REPORT

Bottom Trawl Survey In The Bulgarian Black Sea Area Autumn 2016

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 to the Agricultural Academy under contract No./D-46/14.05.2016 between IFR and the National Agency for Fisheries and Aquaculture (NAFA) - Burgas, for turbot stock assessment in the Bulgarian Black Sea waters during the autumn season of 2016.

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 26 November – 19 December 2016 in the Bulgarian Black Sea waters on board the "EGEO 2" fishing vessel.

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1. Results from the National Seabed Study in November - December 2016.....5

2. Fishing vessel and fishing gear.....6

3. Material and methods.....7

3.1. Sampling scheme.....8
3.2. Primary processing on board the ship.....9
3.3. Laboratory analysis.....11
3.4. Statistical methods..... .12
3.4.1 "Swept area method" 12
3.4.2 MSY.....12

4. Results.....13

4.1. Population number and biomass.....13
4.2. Catch per unit effort (CPUE)..... 20
4.3. Catch per unit area (CPUA).....23
4.4. Size structure of *S. maximus*.....26
4.5. Age and growth of *S. maximus*..... 28
4.6. Biological parameters of *S. maximus*.....30
4.7. Sex structure of *S. maximus*.....30
4.8. Food spectrum of *S. maximus*.....33
4.9. Exploitation of *S. maximus*.....35

5.Conclusions and recommendations.....37

6. Bibliography.....38

LIST OF FIGURES IN THE TEXT

Fig.1. Map of the surveyed sectors……..8
Fig.2. Grid lines used for calculations of the area.....9
Fig.3. Map and scheme of the fields used in the design of the sampling,……..9
Fig.4 Distribution of the relative biomass (t/km^2) of *S. maximus* off the Bulgarian Black Sea coast…. 17
Fig.5 Relative biomass (t/km^2) of *S. maximus* by strata off the Black Sea coast, autumn, 2016.. 18
Fig. 6 Distribution of catch per unit effort (CPUE)..... 22
Fig.7 Length structure of turbot *S. maximus* 25
Fig. 8 Distribution of the *S. maximus* abundance (ind/km^2) and ratio between the undersized individuals a) and with standard length b). 26
Fig.9 Biomass by mean size classes of *S. maximus*.....27
Fig.10 Summary: age structure of *S. maximus* in November - December 2016 27
Fig. 11 Age structure of *S.maximus* in the autumn of 2016.....28
Fig.12 Length-weight relation for *S. maximus*, XI-XII/2016……29
Fig.13 Sex structure of turbot *S. maximus,* XI-XII/2016 30
Fig. 14 Percentage distribution by sex and juvenile stages of *S.maximus* in November - December 2016 (a) females, (b) males, (c) juvenile stages 31
Fig.15 Percentage distribution of females by length classes.....32
Fig.16 Percentage distribution of males by length classes……..32
Fig.17 Indexes of relative importance (IRI) by food items……..36
Fig.18 Food spectrums (IRI %): percentage of the main taxonomic groups in the turbot stomach content……36

1. Results from the National Bottom Trawl Survey in November - December 2016

In the period 26 November – 19 December 2016, in compliance with a contract with NAFA - Burgas/D-46/14.05.2016**,** under the National programme for fisheries data collection, the research team from IFR - Varna 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.

This report is based on the data collected during the trawl survey, which are indicative of the distribution and values of the relative biomass and abundance of the reference species *Scophthalmus maximus*. The analyses include an estimation of the biomass and density of the reference species by depth strata, and a study of size/age and sex structure of the stock. The turbot stock assessment is based on application of standard methods (methodology and software), analogous to those, used during the preceding trawl surveys of the species in the Black Sea.

This document contains a series of tables and figures that show the relative biomass distribution, as well as size/age and sex structure analysis of the reference species.

The trawl survey in 2016 included the following activities:

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

2. Fishing vessel and fishing gear

The trawl survey was 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 – 4 people;
- Research team – 3 people.

Picture 1 Fishing ship “EGEO 2”

During the study, 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.

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

3. Material and methods

The target species of this study was turbot - *Scophthalmus maximus,* as the by-catch species - the spiny dogfish (*Squalus acanthias)* and the thornback ray (*Raja clavata*) were also analysed.

The methodology and techniques that were used for collection, verification, processing, and data analysis and for overall turbot stock assessment in autumn 2016 were following the generally applied methodology during the previous turbot data collection programs in the Bulgarian Black Sea zone.

The filed data were collected by standard techniques (bottom trawl) and methodology, which remained constant through the survey. 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.

Data analysis was performed by the "swept area method" and the obtained results can be reproduced and compared.

3.1 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;

Specimens with absolute length under the minimum, permitted by Fisheries and Agriculture Act (FAA, 2005), (below 45 cm), were immediately returned into the sea, after the measurements.

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:

- ✓ Surface area (km^2);
- ✓ Average mass per unit area (t/km^2);
- ✓ Limits of variation of mass pet unit area;
- ✓ Total biomass (t.);
- ✓ Abundance index (individual/km^2).

3.2. Sampling scheme

To establish the abundance and biomass of the reference species *Scophthalmus 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.

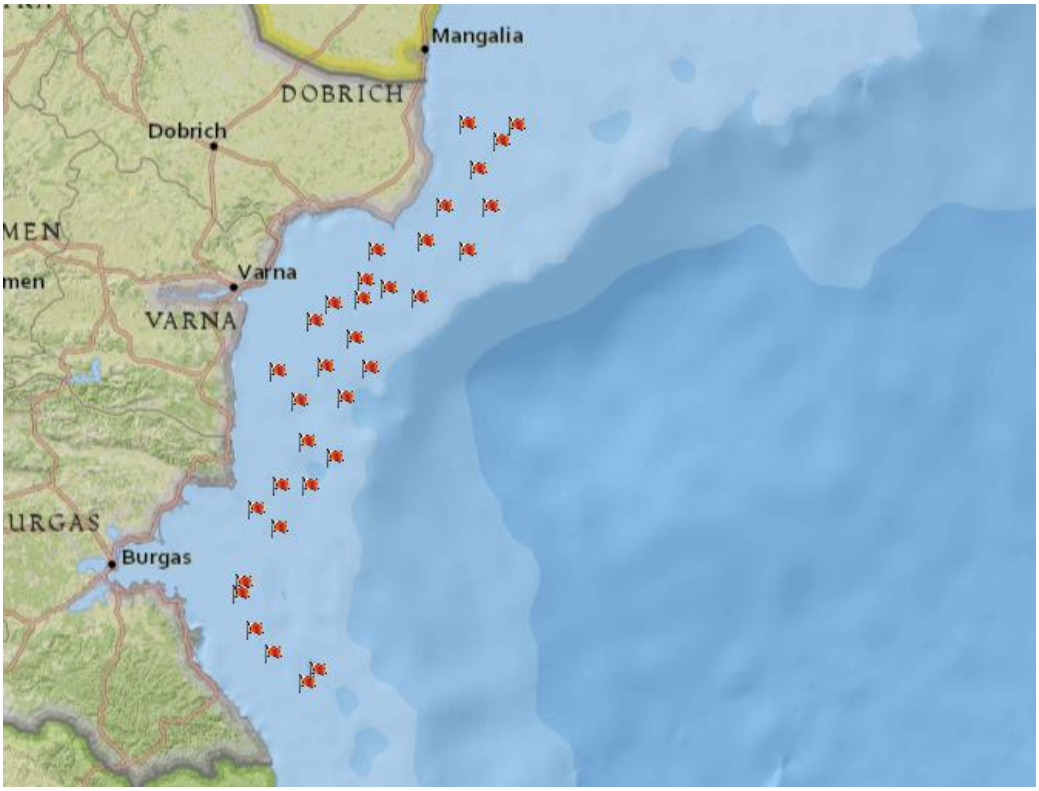


Fig.1. Map of the surveyed sectors.

The surveyed region off the Bulgarian coast 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 Nm2 (or 85.8569 m2) (Fg.2).

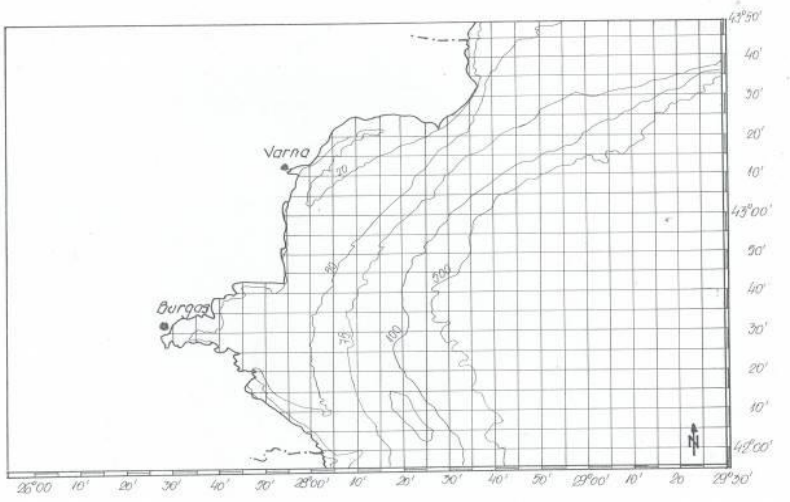


Fig.2. Grid lines used for calculations of the area.

The sampling was carried out at 33 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 km2 (measured by GIS). Each field was marked with letters and digits for better distinction (Fig.3).

