REPORT

Bottom Trawl Surveys In The Bulgarian Black Sea Area Spring-Summer 2021

Agricultural Academy
Institute of Fish Resources (IFR, Varna)
2021

ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО

МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И ГОРИТЕ

ПРОГРАМА ЗА
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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-195/10.12.2019 with the Executive Agency for Fisheries and Aquaculture (EAFA), for turbot stock assessment in the Bulgarian Black Sea waters during the spring-summer period of 2021.
The study was conducted owing to the financial support of the European Commission in compliance with Council Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008 (recast).
The study was performed in the period 09 - 19 May 2021 in the Bulgarian Black Sea waters on board of the “EGEO 2” fishing vessel.

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LIST OF FIGURES IN THE TEXT

Проект BG14MFOP001-3.003-0002-C02, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2020-2021 г.“, финансиран от Програмата за морско дело и рибарство, съфинансиран от Европейския съюз чрез Европейския фонд за морско дело и рибарство

BOTTOM TRAWL SURVEY FOR TURBOT STOCK ASSESMENT IN BULGARIAN BLACK SEA SECTOR DURING SPRING SUMMER SEASON OF 2021

1. Results from the National Bottom Trawl Surveys in V 2021

During 09 - 19 May 2021**,** 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 length -19.5 m;
- Maximum width – 5.9 m;
- The fishing vessel year of built - 2005;
- Engine power – 367.75 kW;
- Maximum tonnage – 38.24t;
- Net tonnage – 11.43 t;
- Speed – 9.5 Nd;
- Crew - 3 people;
- Research team - 3 people.

Picture 1. *Fishing ship*

During the studies, a fishing bottom trawl 32/27-34 was applied (picture 2), with following functional and technical parameters:

- Trawl vertical opening - 2 m;

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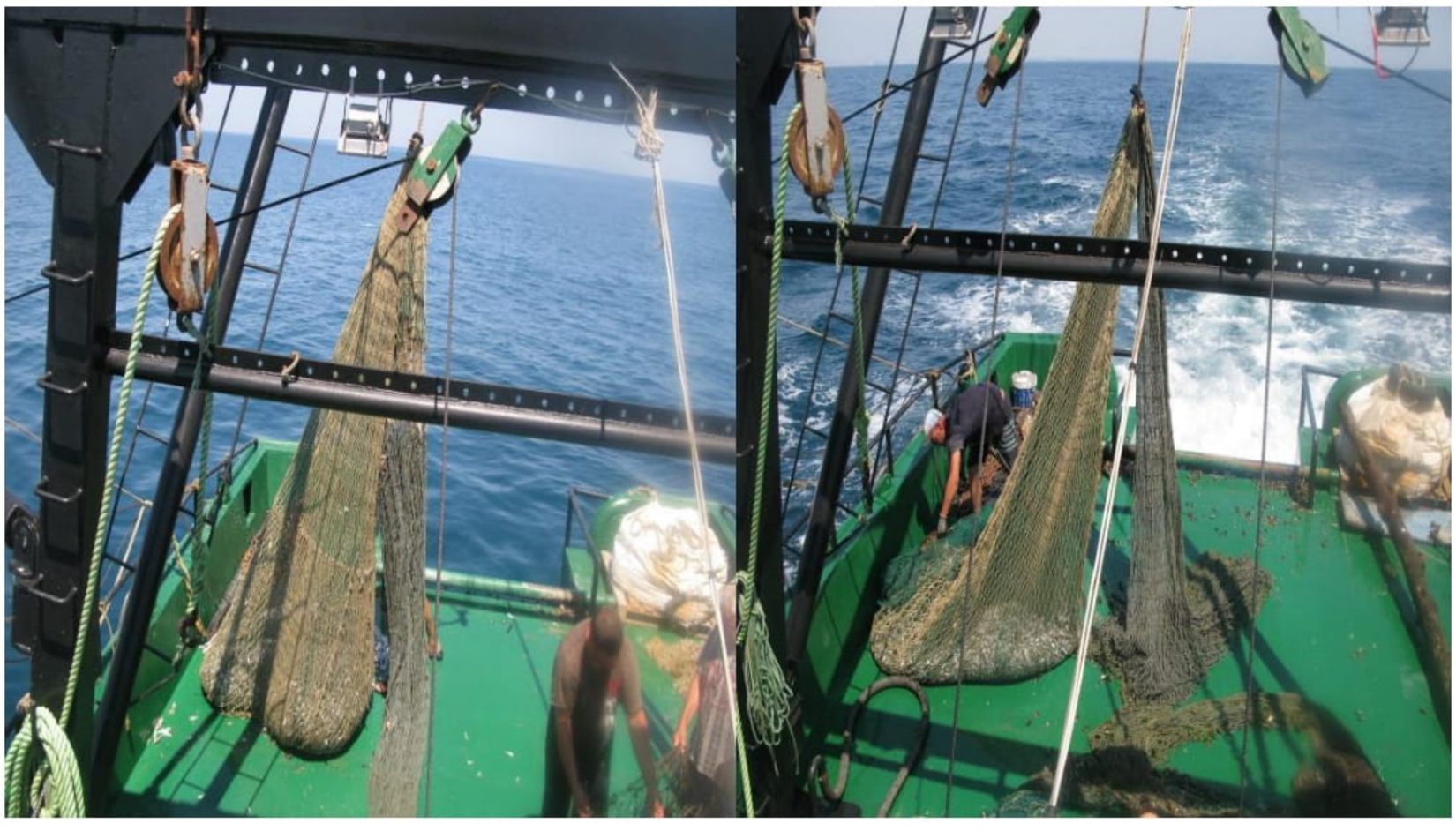
- Effective part of Headrope - 13 m;
- Effective part of Footrope - 15 m;
- Trawling speed - 2.2 - 2.6 Nd;
- Trawling duration - 60 min.
- Mesh size – 200 mm.



Picture 2. *Bottom trawl 32 / 27-34.*

2. Material and methods

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

- Survey area (km2);
- Catch per unit effort (kg/trawl)
- Catch per unit area (t/km^2);
- Abundance index (individual/km^2);
- Limits of variation of CPUA;
- Total biomass (t.);
- 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) 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.

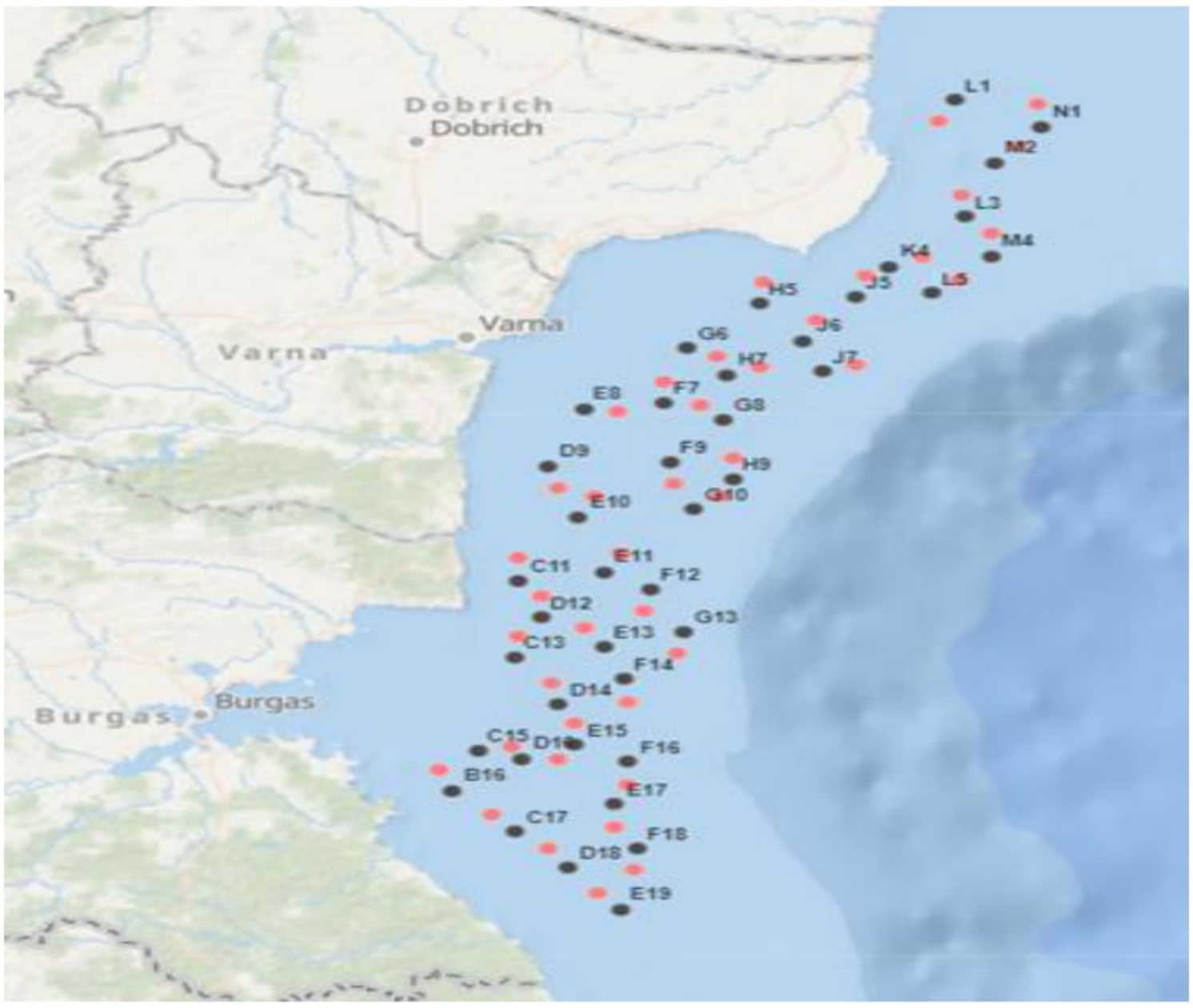


Fig. 1. Map of the surveyed sectors, V 2021

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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 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 63 stomachs were collected in spring -summer 2021. 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:

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

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.

CPUE (Catch per unit effort) - is calculated by dividing the trawl catch by the fishing hours (kilograms/hour):

CPUE = yield/effort

Maximum sustainable yield

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):**

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

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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□□ = 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

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:

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

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

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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.

3. Results

3.1. Population number and biomass

During the demersal trawl survey in V 2021, the following activities were carried out:

- 40 hauls with a bottom trawl, with duration of 60 minutes, at depths between 15 m and 100 m, covering entirely the continental shelf of the Bulgarian Black Sea zone, between Durankulak and Ahtopol (Picture 3).

- for each haul, a qualitative and quantitative analysis of the catch was accomplished, including biometric measurements of 167 turbot specimens, 150 specimens of European flounder, 75 specimens thornback ray (*Raja clavata*) and 2 ind. spiny dogfish (Picture 4 and 5).

Picture 3. *Bottom trawling yield*

***Picture 4**. Yield of turbot (Scophthalmus maximus) and bycatch species - Merlangius merlangus (whiting), Platichthys flesus (European flounder), Raja clavata (thornback ray), spiny dogfish (Squalus acanthias) u crabs (Carcinus aestuarii and Liocarcinus vernalis).*

Constant presence of *S. maximus* was established in almost all bottom trawls at a depth 75-100 m with yield - at least 3-10 individuals per haul (where catch ≠ 0). At depths - 15-50 m, the average recorded catch is small, and at 50-75 m, the average catch of turbot increases. At ten fields, a high yield was obtained, with ranges between 11.28 to 24.25 kg/trawl.

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Two specimens of dogfish (*Sq. acanthias*) were captured during the survey, with size and weight that varied from - 123 см /7.53 kg and 125 см/8.79 kg.

The main bycatch species included whiting (*Merlangius merlangus euxinus*), European flounder (*Platichthys flesus luscus* - 150 ind.) and thornback ray (*Raja clavata*). Other bycatch species were black scorpionfish (*Scopaena porcus*), black mussel (*Mytilus galloprovincialis*), Knout goby (*Mesogobius batrachocephalus*) and Tub gurnard (*Trigla lucerina*).

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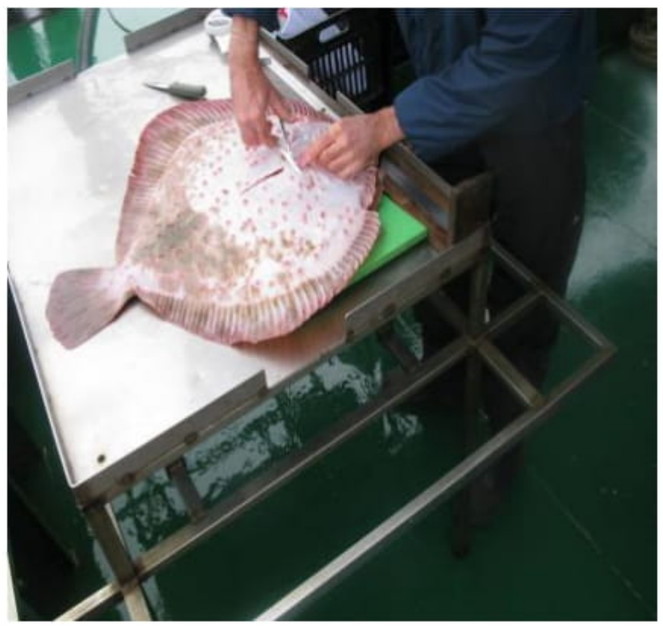

Picture 5. *Conducting biometric measurements and sampling for study of the stomach contents.*

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 - 159.87 kg/km^2, 8.30 kg/km^{2}и 67.74 kg/km^2, with abundance – 133 ind/km^2, 66 ind/km^2 и 83 ind/km^2. At these stations, the highest yield was found off the under Kavarna, while in front of the Varna and Shkorpilovtsi, the turbot biomass attained low levels (Table 1, Figures 2).

The average value of the relative biomass of turbot varies as in stratum 15-50 m it is twice lower (0.05 t/km^2) than stratum 50-75 m (0.10 t/km^2), and the highest average biomass was detected in the stratum 75-100 m - 0.26 t/km^2, while the highest average abundance was found again in the same stratum – 116 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 159.87 kg/km^2, 51.18 kg/km^2 on average (Table 1, Fig. 2). The abundance indices varied between 0 and 133 individuals/km^2, on average - 49 ind/km^2 (Table 2).

