

REPORT

Bottom trawl survey and stock assessment of target species - turbot, spiny dogfish and whiting, and bycatch of thornback ray and other accompanying species of the Bulgarian Black Sea coast during the spring-summer season of 2025.

Agricultural Academy
Institute of Fish Resources (IFR, Varna)

2025

000

SHOT ON MI 10T PRO



The present study was conducted by a team of specialists from the Institute of Fishery Resources (IFR) – Varna, Agricultural Academy, under contract № 153/27.03.2025 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 2025.

This study was carried out with the financial support of the European Commission in accordance with the Delegated Decision (EU) 2021/1167 of the Commission on April 27, 2021, to approve the multiannual program of the Union for the collection and management of biological, ecological, technical, and socio-economic data in the fisheries and aquaculture sectors from 2022 onwards, and Commission Implementing Decision (EU) 2021/1168 of April 27, 2021, approving the list of mandatory scientific research in the high seas and threshold values under the multiannual Union program for data collection and management in the fisheries and aquaculture sectors from 2022 onwards.

The study was performed in the period 30 July - 21 August 2025 in the Bulgarian Black Sea waters on board the “EGEO 2” fishing vessel.

The reference species in the study were turbot, spiny dogfish, and whiting, and information was collected from the bycatch species.

Scientific research team from IFR Varna

Team leader: Assoc. Prof. Elitsa Petrova - Pavlova, PhD

Participants:

Assoc. Prof. Stoyko Stoykov, PhD
Assoc. Prof. Vesselina Mihneva, PhD
Biologist Stanimir Valchev
Biologist Aysel Hyusein
Assistant Krasimir Georgiev
Chief Assistant, Philip Penchev, PhD
Chief Assistant, Feriha Tserkova, PhD

Petrova E., Stoykov S., Mihneva V., Valchev S., Hyusein A., Georgiev K., Penchev Ph., Tserkova F., 2025. Bottom trawl survey and stock assessment of target species - turbot, spiny dogfish and whiting, and bycatch of thornback ray and other accompanying species off the Bulgarian Black Sea coast during the spring-summer season of 2025, Report under Contract with the Executive Agency Fisheries and Aquaculture, Bulgarian Work Plan for data collection in the fisheries and aquaculture sectors 2025, p.87.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



BOTTOM TRAWL SURVEY FOR STOCK ASSESSMENT OF REFERENCE BOTTOM SPECIES IN BULGARIAN BLACK SEA SECTOR DURING SPRING-SUMMER SEASON OF 2025

1. Results from the National Bottom Trawl Surveys in July-August 2025	6
1.1. Fishing vessel and fishing gear.....	7
2. Material and methods	9
2.1 Information collected through the bottom trawling.....	10
2.2. Sampling scheme	11
2.3. Laboratory analyses	12
2.4. Statistical methods	13
3. Results.....	18
3.1. Population number and biomass.....	18
3.2. Catch per unit effort (CPUE)	25
3.3. Catch per unit area (CPUA).....	28
3.4. Size structure.....	33
3.5. Age structure	35
3.6. Biological parameters of <i>S. maximus</i>	37
3.7. Sex structure	40
3.8. Weight structure.....	43
3.9. Other reference species	46
4. Food spectrum of <i>S. maximus</i>	65
5. Fecundity	78
6. Conclusions and recommendations.....	80
7. References.....	82

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

LIST OF FIGURES IN THE TEXT

Figure 1 Map of the surveyed sectors.	12
Figure 2 Relative biomass (kg/km ²) of <i>S. maximus</i> by strata off the Bulgarian Black Sea coast, VII-VIII 2025	24
Figure 3 Distribution of catch per unit effort (CPUE, kg/h).	28
Figure 4 Distribution of the relative biomass (kg/km ²) of <i>S. maximus</i> in July-August, 2025.	29
Figure 5 Distribution of the relative mean biomass (kg / km ²) and abundance (n / km ²) of <i>S. maximus</i> in July-August 2025 using BioIndex version 3.3.	30
Figure 6 Length structure of <i>S. maximus</i> caught by sex.	33
Figure 7 Percentage distribution of the <i>S. maximus</i> abundance (ind/km ²), a) undersized individuals and b) standard length.	34
Figure 8 Biomass by mean size classes of <i>S. maximus</i>	35
Figure 9 Age structure of turbot in July-August, 2025.	36
Figure 10 Spatial distribution by ages and lengths of <i>S. maximus</i>	37
Figure 11 <i>S. maximus</i> : Length-weight relationships in July-August, 2025.	38
Figure 12 Percentage distribution and relation between the average length (ML) and coefficient of Fulton (K) by age groups (A) and an average weight (g) of turbot by age groups (B).	40
Figure 13. Sex structure of <i>S. maximus</i> in July-August 2025: distribution by station (female, male, and juvenile specimens are indicated by purple, blue and grey, dark blue, presence of both sexes, and juveniles).	41
Figure 14 Female specimens: Percentage distribution by length classes.	42
Figure 15 Male specimens: Percentage distribution by length classes.	42
Figure 16 Weight structure of <i>S. maximus</i> catches.	44
Figure 17 Weight structure of <i>S. maximus</i> catches by sex: A) immature specimens, B) female and C) male specimens;	45
Figure 18 Location of stations with bycatch from A) spiny dogfish (<i>S. acanthias</i>), B) flounder (<i>Pl. flesus</i>), C) thornback ray (<i>R. clavata</i>) and D) whiting (<i>M. m. euxinus</i>).	47
Figure 19 Length classes (LC, mm) of <i>M. merlangus</i> catch by sex: A) female, B) male.	49
Figure 20 <i>M. merlangus</i> : Age-size relationships.	50
Figure 21 <i>M. merlangus</i> : Length-weight relationships by sex, A) female, B) male and C) indeterminate, July-August, 2025.	51
Figure 22 Weight structure of <i>M. merlangus</i> catches by sex: A) female, B) male and C) undetermined specimens; ..	52
Figure 23 Gonadosomatic index (GSI) by sex of <i>M. merlangus</i> . Box-plot representation showing the median as a vertical line, the interquartile range and the acceptable minimum and maximum values, with individual points indicating outliers.	53
Figure 24 Abundance (n/km ²) by length classes (LC,mm) and depth strata (1, 2 and 3) for VII-VIII 2025;	54
Figure 25 Distribution of mean A) relative biomass (kg / km ²) and B) abundance (n/km ²) of <i>M. merlangus</i> in July-August 2025, according to the BioIndex version 3.3;	55
Figure 26 Abundance (n/km ²) and length classes (LC, mm) of <i>S. acanthias</i> catches by sex, A) female and B) male specimens;	57
Figure 27 Weight structure of <i>S. acanthias</i> by sex, A) female and B) male specimens;	58

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Figure 28 <i>S. acanthias</i> : Length-weight relationships VII-VIII, 2025;	58
Figure 29 Abundance (n/km ²) by length classes (LC,mm) and depth strata (1, 2 and 3), VII-VIII 2025;.....	59
Figure 30 Distribution of the relative biomass by hauls (kg / km ²) of <i>S. acanthias</i> in VII-VIII 2025 according to BioIndex version 3.3.....	60
Figure 31 Abundance (n/km ²) and length classes (LC, mm) of <i>Raja clavata</i> by sex, A) female, and B) male specimens;	62
Figure 32 Weight structure by sex of <i>Raja clavata</i> catches, A) female and B) male specimens;.....	63
Figure 33 <i>Raja clavata</i> : Length-weight relationships VII-VIII, 2025;	63
Figure 34 Abundance (n/km ²) by length classes (LC, mm) and depth strata (1, 2 and 3) for VII-VIII 2025;	64
Figure 35 Distribution of mean A) relative biomass (kg /km ²) and B) abundance (n/km ²) of <i>Raja clavata</i> in V 2025, according to the BioIndex version 3.3;	65
Figure 36 Box-plot: ISF (% BW) values during the spring-summer of 2025.....	67
Figure 37 Spatial distribution of the turbot stomach fullness index (ISF, % BW) during the spring-summer season 2025.....	68
Figure 38 IRI values by species for the spring-summer season of 2025 – Turbot.....	69
Figure 39 Percentage shares by groups (% IRI) in the turbot diet spectrum during the spring-summer season of 2025	70
Figure 40 Box-plot: ISF values for a) <i>Squalus acanthias</i> , b) <i>Raja clavata</i> , c) <i>Merlangus merlangus</i>	74
Figure 41 IRI values by species for the spring-summer season of 2025 - <i>Squalus acanthias</i> ;.....	76
Figure 42 IRI values by species for the spring-summer season of 2025 – <i>Raja clavata</i> ;.....	77
Figure 43 IRI values by species for the spring-summer season of 2025 - <i>Merlangus merlangus</i> ;.....	77
Figure 44 Absolute and relative fecundity of female turbot, July-August 2025;	78

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

BOTTOM TRAWL SURVEY FOR REFERENCE STOCK ASSESSMENT IN BULGARIAN BLACK SEA SECTOR DURING SPRING-SUMMER SUMMER SEASON OF 2025

1. Results from the National Bottom Trawl Surveys in VII-VIII 2025

During 30 July - 21 August 2025, under contract number 153/27.03.2025 with the EAFA, in the framework of the National Program 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. The survey covered the zone between Durankulak and Ahtopol and included an area within the 100 m isobath.

The field survey included the following main activities:

- Data on the depth and geographic coordinates of the start and end points of the trawling were collected.
- Bottom trawl sampling;
- Qualitative and quantitative analyses of catches, identification of biological diversity, and biometric measurement
- Collection of otoliths for age determination
- Sampling and analysis of stomach contents were performed to identify the quantity and composition of consumed food.

This report is based on collected field data and laboratory analyses that established the distribution and magnitude of the relative biomass and abundance of the target species. Analyses performed in relation to turbot included the assessment of biomass and abundance of this target species by depth strata and the study of the size, age, and sex structure of the stock. Calculations of linear-weight dependences and parameters in the von Bertalanffy equation and identification of the peculiarities of turbot nutrition. Analyses of *Merlangius merlangus* included the study of the

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



size-age and sex structure, calculation of length-weight dependences, and parameters in the von Bertalanffy equation and food spectrum. All applicable biological indicators were determined for all specimens of *S. acanthias* caught. The stock assessment of the target species was based on the application of standard methodology (methodology and software products) used in previous trawl surveys of these species in the Black Sea.

The report contains a series of tables and figures that present the distribution of current biomass and numbers, as well as the size, age, and sex structure of the population of the target species, as well as data on bycatch species in the study area.

1.1. Fishing vessel and fishing gear

The trawl surveys were conducted onboard the fishing ship “EGEO 2’ (picture 1) with the following parameters:

- Fishing vessel length -19.5 m;
- Maximum width – 5.9 m;
- Fishing vessel year of built in 2005
- Engine power – 367.75 kW;
- Maximum tonnage – 38.24t;
- Net tonnage – 11.43 t;
- Speed – 9.5 Nd;
- Crew - 3 people;
- Research team: Three people.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



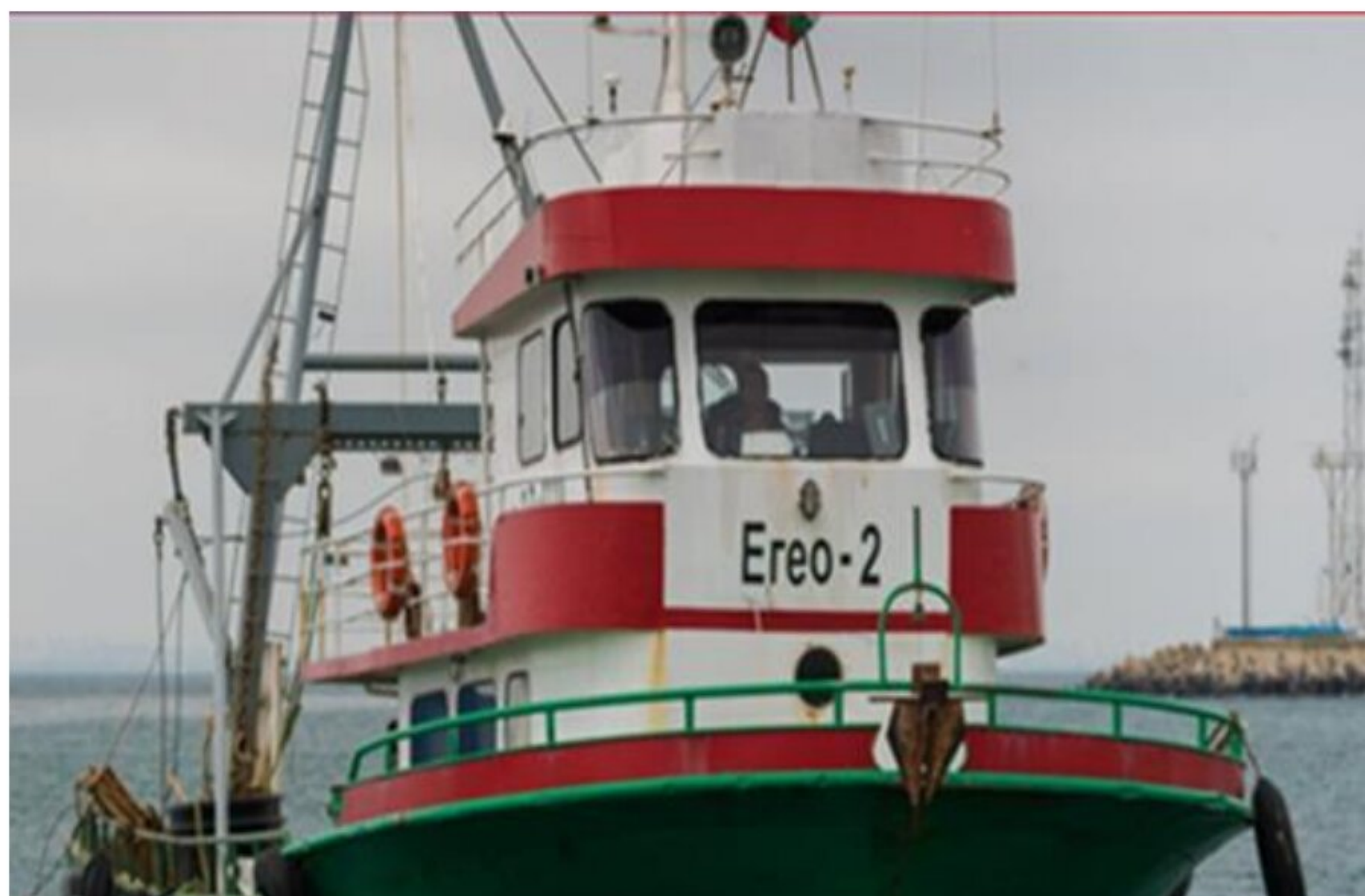
Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME



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;
- Effective part of the headrope - 13 m;
- Effective part of the footrope - 15 m;
- Trawling speed - 2.2 - 2.6 Nd;
- Trawling duration - 60 min.;
- Mesh size - 80/80 mm;

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Picture 2. Bottom trawl 32 / 27-34.

2. Material and methods

The reference species of the demersal survey was turbot (*Scophthalmus maximus*), spiny dogfish (*Squalus acanthias*), whiting (*Merlangius merlangus*) and bycatch from the thornback ray (*Raja clavata*) were also measured and analysed.

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

Field data were collected using standard techniques (bottom trawl) and were kept constant throughout the survey. The GPS system of the ship was connected to the EAFA satellite system to monitor fishing vessels (VMS), and the ship location was strictly controlled during trawling.

A standard methodology for data analysis was applied “swept area”, and the obtained results can be reproduced and compared.

Stratified sampling

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

By sampling individual "strata" the population was divided into geographic regions to spread the monitoring effort evenly across space. Prior information about variable variations was used to improve the efficiency of the survey in estimating mean values and variance. For this purpose, in stratified sampling (of one species), each sample consisted of 50 fish (large fish) and up to 100 fish (small fish) for reliable statistical analysis.

2.1 Information collected through the bottom trawling

- Depth measured with an echo-sounder;
- GPS coordinates of the starting and end points of trawling;
- Trawling duration;
- Abundance of fish species in trawls;
- Weight of total catch in the trawl;
- Absolute and standard length; weight of collected specimens;
- Collection of otoliths for age determination;
- Sex identification;
- Bycatch species composition;
- Stomachs for stomach content analysis of the reference species;
- Measurement of small turbot specimens;

Individuals with an absolute length below the minimum allowed by the ZRA (< 45 cm) are immediately returned to the sea after the measurements.

For biomass calculations of the reference species, catch per unit effort (CPUE) (kg/h) and catch per unit area (CPUA) (kg/km²) were used.

The results are presented in the form of maps and tables that include the following data.

- Survey area (km²);
- Catch per unit effort (kg/trawl)
- Catch per unit area (t/km², kg/km²);

----- www.eufunds.bg -----



- Abundance index (individual/km²);
- Limits of variation in the CPUA
- Total biomass in the entire studied area in front of the Bulgarian coast (t.);
- Abundance in the entire studied area in front of the Bulgarian coast (ind);

2.2. Sampling scheme

To establish the abundance and biomass of the reference species off the coast of the Bulgarian Black Sea, a standard methodology for stratified sampling (Gulland 1966; Sparre and Venema 1998) was applied. The zones in which trawling was performed are shown in Figure 1.

The surveyed region was divided into four strata depending on depth: stratum 1 (15–35 m), stratum 2 (35–50 m), stratum 3 (50–75 m), and stratum 4 (75–100 m). To assess turbot abundance and biomass, the surveyed territory was divided into 143 squares, each with 5 × 5 Nm sides and an area of 25 Nm² (or 85.8569 m²). Sampling was carried out in 40 randomly chosen fields (rectangles), situated at depth between 15-100 m. Each rectangle had sides of 5'Lat × 5'Long, and the total area was 62.58 km² (measured by GIS). Each field was marked with letters and digits for better distinction.

The duration of each haul was 60 min. at a trawling speed of 2.4 knots.