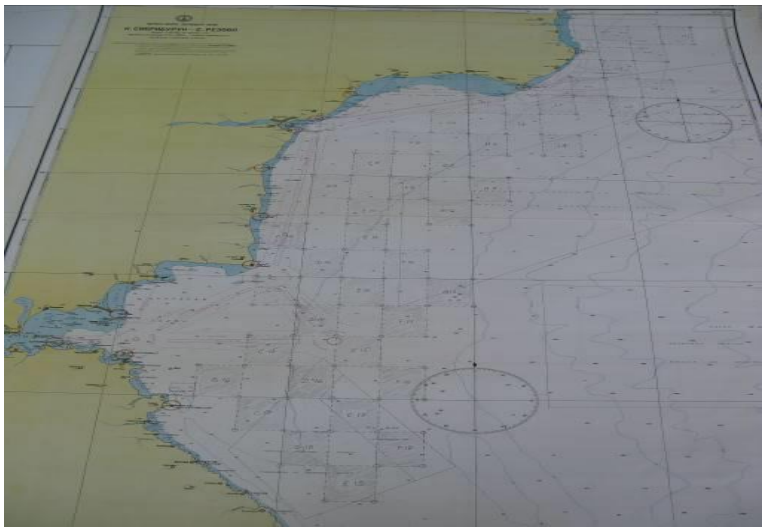


Fig.3. Map and scheme of the fields used in the design of the sampling.

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 2.6 knots.

On the ship board, the absolute and standard length, as well as the individual weight of each specimen were measured 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.

3.3. Laboratory analysis

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

The turbot age was established by otoliths reading under binocular microscope.

To identify the food composition, a total of 43 stomachs were collected in autumn 2016. 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 food components 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.

3.4. Statistical method

3.4.1 Swept areas method

To determine the relative biomass of the reference species (*Scophthalmus 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 is the time spent trawling, hr is 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.

3.4.2 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.

Age and growth

For the estimation of turbot growth rate, the von Bertalanffy growth function (1938) was used, (per Sparre, Venema, 1998):

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

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

Lt, Wt are the length or weight of the fish at age **t** years; L∞ , W∞ - asymptotic length or weight; k – curvature parameter; to - 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:

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

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

$$\ln \mathrm{M} = -0.0152 - 0.279 * \ln \mathrm{L}\infty + 0.6543 * \ln \mathrm{k} + 0.463 * \ln \mathrm{T}^0$$

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 - Efanov (1976)

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

t_{mat} – age at first maturation;

Method of Lukashev (1970)

$$\mathrm{M} = 1 - \left[\frac{1 - e^{-k(t - t_o)}}{1 - e^{-k(t_{+1} - t_o}}\right]^3$$

t = age of mature fish

Method of Alverson - Carney (1975)

$$M = \frac{3.k}{e^{t_{mb}.k} - 1}$$

t_{mb}= age at which biomass is maximal;

4. Results

4.1. Population number and biomass

During the demersal trawl survey in XI-XII/2016 the following activities were carried out:

- 33 hauls were performed with a bottom trawl, with duration of 60 minutes for each trawl at depths between 15.0 m and 100.0 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. (Picture 3);
- Biometric measurements of 92 turbots and 24 spiny dogfishes (Picture 4).

Picture 3 *Bottom trawling yield*

Picture 4 *Conducting biometric measurements and sampling for study of the stomach contents*

During the survey was established: constant presence of *Scophthalmus maximus* in almost all bottom trawls at a depth between 15-50 m and 50-75 m, with yield - at

least 1-2 individuals per haul, mixed with specimens of dogfish (*Squalus acanthias*) and thornback ray (*Raja clavata*) (picture 5).

The highest turbot catches, varying between 8.66 to 27.46 kg/trawl, were observed in ten sectors off the Bulgarian coast.

Picture 5 *Yield of turbot (Scophthalmus maximus) and associated species Merlangius merlangus (whiting), Raja clavata (thornback ray), Platichthys flesus (European flounder), sprat (Sprattus spratus), anchovy (Engraulis encrasicolus) and another species.*

The basic part of the catch consisted of a mixture of species: dogfish (*Squalus acanthias*- 24 individualus) and thornback ray (*Raja clavata* – over 12 individuals). The associated species were identified as whiting (*Merlangius merlangus euxinus*), red mullet (*Mullus barbatus ponticus*), Mediteranean mussel (*Mytilus galloprovincialis*), common jellyfish (*Aurelia aurita*), flounder (*Platichthys flesus luscus*), sprat (*Sprattus spratus*) and anchovy (*Engraulis encrasicolus*).

It should be noted, that in almost all sectors where the bottom trawling was conducted (including the coastal area), large amounts of marine litter was established (drums, boxes and various metal parts, trees, plastic bags, plastic bottles, etc.) (Picture 7).

Picture 7 Marine debris identified during the bottom trawl in autumn 2016.

Comments on the biomass of S. maximus in the Bulgarian waters by strata

Trawling at a depth of up to 30 m cover four stations, and due to their small number, they are 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 four shallow stations (at a depth up to 30 m) reached respectively 72.64 kg/km^2, 69.607 kg/km^2, 244.263 kg/km^2 and 14.049 kg/km^2, with abundance – 128 individuals/km^2, 64 individuals/km^2, 112 individuals/km^2, and 16 individuals/km^2. In shallow stations, the highest yield was found in front of Kamchya, and as small catches to Kavarna.

The information about the yields by stratum:

Stratum 15 - 50 m

This stratum contained the highest number of individuals. The relative turbot biomass varied between 0 and 361.445 kg/km^2, 102.151 kg/km^2 on average (Table 1, Fig. 4 and 5).

The abundance indices varied between 0 and 144 individuals/km^2, on average - 64 ind./km^2 (Table 2, Fig. 7).

Stratum 50 -75 m

The relative turbot biomass varied between 0 and 438.396 kg/km^2, 105.174 kg/km^2 on average (Table 1, Fig. 4 and 5). The abundance indices varied between 0 and 192 ind./km^2, with average value of 43 ind./km^2 (Table 2, Fig. 7).

Stratum 75 - 100 m

In this stratum, the relative biomass varied from 0 to 27.30 kg/km^2, on average 4.55 /km^2 (Table 1, Fig. 4 and 5), and the average abundance was 3 ind./km^2 (Table 2, Fig.7).

Table 1

Turbot biomass by strata, Autumn 2016

15 - 50 м		50 – 75 м		75-100 м	
No. station	**t/sqKm**	**No. station**	**t/sqKm**	**No. station**	**t/sqKm**
1	0.072640	4	0.237238	16	0
2	0.069607	7	0.171942	21	0
3	0.051886	8	0.000000	22	0
5	0.083017	12	0.149591	31	0.000000
6	0.117821	14	0.151347	32	0.000000
9	0.212014	15	0.000000	33	0.027300
10	0.003832	17	0.000000		
11	0	23	0.000000		
13	0.031291	25	0.034963		
18	0.066095	26	0		
19	0.244263	27	0.150708		
20	0.361445	28	0.438396		
24	0.014049	29	0.138256		

		30	0		
Total	**1.327959**	**Total**	**1.472441**	**Total**	**0.027300**
Average	**0.102151**	**Average**	**0.105174**	**Average**	**0.004550**
Variance	0.011563		0.016270		1.242145
Standard deviation	0.107530		0.127553		0.003524
Relative standard deviation	1.052658		1.212777		0.774596
Standard error	0.026882		0.035377		0.0011748

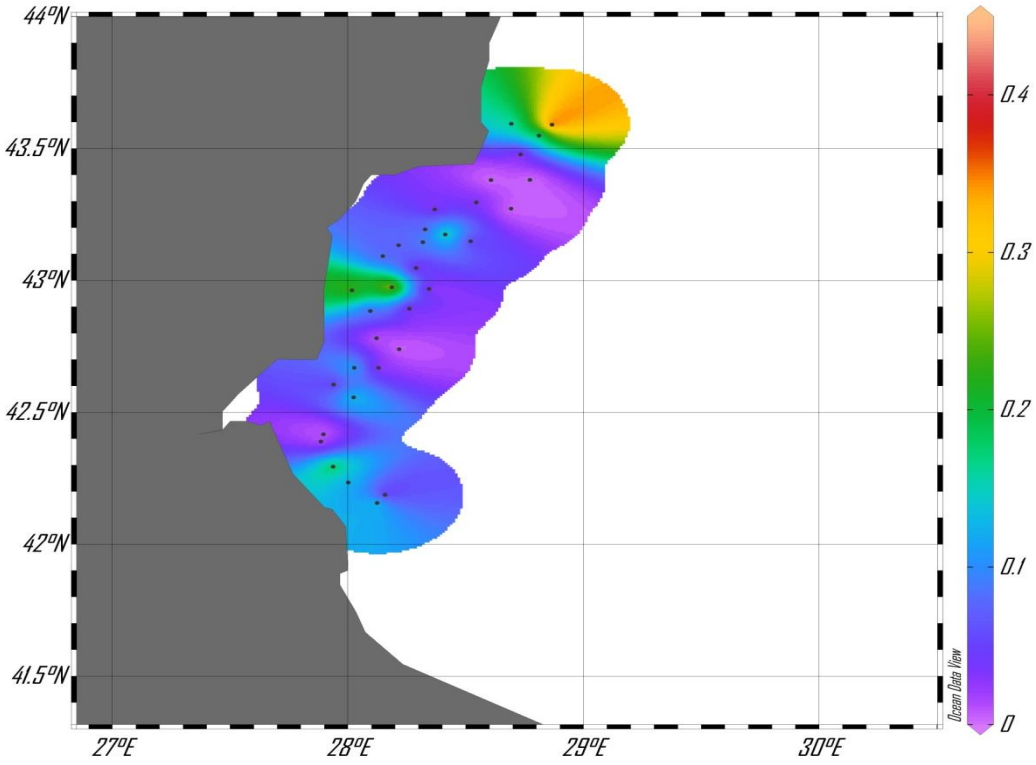


Fig.4 Distribution of the relative biomass *(t/km^2)* of *S. maximus* off the Bulgarian Black Sea coast in autumn, 2016 (The zones with high relative turbot biomass are shown in green and yellow).