Stratum 50 -75 m

The relative turbot biomass fluctuated between 0 and 386.03 kg/km^2, 102.24 kg/km^2 on average (Table 1, Fig. 2 and 3). The abundance indices varied between 0 and 166 ind/km^2, with average value of 54 ind/km^2 (Table 2, Fig. 2 and 4).

Stratum 75 - 100 m

In this stratum, the average value of the relative biomass has the highest values 255.23 kg/km^2 (varied from 147.44 to 339.54 kg/km2), (Table 1, Fig. 2 and 4), with average abundance - 116 ind/km^2 (Table 2).

Table 1

Turbot biomass by strata, May 2021

15 - 50 м		*50 – 75 м*		*75-100 м*	
No. station	*t/км^2*	*No. station*	*t/км^2*	*No. station*	*t/км^2*
11	**0.160**	**33**	**0**	**36**	**0.321**
2	**0.008**	**14**	**0**	**7**	**0.274**
21	**0.068**	**27**	**0.158**	**17**	**0.339**
1	**0.055**	**10**	**0.218**	**35**	**0.187**
23	**0.000**	**4**	**0.131**	**40**	**0.340**
20	**0.037**	**12**	**0.076**	**38**	**0.120**
31	**0.000**	**29**	**0**	**8**	**0.306**
15	**0.087**	**34**	**0.138**	**37**	**0.161**
32	**0.062**	**25**	**0.059**	**18**	**0.314**
24	**0.035**	**19**	**0.039**	**13**	**0.300**
26	**0.088**	**22**	**0.016**	**39**	**0.147**
16	**0.038**	**5**	**0.106**		
30	**0.000**	**6**	**0.147**		
3	**0.080**	**28**	**0.059**		
		9	**0.386**		
Total	**0.717**	Total	**1.534**	Total	**2.807**

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Average	**0.05**	Average	**0.10**	Average	**0.26**
Variance	**0.002**		**0.010**		**0.006**
Standard deviation	**0.043**		**0.099**		**0.080**
Relative standard deviation	**0.842**		**0.973**		**0.313**
Standard error	**0.011**		**0.027**		**0.025**

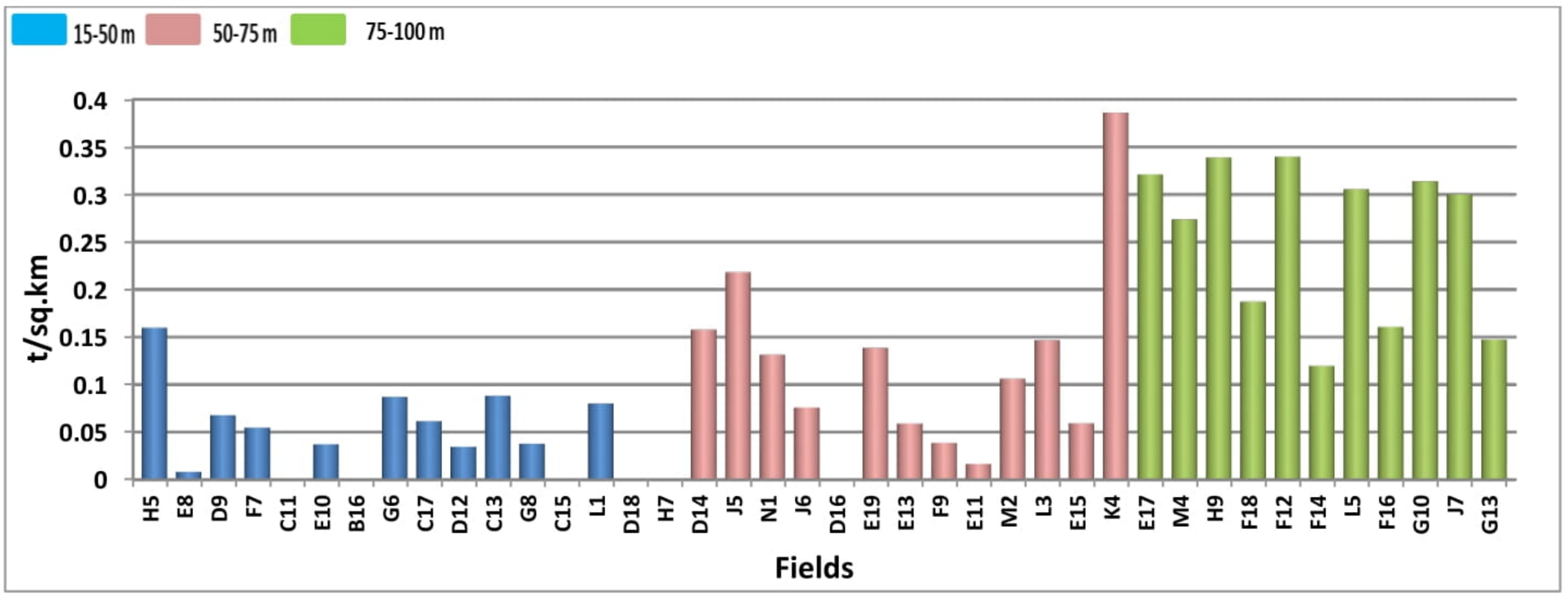

Fig. 2. Relative biomass (t/km^2) of S. maximus by strata off the Bulgarian Black Sea coast, V 2021

Table 2 represents detailed data about turbot abundance by strata in May 2021.

Table 2

Abundance of *S. maximus* by strata May 2021.

15 - 50 м		*50 – 75 м*		*75-100 м*	
No. station	***No. Ind./km2***	***No. station***	***No. Ind./km2***	***No. station***	***No. Ind./km2***

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11	133	33	0	36	116
2	66	14	0	7	149
21	83	27	83	17	183
1	50	10	166	35	100
23	0	4	66	40	116
20	33	12	33	38	50
31	0	29	0	8	133
15	83	34	33	37	83
32	33	25	33	18	133
24	17	19	17	13	133
26	116	22	17	39	83
16	33	5	66		
30	0	6	83		
3	33	28	50		
		9	166		
Total	681	Total	814	Total	1278
Average	49	Average	54	Average	116
Variance	34.39		49.11		10.35
Standard deviation	5.86		7.01		3.22
Relative standard deviation	0.12		0.13		0.03
Standard error	0.22		0.25		0.09

3.2. Catch per unit effort (CPUE)

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

- 6 haul (15 % of total no. hauls), catch 0 кг.;

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- 13 hauls (32.5 %), catch 0.1 – 4.99 kg per haul;
- 11 hauls (35 %), catch 5.0 – 9.99 kg per haul;
- 10 hauls (32.5 %), catch 10.0 – 24.25 kg per haul;

Stratum < 30 м; 3 hauls:

- 3 hauls, catch 0.5 - 10 kg per haul;

Stratum 31 – 50 м; 11 hauls:

- 3 haul, catch - 0 kg per haul;
- 6 hauls, catch - 0.1 - 4.99 kg per haul;
- 2 hauls, catch - 5.0 – 6.0 kg per haul;

Stratum 50 – 75 м; 15 hauls:

- 3 hauls, catch 0 kg per haul;
- 5 hauls, catch 0.1 - 4.99 kg per haul;
- 5 hauls, catch 5.0 – 9.9 kg per haul;
- 2 hauls, catch 10.0 - 24.99 kg per haul;

Stratum 75 – 100 м; 11 hauls:

- 3 hauls, catch 5.0 - 9.99 kg per haul;
- 6 hauls, catch 10.0 - 19.99 kg per haul;
- 2 hauls, catch 20.0 – 24.99 kg per haul;

The CPUE distribution in May 2021 is shown in Table 3 and Fig. 3.

Table 3

The sampling stations, coordinates and CPUE (kg/trawl) in May 2021

№	Field	Starting coordinates		Depth (m)	Speed (Nm)	Trawling time (min)	Catch turbot	
		ϕ	λ				N	Kg
1	F7	4307.64	2813.95	31.5	2.5	60	3	3.29
2	E8	4304.372	2809.42	28	2.5	60	4	0.5

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3	L1	4337.268	2841.558	49.6	2.5	60	2	4.82
4	N1	4339.05	2851.3	58	2.5	60	4	7.92
5	M2	4334.336	2849.207	64	2.5	60	4	6.4
6	L3	4328.86	2843.78	64	2.5	60	5	8.83
7	M4	4324.45	2846.75	76	2.5	60	9	16.4902
8	L5	4319.22	2843.47	81	2.5	60	8	18.41
9	K4	4321.775	2839.781	71	2.5	60	10	23.25
10	J5	4319.64	2834.26	57.5	2.5	60	10	13.1447
11	H5	4319.05	2823.934	19.5	2.5	60	8	9.629
12	J6	4314.73	2829.2	59	2.5	60	2	4.56
13	J7	4309.555	2833.27	85	2.5	60	8	18.07
14	H7	4309.333	2823.673	54	2.5	60	0	0
15	G6	4310.48	2819.48	38	2.5	60	5	5.24
16	G8	4305.118	2817.67	43	2.5	60	2	2.27
17	H9	4259.15	2821.122	77	2.5	60	11	20.4
18	G10	4254.73	2819.615	82	2.5	60	8	18.9
19	F9	4256.1	2814.964	63	2.5	60	1	2.32
20	E10	4254.7	2807.057	35.5	2.5	60	2	2.24
21	D9	4255.755	2803.66	29.7	2.5	60	5	4.08
22	E11	4248.273	2809.9	63	2.5	60	1	0.99
23	C11	4247.6	2759.69	33	2.5	60	0	0
24	D12	4243.36	2801.75	40.5	2.5	60	1	2.08
25	E13	4239.63	2806.19	62	2.5	60	2	3.55
26	C13	4238.82	2759.539	40.7	2.5	60	7	5.3
27	D14	4233.408	2802.77	56	2.5	60	5	9.5
28	E15	4228.8	2805.3	66.5	2.5	60	3	3.56
29	D16	4224.586	2803.423	60	2.5	60	0	0
30	C15	4226.17	2758.817	46.7	2.5	60	0	0
31	B16	4223.37	2751.615	36.5	2.5	60	0	0
32	C17	4218.257	2757.071	39.5	2.5	60	2	3.71
33	D18	4214.3	2802.425	51.7	2.5	60	0	0
34	E19	4209.39	2807.594	61	2.5	60	2	8.34

35	F18	4211.92	2811.03	77	2.5	60	6	11.28
36	E17	4216.88	2809.054	75.5	2.5	60	7	19.33
37	F16	4221.843	2810.3	81.5	2.5	60	5	9.67
38	F14	4231.26	2810.354	79	2.5	60	3	7.21
39	G13	4236.738	2815.498	88	2.5	60	5	8.88
40	F12	4241.64	2811.93	78	2.5	60	7	20.45

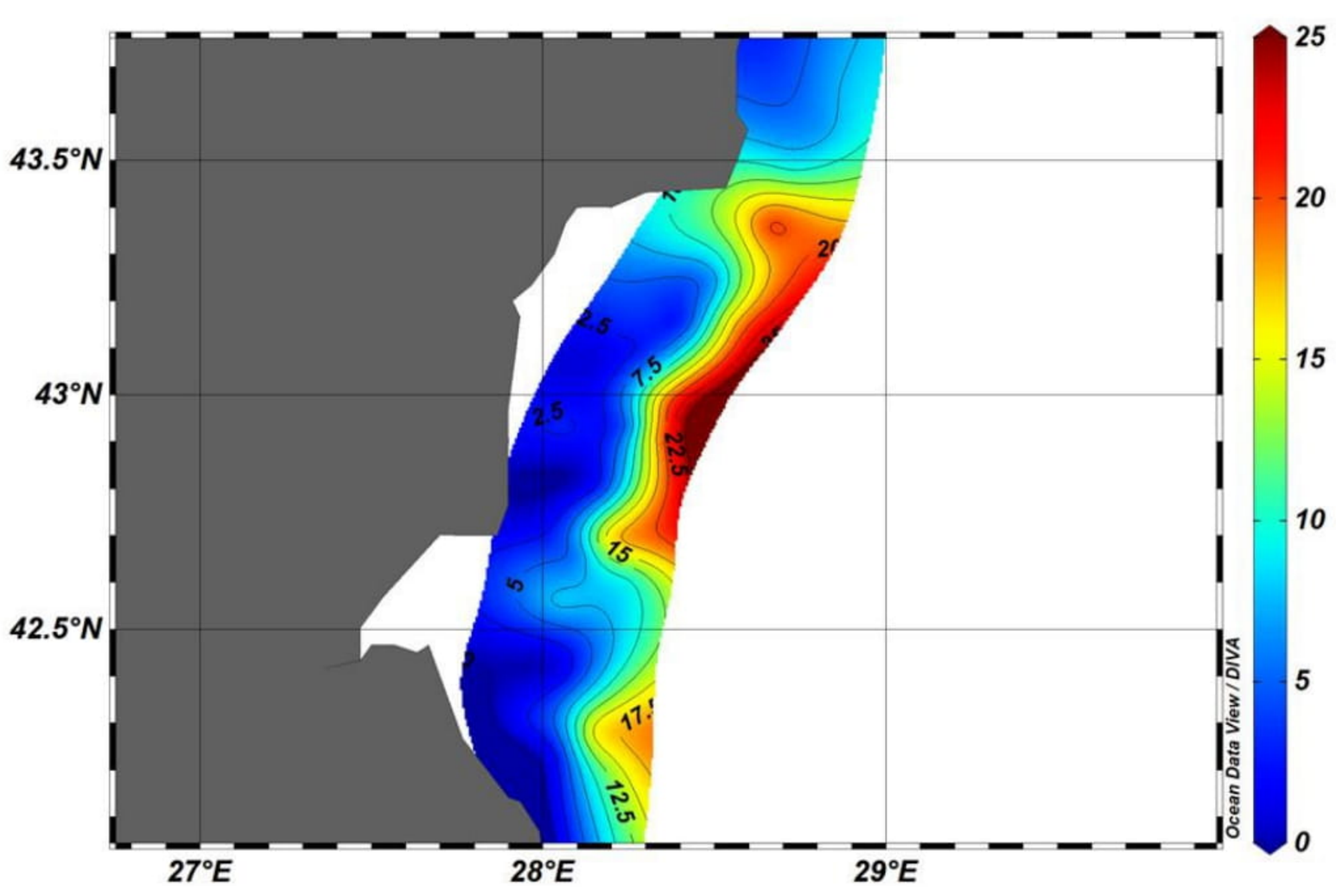

Fig. 3. Distribution of catch per unit effort (CPUE, kg/h)

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, 2021 is presented at Fig.4 and 5.

