	0.55
F14/1	44.5	1450	19.5	1.34
F16/1	57	3580	22	0.61
F16/2	57	3820	36	0.94
F18/2	59.5	4600	30.5	0.66
G6/1	56.5	3530	4.5	0.13
G8/1	51	2550	28	1.10
G10/1	44	1480	10	0.68

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G10/2	44	1630	11.5	0.71
G13/2	46	1780	10.5	0.59
J6/1	45	1520	11	0.72
J7/1	44	1550	9.5	0.61
J7/2	54.5	3540	21.5	0.61
K4/2	45	1820	22	1.21
K4/3	51	2580	19	0.74
K4/4	56	3130	9	0.29
K4/5	65	5110	35	0.68
K4/6	50	2750	8	0.29
L1/1	62	4470	52.5	1.17
L1/2	45	1690	11.5	0.68
L1/3	56	3540	25	0.71
L3/1	52.5	2690	19.5	0.72
L3/2	56	2810	23.5	0.84
L3/3	53	2970	22.5	0.76
L3/4	55.5	2980	1.5	0.05
L5/2	44.5	1660	12	0.72
L5/3	53	2410	14.5	0.60
L5/4	61	4610	34	0.74
L5/5	52.5	2720	18.5	0.68
M2/2	44	1620	11.5	0.71
M2/3	52	2790	27.5	0.99
M2/4	53	2840	22.5	0.79
N1/1	45	2120	15.5	0.73
N1/2	51.5	2690	18.5	0.69
N1/4	61	4170	29.5	0.71
N1/5	60	4340	37.5	0.86
N1/6	50	2430	20	0.82

Table 7

General statistical data for the measured parameters in stomach content analysis.

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	L (mm)	W (kg)	St. content (g)	ISF (% BW)
Mean	52.60	2.91	20.26	0.72
Standard Error	0.95	0.15	1.54	0.04
Median	52.75	2.77	18.75	0.72
Mode	45.00	1.78	11.50	#N/A
Standard Deviation	6.83	1.11	11.09	0.28
Sample Variance	46.64	1.23	122.90	0.08
Kurtosis	-0.98	-0.91	0.41	0.40
Skewness	0.20	0.44	0.82	-0.29
Range	25.50	3.84	51.00	1.29
Minimum	41.00	1.45	1.50	0.05
Maximum	66.50	5.29	52.50	1.34
Sum	2735.00	151.18	1053.50	37.18
Count	52.00	52.00	52.00	52.00
Confidence Level(95.0%)	1.90	0.31	3.09	0.08

The average stomach fullness index reached 0.72 % BW ± 0.04 SE (Table 7) and showed an increase of 55 % compared to the data for the spring season of 2018. The analysis of the spatial distribution of the stomach fullness index (Fig. 17) indicated high values (~ 1.25% BW) in the open sea along the Bulgarian Black Sea coast.