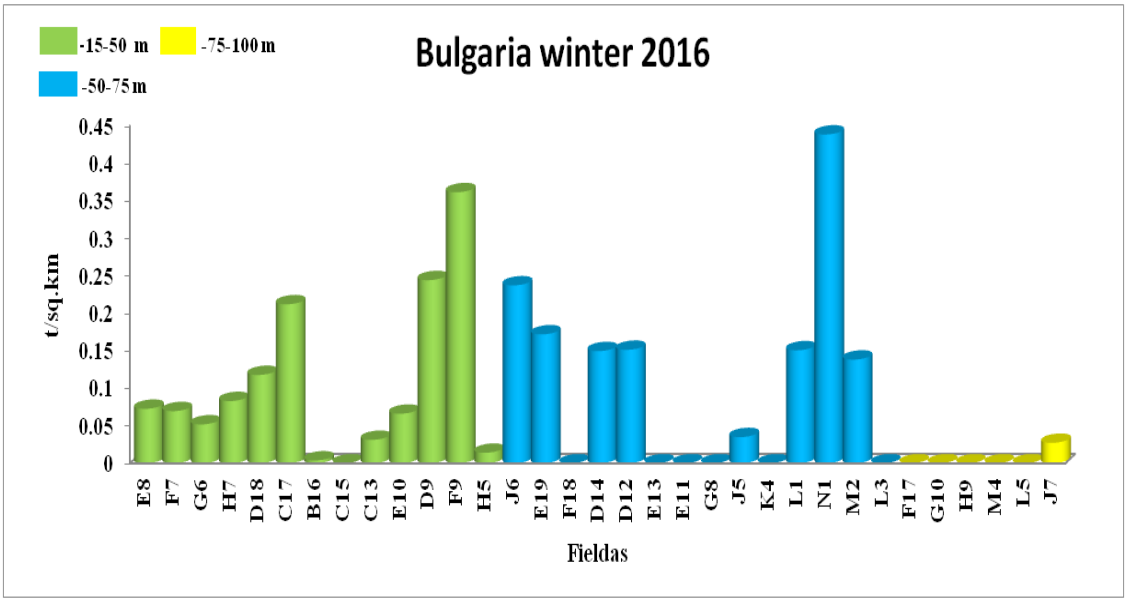


Fig.5 Relative biomass (t/km^2) of *S. maximus* by strata off the Black Sea coast, autumn - autumn, 2016.

High relative biomass was established in tree sectors of the Bulgarian Black Sea zone, in the north – south direction between Durankulak and Shabla at a depth of 60 - 64.5 m (stations N2 and L1). Along the central part of the coast, the relative turbot biomass was high in front of the River Kamchia and Shkorpilovtsi Beach (st. F9 and D9) at a depth of 26-41 m, and in south direction – in front of the Primorsko and Ahtopol (30-50 m, st. C17 and F19). In the above-mentioned sectors, the relative biomass of turbot varied between 171.942 kg/km^2 - 438.396 kg/km^2.

Table 2 shows the results of the study of turbot abundance in XI-XII, 2016.

Table 2

Current abundance of S. maximus by strata in XI-XII 2016

15 - 50 м		*50 – 75 м*		*75-100 м*	
No. station	*No. Ind./km^2*	*No. station*	*ind./km^2*	*No. station*	*ind./km^2*
1	128	4	80	16	0
2	64	7	64	21	0
3	80	8	0	22	0
5	48	12	48	31	0

6	32	14	48	32	0
9	112	15	0	33	16
10	16	17	0		
11	0	23	0		
13	48	25	16		
18	32	26	0		
19	112	27	80		
20	144	28	192		
24	16	29	96		
		30	0		
Total	**830**	***Total***	**623**	***Total***	**16**
Average	**64**	***Average***	**44**	***Average***	**3**
Variance	31.93645		60.79295		13.27487
Standard deviation	5.651234		7.796983		3.643469
Relative standard deviation	0.088495		0.149942		1.36931
Standard error	0.196157		0.31238		0.910867

4.2 Catch per unit effort (CPUE)

Catches from a total of 33 trawls are distributed as follows:

- 12 hauls (36.36 % of total no. hauls), catch 0 kg;
- 9 hauls (27.27 % of total no. hauls), catch 0.1 – 4.99 kg per haul;
- 6 hauls (18.18 % of total no. hauls), catch 5.00 – 9.99 kg per haul;
- 3 hauls (9.09 % of total no. hauls), catch 10.00 – 14.99 kg per haul;
- 1 hauls (3.03 % of total no. hauls), catch 15.00 – 19.99 kg per haul;
- 2 hauls (6.06 % of total no. hauls), catch 20.00 – 27.99 kg per haul;

Stratum < 30 m; 4 hauls:

- 3 haul, catch 0 – 4.99 kg;
- 1 hauls, catch 15.00-19.99 kg per haul;

Stratum 31 – 50 m; 9 hauls:

- 1 hauls, catch - 0
- 4 hauls, catch - 0.1 - 4.99 kg per haul;
- 2 hauls, catch - 5.0 - 9.99 kg per haul;
- 2 hauls, catch – 10.00 – 22.99 kg per haul;

Stratum 50 – 75 m; 14 hauls:

- 6 hauls, catch 0 kg per haul;
- 1 hauls, catch 0.1 – 4.99 kg per haul;
- 4 hauls, catch 5.0 – 9.99 kg per haul;
- 2 haul, catch 10.00 – 14.99 kg per haul;
- 1 haul, catch 20.00 – 27.99 kg per haul;

Stratum 75 – 100 m; 6 hauls:

- 5 hauls, catch 0 kg per haul;
- 1 hauls, catch 0.1 – 4.99 kg per haul;

The CPUE distribution during the expedition off the Bulgarian coast in XI - XII 2016 is shown in Table 3 and Fig. 6.

Table 3

Results achieved in the survey of the month in November - December 2016

№	Field	Starting Coordinates		Depth (m)	Speed (Nm)	Trawling time (min)	Catch turbot	
		ϕ	λ				№	*kg*
1	E8	43º04'594''	28º06'357''	24-26.8	2.6	60	8	**4.55**
2	F7	43º05'364''	28º11'460''	30-27.9	2.6	60	4	**4.36**
3	G6	43º10'221''	28º15'980''	31-36	2.6	60	5	**3.25**
4	J6	43º10'240''	28º27'630''	66-53	2.6	60	5	**14.86**
5	H7	43º09'836''	28º22'484''	46-39	2.6	60	3	**5.2**

6	D18	42º14'400''	27º59'355''	43-44	2.6	60	2	**7.38**
7	E19	42º09'900''	28º06'692''	58-63	2.6	60	4	**10.77**
8	F18	42º11'360''	28º09'417''	70-70.5	2.6	60	0	**0**
9	C17	42º17'085''	27º56'550''	38-36	2.6	60	7	**13.28**
10	B16	42º21'840''	27º53'500''	35-36	2.6	60	1	**0.24**
11	C15	42º24'900''	27º52'670''	37-38	2.6	60	0	**0**
12	D14	42º32'790''	28º01'615''	51.1-47.0	2.6	60	3	**9.37**
13	C13	42º34'500''	27º54'400''	41.0-44.0	2.6	60	3	**1.96**
14	D12	42º40'071''	28º01'316''	43.1-53.0	2.6	60	3	**9.48**
15	E13	42º40'120''	28º05'820''	59.0-70.0	2.6	60	0	**0**
16	F12	42º41'400''	28º12'198''	77.1-80.0	2.6	60	0	**0**
17	E11	42º46'530''	28º07'430''	56.7-45.0	2.6	60	0	**0**
18	E10	42º51'300''	28º05'853''	38.0-44.0	2.6	60	2	**4.14**
19	D9	42º55'400''	28º00'656''	26.0-24.4	2.6	60	7	**15.3**
20	F9	42º59'750''	28º10'700''	35.0-41.5	2.6	60	9	**22.64**
21	G10	42º53'300''	28º14'700''	70.1-79.0	2.6	60	0	**0**
22	H9	42º55'800''	28º20'142''	80.9-77.0	2.6	60	0	**0**
23	G8	43º00'700''	28º16'900''	55.2-48.0	2.6	60	0	**0**
24	H5	43º15'650''	28º20'016''	24.4-30.0	2.6	60	1	**0.88**
25	J5	43º17'500''	28º30'300''	51.0-63.0	2.6	60	1	**2.19**
26	K4	43º20'776''	28º36'017''	61.0-54.7	2.6	60	0	**0**
27	L1	42º35'329''	28º41’250''	51.7-54.1	2.6	60	5	**9.44**