High relative biomass, between 0.30 - 0.39 t/km^2 was established in three sectors of the Bulgarian Black Sea zone:

- in north direction – under of cape Kaliakra (st. K4), at a depth of 71-63.5 m;
- off the central part of the coast, between Varna, Kamchiya River mouth and near to the cape Emine (st. J7, H9, G10 and F12) at depths of 77-85 m;

- in south direction, between Primorsko and Ahtopol (st. E17, 75-78 m), (Fig.2 and 4).

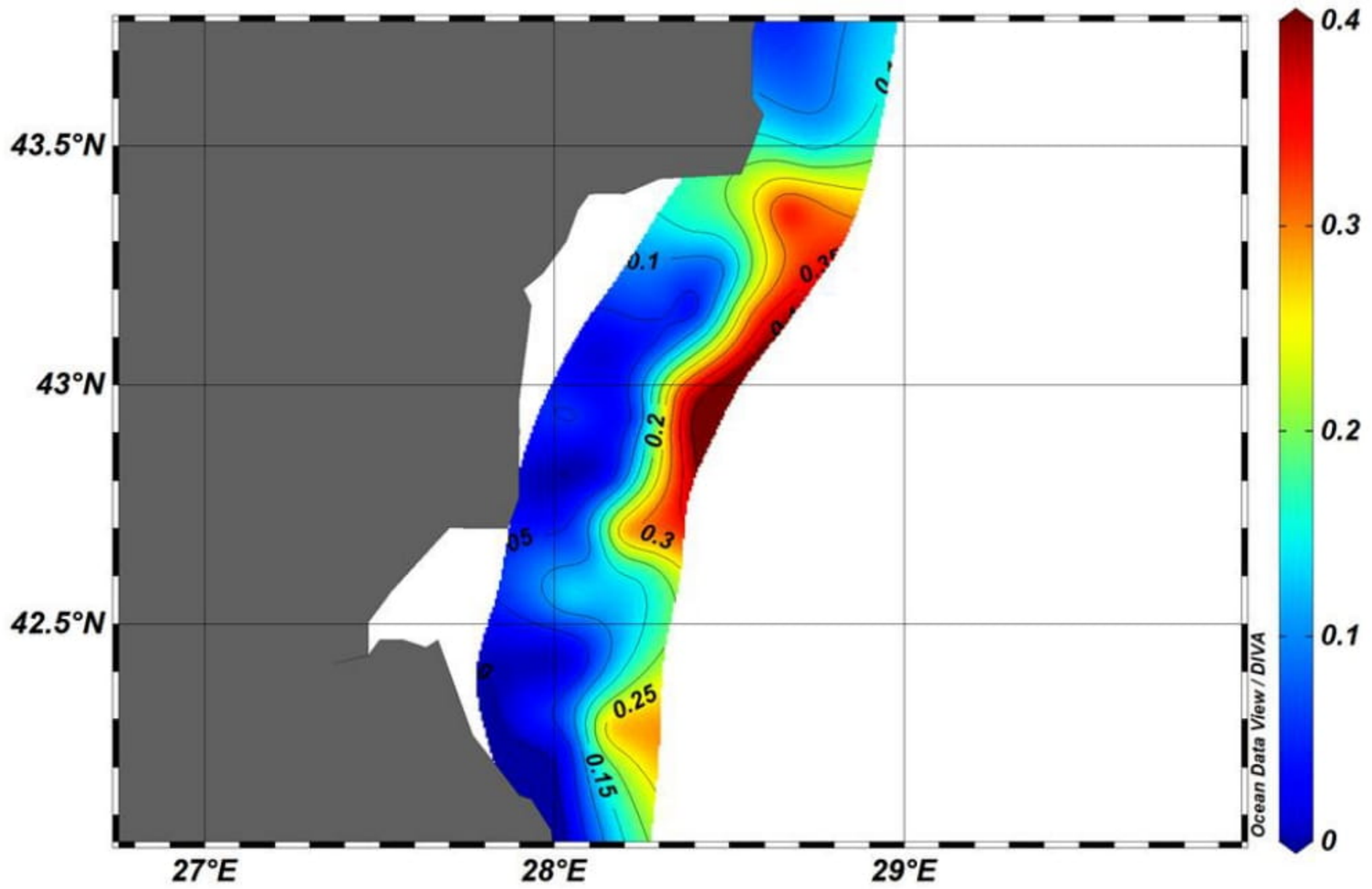

Fig. 4. Distribution of the relative biomass (t/km^2) of S. maximus in May, 2021.

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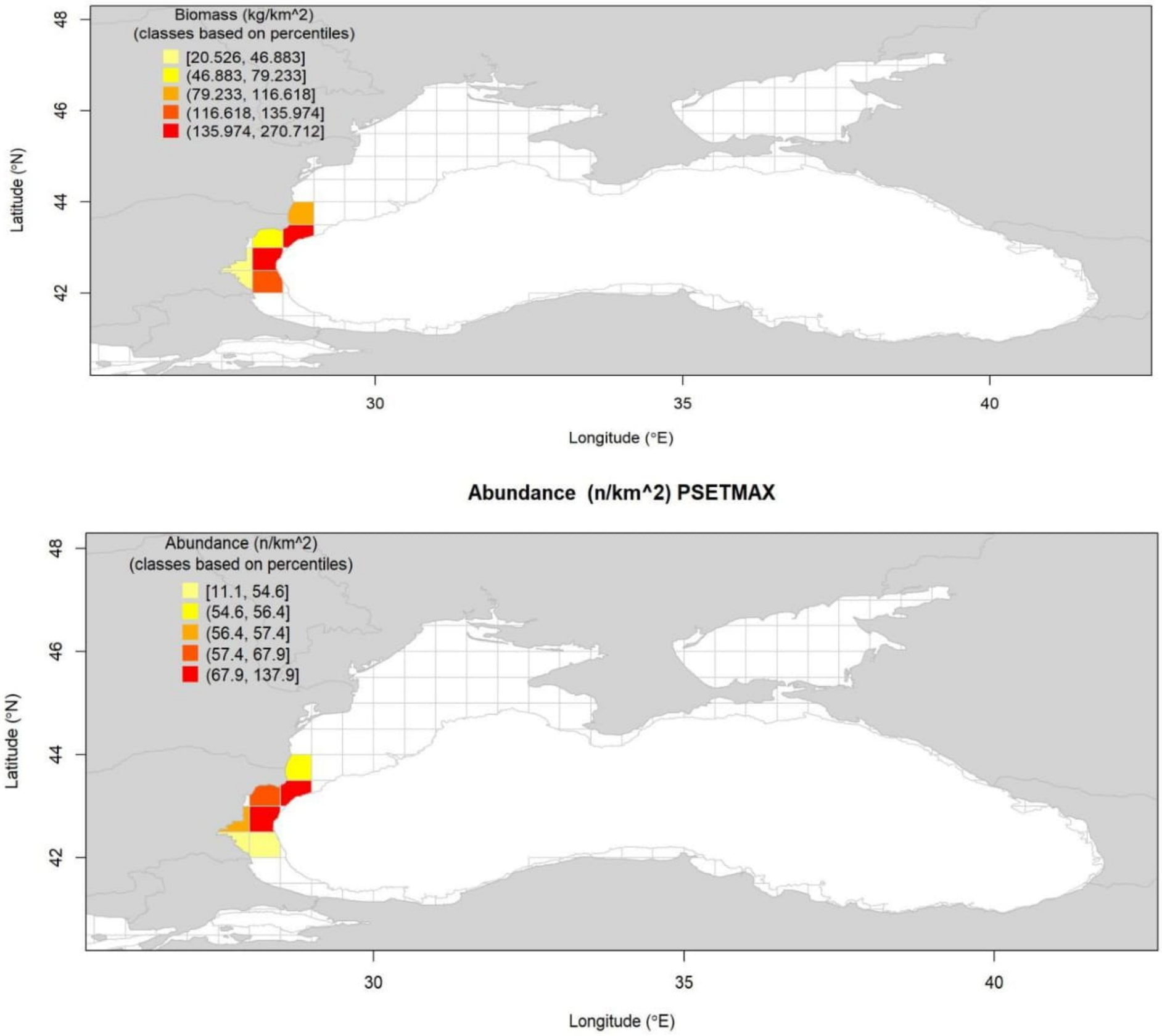

Fig. 5. Distribution of the relative biomass (kg / km2) and abundance (n / km2) of S. maximus in May, 2021 by BioIndex version 3.1.

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Table 4

Turbot abundance and biomass observed in the Bulgarian waters in May, 2021

No. Station	*Field*	*No. ind./km²*	*t/km²*
1	F7	50	0.055
2	E8	66	0.008
3	L1	33	0.080
4	N1	66	0.131
5	M2	66	0.106
6	L3	83	0.147
7	M4	149	0.274
8	L5	133	0.306
9	K4	166	0.386
10	J5	166	0.218
11	H5	133	0.160
12	J6	33	0.076
13	J7	133	0.300
14	H7	0	0.000
15	G6	83	0.087
16	G8	33	0.038
17	H9	183	0.339
18	G10	133	0.314
19	F9	17	0.039
20	E10	33	0.037
21	D9	83	0.068
22	E11	17	0.016
23	C11	0	0.000
24	D12	17	0.035
25	E13	33	0.059
26	C13	116	0.088

27	D14	83	0.158
28	E15	50	0.059
29	D16	0	0.000
30	C15	0	0.000
31	B16	0	0.000
32	C17	33	0.062
33	D18	0	0.000
34	E19	33	0.138
35	F18	100	0.187
36	E17	116	0.321
37	F16	83	0.161
38	F14	50	0.120
39	G13	83	0.147
40	F12	116	0.340
Total		2772.781	5.058
Average		69.32	0.13
Total in the Bulgarian area		803 460 Ind.	1465.54 tonnes

	№ ind./км²	*t/км²*
Variance	2825.8	0.013
Standard deviation	53.2	0.115
Relative standard deviation	0.8	0.909
Standard error	8.4	0.018

The calculated turbot biomass in the Bulgarian Black Sea waters amounted to **1465.54 tons**, by abundance - **803 460** individuals (Table 4).

3.4. Size structure

The information about the size structure of turbot population was based on biometric

measurements of 167 turbot specimens, and included data on the absolute and standard length, and individual weight (pic.4).

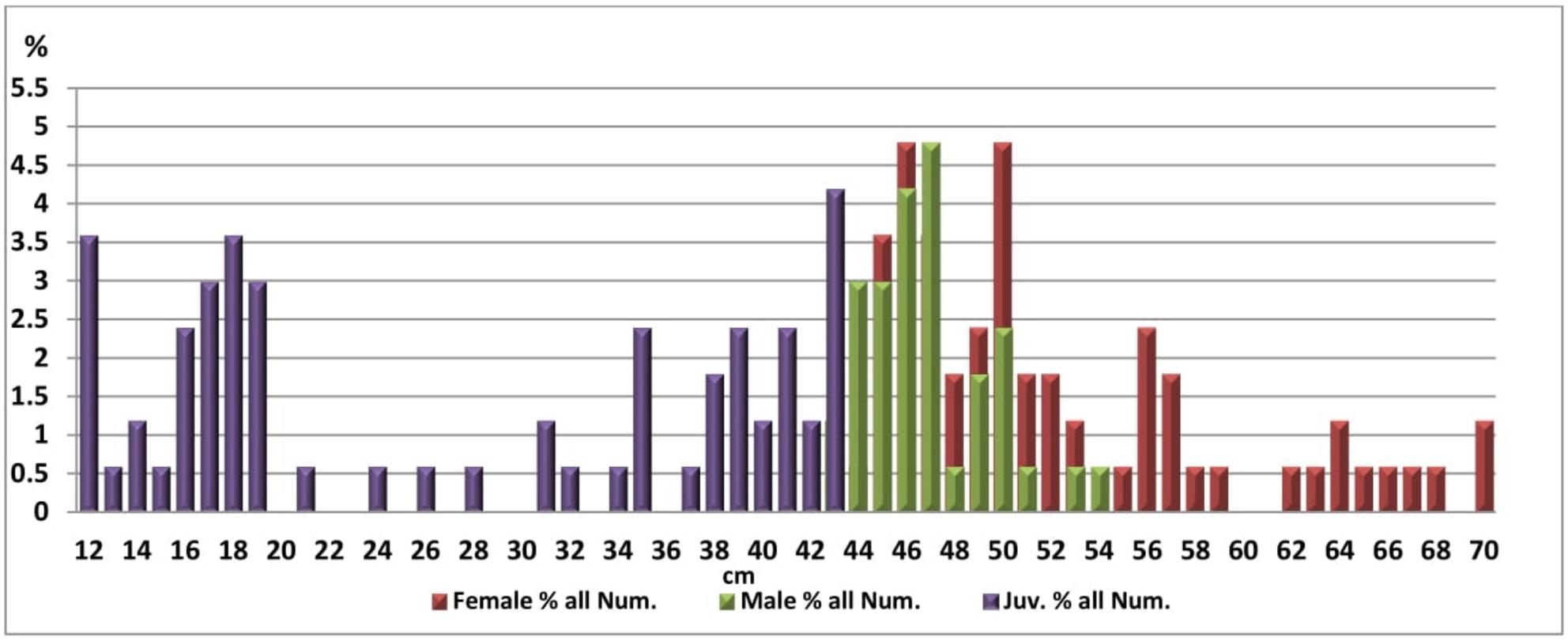


Fig. 6. Length structure of S. maximus.

The absolute length of the measured individuals varied between 12 and 70 cm, by weight - between 50 and 7160 g. The total turbot catches reached 304.614 kg. Distribution of the length classes was as follows: thirty-one individuals were of sizes between 12-21.5 cm (18.56 %), 48 individuals - between 24.5-45 cm (28.74 %), 69 - in the range between 45.5-55 cm (41.32 %) and 19 individuals - between 56-70 cm (11.38%) (Fig. 6).