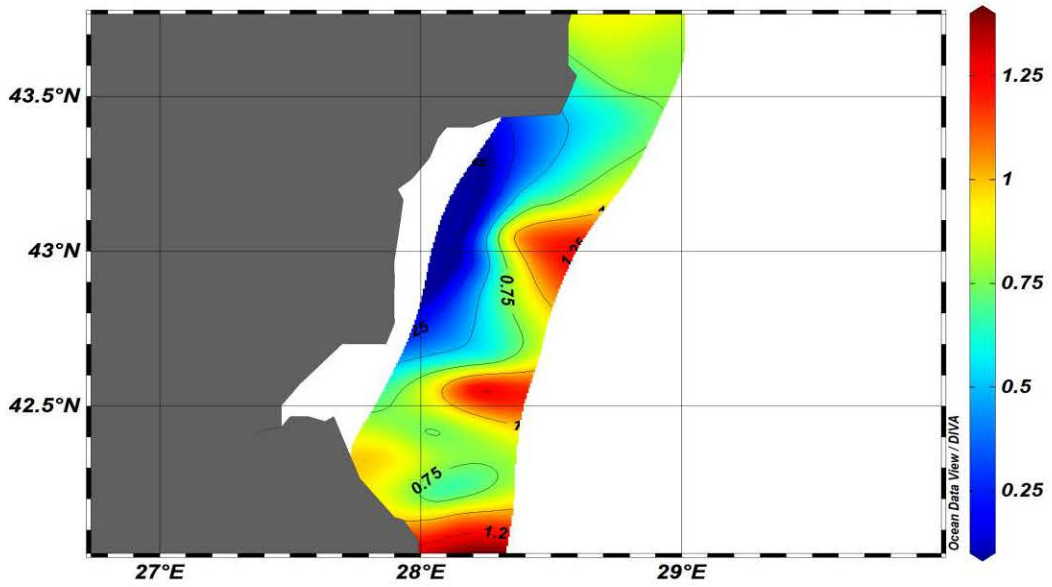

Fig. 17 Spatial distribution of ISF (% BW) during the spring season of 2019.

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.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

The qualitative composition of the turbot food included mostly fish (*Pisces*) and decapod crabs (*Decapoda*) (Table 8).

Table 8

Diet spectrum of turbot in the spring season of 2019. (Data for feeding individuals).

Species composition of food	CN (% by number)	CW (% by biomass)	FQ (Frequency of occurrence)	IRI (Index of relative importance)	IRI %
Pisces	93.94	91.80		4938.81	96.04
Merlangius merlangus	81.82	81.81	90.90	4519.22	87.88
Solea solea	9.09	9.09	9.09	363.64	7.07
Alosa pontica	3.03	0.89	9.09	55.95	1.09
Decapoda	6.06	8.20	18.18	203.79	3.96
Liocarcinus holsatus	6.06	8.2	18.18	203.79	3.96

The turbot feeds mainly on fish, and the percentage of this component was 93.94 % of the total number of food components in the stomachs of the feeding specimens and 91.8 % of the food mass. A relatively low presence was detected for the *Decapods*, which occupied 6.06 % by the number and 8.2 % of the food mass.

In the spring season of 2019, the turbot food was mainly formed by *Merlangius merlangus* - IRI = 4519.22 (87.88 %IRI), by the incidental presence of common sole and pontic shad (Fig. 18).

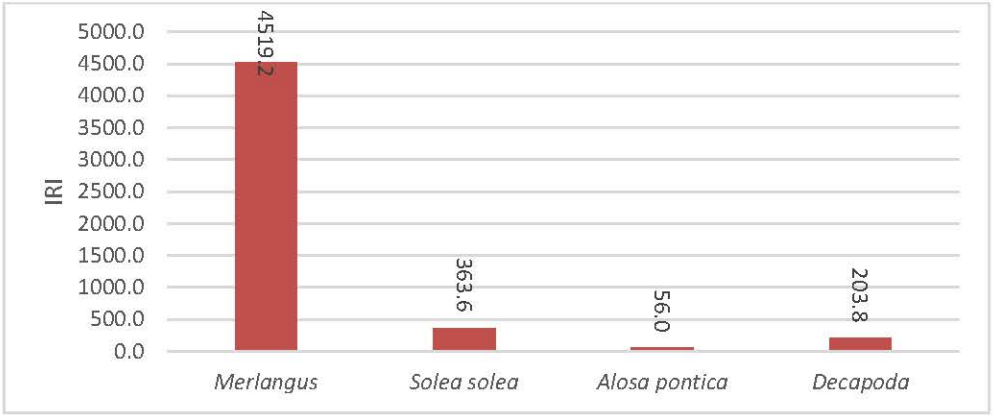

Fig. 18 *IRI values of different species in turbot food in spring 2019.*

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The percentage proportions of IRI by species were distributed as follows: 88 % and 12 % shared between common sole, pontic shad and Decapoda (Fig.19).