28	N1	43º38'113''	28º51'208''	60.5-65.0	2.6	60	12	**27.46**
29	M2	43º33'424''	28º49'070''	67.5-69.0	2.6	60	6	**8.66**
30	L3	43º29'554''	28º43'800''	62.3-66.0	2.6	60	0	**0**
31	M4	43º25'265''	28º45'015''	73.7-75.7	2.6	60	0	**0**
32	L5	43º18'931''	28º43'760''	81.0-84.4	2.6	60	0	**0**
33	J7	43º10'220''	28º33'950''	84.3-82.0	2.6	60	1	**1.71**

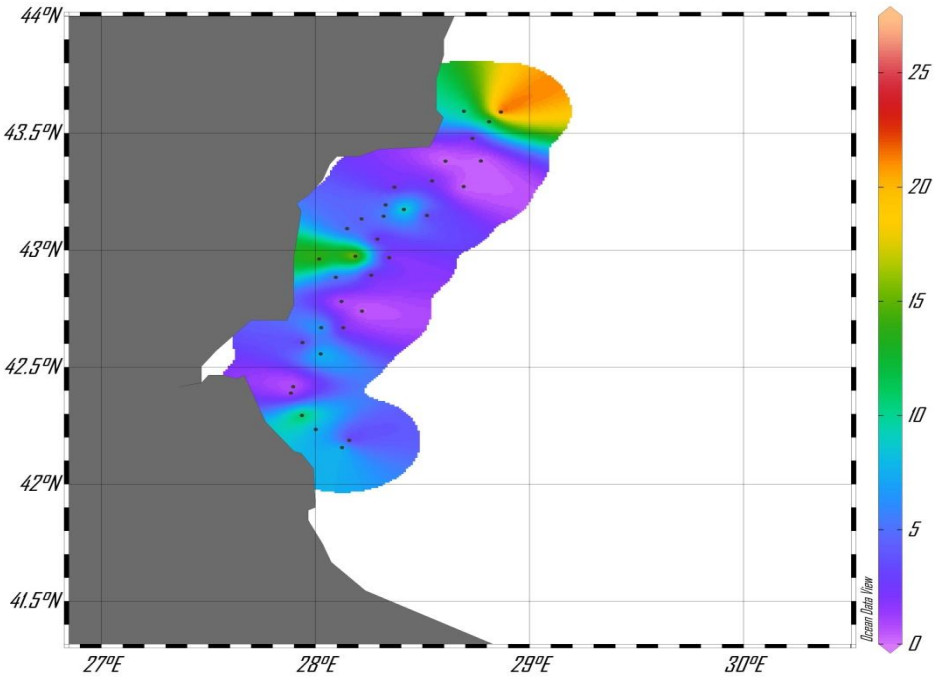


Fig. 6 Distribution of catch per unit effort (CPUE)

4.3. Catch per unit area (CPUA)

After processing, the data for turbot abundance and biomass per unit area were obtained (table 4):

Table 4

Turbot abundance and biomass in the Bulgarian waters during November – December 2016

No. Station	Field	No. individulals/sqKm	t/sqKm
1	E8	128	0.07264
2	F7	64	0.069607
3	G6	80	0.051886
4	J6	80	0.237238
5	H7	48	0.083017
6	D18	32	0.117821
7	E19	64	0.171942
8	F18	0	0.000000
9	C17	112	0.212014
10	B16	16	0.003832
11	C15	0	0
12	D14	48	0.149591
13	C13	48	0.031291
14	D12	48	0.151347
15	E13	0	0
16	F12	0	0
17	E11	0	0
18	E10	32	0.066095
19	D9	112	0.244263
20	F9	144	0.361445

21	G10	0	0
22	H9	0	0
23	G8	0	0
24	H5	16	0.014049
25	J5	16	0.034963
26	K4	0	0
27	L1	80	0.150708
28	N1	192	0.438396
29	M2	96	0.138256
30	L3	0	0
31	M4	0	0
32	L5	0	0
33	J7	16	0.0273
Total		1469	2.8277
Average		45	0.085688
Total in the Bulgarian area		**515 880 Ind.**	**993.18 tonnes**

	№ ind./км²	*t/км²*
Variance	2560.842	0.012476
Standard deviation	50.60477	0.111694
Relative standard deviation	1.136977	1.303502
Standard error	8.809159	0.019443

The calculated current turbot biomass in the Bulgarian Black Sea waters amounted to **993.18** tons (Table 4). The turbot abundance in the surveyed area amounted to **515 880** individuals (Table 4).

4.4. Size structure of *S. maximus*

The data about the size structure of turbot population in the Bulgarian Black Sea waters in November - December 2016 were based on analysis of 92 individuals (the absolute and standard length and individual weight of each specimen were measured, Picture 4).

The absolute length of the measured individuals varied between 18.50 and 67.50 cm, and their weight - between 120 and 5830 g. The total catch of turbot was 177.120 kg. Out of the total number of 92 individuals, twenty-four was of size under 30 cm (26.08%), 4 were of sizes between 30 - 40 cm (4.35%), 34 individuals - between 40-50 cm (36.96%), 24 - in the range between 51-60 cm (26.08%) and 6 individuals - between 61-73 cm (6.52%) (Fig. 7).

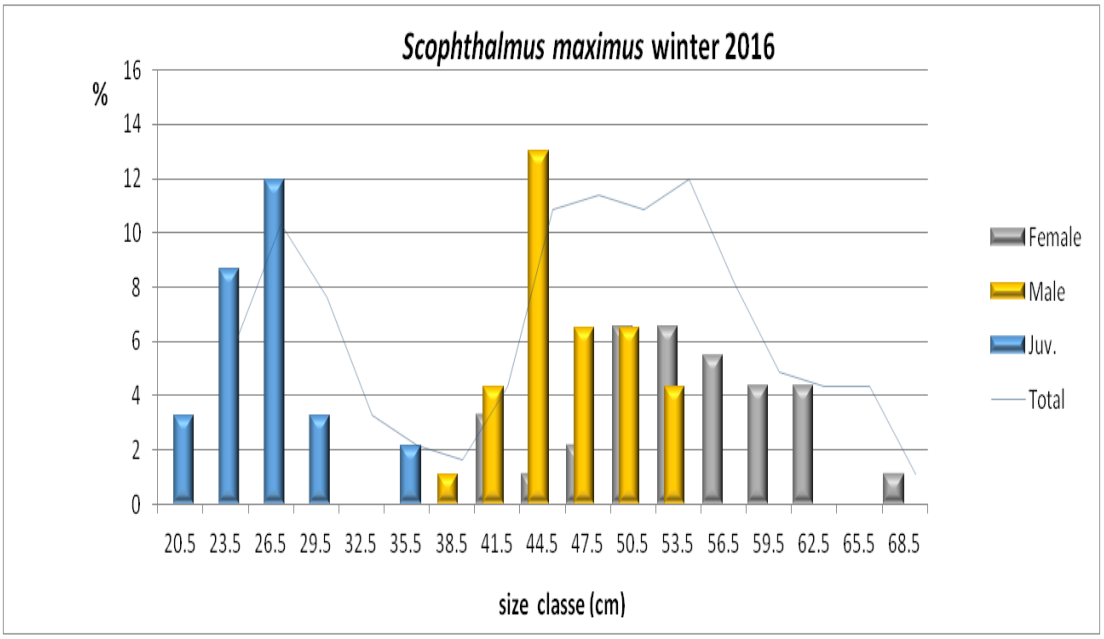


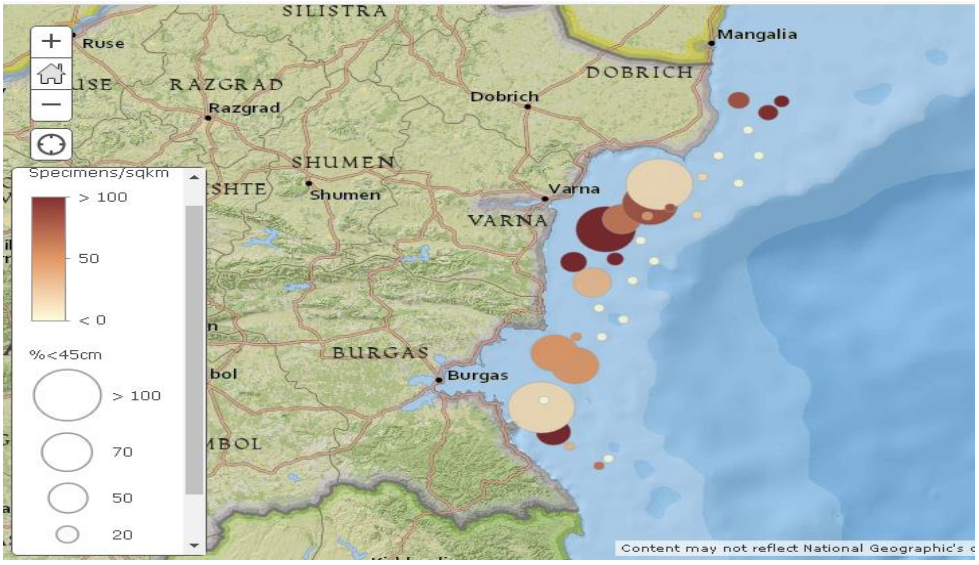
Fig.7 Length structure of turbot *S. maximus*

Sexually mature individuals predominate in the total catch 70.65% /65 individuals/ and juveniles are respectively 29.35% or 27 individuals. The male individuals dominated - 35.87% /33 individuals/ over the female ones - 34.78 % /33 individuals/.