Adult specimens predominated in the total catch - 61.08 % /102 individuals/, and young specimens were 65 /38.92%/, as females dominated - 38.32% /64 specimens/ over males 22.75 % /38 individuals/.

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 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.

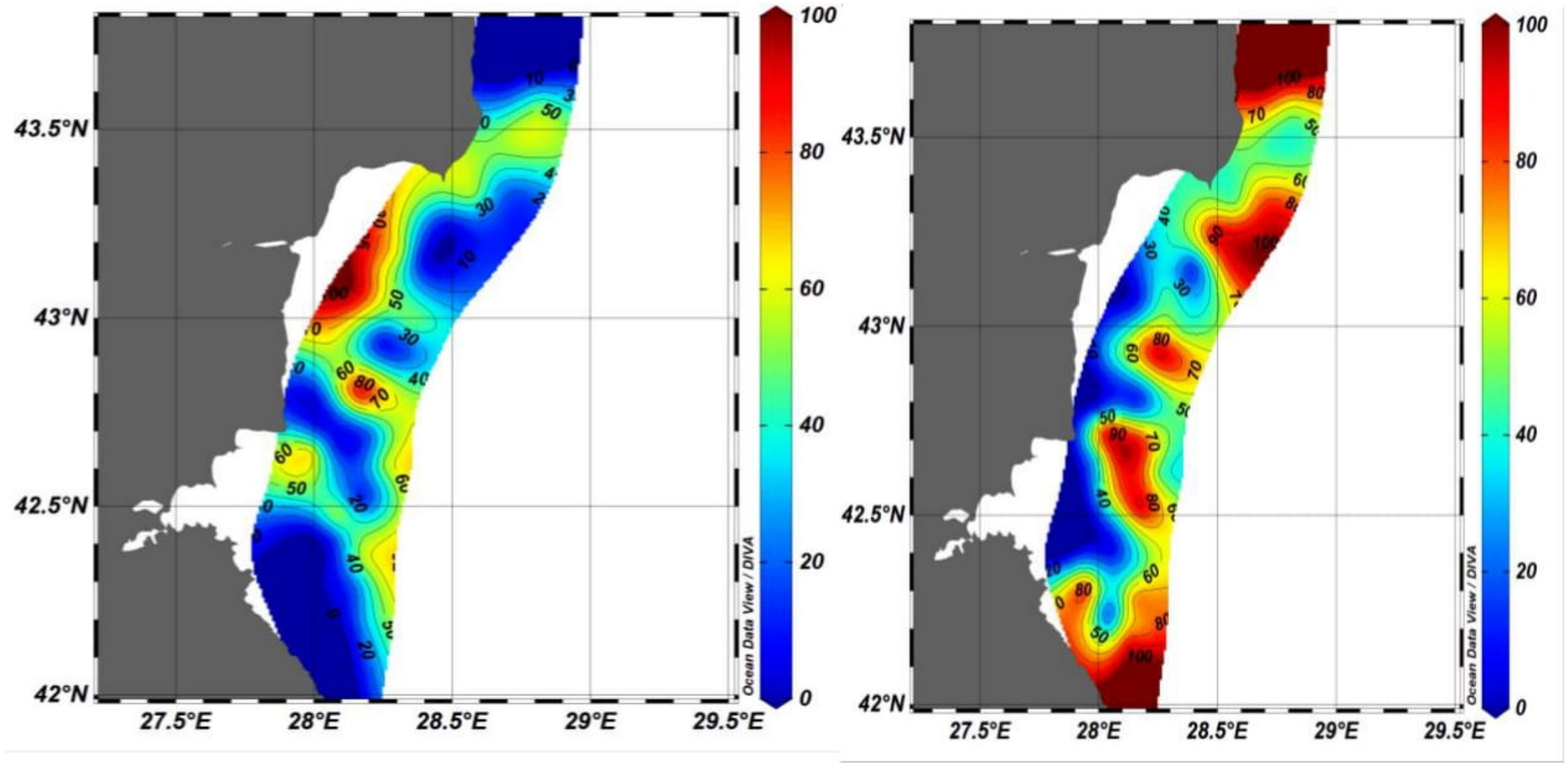


Fig. 7. Percentage distribution of the S. maximus abundance (ind/km^2), a) undersized individuals and b) standard length.

The relative turbot biomass by size classes is given in Fig. 8, presenting high biomass for two size classes - those of 43-53 cm and 56-64 cm.

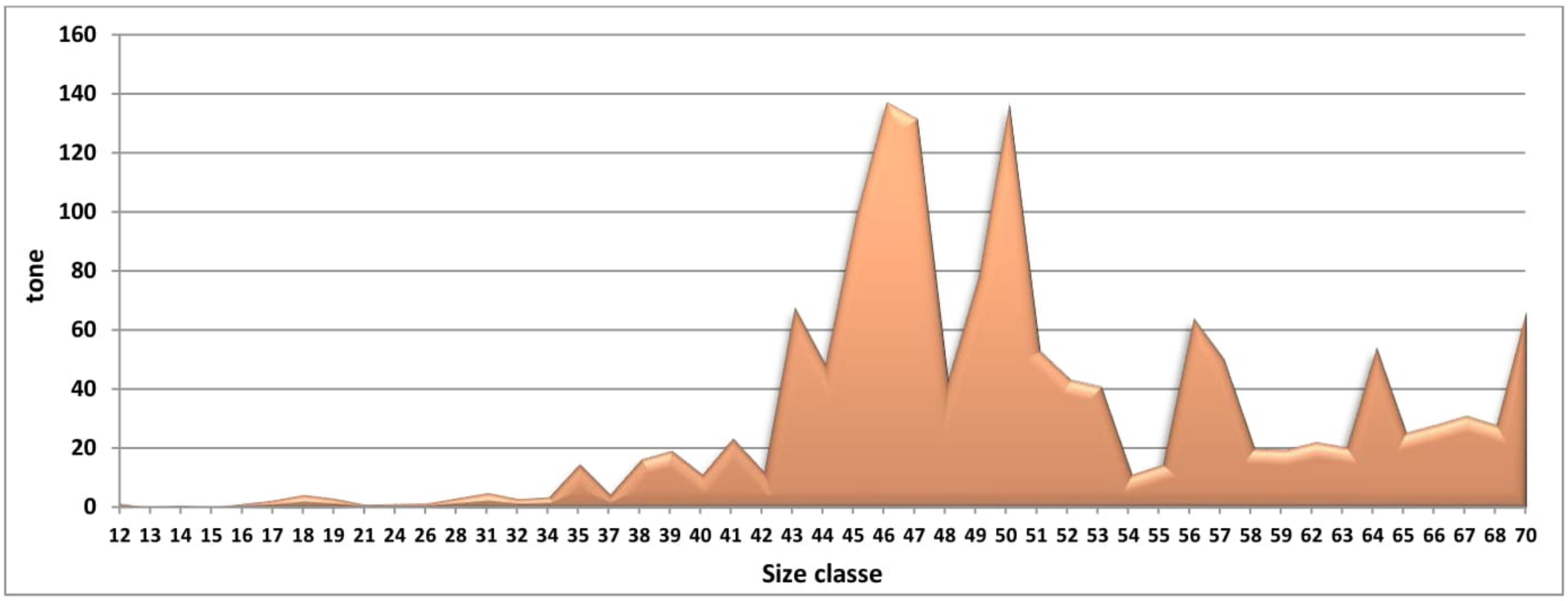


Fig. 8. Biomass by mean size classes of S. maximus.

3.5. Age structure

The turbot age composition was determined through analysis of 102 pairs of otoliths. The age structure included 1 - to 10 - years classes, with domination of the 4 (29.94%), 5 (16.17%) and 1 (17.96%), (64.07% in total), followed by 2 and 3 - annual classes – 23.35 % (Fig. 9).

The adults predominated in the spring season of 2021, with a percent share of 61.1 % and juveniles constituted 38.9 % of all collected turbot individuals.

Although having small frequency of occurrence, specimens from 7 - to 10 - years classes were registered in the yield.

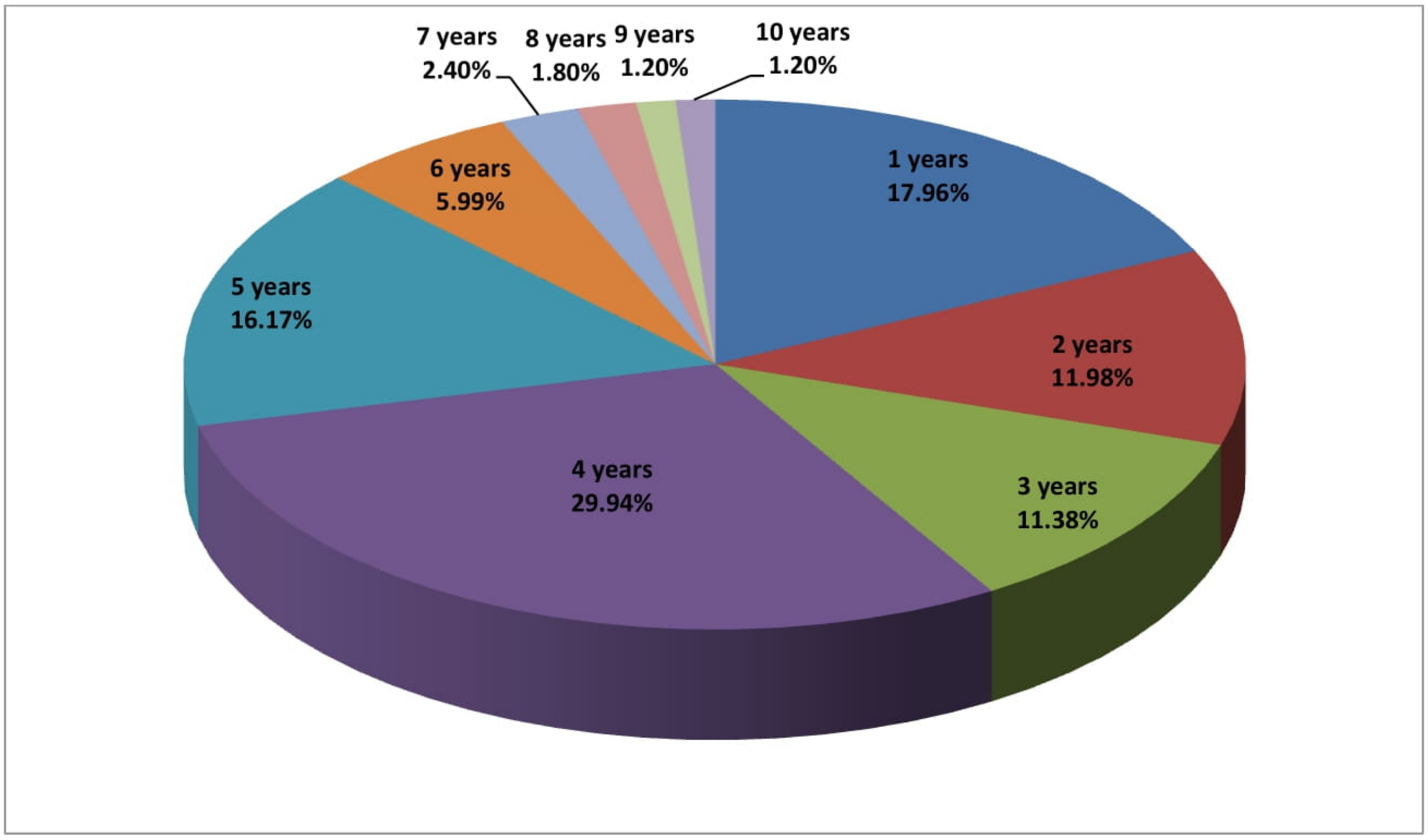


Fig. 9. Age structure of turbot in May, 2021.

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

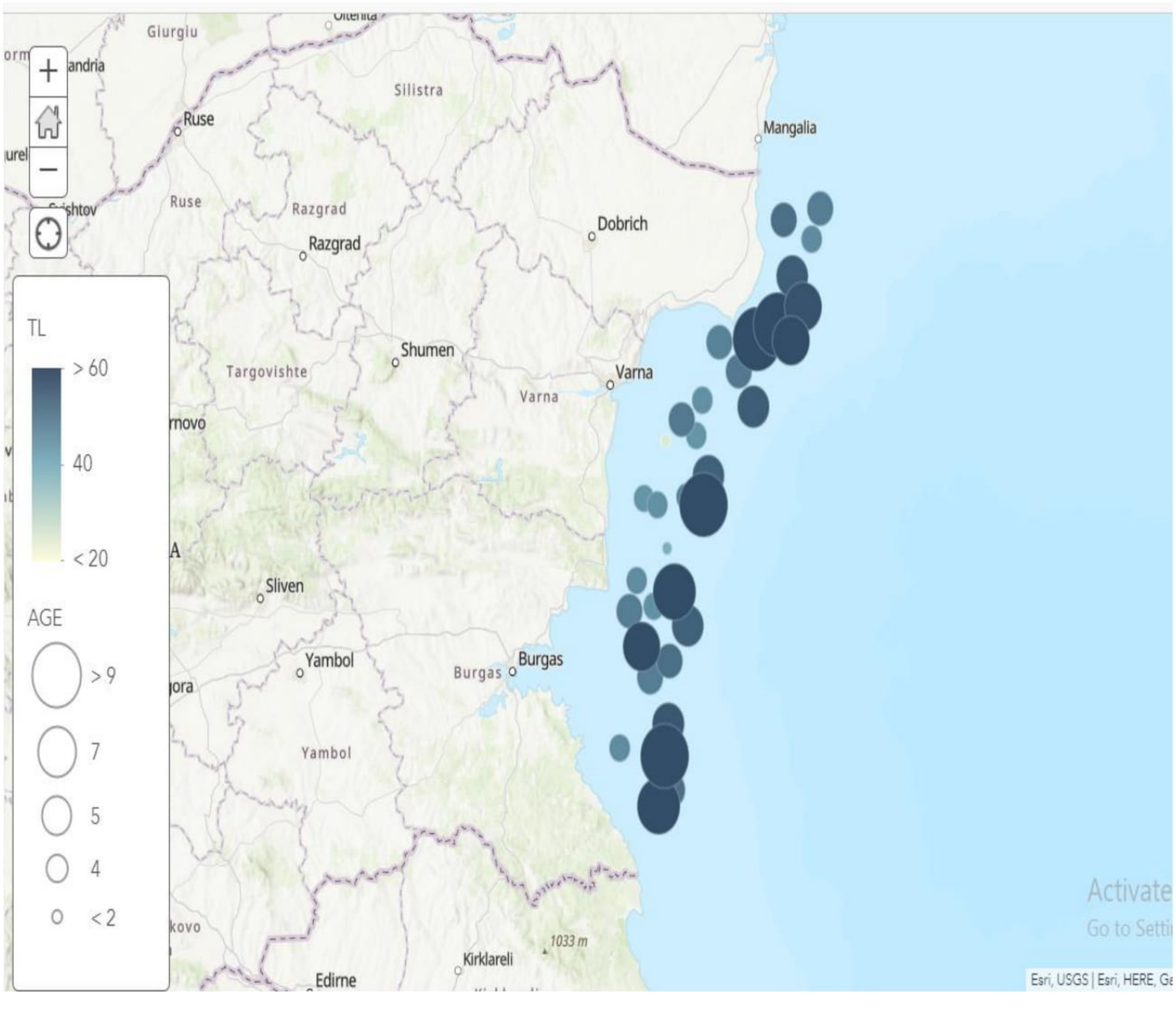


Fig. 10. Spatial distribution and age structure of S. maximus in May, 2021.