On the shipboard, the absolute and standard lengths, as well as the individual weight of each specimen from the reference species, were measured to determine the size and weight structure of the stocks.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

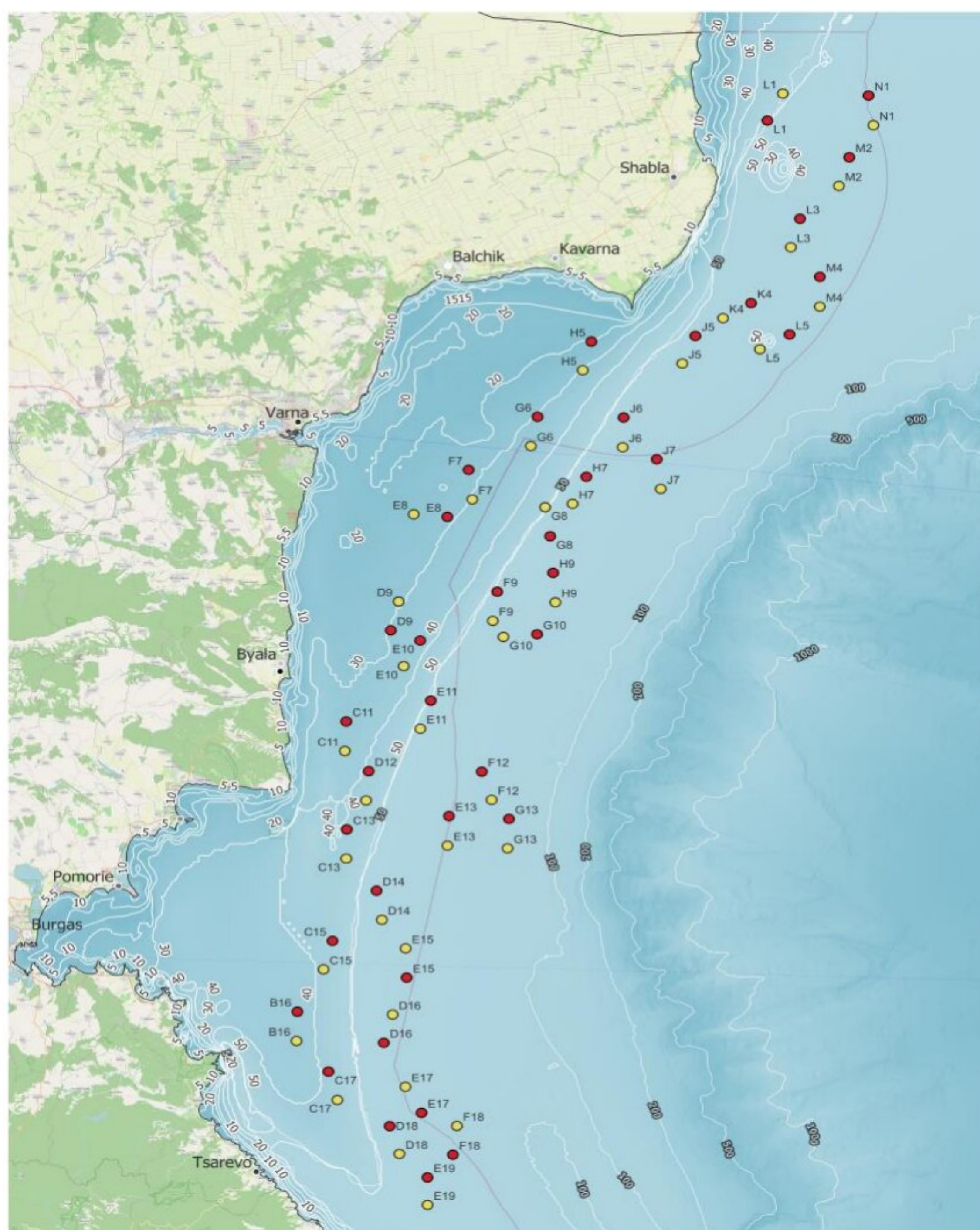


Figure 1 Map of the surveyed sectors.

2.3. Laboratory analyses

After collecting samples onboard, the ship, age, degree of sexual maturity, and nutritional spectrum of the target species were determined under laboratory conditions. The ages of the turbot and whiting were determined from otoliths using a binocular microscope. To determine the size-weight structure of the catches, the average, minimum, and maximum lengths and weights of individuals of both sexes were calculated, and the percentage distribution by size class (TL, cm) was determined.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

During the spring-summer season of 2025, 104 stomachs were analyzed to determine the food spectrum of turbot, and a total of 100 stomachs from additional species - *Squalus acanthias*, *Raja clavata* and *Merlangus merlangus*. Stomach content analysis included the identification of the taxonomic composition and total number of food components, weight, and frequency of occurrence of each food component. Index of stomach fullness (ISF) as a percentage of body mass: (weight of stomach contents/weight of fish body) × 100 (Pinkas et.al., 1971).

IRI, expressed as a percentage, was calculated using the following 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

Index of relative importance (IRI; Pinkas et al., 1971): $IRI = (CN + CB) * FO$, where CN is the proportion of the taxon (species) of the prey in the food by number, CB is the proportion of the taxon (species) of the prey in the food by biomass, and FO is the frequency of occurrence of the taxon (species).

2.4. Statistical methods

Swept areas method

To determine the relative biomass of the reference species, the swept area method was applied using the BioIndex program : R code to perform bottom trawl data analysis using the MEDITS file format (TA,TB and TC), which enables the calculation of standardized biomass and abundance and length frequency distributions, sex ratio by size class and many other useful results such as: quality checks, trawl positions, period, etc.

(<https://data.europa.eu/doi/10.2760/5799>,

<https://cran.r-project.org/web/packages/MEDITS/MEDITS.pdf>)

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

The swept area is computed according to a simple formula: in the TA file are stored distance covered and net wing opening, so it is only a matter to run $sqkm = \frac{TA \times \text{wing_opening}}{10000000 \times \text{distance}}$ assignment of each haul to one of the five stratification MEDITS depth strata is performed according to the haul mean depth $= \frac{(TA \times \text{shooting_depth} + TA \times \text{hauling_depth})}{2}$.

<https://data.europa.eu/doi/10.2760/5799>,

Biomass and abundance indices (kg/km², n/km²)

To estimate the mean, variance, standard deviation, and coefficient of variation of the abundance indices in number and weight by square kilometer using stratified random sampling, the following formulations were used (Cochran 1977; Souplet 1996):

Average by strata:

$$\bar{x}_i = \frac{\sum_{j=1}^{n_i} x_{i,j}}{\sum_{j=1}^{n_i} A_{i,j}}$$

$x_{i,j}$ is the weight of individuals caught in the individual hauls of the stratum and $A_{i,j}$ is the corresponding swept area. Variance was calculated using the following formula:

$$S_{x_i}^2 = \frac{1}{n_i - 1} \sum_{j=1}^{n_i} A_{i,j} \left(\frac{x_{i,j}}{A_{i,j}} - \bar{x}_i \right)^2$$

The abundance index of the main strata (shelf, slope, and total) was computed using the following formula (Souplet, 1996):

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



$$I = \sum_{i=1}^N W_i \bar{X}_i$$

W_i is the weight of each individual stratum, calculated as the ratio between the area of the stratum and total area of the study area. The variance in this case is given by the following formula:

$$\text{var}(I) = \sum_{i=1}^N \frac{W_i^2 S_{x_i}^2}{\sum_{j=1}^{n_i} A_{i,j}} (1 - f_i)$$

where f_i is the ratio between the swept area and the area of the stratum, that is, the correction factor for finite populations (fpc).

Standard deviation is:

$$\text{s.d.} = \sqrt{\text{Var}(I)}$$

and the Coefficient of Variation is.

$$\text{CV\%} = (\text{s.d.}/I) * 100$$

The catch per unit effort (CPUE) was calculated by dividing the trawl catch by the fishing hours (kilograms/h):

$$\text{CPUE} = \text{yield/effort}$$

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Maximum sustainable yield

Gulland's formula for virgin stock is

$$MSY = 0.5 * M * B_v$$

M – coefficient of natural mortality, B_v- 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:

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

$\bar{B}$ - Mean annual biomass, Z = total mortality.

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

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

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

TAC - total allowable catch, Prediction models

Beverton and Holt yield per recruit model (1957):

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

$S = \exp [-K (T_c - t_0)]$, K = von Bertalanffy growth parameter, t_0 = von Bertalanffy growth parameter, T_c = age at first capture, T_r = age at recruitment, W_{∞} = asymptotic body weight, F = fishing mortality, M = natural mortality, $Z = F + M$, total mortality.

The formulae of **Pauly (1983)** were used to evaluate the exploitation ratio: $E = F/Z$, E = exploitation ratio, F = fishing mortality, and Z = total mortality.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Jones' Length-Based Cohort Analysis (1981)

Jones' length-based cohort analysis:

$$\exp\left(\frac{M}{2} \Delta t\right) = \exp\left[\frac{M}{2} \cdot \frac{1}{K} \cdot \ln\left(\frac{L_{\infty} - L_1}{L_{\infty} - L_2}\right)\right] = \exp\left[\ln\left(\frac{L_{\infty} - L_1}{L_{\infty} - L_2}\right)^{M/2K}\right] = \left[\frac{L_{\infty} - L_1}{L_{\infty} - L_2}\right]^{M/2K}$$

Age and growth

To estimate the turbot growth rate, the von Bertalanffy growth function (1938) was applied according to Sparre and Venema (1998):

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

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

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_0 - the initial condition parameter.

The length - weight relationship was obtained using the following equation:

$$W_t = qL_t^n$$

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

Fulton's coefficient - K (Nash et al. 2006) is calculated using the measured weight and length of the respective specimens: $K = 100 \cdot (W/L^3)$, where: W - weight, L - length.

Natural mortality (M)

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

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

$$\log M = -0.2107 - 0.0824 \cdot \log W_{\infty} + 0.6757 \cdot \log k + 0.4687 \cdot \log T^{\circ}C$$

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

L_{∞} , W_{∞} and k – parameters in von Bertalanffy's equation; $T^{\circ}\text{C}$ - 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.

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, the following activities were conducted:

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

For each haul, qualitative and quantitative analyses of the catch were performed, including biometric measurements of 206 specimens of turbot, 2 european flounder, 102 thornback ray and 35 spiny dogfish specimens (Pictures 4 and 5);

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME



Pictures 3. Bottom trawling yield

The constant presence of the species *S. maximus* in almost all bottom trawls at a depth of between 50-75 m has been established, when catching - at least 2-5 specimens per trawl (at catch $\neq 0$). At depths - 75-100 m., the average recorded catch is low, and at 15-50 m, the average catch from turbot increases. In seven sectors, the highest catch was obtained, which ranged between 20.5-40.8 kg/trawl.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME



Photo 4. Catch of turbot (*Scophthalmus maximus*) and accompanying species - *Merlangius merlangus* (whiting), *Mullus barbatus* (red mullet), *Raja clavata* (thornback ray) and spiny dogfish (*Squalus acanthias*);

During the study, 35 specimens of spiny dogfish (*Squalus acanthias*) were caught and measured, and their size ranged from 41 cm (0.260 kg) to 141 cm (13.1 kg) (photo 4). In addition to turbot catches, relatively high quantities of whiting (*Merlangius merlangus euxinus*) and thornback ray (*Raja clavata*) have been identified. Companion species also include plaice (*Platichthis flesus*) and red mullet (*M. barbatus*).

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME



Pictures 5. Performing biometric measurements and collecting samples for research of stomach contents.

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

Trawling at a depth of up to 30 m covers three stations and due to their small number, they are grouped together with the stations up to 50 m, and the statistical analysis was carried out on a stratum of 15 - 50 m. The instantaneous biomass of the three stations with a depth of up to 30 m reaches respectively - 226.5 kg/km², 92.7 kg/km² and 174.2 kg/km², with abundance - 103 ind./km², 34 ind./km² and 68 ind./km². High catches at the stations at shallow depth are realized in front of Shkorpilovtsi and Kavarna (Table 1, Fig. 2).

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

The average value of the relative biomass of turbot is high in a stratum of 50-75 - 320 kg/km² and respectively the average abundance is 148 specimens/km², and in a stratum of 15-50 m, the average relative biomass remains lower - 123 kg/km² and the average abundance - 51 specimens/km², (Table 1, Fig. 2 and Fig. 3).

Information on the yields by stratum is provided below.

Stratum 15-50 m

In this stratum, the mean value of the relative biomass varies 0 - 375 kg/km², with an average of 123 kg/km² (Table 1, Figs. 2 and 3). Abundance indices vary between 0 and 138 specimens/km², average - 51 specimens/km² (Tab. 2).

Stratum 50 -75 m

Turbot relative biomass in this stratum is high, ranging from 40 to 700 kg/km² and averaging 320 kg/km² (Tab. 1, Figs. 2 & 3). Abundance ranges from 17 to 378 individuals/km², averaging 148 individuals/km² (Tab. 2).

Stratum 75-100 m

In this stratum, the average value of the relative biomass is between - 0 - 267 kg/km², the average is 124 kg/km² (Tab. 1, Fig. 2 and 3), and the average value of the abundance is 64 specimens/km² (Tab. 2).

Table 1

Relative biomass of turbot (kg/km²) by stratum, July-August 2025.

15 - 50 m		50 – 75 m		75-100 m	
No. station	kg/km ²	No. station	kg/km ²	No. station	kg/km ²
12	227	19	40	17	146
2	93	33	270	35	267
3	174	29	295	25	215
21	2	16	700	8	228
1	0	37	101	14	0
26	73	13	271	18	220
20	165	5	350	9	0
31	62	15	606	23	40
27	259	11	498	24	0
28	375	34	355		
32	154	6	366		
30	33	7	191		
4	0	36	195		
22	105	38	482		
		10	79		
Total	1721	Total	4798	Total	1115
Average	123	Average	320	Average	124
Standard error	29		49		38
Median	99		295		146
Standard deviation	110		191		113
Sample variance	12183		36503		12816



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

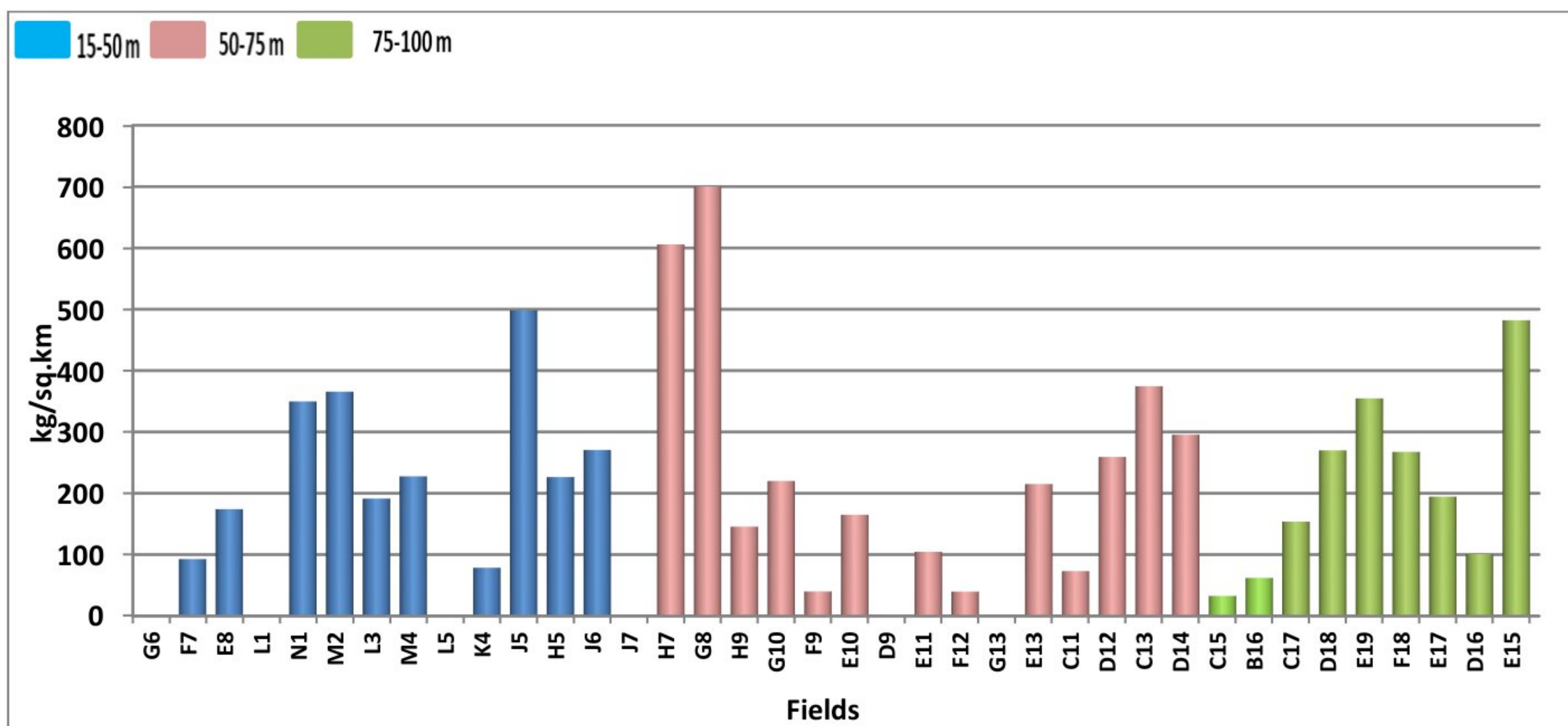


Figure 2 Relative biomass (kg/km²) of *S. maximus* by strata off the Bulgarian Black Sea coast, VII-VIII 2025

Table 2 presents detailed data on turbot abundance by strata in July-August 2025.

Table 2

Abundance of *S. maximus* by stratum in July-August 2025.