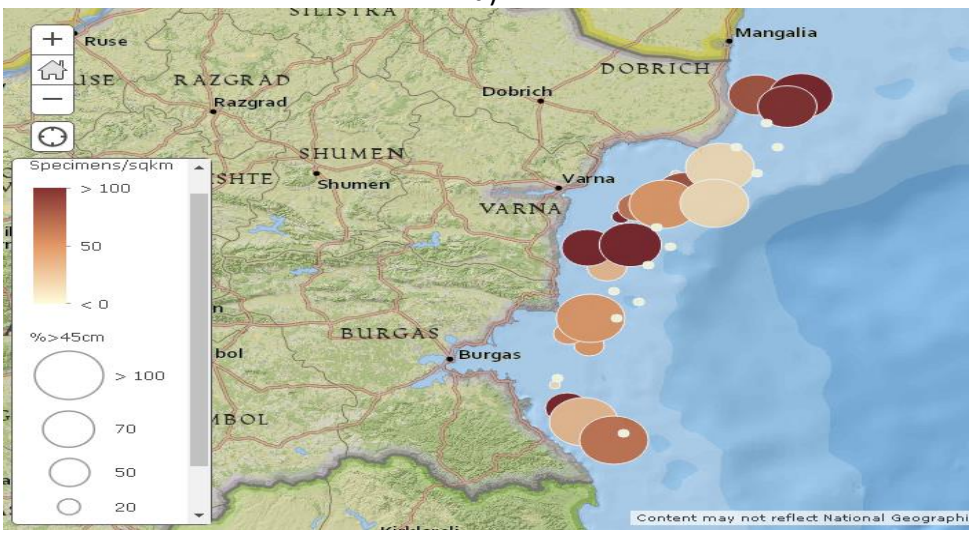
The size structure was analysed in compliance with the national regulations, setting out the minimum permissible length of the individuals for fishing purpose. The

individuals with absolute length under 45 cm are marked as undersized, and those with length > 45 cm - as standard.

Fig. 8 shows the total turbot abundance (individual/km^2) and the distribution of the ratio between the undersized individuals and those of standard length.



a)



b)

Fig. 8 Distribution of the *Scophthalmus maximus* abundance (individuals/km^2) and ratio between the undersized individuals a) and those with standard length b).

Analysis of the biomass distribution by size classes, show that the maximal biomass (x) – 160 t. was formed by the size classes 50.5 cm and 53.5 cm, while specimens with size 44.5 cm have produced ~ 120 t. At the third position by importance in biomass formation were the specimens of the size class 62.5 cm ~ 105 t (Fig.9).

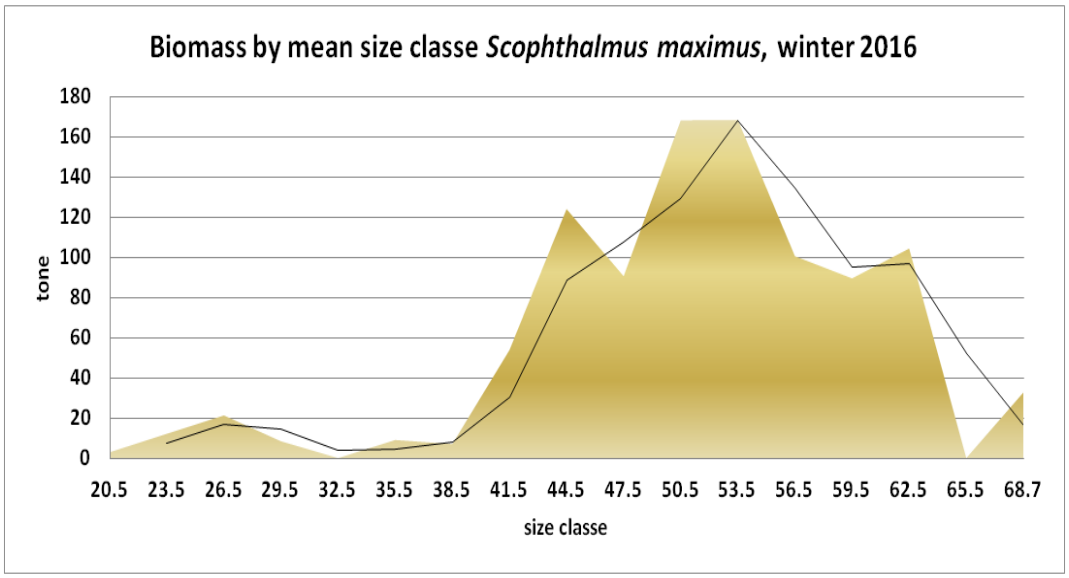


Fig.9 Biomass by mean size classes of *S. maximus.*

4.5. Age structure of turbot

The turbot age composition was determined based on an analysis of 65 pairs of otoliths.

The turbot age structure included 1 to 9 years classes, with domination of the 2 (26.09 %) and 4 (23.91 %) – years (50 % in total), followed by 5 – 19.57 % and 3 - 14.13 % years classes (Fig. 10). In the autumn season of 2016, the share of the replenishment of 2 and 3 years classes was 40.22 %. Although having small frequency of occurrence, specimens from 6, 7 and 9 years classes were registered in the yield.

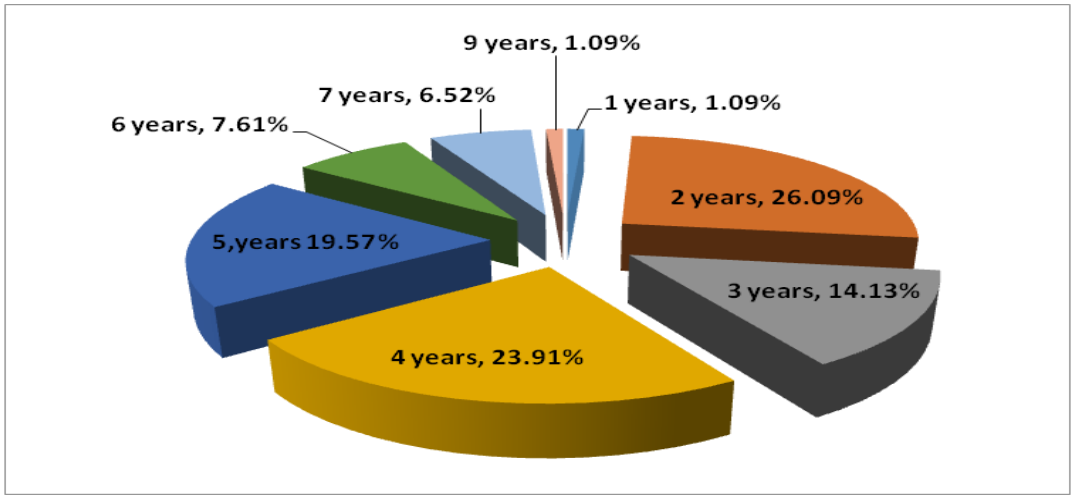


Fig.10 Age structure of turbot *S. maximus* in November - December 2016.

The distribution of the age composition of *S. maximus* in the surveyed areas is shown in Fig.11.

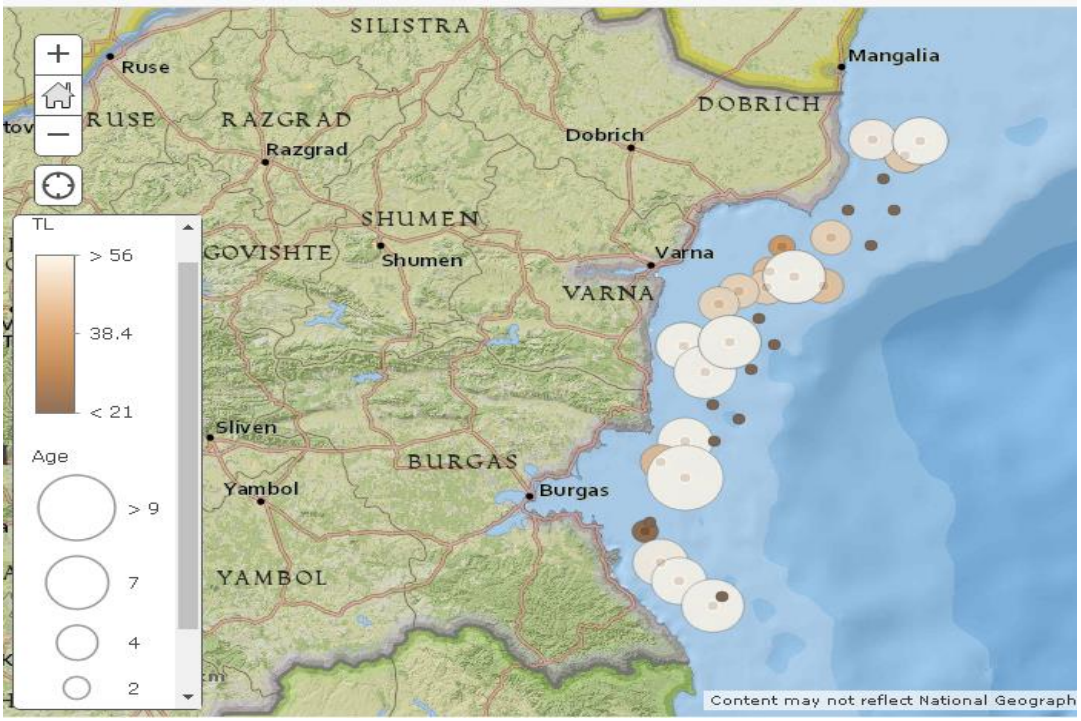


Fig. 11 Age structure of *Scophthalmus maximus* in the autumn 2016.