3.6. Biological parameters of *S. maximus*

To estimate the turbot growth rate, the data about the total length and weight by age

groups of 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 = 0.02, b = 2.94, q = -1.62, $L\infty$ = 73.68, k = 0.28, to = -0.48.

The turbot length-weight relationship, based on the summer survey data is shown in Fig.11.

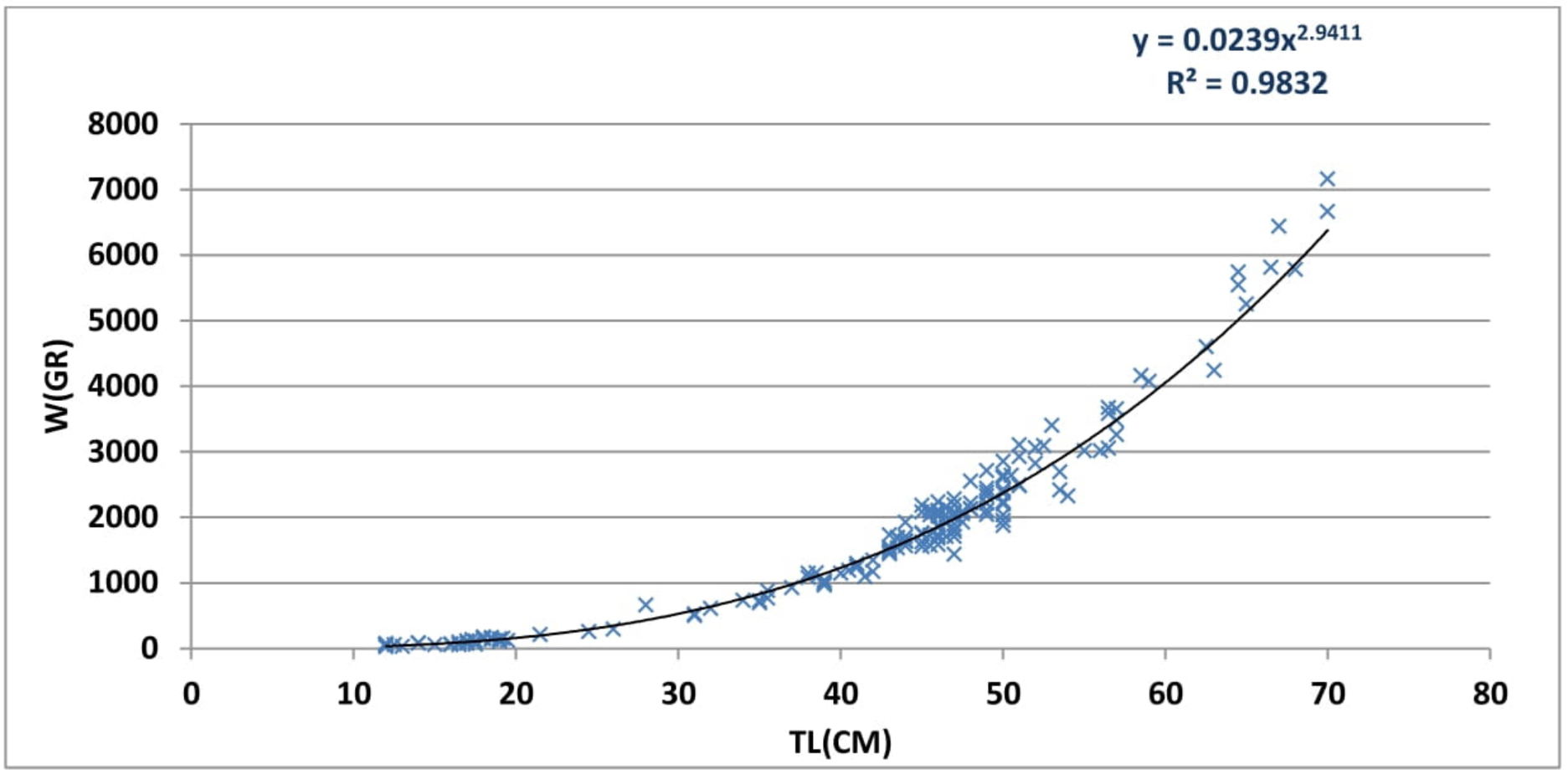


Fig. 11. S. maximus: Length-weight relationships in May, 2021.

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

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

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

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

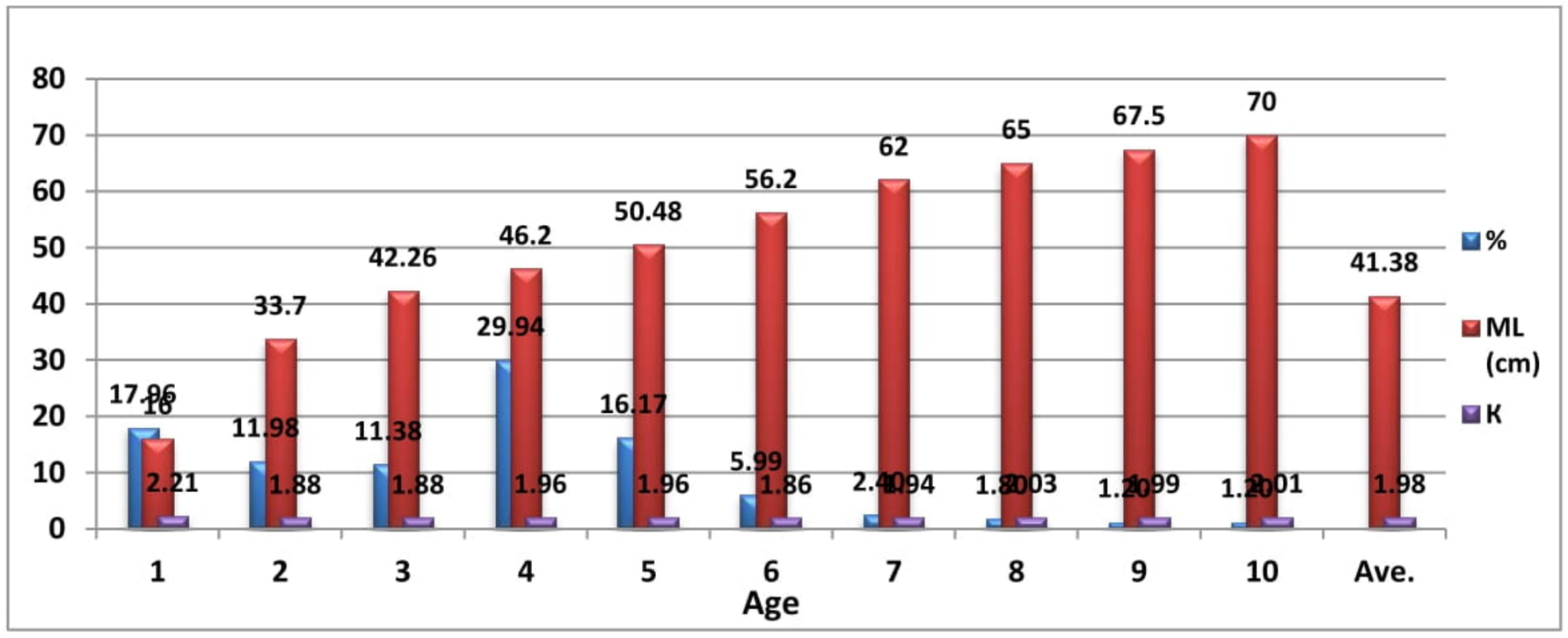
$\ln M=-0.0152-0.279\ln L\infty+0.6543\ln k+0.463\ln t_0$

Considering, that the water temperature was 8 °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).

A)



B)

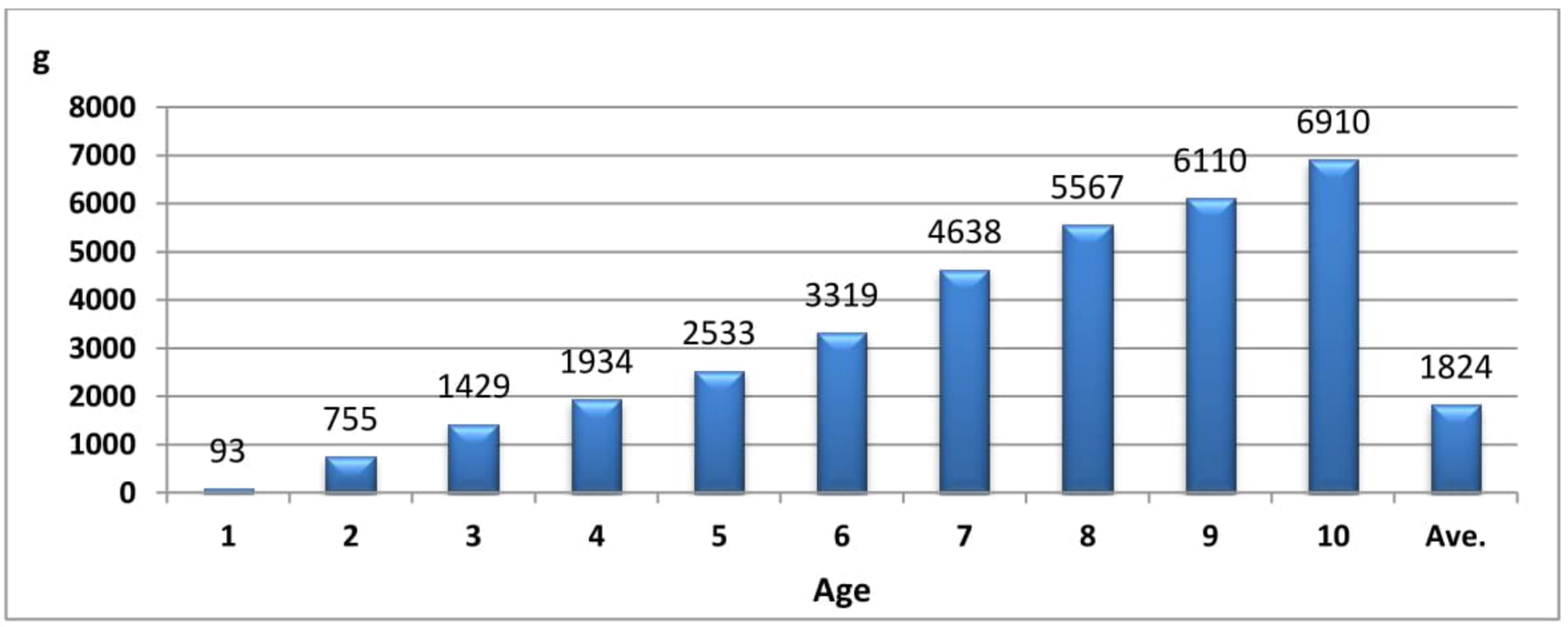


Fig. 12. Percentage distribution and relation between the average length and coefficient of Fulton by age groups (A) and an average weight (g) of turbot by age groups (B)

3.7. Sex structure

Sex ratio

The results of the turbot sex structure analysis in spring 2021 are shown in Fig.13.

The results of the analysis of the sex structure of turbot catches in the Bulgarian sector of the Black Sea in the spring-summer season of 2021 show that the total share of sexually mature individuals is 61.1% of the total catch, females form 38.3% and males - 22.8% and the immature individual are 38.9%.

From a total of 40 fields, studied off the Bulgarian coast in May, 2021, female specimens were not identified in 8 fields, in 20 fields - males were not estimated, and in 2 fields - only young forms were found, while adult specimens were absent (Fig.13).