15 - 50 m		50 – 75 m		75-100 m	
No. station	No. Ind./km2	No. station	No. Ind./km2	No. station	No. Ind./km2
12	103	19	17	17	85
2	34	33	86	35	120
3	68	29	136	25	102
21	17	16	378	8	171
1	0	37	51	14	0
26	17	13	136	18	85
20	85	5	136	9	0
31	17	15	324	23	17
27	85	11	237	24	0
28	138	34	109		
32	68	6	169		

www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

30	17	7	86		
4	0	36	118		
22	68	38	205		
		10	35		
Total	717	Total	2222	Total	579
Average	51	Average	148	Average	64
Median	11		26		21
Standard error	51		136		85
Standard deviation	43		102		63
Sample variance	1807		10388		3910

3.2. Catch per unit effort (CPUE)

The catches, from a total of 38 trawls, are distributed as follows:

12 trawls (31.58%), catch 0 - 4.99 kg per trawl;

6 trawls (15.79%), catch 5.0 - 9.99 kg. per trawl;

11 trawls (28.95%), catch 10.0 - 15.99 kg per trawl;

9 trawls (23.68%), catch 16.0 - 40.99 kg per trawl;

Sector < 30 m; 4 trawls:

- o 4 trawls, catch 0.1 – 13.99 kg per trawl;

Sector 31 - 50 m; 10 trawls:

- o 4 trawls, catch - 0.1 - 4.99 kg per trawl;
- o 3 trawls, catch - 5.0 - 10.0 kg per trawl;
- o 3 trawls, catch - 10.0 - 40.99 kg per trawl;

Sector 50 – 75 m; 17 trawls:

- o 3 trawls, catch 0 - 4.99 kg per trawl;
- o 7 trawls, catch 5.0 - 15.99 kg per trawl;

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

- o 7 trawls, catch 16.0 -29.99 kg per trawl;

Sector 75 – 100 m; 7 trawls:

- o 4 trawls, catch 0 - 4.99 kg per trawl;
- o 3 trawls, catch 8.0 - 15.99 kg per trawl;

The data on catch per unit effort (CPUE) during the expedition in VII-VIII/2025 were presented in Table 3 and Fig.3.

Table 3

The sampling stations, coordinates and CPUE (kg/trawl) in July-August 2025

№	Field	Starting coordinates		Depth (m)	Speed (Nm)	Trawling time (min)	Catch turbot	
		ϕ	λ				№	Kg
1	G6	4312.84	2818.584	31	2.4	60	0	0
2	F7	4308.47	2811.757	27	2.4	60	2	5.46
3	E8	4304.604	2809.65	28	2.4	60	4	10.225
4	L1	4337.115	2841.363	48.5	2.4	60	0	0
5	N1	4339.156	2851.38	57	2.4	60	8	20.56
6	M2	4334.115	2849.47	64	2.4	60	10	21.609
7	L3	4329.086	2844.59	65	2.4	60	5	11.17
8	M4	4324.325	2846.558	75	2.4	60	10	13.34
9	L5	4319.6	2843.56	79	2.4	60	0	0
10	K4	4322.175	2839.745	69	2.4	60	2	4.48
11	J5	4319.48	2834.222	58	2.4	60	14	29.39
12	H5	4319.015	2823.914	20	2.4	60	6	13.25
13	J6	4312.78	2827.113	57	2.4	60	8	15.91
14	J7	4309.34	2830.4	78	2.4	60	0	0
15	H7	4307.9	2823.42	57	2.4	60	19	35.49
16	G8	4303	2819.84	55	2.4	60	22	40.81
17	H9	4259.982	2820.13	71	2.4	60	5	8.53
18	G10	4254.91	2818.54	78	2.4	60	5	12.98
19	F9	4258.42	2814.59	53.5	2.4	60	1	2.33
20	E10	4254.394	2806.958	36	2.4	60	5	9.66

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

21	D9	4255.236	2804.046	30.5	2.4	60	1	0.13
22	E11	4249.42	2808.014	51	2.4	60	4	6.16
23	F12	4243.535	2813.065	79	2.4	60	1	2.33
24	G13	4239.622	2815.76	87	2.4	60	0	0
25	E13	4239.85	2809.817	74	2.4	60	6	12.69
26	C11	4247.692	2759.638	32	2.4	60	1	4.31
27	D12	4243.58	2801.855	40	2.4	60	5	15.23
28	C13	4238.743	2759.689	40.5	2.4	60	8	21.78
29	D14	4233.66	2802.632	54	2.4	60	8	17.4
30	C15	4229.487	2758.263	44	2.4	60	1	1.93
31	B16	4223.59	2754.79	37.5	2.4	60	1	3.63
32	C17	4218.59	2757.875	41	2.4	60	4	9.07
33	D18	4214.045	2803.94	54	2.4	60	5	15.79
34	E19	4209.755	2807.68	60.5	2.4	60	6	19.607
35	F18	4211.653	2810.2	73	2.4	60	7	15.61
36	E17	4215.16	2807.1	65	2.4	60	7	11.57
37	D16	4221	2803.354	57	2.4	60	3	5.93
38	E15	4226.432	2805.622	66.5	2.4	60	12	28.21

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

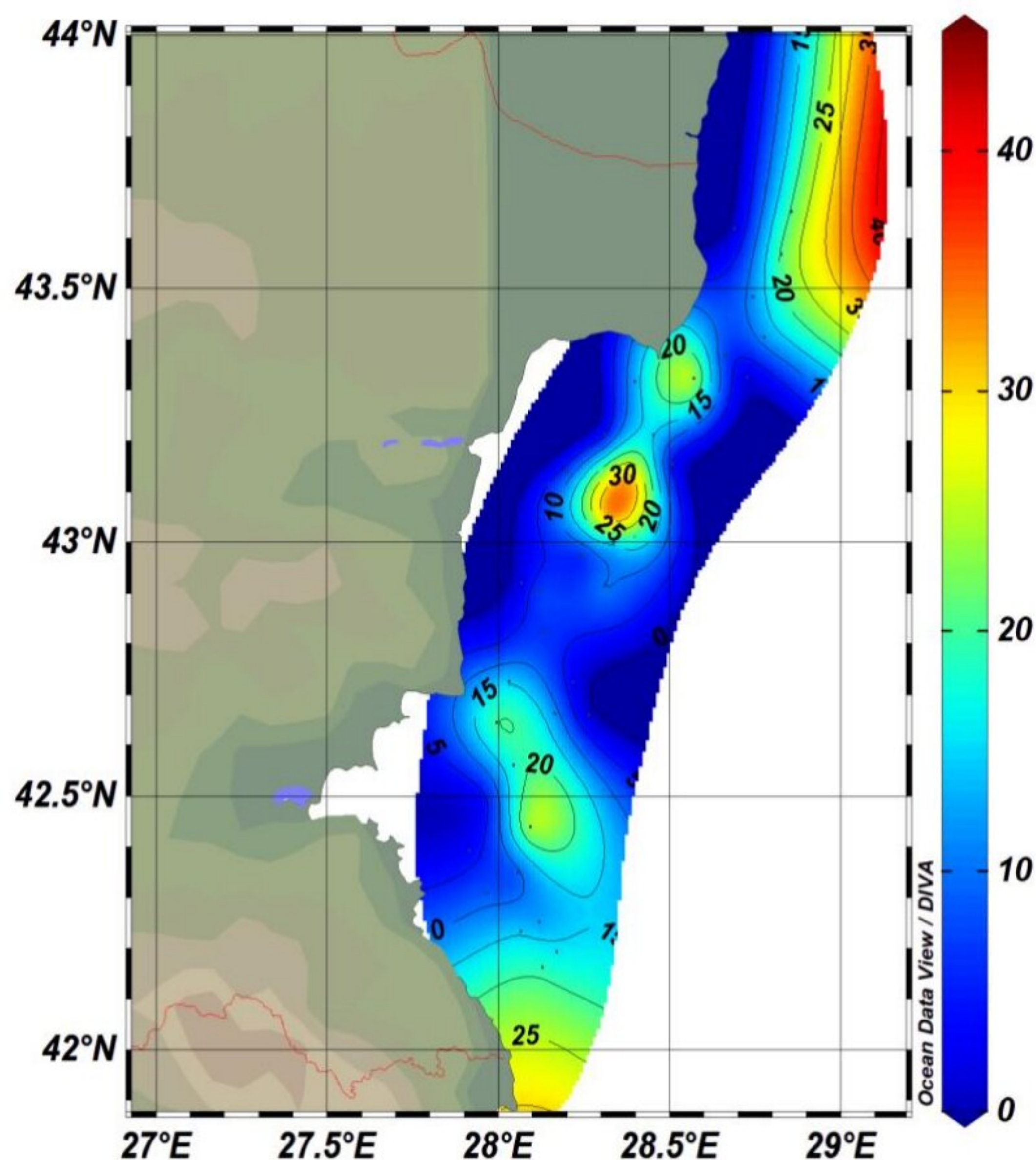


Figure 3 Distribution of catch per unit effort (CPUE, kg/h).

3.3. Catch per unit area (CPUA)

The results of processing the data on the abundance and biomass of turbot are presented in Table.4, Fig. 2, Fig. 4 and Fig. 5.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

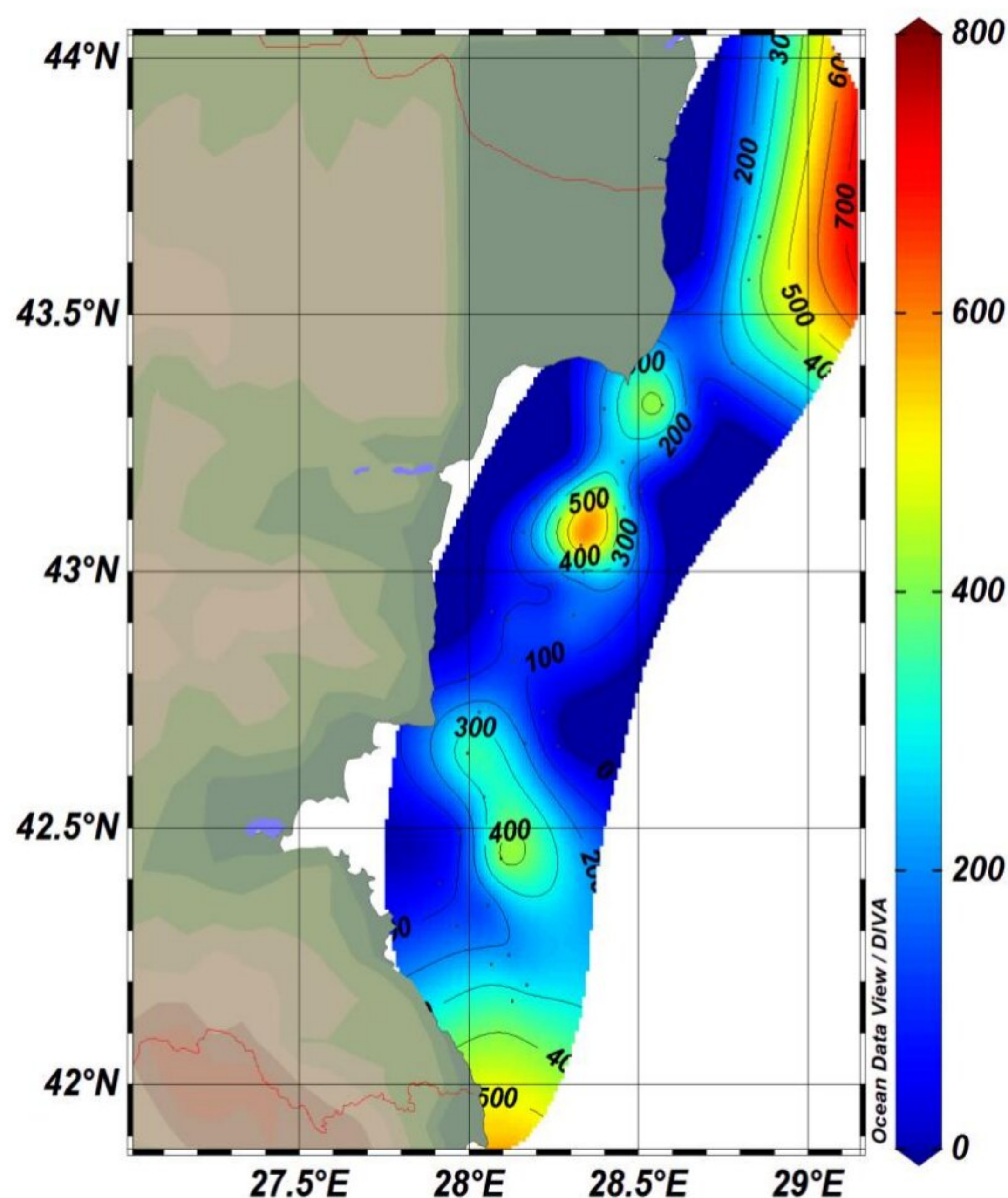


Figure 4 Distribution of the relative biomass (kg/km²) of *S. maximus* in July-August, 2025.

In seven fields in the Bulgarian Black Sea has been found a relatively high biomass levels were recorded - 355 - 700 kg/km², in the direction from north to south, in front of Shabla – C. Kaliakra (f. M2, J5) with a depth of 58 - 68 m, in front of Varna at a depth of 55 - 60 m (f. H7, G8), under C. Emine 40 - 66 m (C13, E15), and opposite Tsarevo (f. E19) with a depth of 60-62 m (Figs. 2 and 4).



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

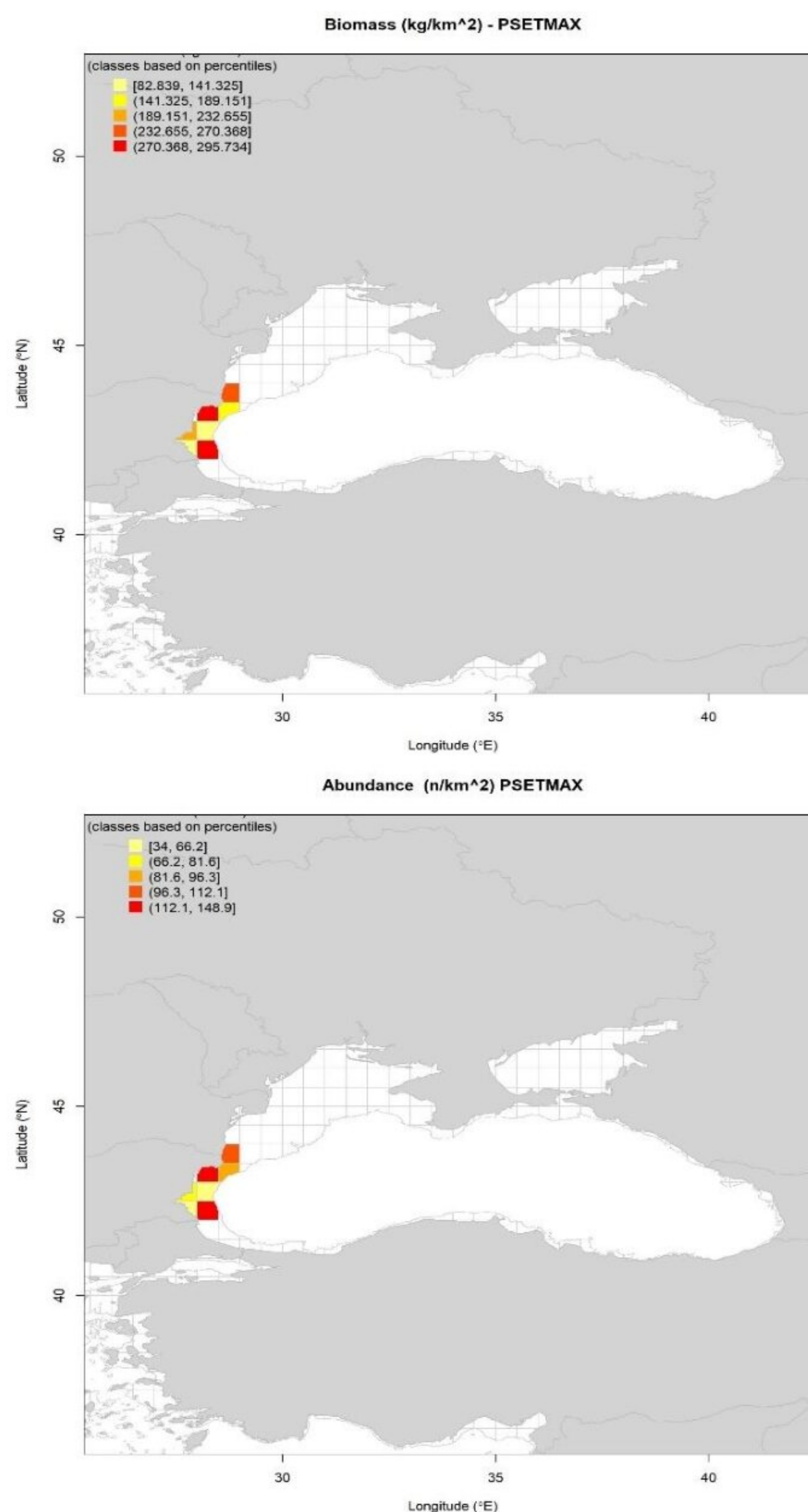


Figure 5 Distribution of the relative mean biomass (kg / km²) and abundance (n / km²) of *S. maximus* in July-August 2025 using BioIndex version 3.3.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

Table 4

A) Abundance and biomass per fields and B) standard deviations overall for all fields, of turbot in the Bulgarian waters area during July-August 2025.