4.6. Biological parameters of *S. maximus*

To identify the turbot growth rate in the Bulgarian Black Sea waters in autumn 2016, the data about the average length and weight by age groups for the two sexes were combined and used.

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

b = 2.995
q= -1.71
a= 0.019
L∞ = 71.05
k = 0.337
to = - 0.39

The length/weight relation of *S. maximus* in the autumn survey is shown in Fig.12.

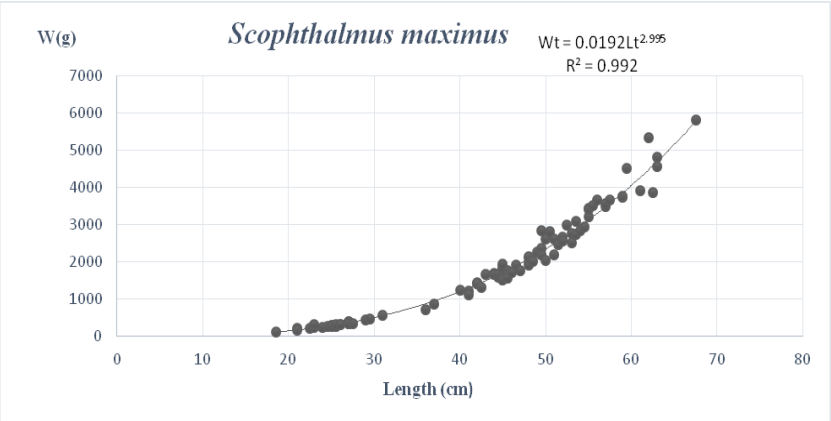


Fig.12 Length - weight relation for *S. maximus*, XI-XII/2016.

The coefficient of natural mortality was calculated using Pauly's empirical formula (1980), describing the natural mortality as a function of k, L∞, W∞ and the temperature (T) of the environment. The measured temperature of the environment was 11 °C during the study. For both sexes: M = 0.21.

L_∞ = Lt max/0.95 – empirical formula

k = $1/(t_2-t_1)*\ln(\mathbf{L_\infty-L_1})/(\mathbf{L_\infty-L_2})$ by age composition

log $(-t_0)$ = -0.3922 – 0.2752*logL_∞ - 1.038*logk

4.7. Sex structure of *S. maximus*

Sex ratio

The results of analysis of the sex structure of turbot in the Bulgarian Black Sea waters in autumn 2016 are shown in Fig.13. The total share of sexually immature individuals comprised 29.35 % of the total yield, the female individuals formed 34.78 %, and the share of males was 35.87 %.

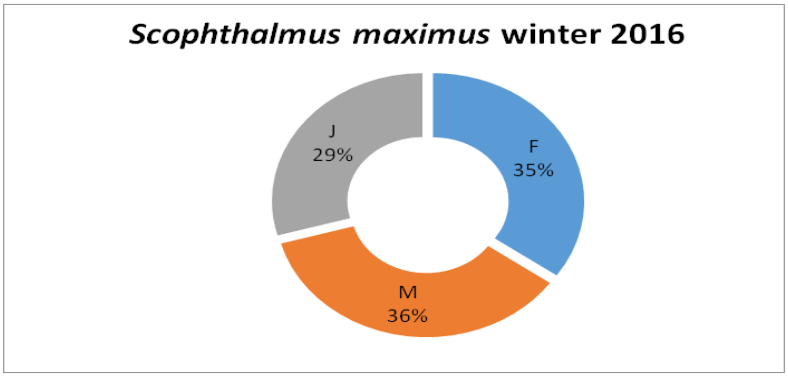
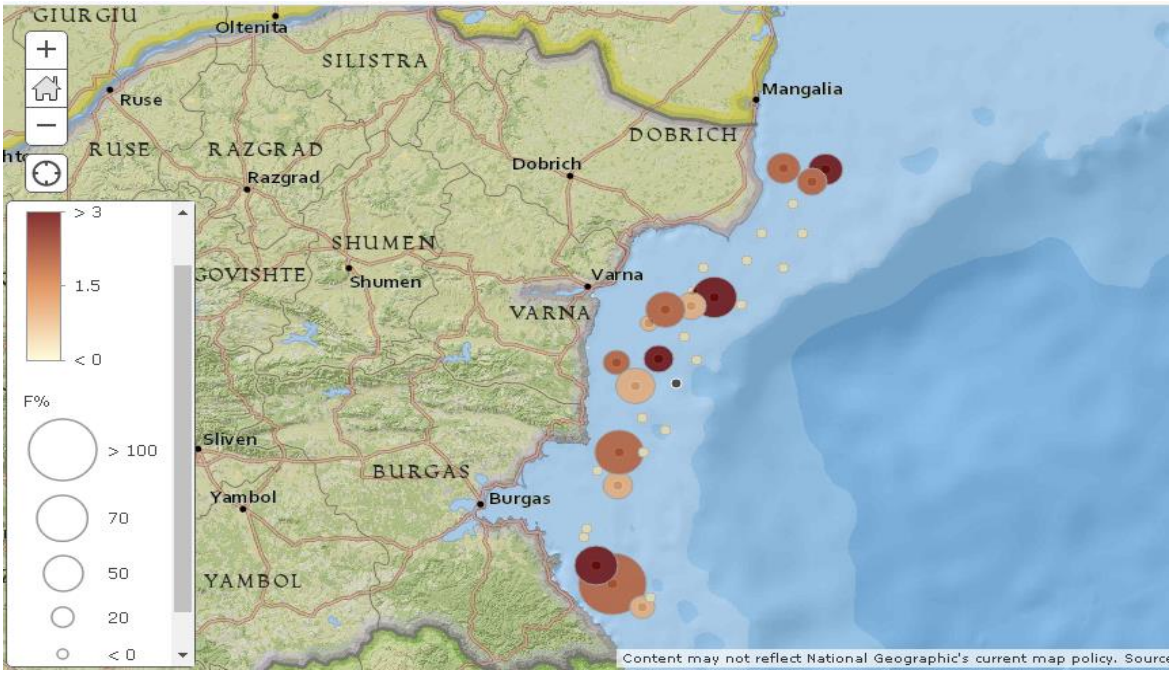


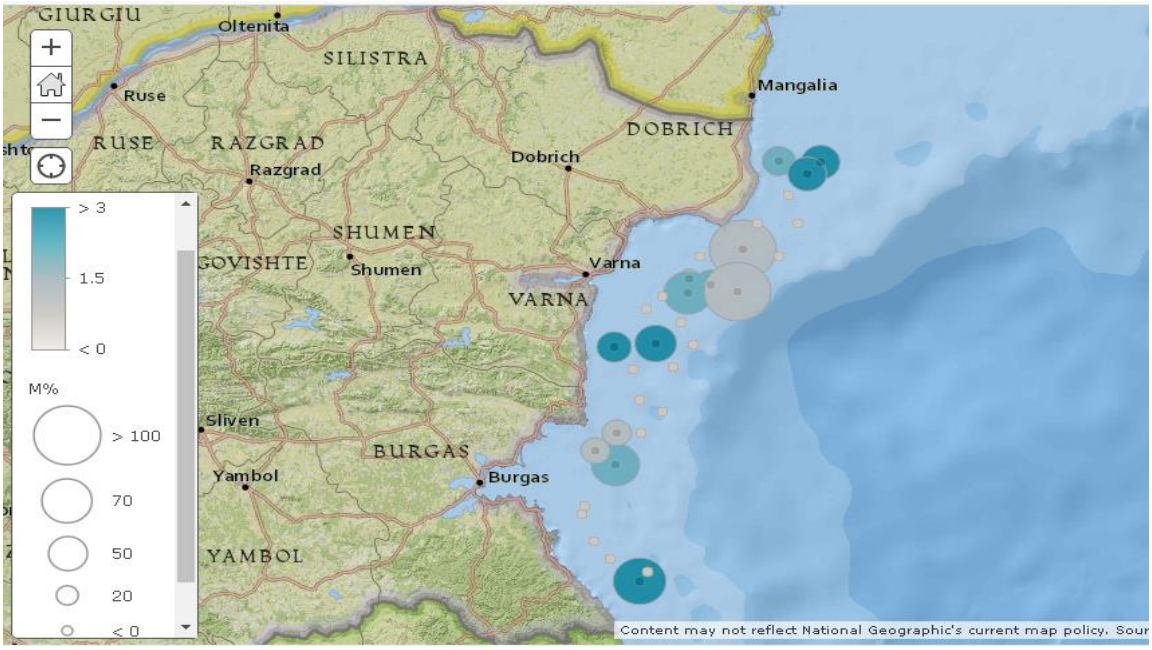
Fig.13 Sex structure of turbot *S. maximus* in the Bulgarian Black Sea waters during November - December 2016.

Of the studied total of 33 fields off the Bulgarian coast, in 18 fields no female individuals were identified, in 19 fields there were no males specimens, and in 2 fields only young forms were found and there were no adult individuals (Fig.14).