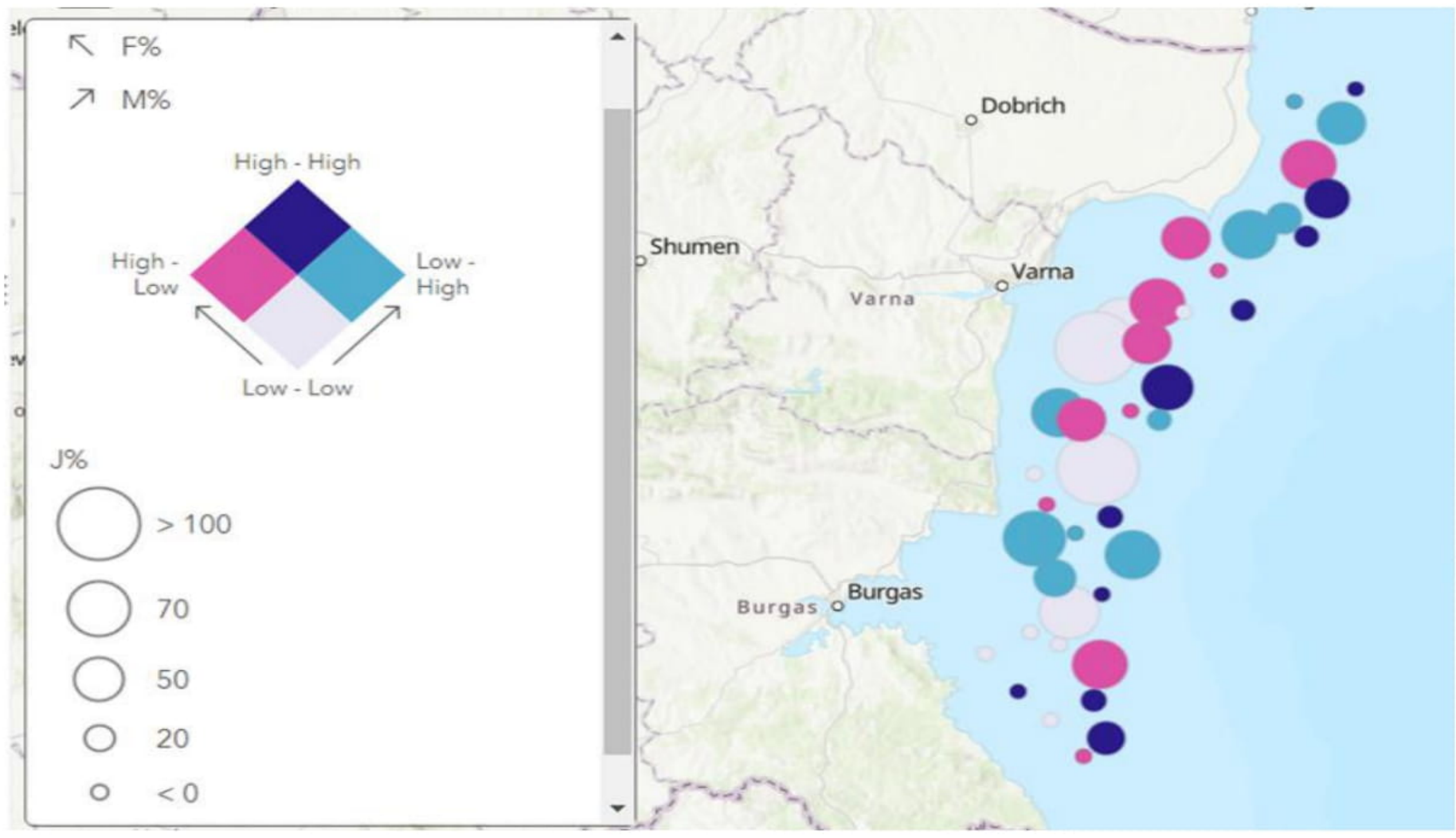


Fig.13. Sex structure of S. maximus in May, 2021: distribution by stations (female, male and juvenile specimens are indicated by: purple, blue and white, dark blue – presence of both sexes and juveniles).

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Male specimens were found over the depths of 49-64 to 81 m., and the female specimens were observed from 40 to 85 m deep. The juveniles were concentrated in the section - in front of Shabla (64-68 m), between Cape Kaliakra (57-61 m), and between Varna - Bqla (28-24 m и 63 m), Cape Emine - Sozopol they were observed at different depths (40-88 m).

The females were established mainly in the regions - Kranevo, Kamchia, Cape Emine and Sozopol - Ahtopol, while high concentrations of males were detected in the region of Shabla, Cape Kaliakra and between Bqla and C. Emine.

The average weight of females was 3040.47 g, with average length TL = 54.95 cm and standard length SL = 41.75 cm. The maximum weight of females reached 7160 g, besides the minimum weight was 1920 g.

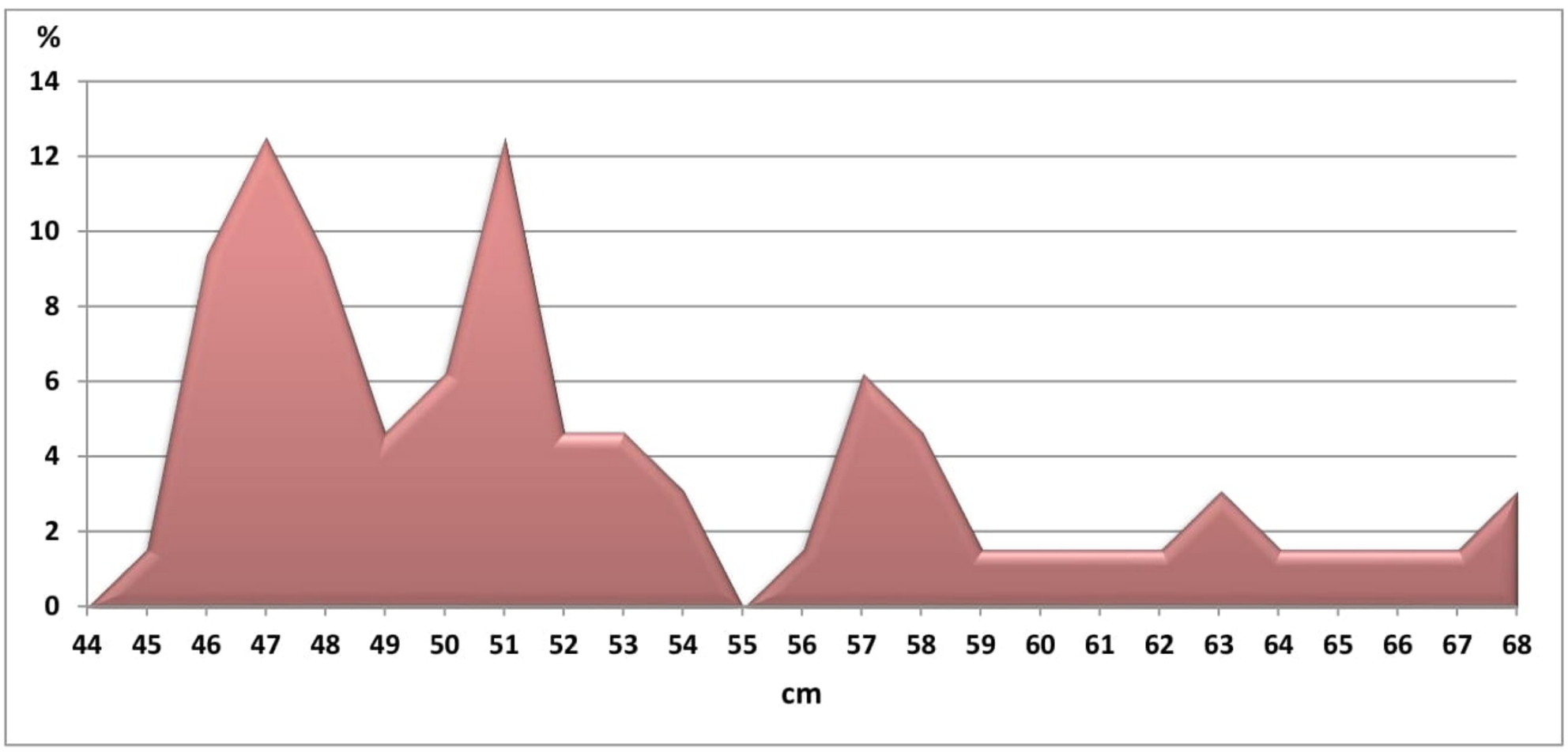


Fig.14. Females' specimens: Percentage distribution by length classes.

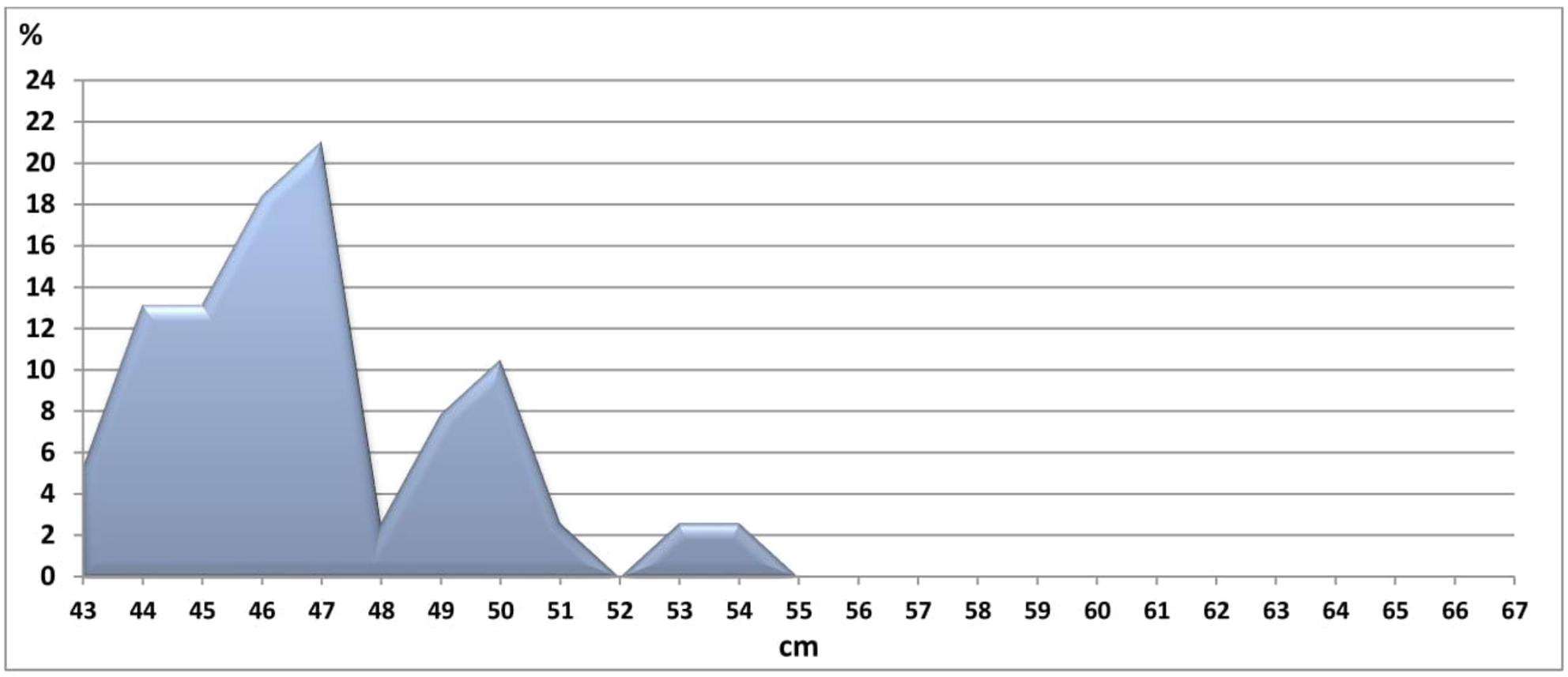


Fig.15. Male specimens: Percentage distribution by length classes.

Among females, the dominant classes were - 45 to 50 cm, and these size groups have formed 54.68 % of all studied females (Fig. 14).

For the length classes over > 55 cm (up to 70 cm), all specimens were only females, comprising 31.25 % of the total abundance.

For males (Fig.15), the most significant proportion of total abundance – 68.79 % belonged to the length class 44 - 47 cm.

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 two specimens of dogfish (*Squalus acanthias*), 75 specimens thornback ray (*Raja clavata*) and 150 individuals of European flounder (*Platichthys flesus*) (Table 5).