A)

No. Station	Field	t/km²	No. ind./km²
1	G6	0.00	0
2	F7	0.09	34
3	E8	0.17	68
4	L1	0.00	0
5	N1	0.35	136
6	M2	0.37	169
7	L3	0.19	86
8	M4	0.23	171
9	L5	0.00	0
10	K4	0.08	35
11	J5	0.50	237
12	H5	0.23	103
13	J6	0.27	136
14	J7	0.00	0
15	H7	0.61	324
16	G8	0.70	378
17	H9	0.15	85
18	G10	0.22	85
19	F9	0.04	17
20	E10	0.17	85
21	D9	0.00	17
22	E11	0.10	68
23	F12	0.04	17
24	G13	0.00	0
25	E13	0.22	102
26	C11	0.07	17
27	D12	0.26	85
28	C13	0.37	138

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

29	D14	0.30	136
30	C15	0.03	17
31	B16	0.06	17
32	C17	0.15	68
33	D18	0.27	86
34	E19	0.35	109
35	F18	0.27	120
36	E17	0.19	118
37	D16	0.10	51
38	E15	0.48	205
Total		7.63	3518
Average		0.20	93

B)

	t/km ²	No ind./km ²
Standard error	0.03	14
Median	0.18	85
Standard deviation	0.17	87
Sampling dispersion	0.03	7505

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

The turbot biomass in the entire studied area in front of the Bulgarian coast of the Black Sea was estimated at **1945.75** tonnes (Table 4). The abundance in the studied area was estimated at **897.56 *10³** specimens (Table 4).

3.4. Size structure

The information about the size structure of the turbot population was based on biometric measurements of 206 turbot specimens and included data on the absolute and standard length and individual weight (pic.5).

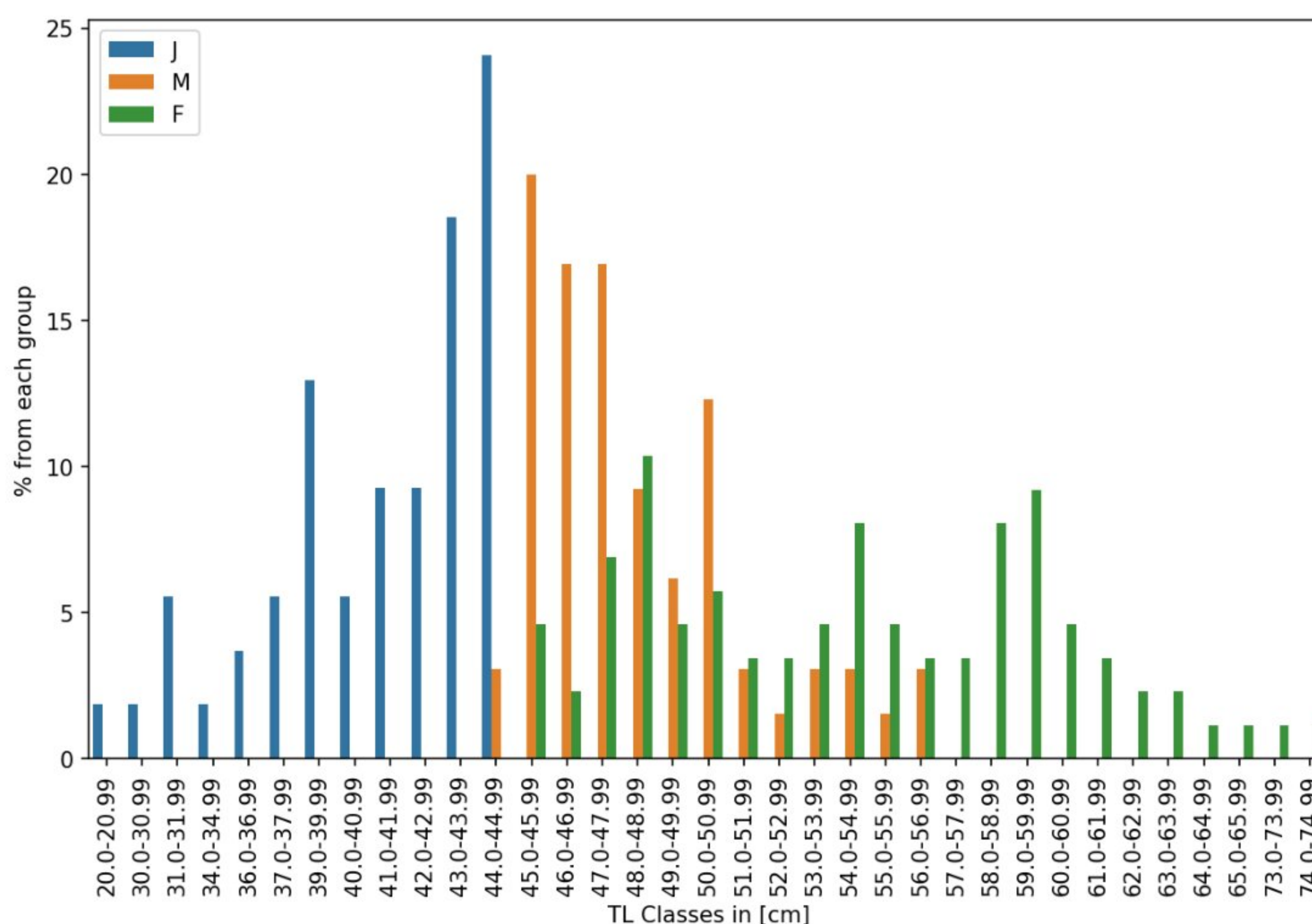


Figure 6 Length structure of *S. maximus* caught by sex.

The total length ranges between 20 and 74 cm, with a weight between 130 and 7100 g. The total catch of turbot reaches 446.57 kg. Of the total number of specimens - 206, 18 have sizes between 19-39.5 cm (8.74%), 38 specimens - between 40.0-44.5 cm (18.45%), 70 - in the range between 45.0-49.0 cm (33.98%) and 80 - in the range between 50.0-74.0 (38.83%).

Specimens over 45.0 cm predominate in the total catch 73.79% /152 individuals/, and those under 45.0 cm are 54 /26.21%/, females dominate 42.23% /87 specimens/ over males 31.55% /65 individuals/.

The size structure was analyzed in compliance with national regulations, setting out the minimum permissible length of individuals for fishing purposes. Thus, individuals with an absolute length < 45 cm were marked as undersized, and those with a length > 45 cm were marked as the standard.

Fig. 7 shows the total turbot abundance (ind/km²) and the distribution of undersized individuals and those of standard length.

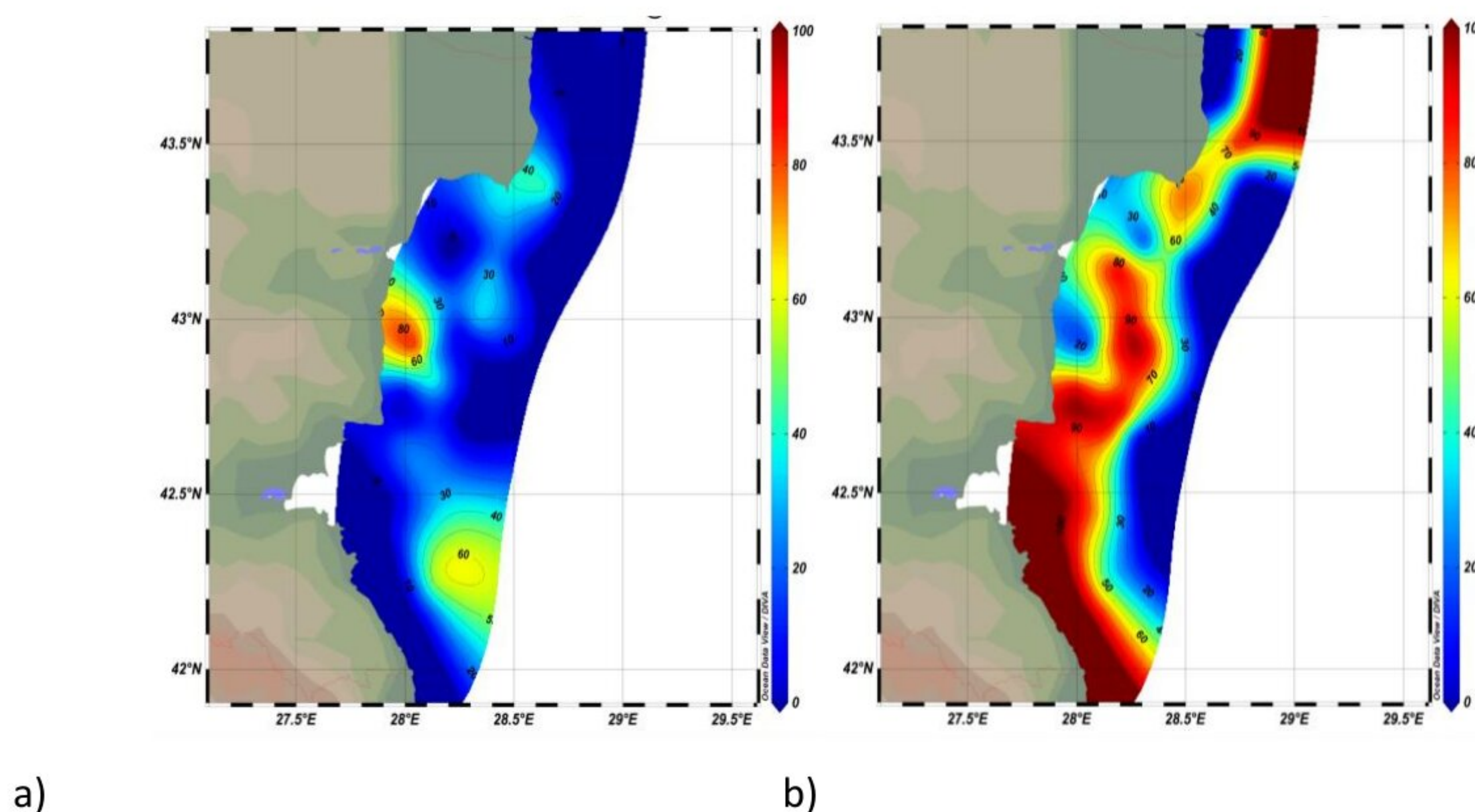


Figure 7 Percentage distribution of the *S. maximus* abundance (ind/km²), a) undersized individuals and b) standard length.

The relative turbot biomass by size class is shown in Fig. 8, indicating high biomass for two length classes - those 43-51 cm and 58-61 cm.

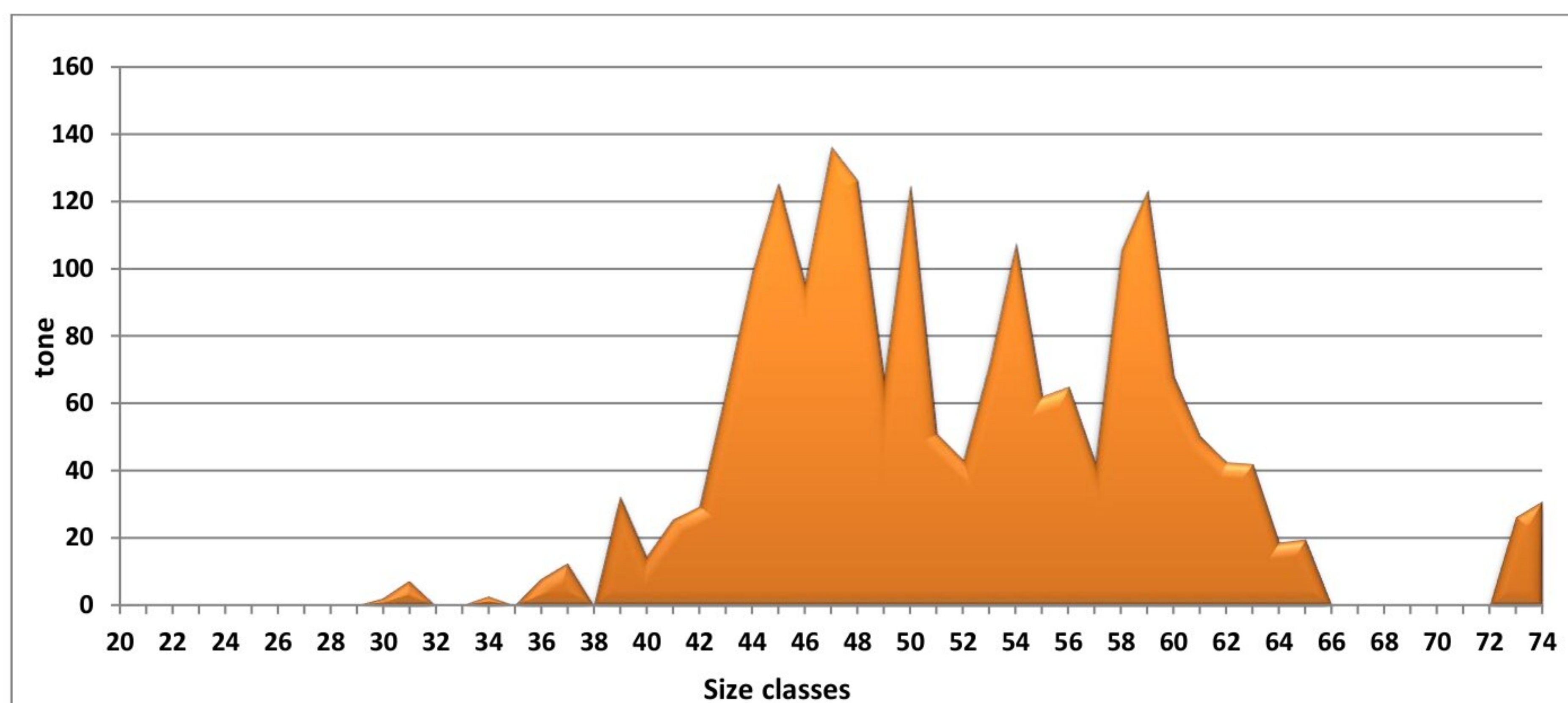


Figure 8 Biomass by mean size classes of *S. maximus*.

3.5. Age structure

The age composition of turbot was determined by analysis of 152 pairs of otoliths. The age structure of turbot includes from 1 to 10 year old specimens, with a dominant role of 3 (29.61%), 4 (25.73%) and 5 (19.42%) - the annual (74.76% total), followed by the 6-year-old specimens - 10.19% (Fig. 9).

During the spring-summer season of 2025, specimens exceeding 45 cm (73.79%) are more prevalent than those measuring under 45 cm (26.21%).

Specimens aged 8, 9, and 10 years are recorded in the catches.

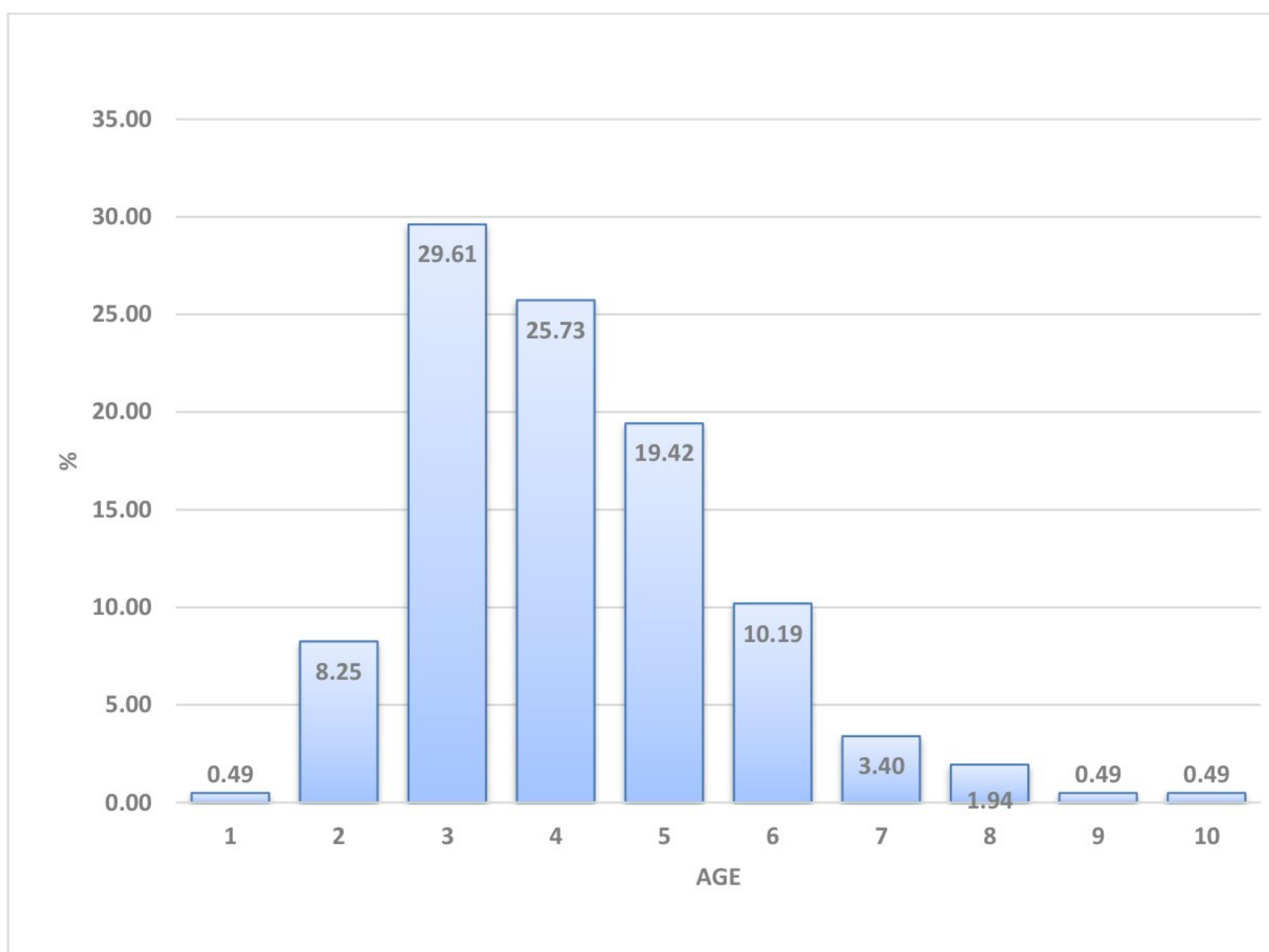


Figure 9 Age structure of turbot in July-August, 2025.