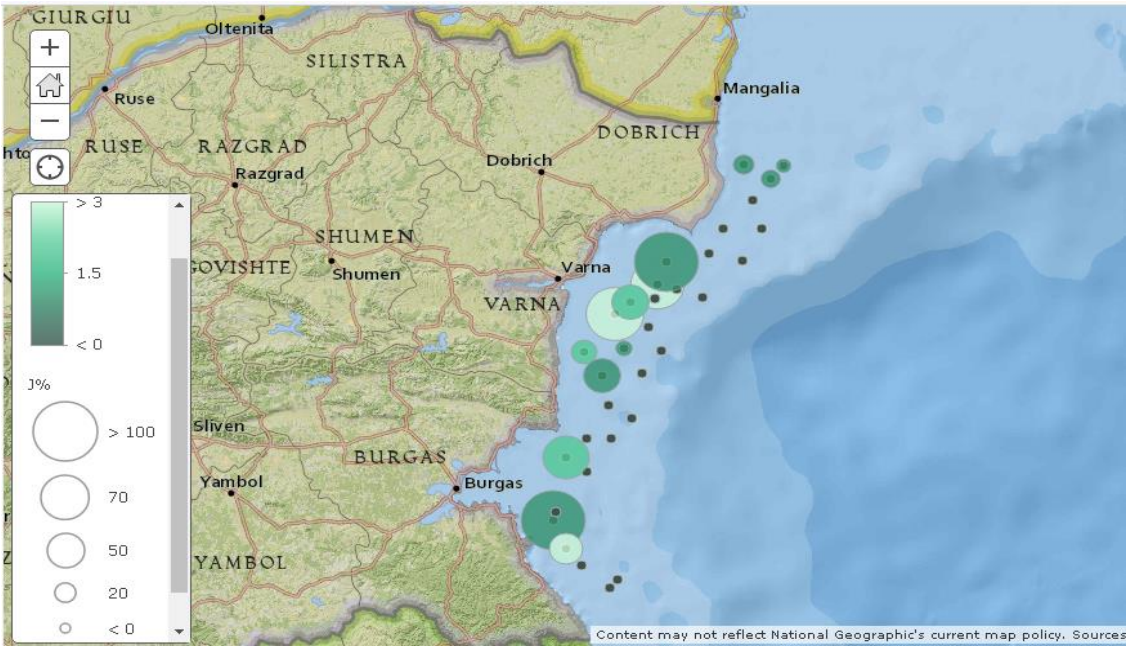
The percentage distribution of turbot yields by sex, as well as the share of young individuals are shown in Fig. 14.



a)



b)



c)

Fig. 14 Percentage distribution by sex and juvenile stages of *S.maximus* in November - December 2016 (a) females, (b) males, (c) juvenile stages.

Scophtalmus maximus is predominantly found in sectors with a depth of 25 to 65 meters, as the species is feeding intensively in coastal waters during the autumn-winter season. The juveniles were concentrated in the section below the cities of Balchik, Varna and Sozopol (Fig.14 c). The females were established mainly in the regions between Emine and Sozopol (Fig.14 a), while males are relatively equally distributed along the Bulgarian coast (Фиг.14 b).

The average weight of females was 3189.375 g, with average absolute length TL – 54.09 cm. The maximum weight of females was 5830 g, and the minimum - 1110 g.

The length distribution analysis for both sexes showed that by females the length class 50.5-53.5 cm formed the greatest share – 37.5%, followed by size class 56.5 cm – 15.63 % (Fig.15). The females with length 50.5-59.5 cm comprised totally 65.63 % of all studied females. For the length classes over 62.5 cm (up to 68.5 cm), all studied specimens were only females and comprised 15.62 %. The results demonstrate sexual dimorphism regarding the body length and superior number of large size classes of females (Fig.15 and 16).

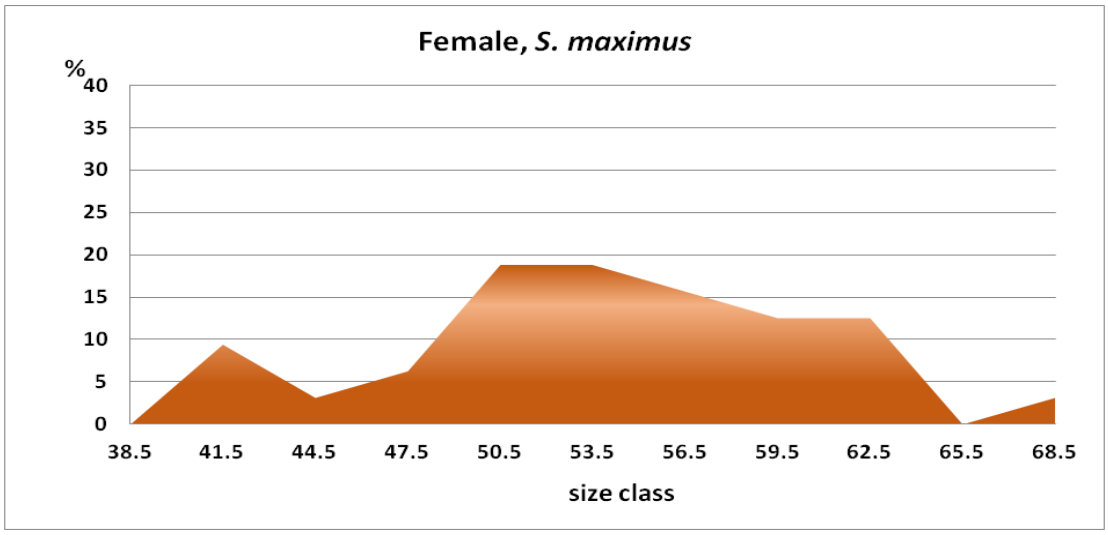


Fig.15 Percentage distribution of females by length classes.

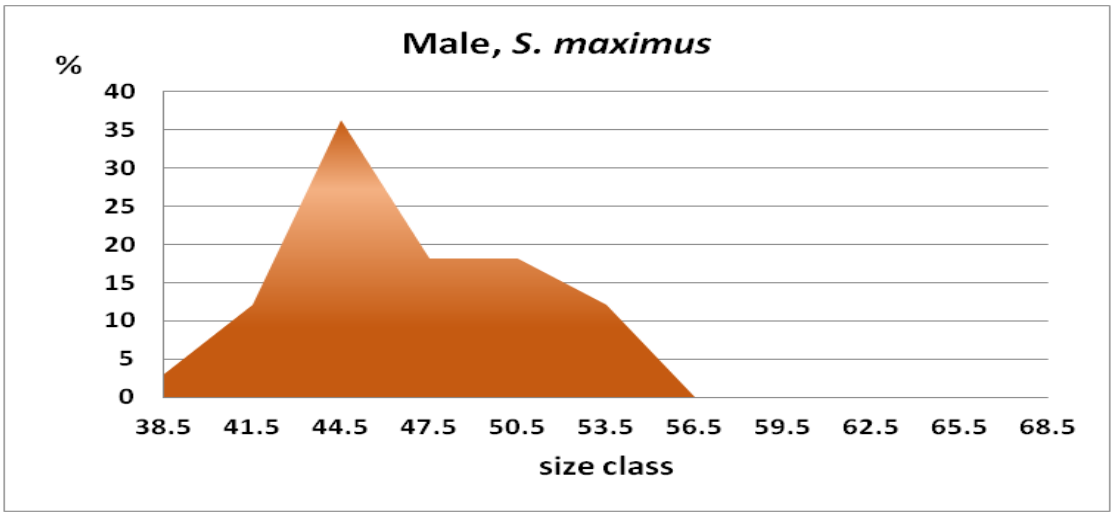


Fig.16 Percentage distribution of males by length classes.

For males, the largest proportion – 72.73 % belonged to the length class 44.5 – 50.5 cm, (Fig.16).

4.8. Food composition

To identify the food spectrum, a total of 43 stomachs were collected in autumn 2016 (Table 5). 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. From the total 43 investigated fish stomachs, 35 % were empty.

Table 5

Surveyed area, length, weight of specimens, and weight of stomachs (full, empty), and of stomach contents, index of stomach fullness (ISF).