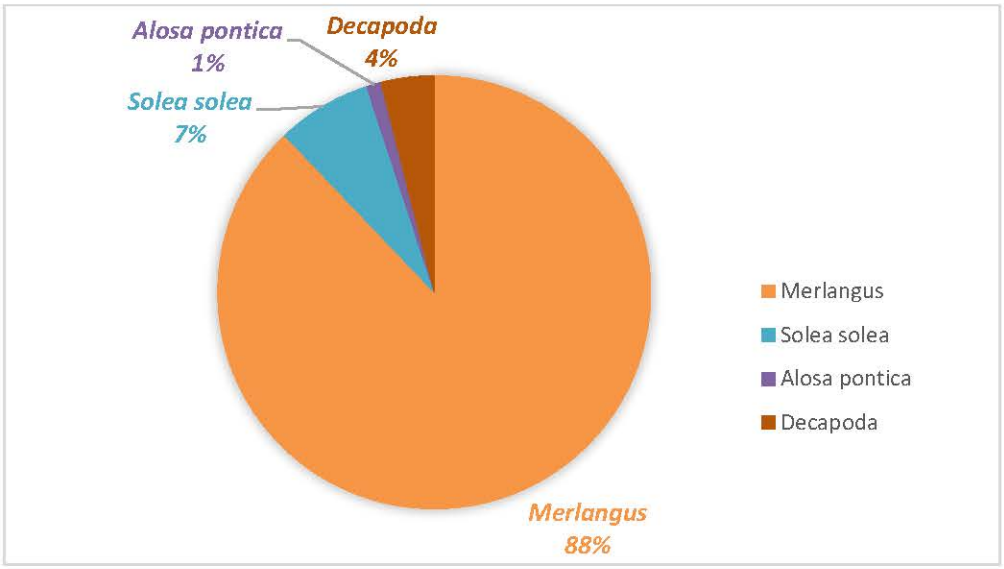

Fig. 19 Percentages by species (%, IRI) in the turbot food spectrum in spring 2019.

Observed other particular problems

During the expedition activity, the dominant wind direction was - West, Northwest and Southwest by force between 1-2º BF - along the coast and 2-4º BF - at sea.

In the spring season of 2019, the conditions in the field were normal for conducting the research activities for turbot stock assessment in the Bulgarian Black Sea waters.

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4. Conclusions and recommendations

By the collected information and obtained results from the trawl survey in May 2019, the following conclusions and recommendations can be made:

- The **turbot biomass** in the Bulgarian Black Sea waters was assessed at **1063.36 tons** and the **turbot abundance** was estimated at **447 436 individuals**.
- The recommended **MSY (maximum sustainable yield)** for Bulgaria will be included in the final report for 2019, based on data from the trawl surveys, both in spring and autumn seasons of 2019.
- **The size structure** of the turbot population in the Bulgarian Black Sea zone included length classes from **12.5 cm to 68.5 cm**, with a weight between **30 g and 5510 g**. The average turbot weight was estimated as **2376.6 g**. In the turbot length structure, **the undersized individuals**, with length < 45 cm, formed **23.66 %** from the total number, while those of **standard length** made up **76.34 %**.
- **The age composition** of the population included age classes from **1 to 9 - years**, with the domination of the 4- (21.51 %) and 5- (21.51 %) year classes, (43.01% total), followed by 6-years specimens - 16.13%.
- The **established ratio between female, male and sexually immature** individuals in the yield were - **44.09 %: 32.26 %: 23.66 %.**
- Of the studied **52** turbot specimens, by **21.15 %** were found food components and **78.85 %** were with empty stomachs. The average stomach fullness index reached 0.72 % BW ± 0.04 SE. The analysis of spatial distribution of the stomach

fullness index indicated relatively high values (~ 1.25 % BW) in the open sea area. In the current year, the turbot food spectrum was mainly formed by Merlangius merlangus - **IRI = 4519.22** (87.88 % IRI), by relatively low presence of common sole, pontic shad, and *Decapoda* crabs.

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