The spatial distribution of *S. maximus* according to the age class in the surveyed area is shown in Fig.10.

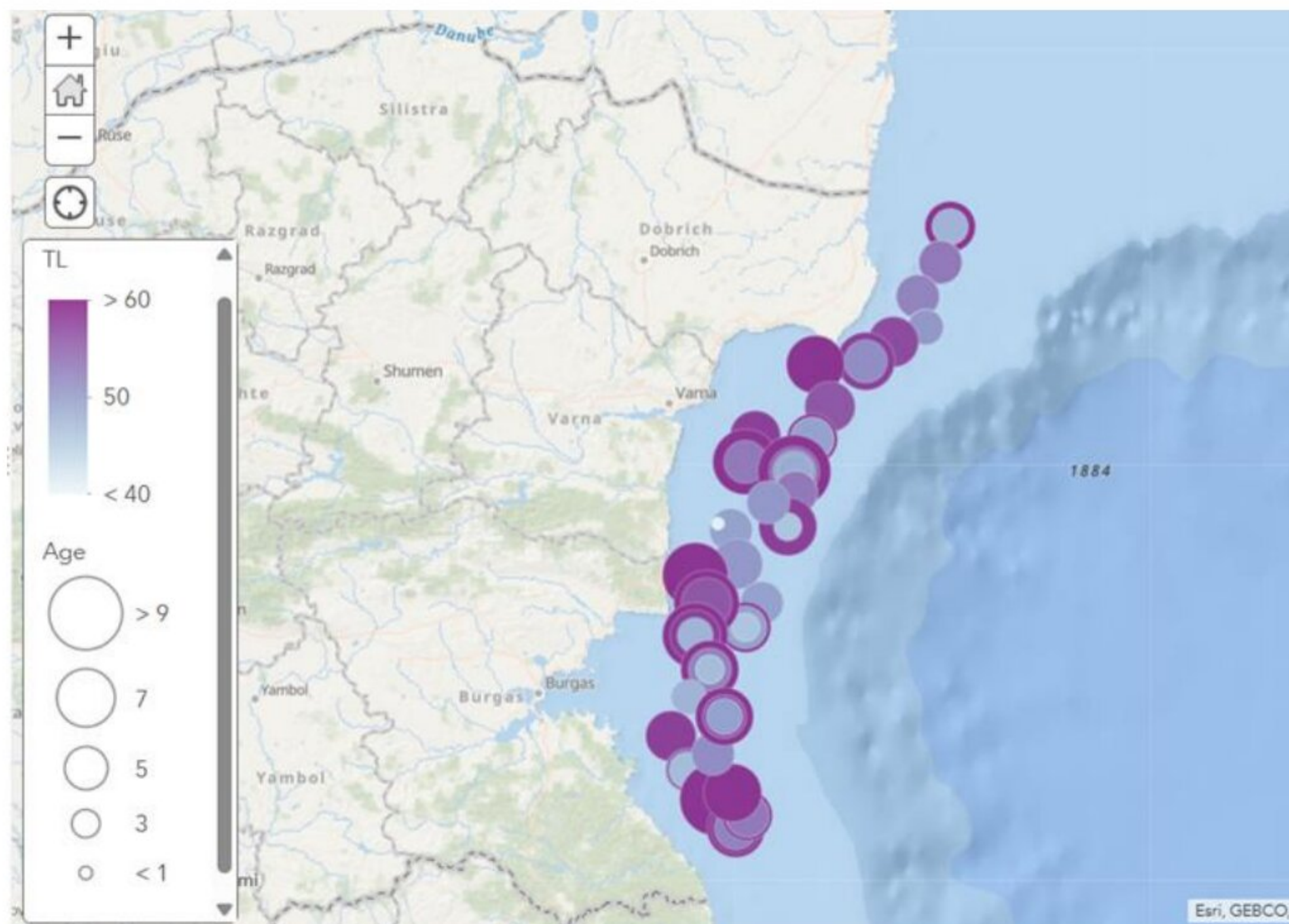


Figure 10 Spatial distribution by ages and lengths of *S. maximus*.

3.6. Biological parameters of *S. maximus*

To establish the rate of turbot growth in the Bulgarian waters of the Black Sea during the spring-summer season of 2025, data on the absolute lengths and weights of all measured specimens were analyzed. The von Bertalanffy growth equations were derived from the absolute length-at-age data, which included both sexes, undersized individuals, and combined samples. The parameters k , L_{∞} , and t_0 were estimated (see Table 5). The values of these parameters in the von Bertalanffy equation were computed as follows:

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

Table 5

Von Bertalanffy parameters and L-W dependence.

sex	Linf (mm)	k	t0	a	b
F	831.0657	0.1578	-1.5747	2.85	2.92
M	560.3565	0.4824	-0.0977	4.85	2.84
C	889.7015	0.1284	-2.1233	1.90	2.98

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

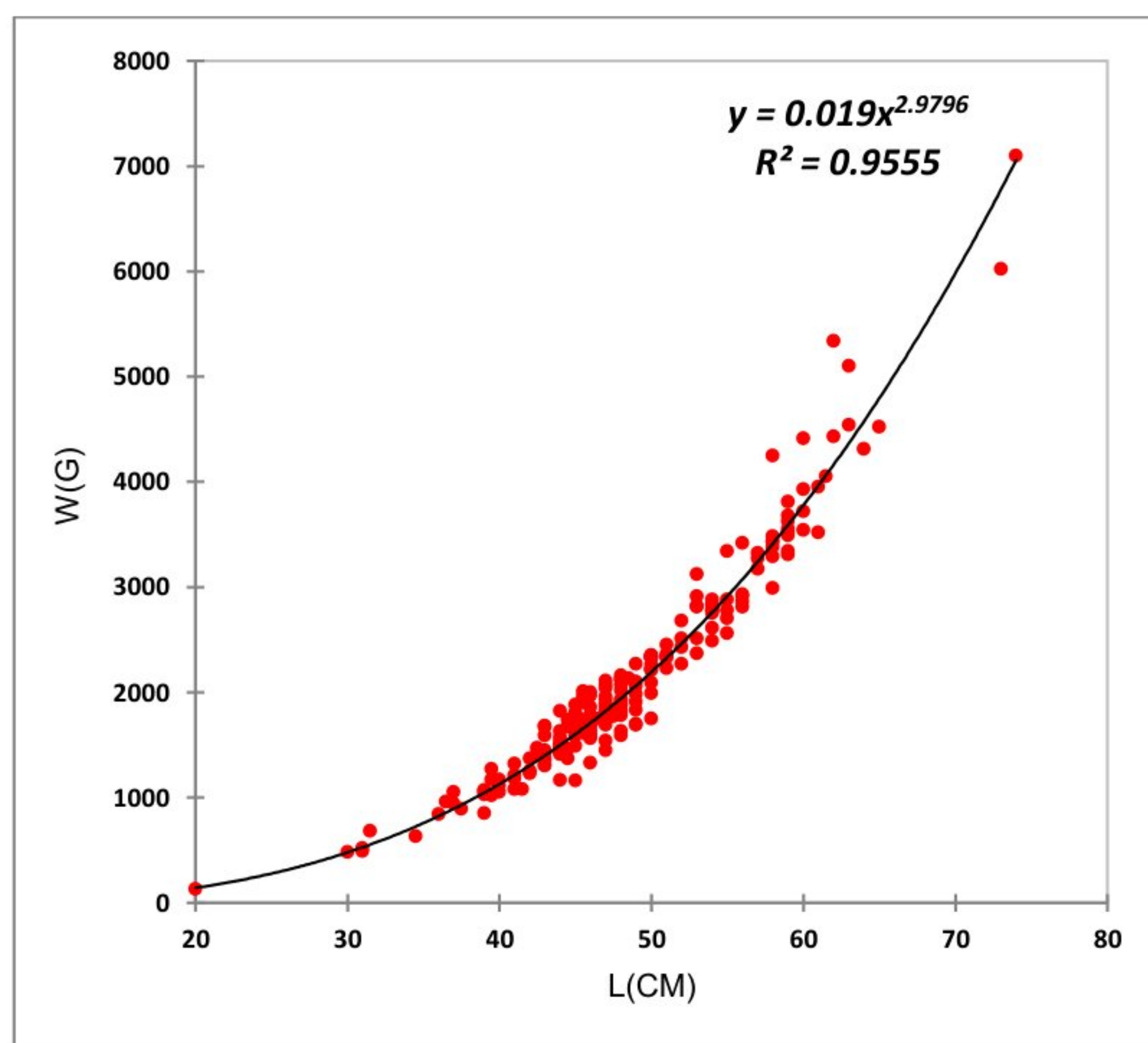


Figure 11 *S. maximus*: Length-weight relationships in July-August, 2025.

The coefficient of natural mortality (M) was calculated according to Pauly's formula (1980), which describes natural mortality as a function of k , L_{∞} , W_{∞} , and water temperature at the bottom layer.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

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

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

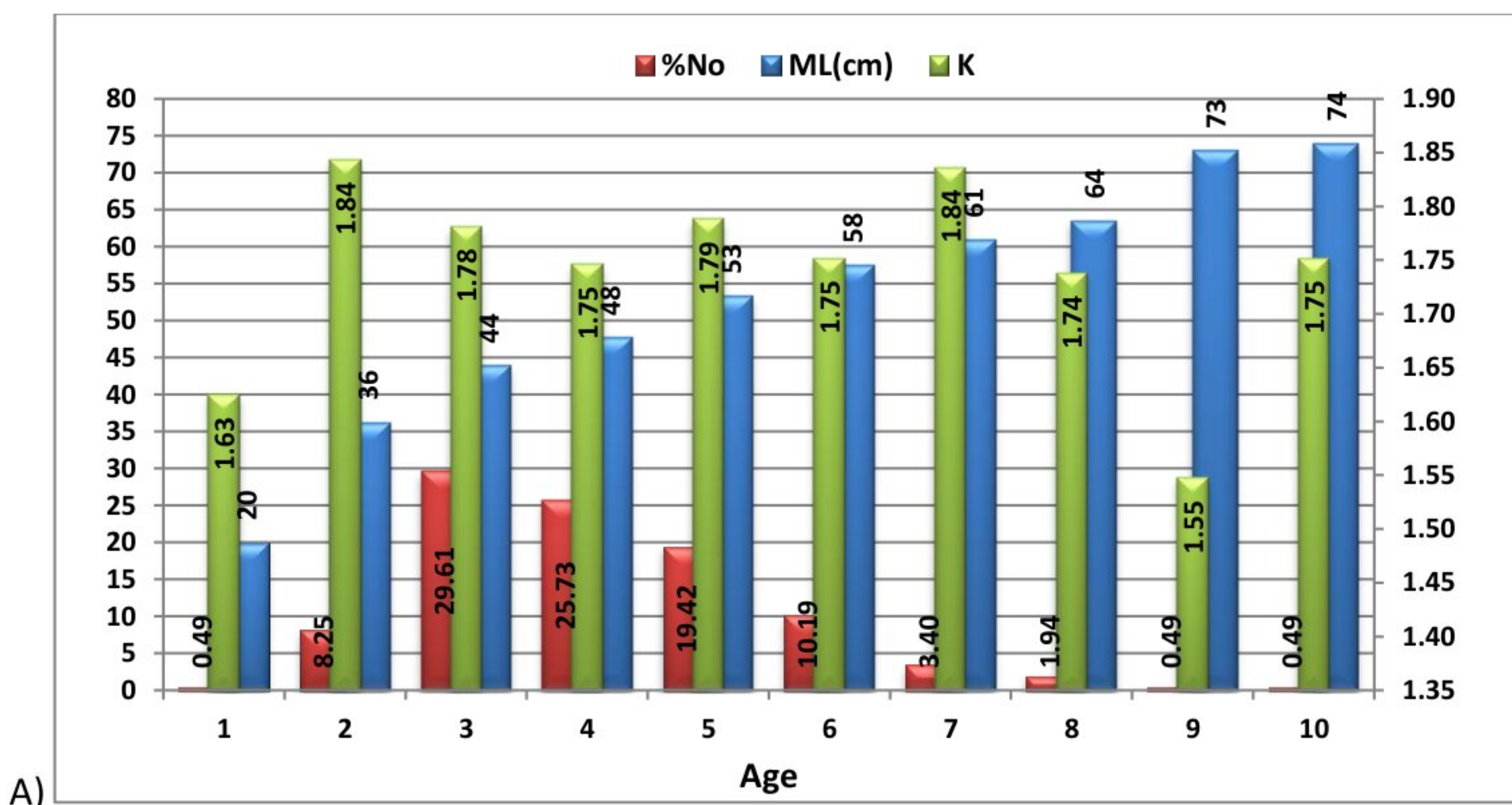
$$\log(-t_0) = -0.3922 - 0.2752 * \log L_{\infty} - 1.038 * \log k$$

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

Considering that water temperature was 8 °C during the study period, the coefficient of natural mortality (M) for both sexes was: 0.31.

Fulton's condition factor (K)

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



www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

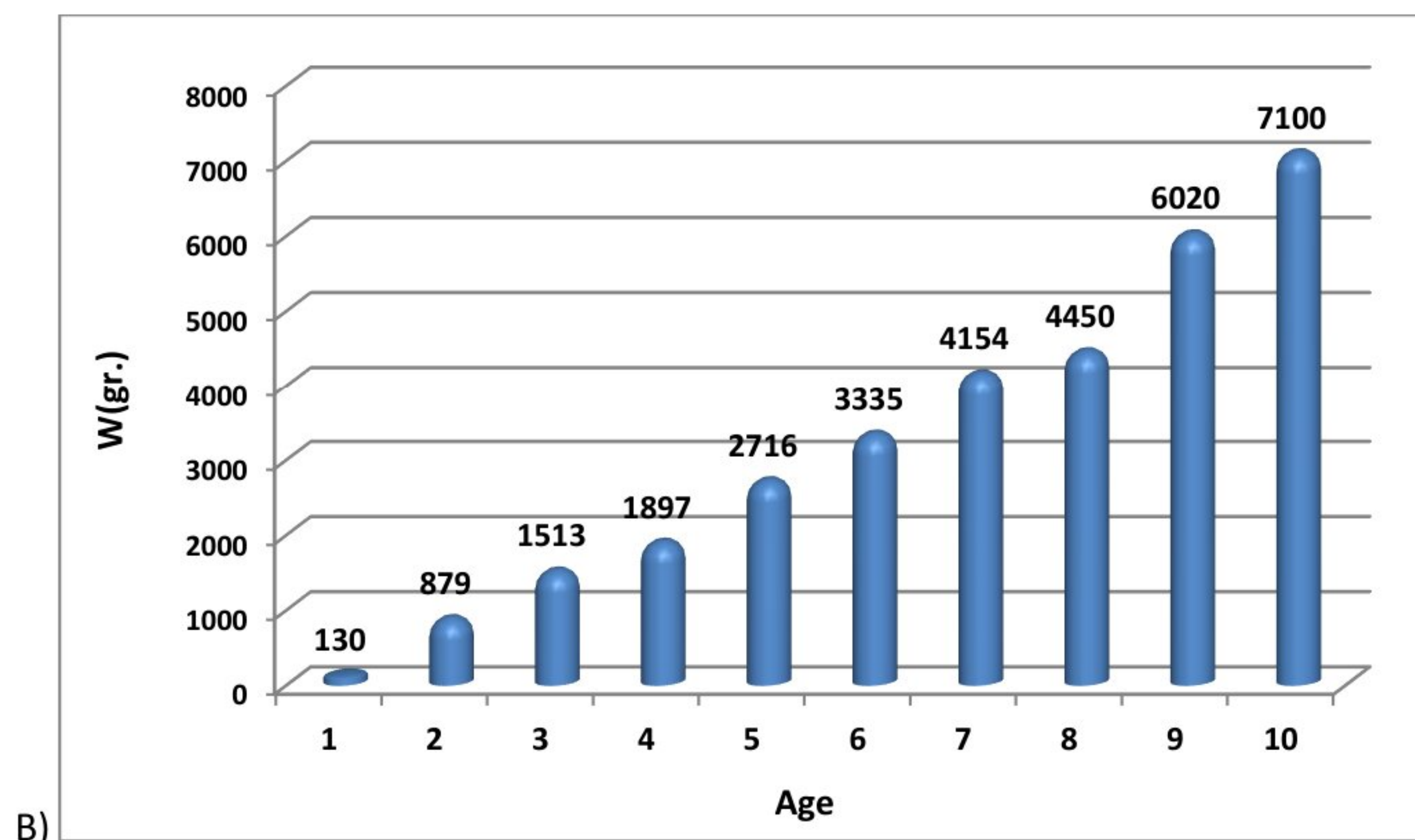


Figure 12 Percentage distribution and relation between the average length (ML) and coefficient of Fulton (K) by age groups (A) and an average weight (g) of turbot by age groups (B).

3.7. Sex structure

Sex ratio

The results of the turbot sex structure analysis of turbot catches in the Bulgarian sector of the Black Sea during the spring-summer season of 2025 reveals that immature individuals constitute for 26.21 % of the total catch, while sexually mature individuals represent 73.79%. Females comprise 42.23 %, and males constitute 31.55 %. The sex ratio of sexually mature individuals is 57.24 % females and 42.76 % males.

Among the 38 surveyed areas along the Bulgarian coast, no female individuals were detected in 9 areas, no male specimens were identified in 15 areas, and no juvenile specimens were found in 17 areas (Fig. 13).