L (cm)	W (gr)	St./full(gr)	St./empty (gr)	St. contents. (gr)	ISF	L (cm)
C13/3	44.5	1610	32.3064	14.4974	17.809	1.10614
C17/4	54	2840	32.4035	0	0	0
C17/5	52.5	3010	81.5626	35.478	46.0846	1.53105
C17/6	55	3450	126.703	35.0033	91.6997	2.657962
C17/7	50.5	2830	71.4656	33.0319	38.4337	1.358081
D9/3	57.5	3670	76.1381	39.0774	37.0607	1.009828
D9/4	52	2670	41.9327	30.7521	11.1806	0.418749
D9/5	52	2560	50.9489	32.0908	18.8581	0.736645
D9/6	48.5	2030	30.2967	0	0	0
D9/7	56	3670	61.1607	40.3864	20.7743	0.566057
D12/1	57	3490	88.562	39.842	48.72	1.395989
D12/2	51.5	2460	19.5927	0	0	0
D12/3	55.5	3530	23.8223	0	0	0
D14/1	65	5830	41.657	0	0	0
D14/2	45	1800	46.9291	22.1289	24.8002	1.377789
D14/3	43	3700	15.2396	0	0	0
D18/1	49.5	2860	55.1925	40.0822	15.1103	0.528332
D18/2	59.5	4520	98.6555	55.9691	42.6864	0.944389
E8/8	50	2050	24.7427	0	0	0
E10/1	21	220	37.2843	0	0	0
E19/1	55	3220	218.5	39	179.5	5.574534
E19/2	62.5	3870	36.8604	0	0	0
E19/3	45.5	1760	51.5532	15.5185	36.0347	2.047426
E19/4	48	1920	75.3752	22.2085	53.1667	2.769099
F7/3	49.5	2380	30.8711	0	0	0
F7/4	42	1420	29.3994	26.2974	3.102	0.218451
F9/9	62	5340	91.529	48.1655	43.3635	0.812051
G6/5	45	1830	52.8117	18.6742	34.1375	1.865437
H7/1	49	2260	34.0162	20.2958	13.7204	0.607097
H7/2	40	1250	27.5288	14.4873	13.0415	1.04332
H7/3	44	1690	16.3079	0	0	0

J5/1	49.5	2190	49.9616	20.0796	29.882	1.364475
J6/1	51.1	2610	83.0209	29.1551	53.8658	2.063824
J6/2	59	3750	38.2628	0	0	0
J6/3	46.5	1930	21.6557	0	0	0
J6/4	63	4580	33.2932	0	0	0
J6/5	48	1990	57.1949	19.0544	38.1405	1.916608
J7/1	46	1710	41.8901	19.954	21.9361	1.282813
L1/5	53	2780	24.7958	0	0	0
M2/2	44.5	1680	47.0232	17.8816	29.1421	1.734649
M2/6	45	1530	28.5075	12.9691	15.5384	1.015582
N1/2	52	2570	53.0543	21.4018	31.6325	1.230837
N1/5	53.5	3100	50.8158	30.4897	20.3261	0.655681

The index of relative importance (IRI) was used to evaluate the significance of different food components in the trophic spectrum (Pinkas et.al., 1971) (Table 6).

Table 6

Turbot food spectrum in autumn 2016. (CN - percentage share of different food items in total number; CW - percentage share of different food items in the total weight; F – frequency of occurrence).

Species	C_N	C_W	F	IRI
Pisces	**96.42**	**96.43**	**65.11**	**11188**
Merlangius merlangus (Linnaeus, 1758)	92.53	92,18	60,47	11169
Mullus barbatus Linnaeus, 1758	0.32	0.67	2,33	2.31
Engraulis encrasicolus, Linnaeus, 1758	3.57	3.57	2,33	16.64
Remains	**3.57**	**3.57**	**2,33**	**16.63**

In autumn 2016, the turbot feeds mainly on fish species, as the percent share of this group has increased to 96.42 % of the total food items abundance and formed 96.43 % of the total food biomass.

Based on IRI calculations, the most important food source for turbot was whiting – IRI =11169, as all other food components were represented by separate items i.e. the food spectrum is significantly limited during the observed period (Fig. 17).

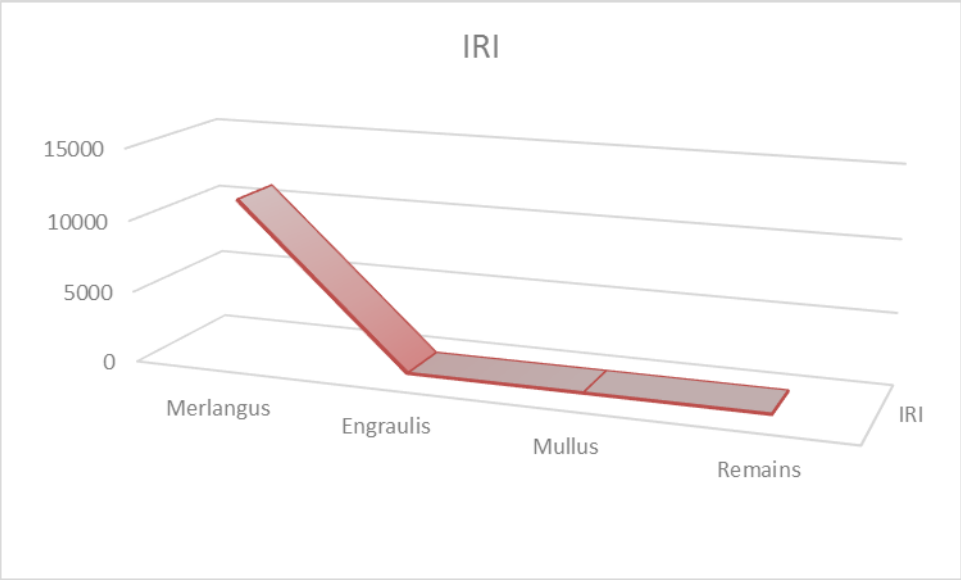


Fig. 17 Indexes of relative importance (IRI) by food items.

With highest percentage in IRI is the species *Merlangius merlangus* – 99.68 %, while *Mullus barbatus* and *Engraulis encrasicolus* formed - 0.15 % и 0.02 % (Fig.18).

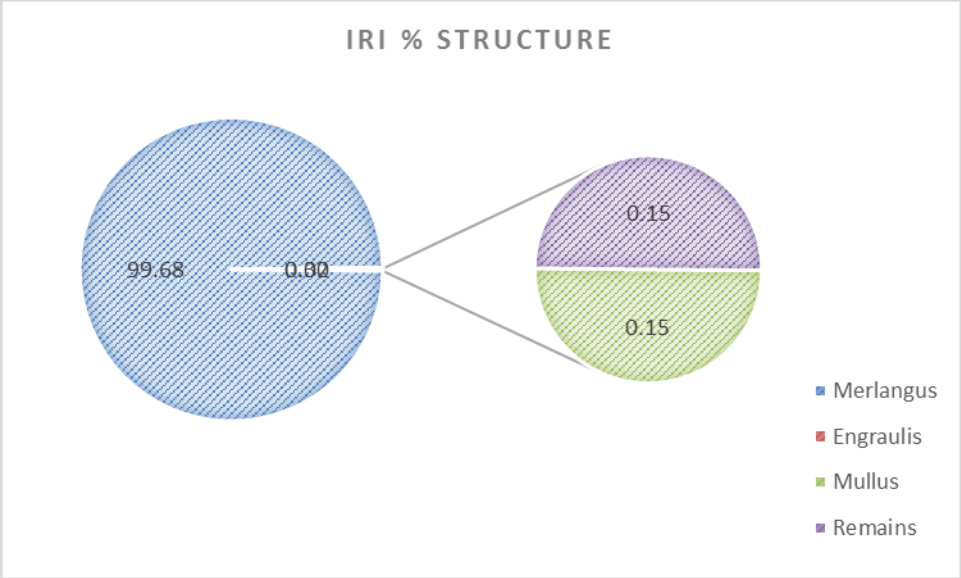


Fig. 18 Food spectrums (IRI %): percentage of the main taxonomic groups in the turbot stomach content.

In the stomach content were also found Nematodes, that form the group of parasites.

4.9. Forecasts and opportunities for exploitation

The estimation of maximum sustainable yield (MSY) was realised using Gulland's formula for virgin stocks.

$$MSY = 0.5*M*Bv$$

The coefficient of natural mortality (M) is calculated by Pauly's empirical formula (1979, 1980). The calculation uses the mean value of M = 0.2, as turbot is a species with relatively long life cycle.

By MSY value of **99 tons**, it is assumed that the total allowable catch (TAC) of turbot in the Bulgarian Black Sea waters could comprise 50 tons as a relatively acceptable quantity.

Observed other particular problems

During the expedition in XI-XII/2016, the wind direction East, North and Northwest dominated, and its power varied between Beaufort 2-4º along the coast and Beaufort 5-6º in the open sea. Sea state - Beaufort 2-3º in the coastal zone, and Beaufort 3-4º in the open sea. The conditions in the field were normal for conducting the research activities for estimation of turbot stocks in the Bulgarian Black Sea waters.

5. Conclusion and recommendations

In accordance with the collected information and obtained results from the trawl survey in November - December 2016, the following conclusions and recommendations can be made:

- The turbot biomass in the Bulgarian Black Sea waters was assessed at **993.18** tons. The turbot abundance in the surveyed area was estimated as **515 880** individuals.
- The size structure of the turbot population in the Bulgarian Black Sea zone included length classes from **18.50** cm to **67.50** cm, with weight between **120** g and **5830** g. The total catch of turbot was 177.120 kg. Out of the total number of 92 individuals, twenty-four was of size under 30 cm (26.08%), 4 were of sizes between 30 - 40 cm (4.35%), 34 individuals - between 40-50 cm (36.96%), 24 - in the range between 51-60 cm (26.08%) and 6 individuals - between 61-73 cm (6.52%).
- The turbot age structure included 1 to 9 years classes, with domination of the 2 (26.09 %) and 4 (23.91 %) – years (50 % in total), followed by 5 – 19.57 % and 3 - 14.13 % years classes. The established ratio between female, male and sexually immature individuals in the yield was **34.78%: 35.87%: 29.35%.**
- The most important component of the turbot diet was whiting (*Merlangius merlangus*) with IRI = 11169, while another fish species were represented by separate specimens which indicated a limited food spectrum.
- The recommended MSY (maximum sustainable yield) for Bulgaria should not exceed **99** t., it is assumed that the total allowable catch (TAC) of turbot in the Bulgarian Black Sea waters could comprise **50** tons as a relatively acceptable quantity.

6. References

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