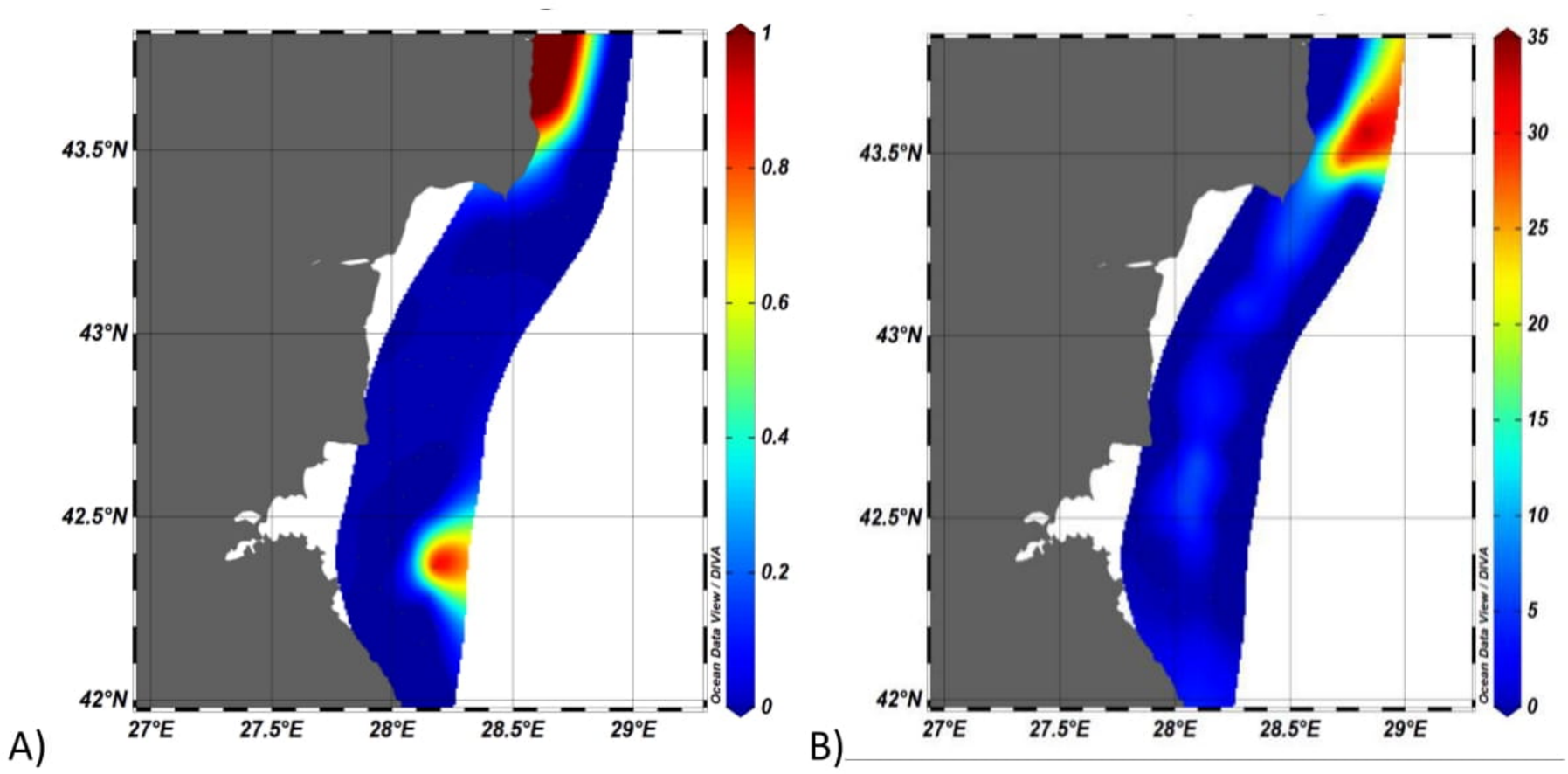
Table 5

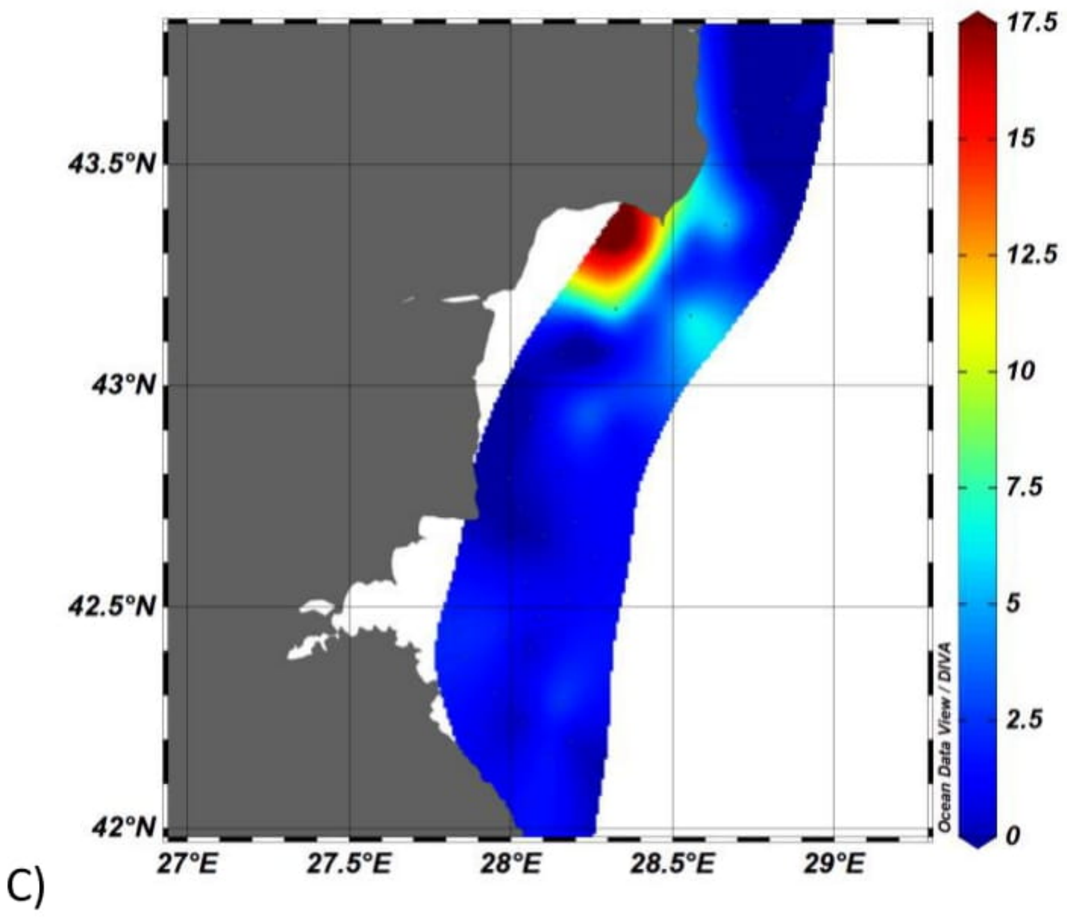
Data on species composition and biological characteristics of the bycatch species

Bycatch species	N	Size (cm)			Weight (kg)		
		Min.	Max.	Ave.	Min.	Max.	Ave.
Squalus acanthias	2	123	125	124	7.53	8.79	8.16
Raja clavata	75	31	85.5	62.57	0.18	4.94	1.87
Platichthys flesus luscus	150	12	28	18.19	0.02	0.23	0.07

Map, showing the location of stations with above mentioned bycatch species is presented in Fig. 16. The relationship between length and weight (LWR) of M. merlangus euxinus, in V 2021 is presented in Fig. 17.

The species *Squalus acanthias* was mainly observed in the regions in in front of the Duranculac (50 m) and Primorsko (81.5 m). Large number of *Pl. flesus* was caught in north direction - Duranculaк – Cape Kaliakra (45-68 м). Thornback ray were observed in the vast area - under Cape Kaliakra at depths 38 - 89 m.





C)

Fig. 16. Location of stations with bycatch from A) spiny dogfish (S. acanthias), B) flounder (Pl. flesus), and C) thornback ray (R. clavata)

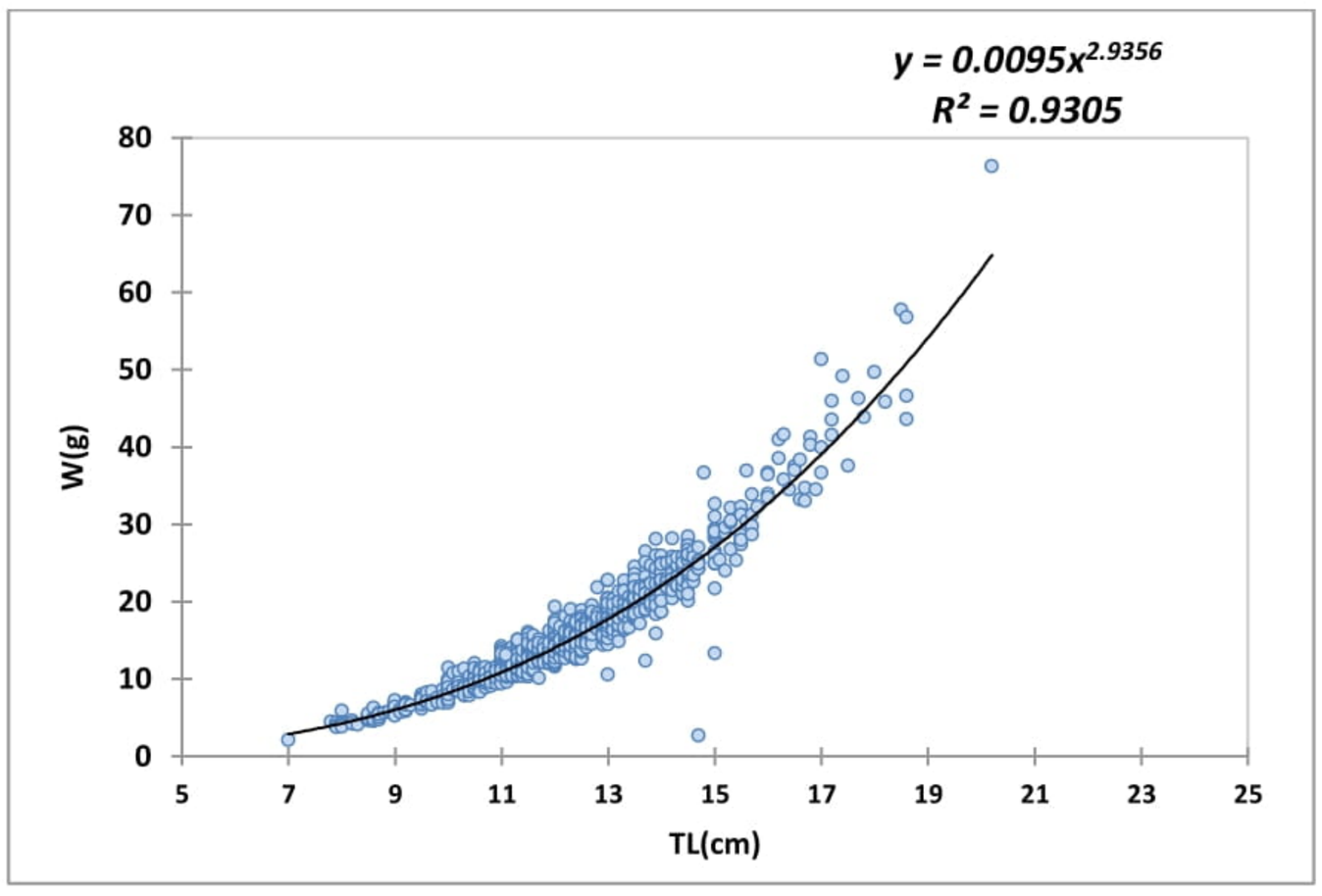


Fig. 17 LWR of M. merlangus euxinus, in V/2021.

3.9. Food spectrum of *S. Maximus*

In the spring season of 2021, a total of 63 stomachs were gathered to determine the dietary spectrum of turbot. The food components were found in 21.25 % of the examined specimens and 78.75 % 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, stomach contents and index of stomach fullness (ISF).

Zona	L	W (kg)	ST/cont	ISF
C13/6	45	1.74	0	0.00
C13/7	50	2.03	0	0.00
C17/1	47	1.43	0	0.00
C17/2	47	2.28	2.84	0.12
D14/4	47	2.19	0	0.00
D14/5	63	4.24	0	0.00
E10/2	46	2.1	0	0.00
E13/2	46.5	1.91	0	0.00
E15/3	50	2.37	0	0.00
E17/2	70	7.16	0	0.00
E17/3	47	2.03	0	0.00
E17/4	56.5	3.67	0	0.00
E17/7	46.5	2.15	0	0.00
E19/1	65	5.25	0	0.00
E19/2	52.5	3.09	0	0.00
F7/3	51	3.1	0	0.00
F9/1	49	2.32	0	0.00
F14/1	45.5	2.03	0	0.00
F14/3	53	3.4	73.28	2.16
F16/4	58.5	4.16	0	0.00

Проект BG14MFOP001-3.003-0002-C02, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2020-2021 г.“, финансиран от Програмата за морско дело и рибарство, съфинансиран от Европейския съюз чрез Европейския фонд за морско дело и рибарство

F18/4	45.5	2.1	0	0.00
F18/5	52	3.06	0	0.00
F18/6	53.5	2.41	0	0.00
G6/4	46	2.23	18.9	0.85
G6/5	46.5	2.03	0	0.00
G8/2	40.5	2.11	0	0.00
G10/5	47	1.89	0	0.00
G10/7	50	2.6	0	0.00
G10/8	70	6.66	0	0.00
H5/5	46	2.08	25.79	1.24
H5/7	47	2.07	16.62	0.80
H9/7	47	2.07	0	0.00
H9/8	50	2.61	0	0.00
H9/11	50	2.85	0	0.00
J5/7	45	1.76	9.05	0.51
J5/8	48	2.55	0	0.00
J5/10	67	6.44	6.67	0.10
J6/1	45	2.08	0	0.00
J6/2	51	2.48	11.36	0.46
J7/2	54	2.32	0	0.00
J7/4	48	2.21	0	0.00
J7/8	57	3.65	0.74	0.02
K4/4	47	1.82	0	0.00
K4/6	66.5	5.81	14.05	0.24
K4/7	68	5.78	8.66	0.15
K4/8	51	2.49	0	0.00
L1/1	48	2.13	0	0.00
L1/2	53.5	2.69	5.28	0.20
L3/4	50	2.64	3.59	0.14
L5/1	46	1.87	0	0.00
L5/5	49	2.21	0	0.00
L5/7	50.5	2.64	0	0.00

L5/8	64.5	5.74	3.22	0.06
M2/3	47.5	2.05	0	0.00
M2/4	46	1.87	6.07	0.32
M4/5	50	1.95	0	0.00
M4/6	46	1.68	0.63	0.04
M4/7	55	3.01	0	0.00
M4/9	59	4.07	0	0.00
N1/1	47.5	1.92	0	0.00
N1/2	45	2.18	0	0.00
N1.3	45	1.62	9.26	0.57
N1/4	50	2.2	0	0.00

Table 7

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

	L	*W (kg)*	*g*	*ST/full/*	*ST/empty*	*ST/cont*	*ISF*
Mean	51.22	2.81	2813.97	23.39	6.26	3.43	0.13
Standard Error	0.88	0.17	168.50	1.96	1.49	1.30	0.04
Median	49.00	2.23	2230.00	18.72	0.00	0.00	0.00
Mode	50.00	2.03	2030.00	37.82	0.00	0.00	0.00
Standard Deviation	6.97	1.34	1337.45	15.58	11.81	10.35	0.35
Kurtosis	1.14	2.66	2.66	7.69	3.43	34.31	19.30
Skewness	1.40	1.86	1.86	2.44	1.97	5.39	4.07
Range	29.50	5.73	5730.00	87.63	50.21	73.28	2.16
Minimum	40.50	1.43	1430.00	9.63	0.00	0.00	0.00
Maximum	70.00	7.16	7160.00	97.26	50.21	73.28	2.16
Sum	3227.00	177.28	177280.00	1473.27	394.42	216.01	7.98
Count	63.00	63.00	63.00	63.00	63.00	63.00	63.00

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The average stomach fullness index reached 0.13 % BW ± 0.04 SE (Table 7). The analysis of the spatial distribution of the stomach fullness index (Fig.18) indicated higher values (~ 1.5 - 2.09 % BW) in the southern part along the Bulgarian Black Sea coast.