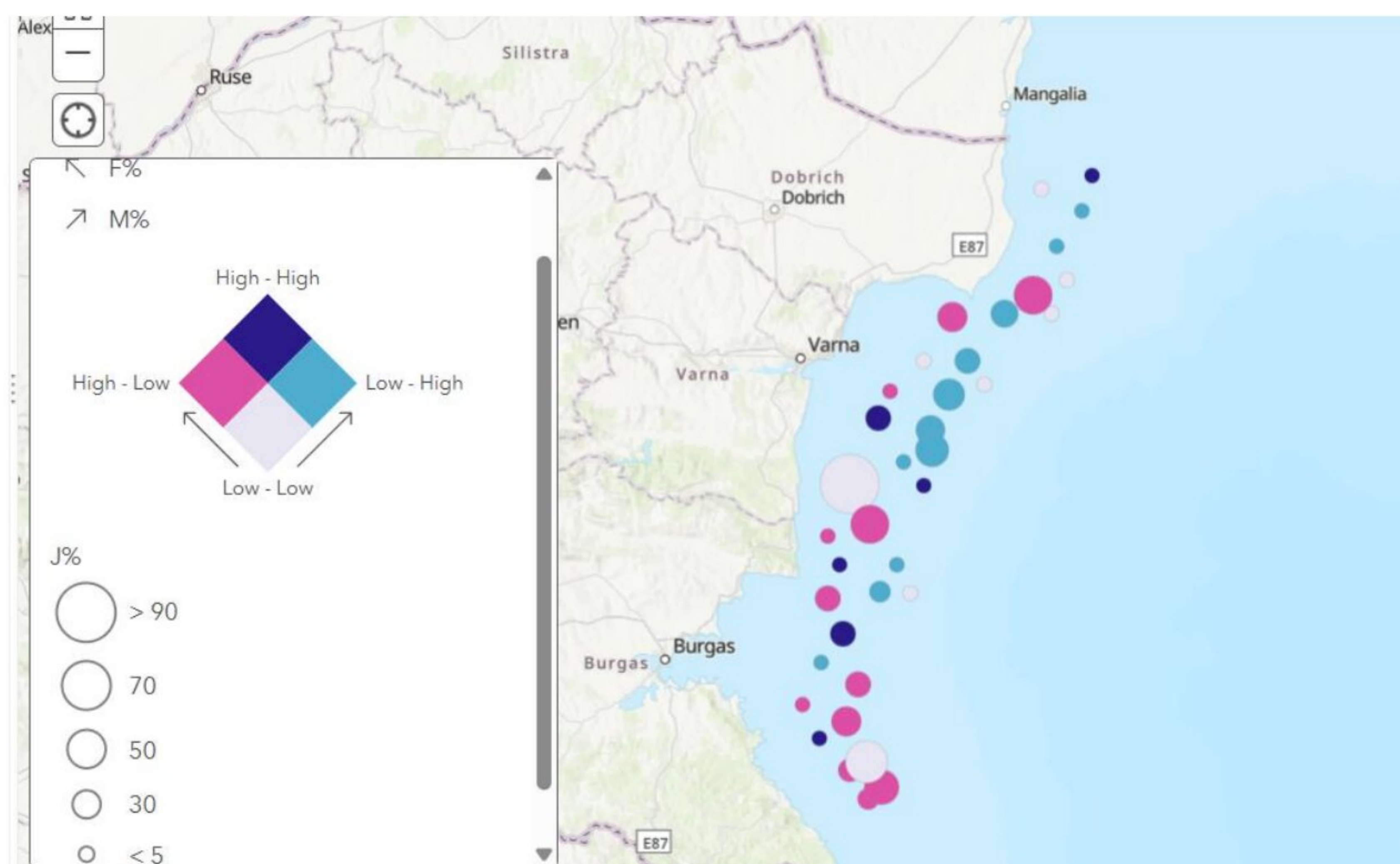


Figure 13. Sex structure of *S. maximus* in July-August 2025: distribution by station (female, male, and juvenile specimens are indicated by purple, blue and grey, dark blue, presence of both sexes, and juveniles).

Male specimens are mainly found at depths ranging from 55 to 75 meters, while female specimens are observed in significant numbers at depths between 40 to 66 meters. Juvenile individuals are primarily concentrated in the area between C. Kaliakra-Byala, specifically at depths of 55 to 75 meters.

Female specimens are predominantly located in the Shabla, C. Emine, and Primorsko regions, while male specimens are more concentrated in Shabla, Varna, and Burgas Bay.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

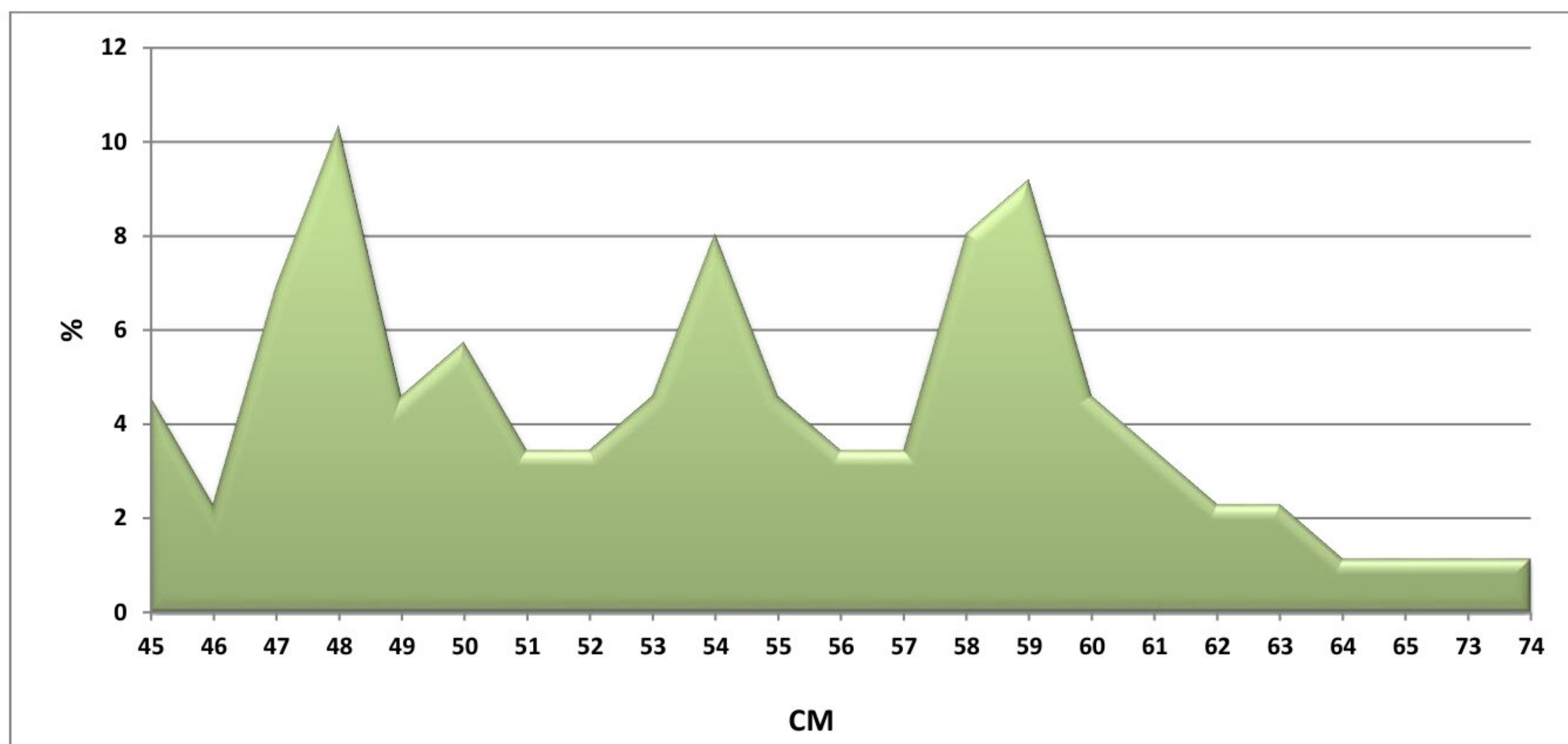


Figure 14 Female specimens: Percentage distribution by length classes.

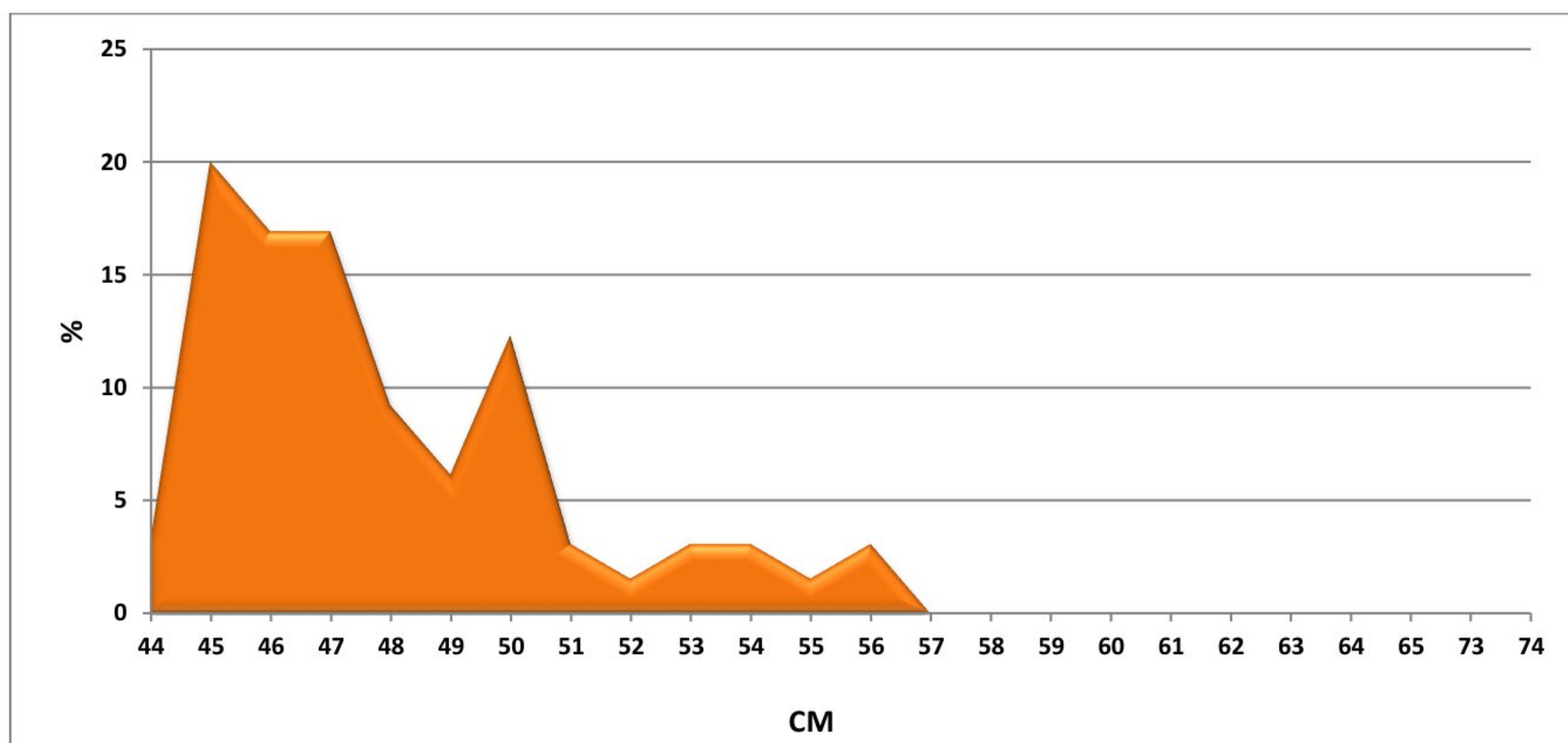


Figure 15 Male specimens: Percentage distribution by length classes.

www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



The distribution by sex and size groups shows that female specimens predominantly fall within the size range of 47 to 60 cm, accounting for 80.46% of the measured female population (Fig. 14). All individuals measuring between 57cm and 74 cm are female, accounting for 16.02 % of the total population.

For male specimens, the largest group-comprising 61.54 %-is found in the size category of 46 to 50 cm (Fig. 15).

These findings highlight a clear sexual dimorphism in body size, with females exhibiting larger sizes overall (Figs. 14 and 15).

3.8. Weight structure

Data on the weight distribution of the turbot population in the Bulgarian waters of the Black Sea during July–August 2025 were collected from an analysis of 206 individuals, with each specimen's weight recorded. The analysis revealed that the majority of specimens had an average weight of 2167.82 g (Fig. 16).

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

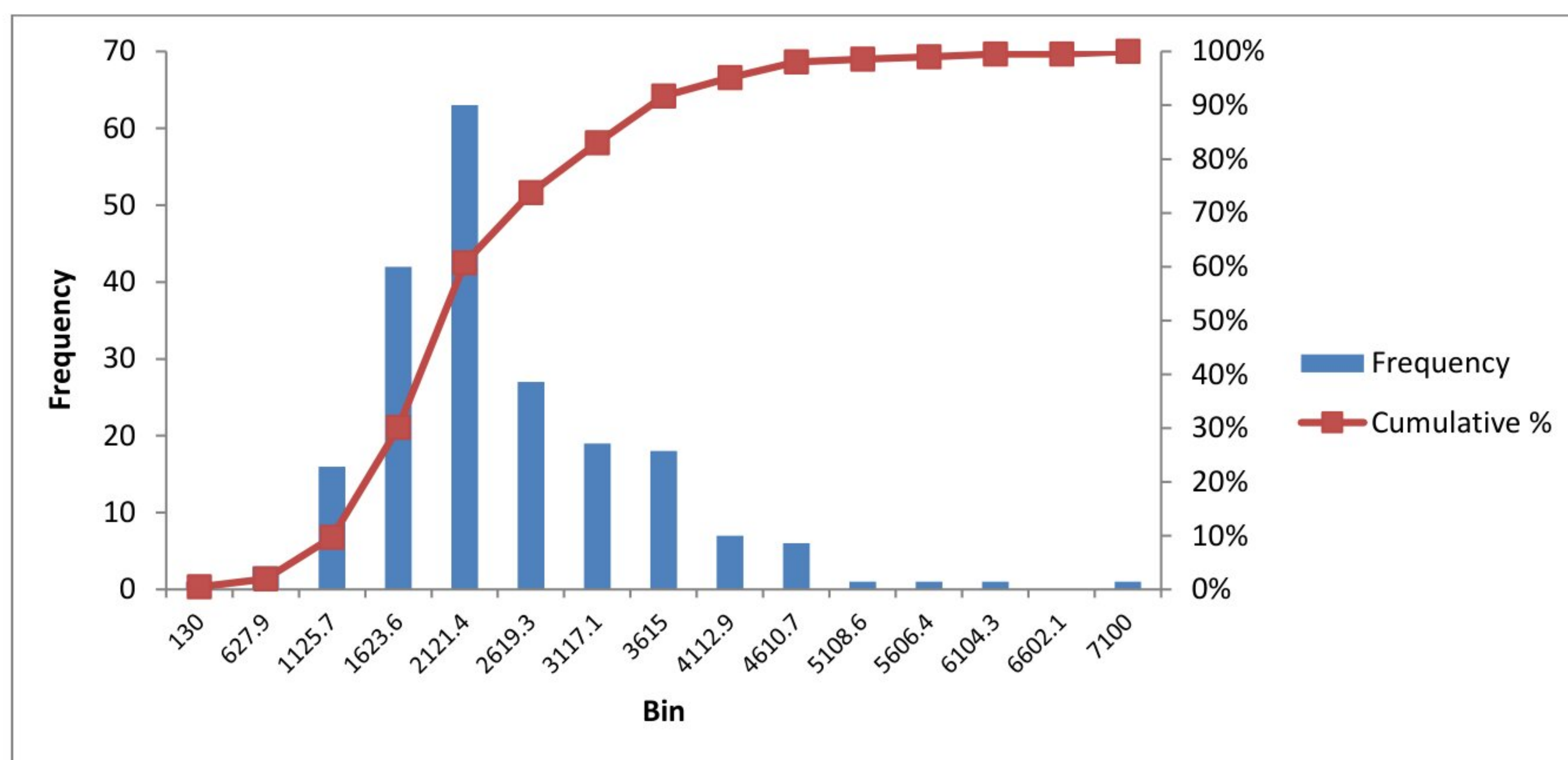
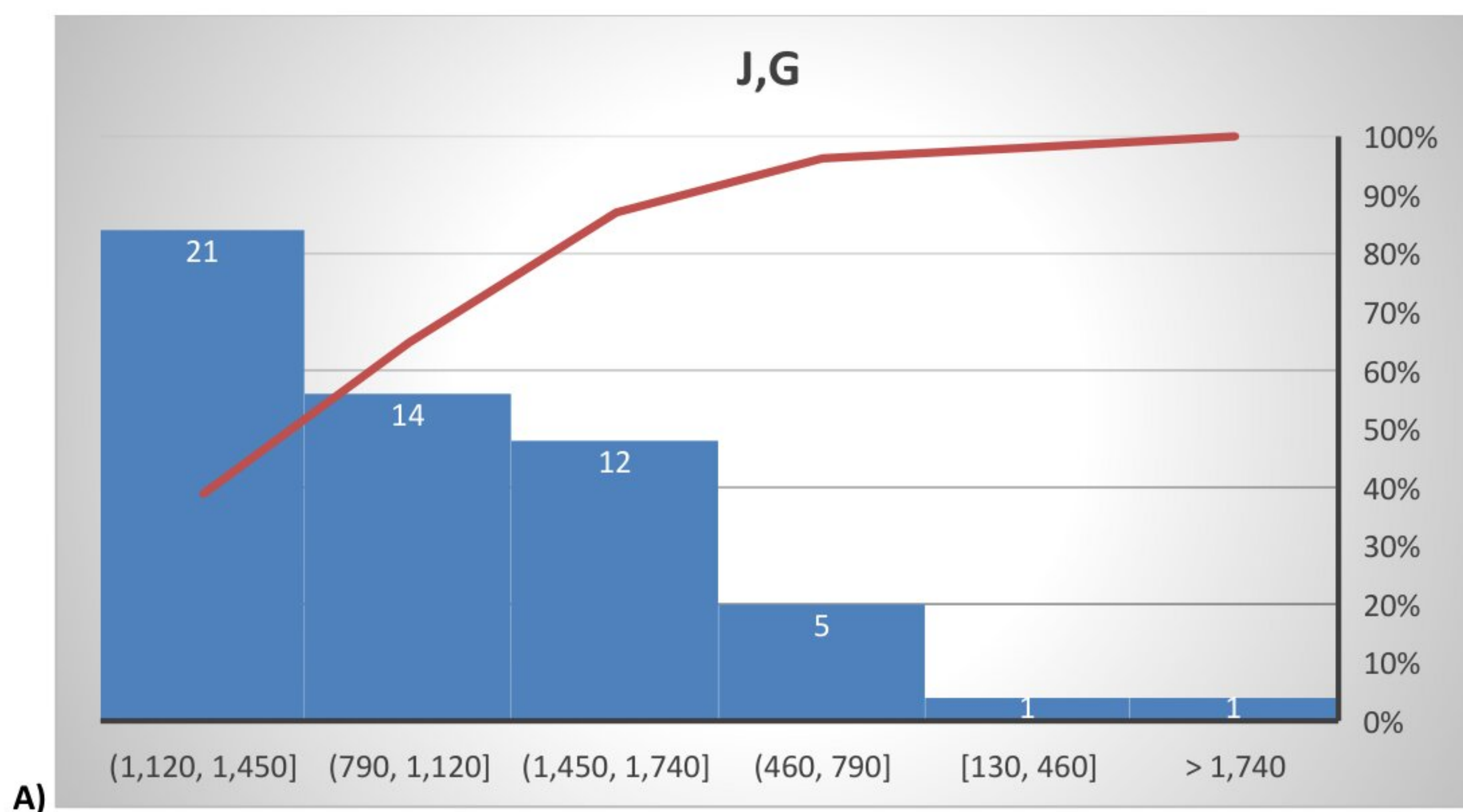


Figure 16 Weight structure of *S. maximus* catches.

Immature specimens weigh between 130.0 and 1740.0g grams, with an average weight of 1212.81 grams. Female specimens range from 1330.0 to 7100.0grams, averaging 2909.42 grams. Male specimens weigh between 1159.0 and 2880.0grams, with an average weight of 1939.5 grams (see Fig. 17, A, B, and C).



A)

www.eufunds.bg

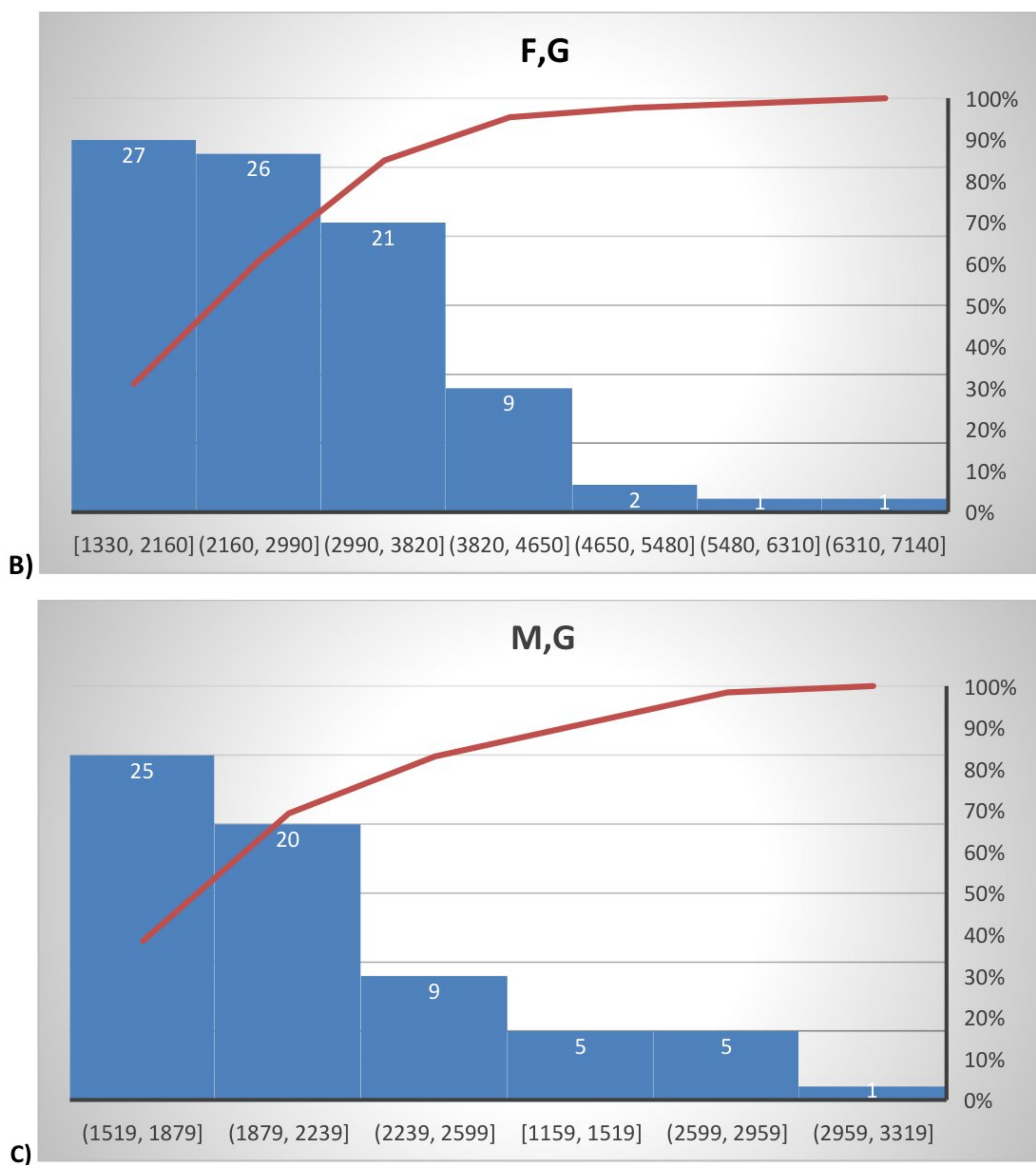


Figure 17 Weight structure of *S. maximus* catches by sex: A) immature specimens, B) female and C) male specimens;



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

3.9. Other target species and bycatch

During bottom survey in the spring-summer season of 2025, 35 specimens of spiny dogfish (*Squalus acanthias*), 102 specimens of thornback ray (*Raja clavata*), and 2 specimens of flounder (*Platichthys flesus*) were collected (Table 6).

Table 6

Data on species composition and biological characteristics of the reference species

Bycatch species	N	Size (cm)			Weight (kg)		
		Min.	Max.	Ave.	Min.	Max.	Ave.
<i>Squalus acanthias</i>	35	41	141	117	0.41	13.1	7.19
<i>Raja clavata</i>	102	31	90	59	0.22	4.14	1.36
<i>Platichthys flesus luscus</i>	2	23	23	23	0.13	0.20	0.165
<i>M. merlangus</i>	1300	6.5	21.3	12.82	0.0021	0.071	0.0159

Catch per unit effort (CPUE), (kg/trawl) distribution maps of *S. acanthias*, *R. clavata*, *Pl. flesus* and *M. merlangus* are presented in Fig.18.

Specimens of *S. acanthias* are observed between Varna and Byala (27-36 m), where only female specimens have been caught, and in front of the C. Kaliakra and C. Emine (79-83 m) there is an accumulation of males; clusters of *Pl. flesus* occurs in the northern part of the Bulgarian coast in front of Kavarna and in front of the central part of the coast of Varna, at a depth of 60 – 68 m. Representatives of the species *R. clavata* are observed near Primorsko-Tsarevo at depths of 60 – 75 m. Specimens of the species *M. merlangus*, with a large concentration of the species is observed in the south between Primorsko and Tsarevo at a depth of 45 – 65 m.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

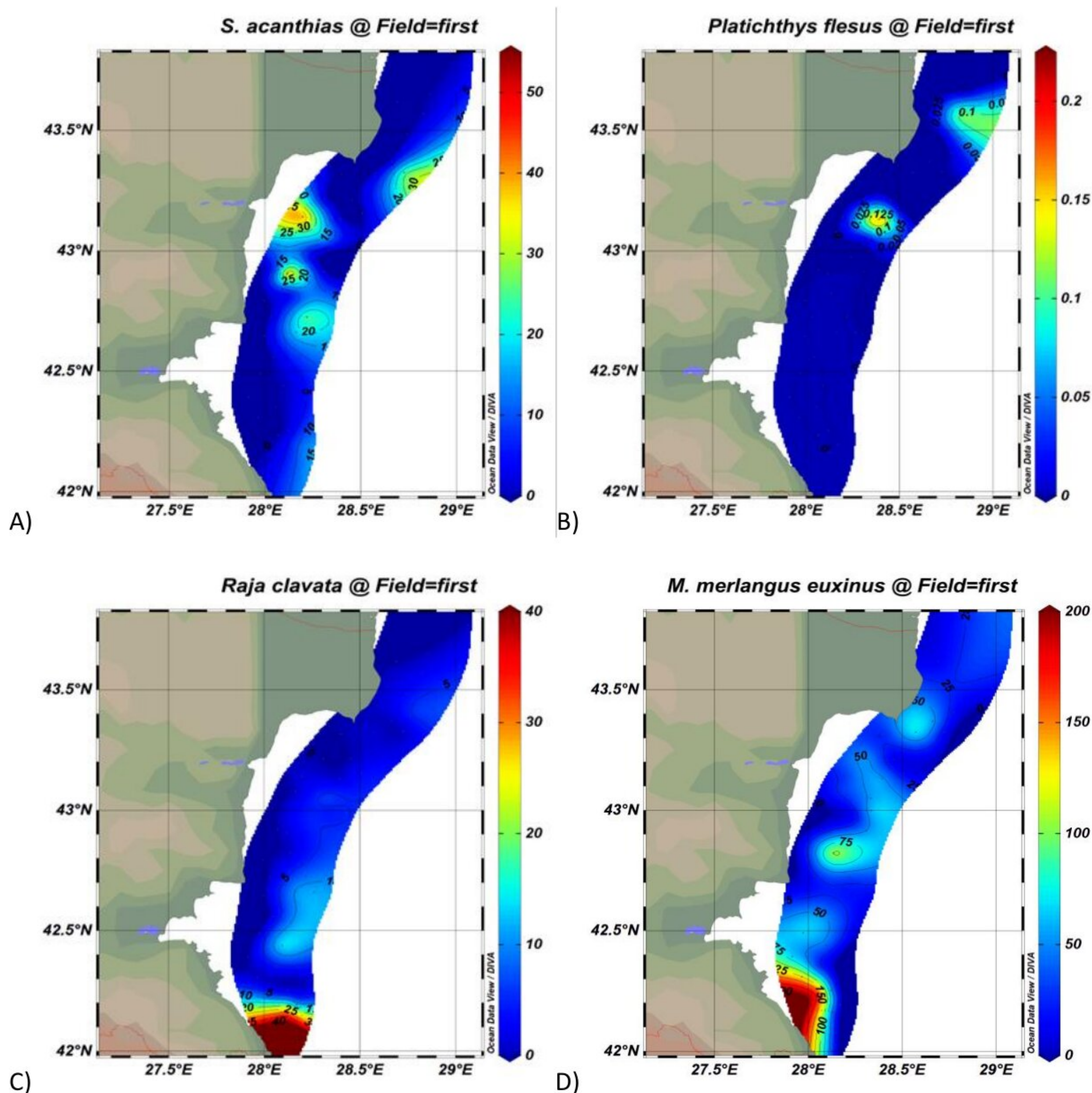


Figure 18 Catch per unit effort kg/h A) spiny dogfish (*S. acanthias*), B) flounder (*Pl. flesus*), C) thornback ray (*R. clavata*) and D) whiting (*M. m. euxinus*).

www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Catch per unit effort (CPUE) on whiting (*M. merlangus*)

The distribution of the catch per unit effort (CPUE), (kg/h), of the whiting (measurement of 1300 specimens) is presented in Tab.7 and Fig. 18 (D).

Table 7

Results of CPUE (catch per unit effort kg/h) of whiting (*M. merlangus*) by month, July-August 2025

No	Field	Depth (m)		Catch (Kg/h)
1	G6	31	35	60
2	F7	27	30.5	25
3	E8	28	26	30
4	L1	48.5	50.5	10
5	N1	57	63	30
6	M2	64	68	30
7	L3	65	65	25
8	M4	75	76	15
9	L5	79	80	10
10	K4	69	69	60
11	J5	58	62	80
12	H5	20	30	20
13	J6	57	63.5	3
14	J7	78	84	12
15	H7	57	60	60
16	G8	55	49	50
17	H9	71	77	70
18	G10	78	69	50
19	F9	53.5	60.5	2.5
20	E10	36	36	30
21	D9	30.5	28.5	10
22	E11	51	50	120
23	F12	79	83	30
24	G13	87	86.5	20
25	E13	74	75	20
26	C11	32	34.5	15
27	D12	40	43	18

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

28	C13	40.5	43	20
29	D14	54	57	60
30	C15	44	41.5	70
31	B16	37.5	37	60
32	C17	41	43	130
33	D18	54	55	200
34	E19	60.5	62	30
35	F18	73	79	20
36	E17	65	62	40
37	D16	57	61	15
38	E15	66.5	66	50

The main biological parameters of *M. merlangus* (measurement of 1300 specimens) are presented in Fig.19, 20, 21 and 22.

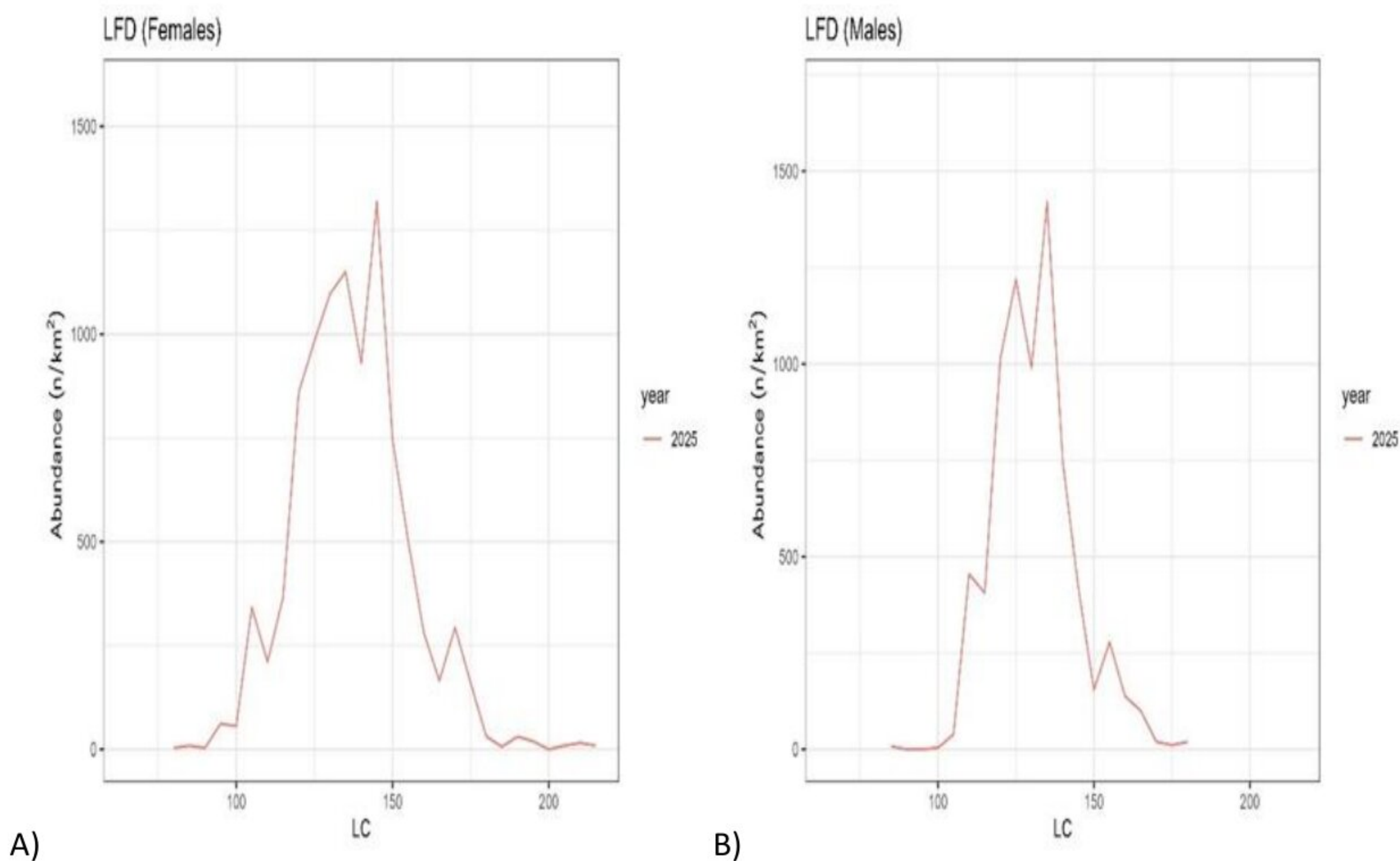


Figure 19 Length classes (LC, mm) of *M. merlangus* catch by sex: A) female, B) male.