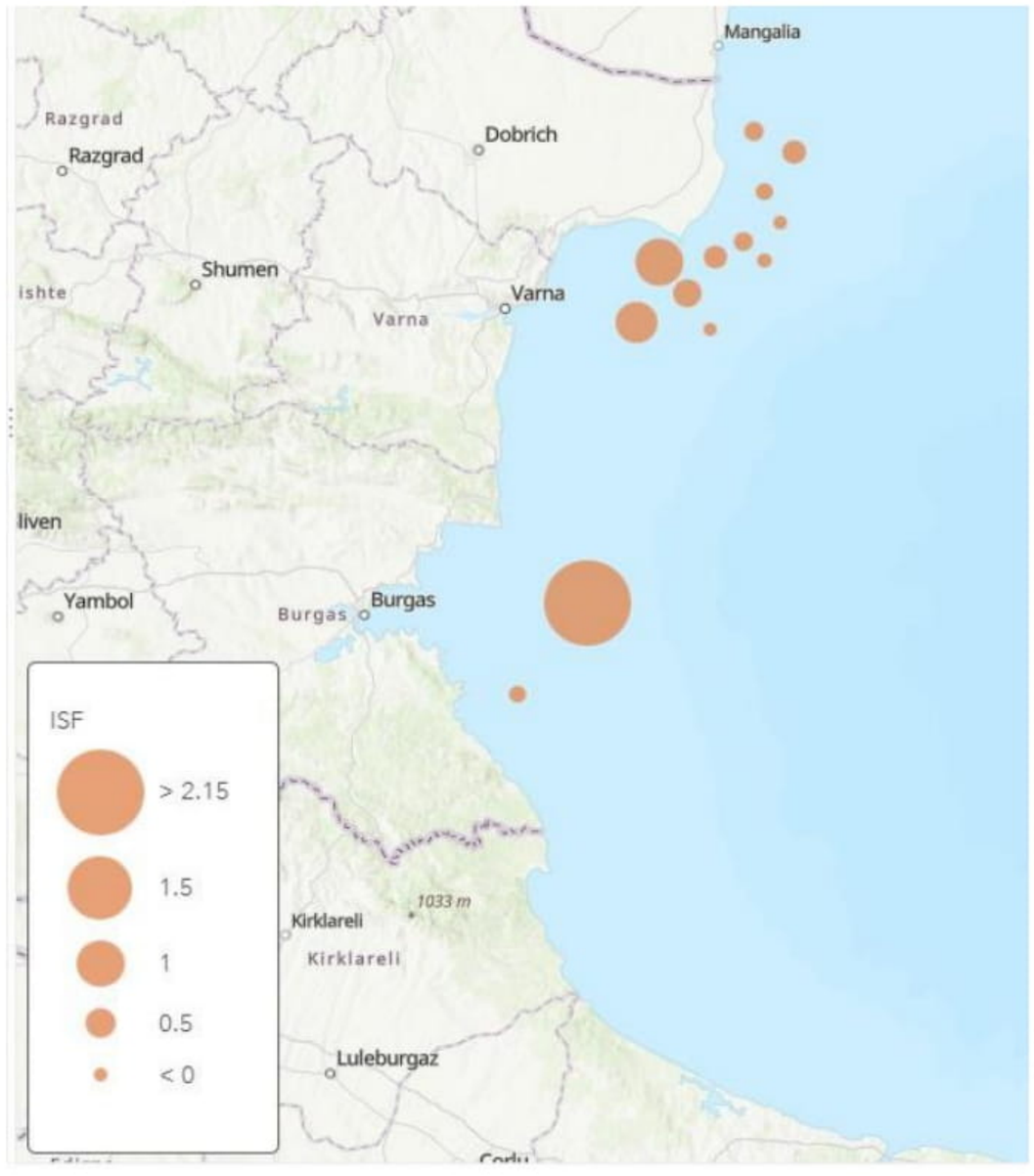

Fig. 18. Spatial distribution of ISF (% BW) during the spring season of 2021.

The turbot diet included mostly fish (*Pisces*) (Table 8).

Table 8

Diet spectrum of turbot in the spring season of 2021 (Data for feeding individuals).

Видове	CN	CB	F	IRI	IRI%

Pisces					
Merlangius merlangus	58.33	47.93	58.82	6250.95	79.12
Gobiidae sp.	20.00	17.65	17.65	664.36	8.41
Engraulis encrasicolus	11.67	11.55	17.65	409.70	5.19
Sprattus sprattus	3.33	0.76	5.88	24.10	0.31
Trachurus mediteraneus	6.67	5.88	5.88	73.82	0.93
Food remains	0.00	16.22	29.41	477.17	6.04

During the study period, the turbot diet was mainly formed by *Merlangius merlangus* - IRI = 6250.95 (79.12 % IRI), Gobiidae - IRI = 664.36 (8.41%) and *Engraulis encrasicolus* - IRI = 409.70 (5.19 %). The food remains show relatively high share - IRI = 477.17 (6.04 %) (Fig. 19).

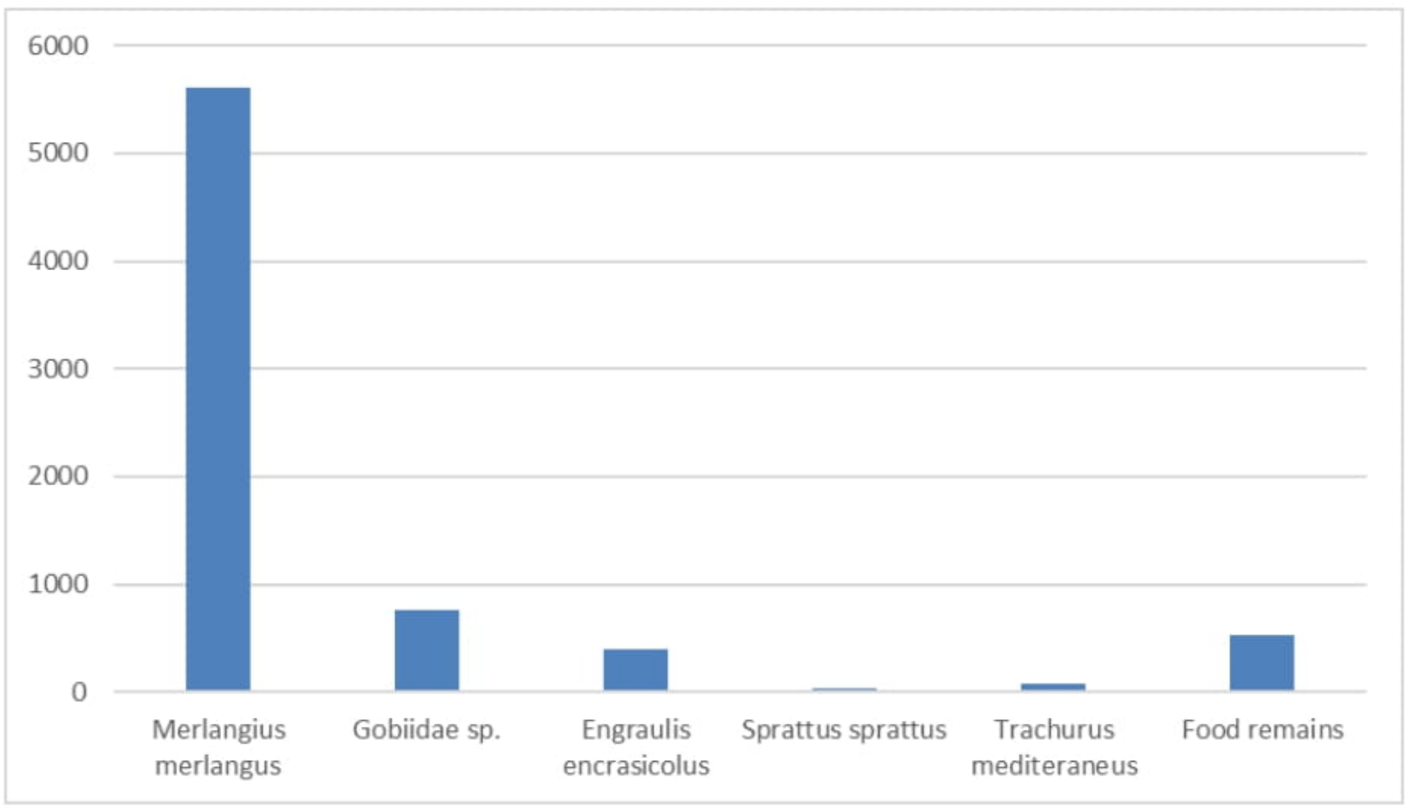

Fig. 19. IRI values of different species in turbot food in spring 2021.

The percentage of individual fish species according to IRI (% IRI) is distributed as follows: 79 % whiting, Gobidae 8 %, anchovy – 5 % and a small percentage distributed among other fish species (Fig. 20).

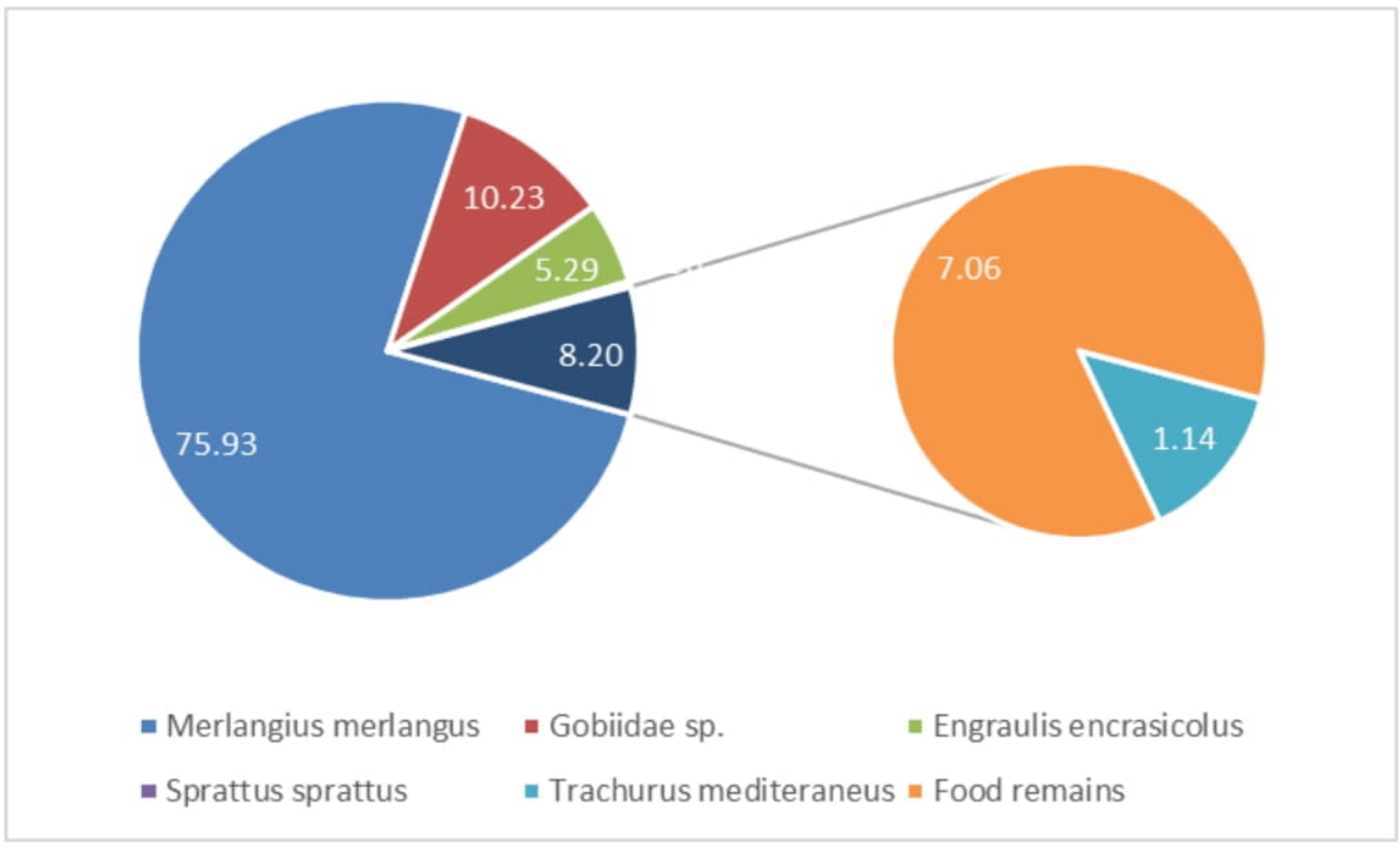

Fig. 20. Percentages by species (%, IRI) in the turbot food spectrum in spring 2021.

Weather conditions during the survey

During the expedition activity, the dominant wind direction was - Northeast, West, Northwest and Southwest by force between 1-2º BF - along the coast and 2-3º BF - at sea.

In the spring-summer season of 2021, the field conditions were normal for conducting the research activities for turbot stock assessment in the Bulgarian Black Sea waters.

Large quantities of marine litter were not found.

4. Conclusions and recommendations

By the collected information and obtained results from the trawl survey in May, 2021 the following conclusions and recommendations can be made:

- The **turbot biomass** in the Bulgarian Black Sea waters was assessed at **1465.54 tons** and the **turbot abundance** was estimated at **803 460 individuals**.

- The recommended **MSY (maximum sustainable yield)** for Bulgaria will be included in the final report for 2021, based on data from the trawl surveys, both in summer and autumn seasons of 2021.

- **The size structure** of the turbot population in the Bulgarian Black Sea zone included length classes from **12 cm to 70 cm**, with a weight between **50 g and 7160 g**. The average turbot weight was estimated as **1824.04 g**. In the turbot length structure, **the undersized individuals**, with length < 45 cm, formed **38.9 %** from the total number, while those of **standard length** made up **61.1 %**.

- **The age composition** of the population included age classes from **1 to 10 - years**, with the domination of the 4 (29.94%), 5 (16.17%) and 1 (17.96%) year classes, (64.07% total), followed by 2 and 3 - years specimens – 23.35 %.

- The **established ratio between female, male and sexually immature** individuals in the yield were - **38.3%:22.8%:38.92%.**

- The average stomach fullness index was 0.13 % BW ± 0.04 SE. The analysis of spatial distribution of the stomach fullness index indicated high values in the

southern zones along the Bulgarian Black Sea coast. In the current year, the turbot food spectrum was mainly formed by *Merlangius merlangus* - IRI = 6250.95 (79.12 % IRI), Gobiidae c IRI = 664.36 (8.41%) and *Engraulis encrasicolus*, IRI = 409.70 (5.19 %).

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