www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

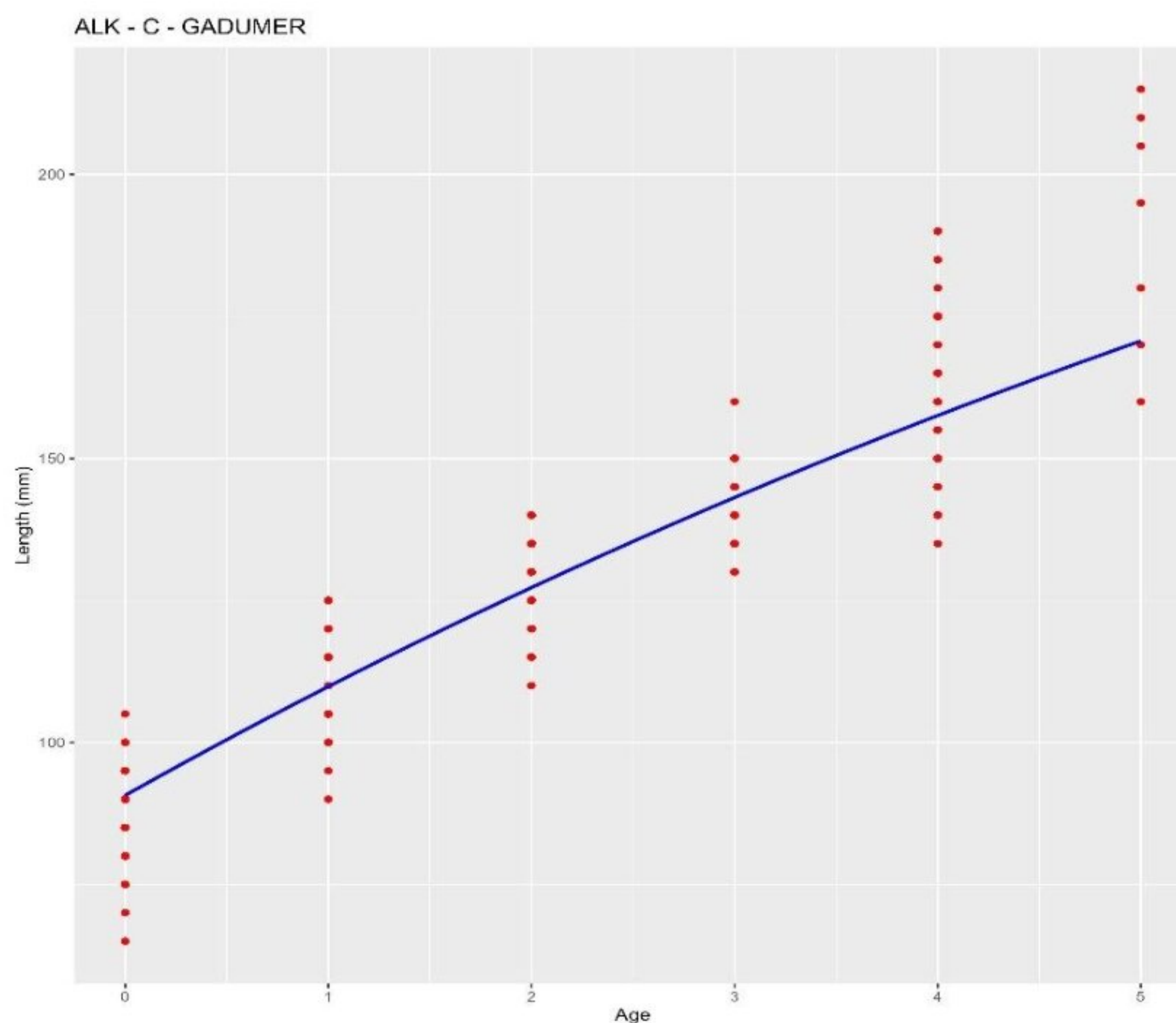
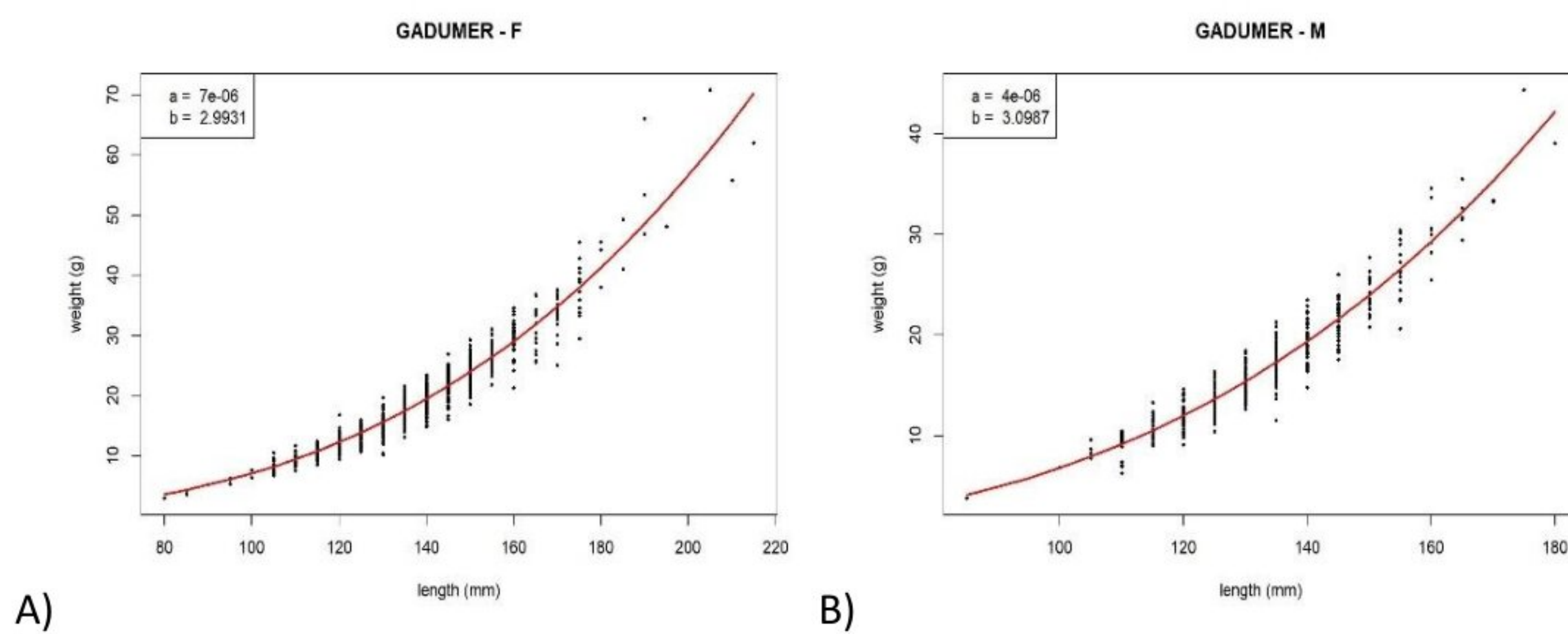
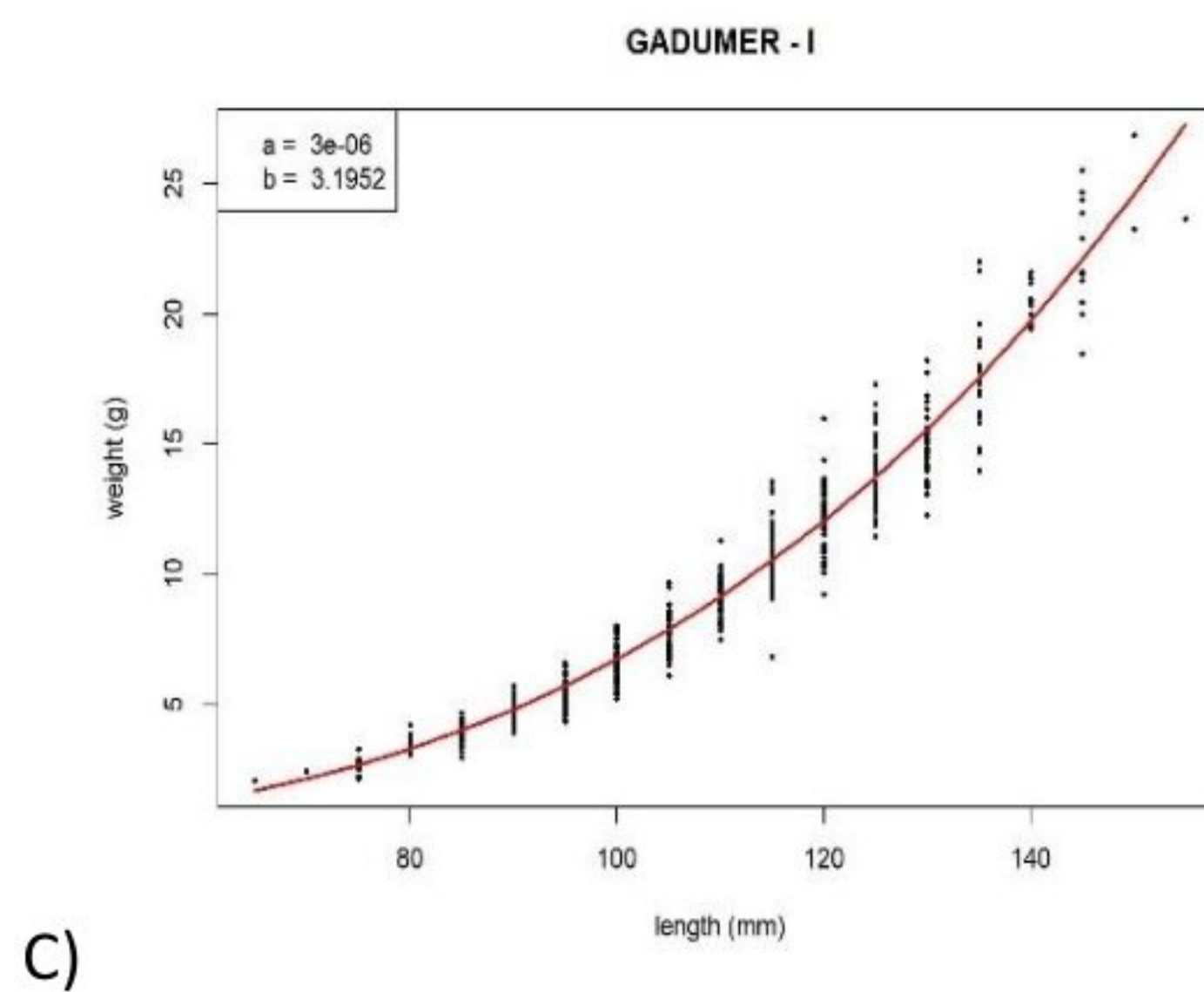


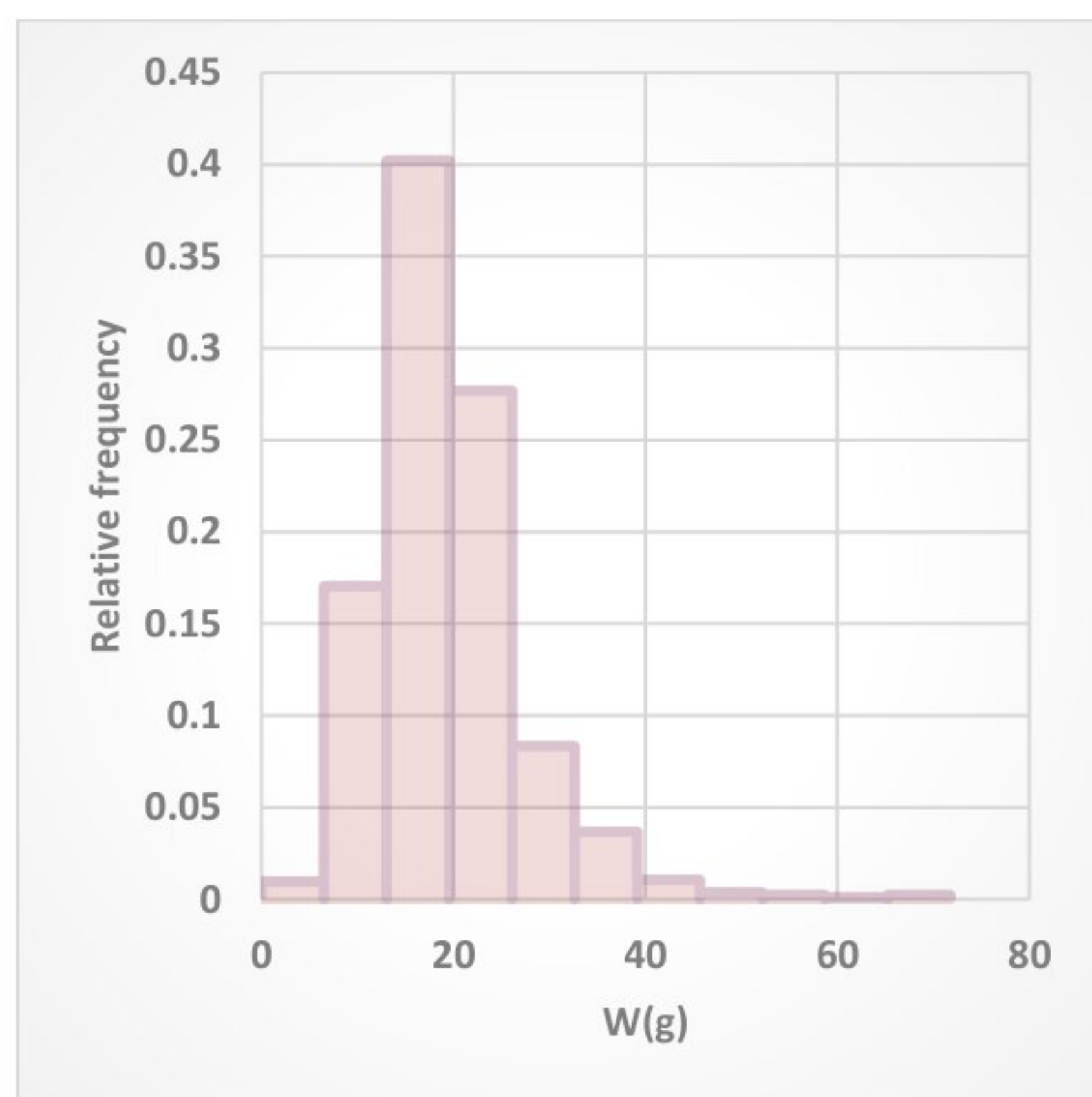
Figure 20 *M. merlangus*: Age-size relationships.



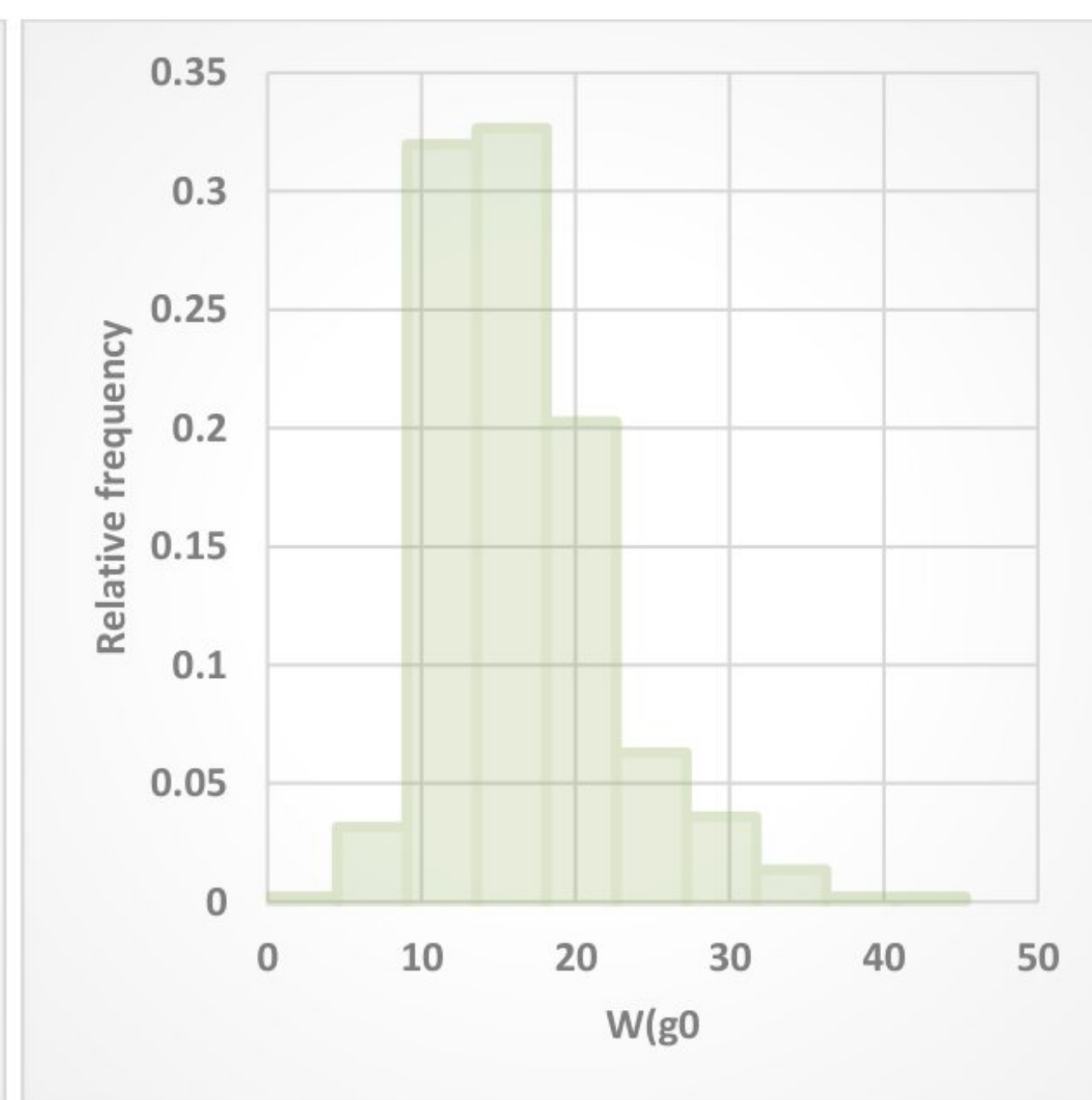


C)

Figure 21 *M. merlangus*: Length-weight relationships by sex, A) female, B) male and C) indeterminate, July-August, 2025.



A)



B)

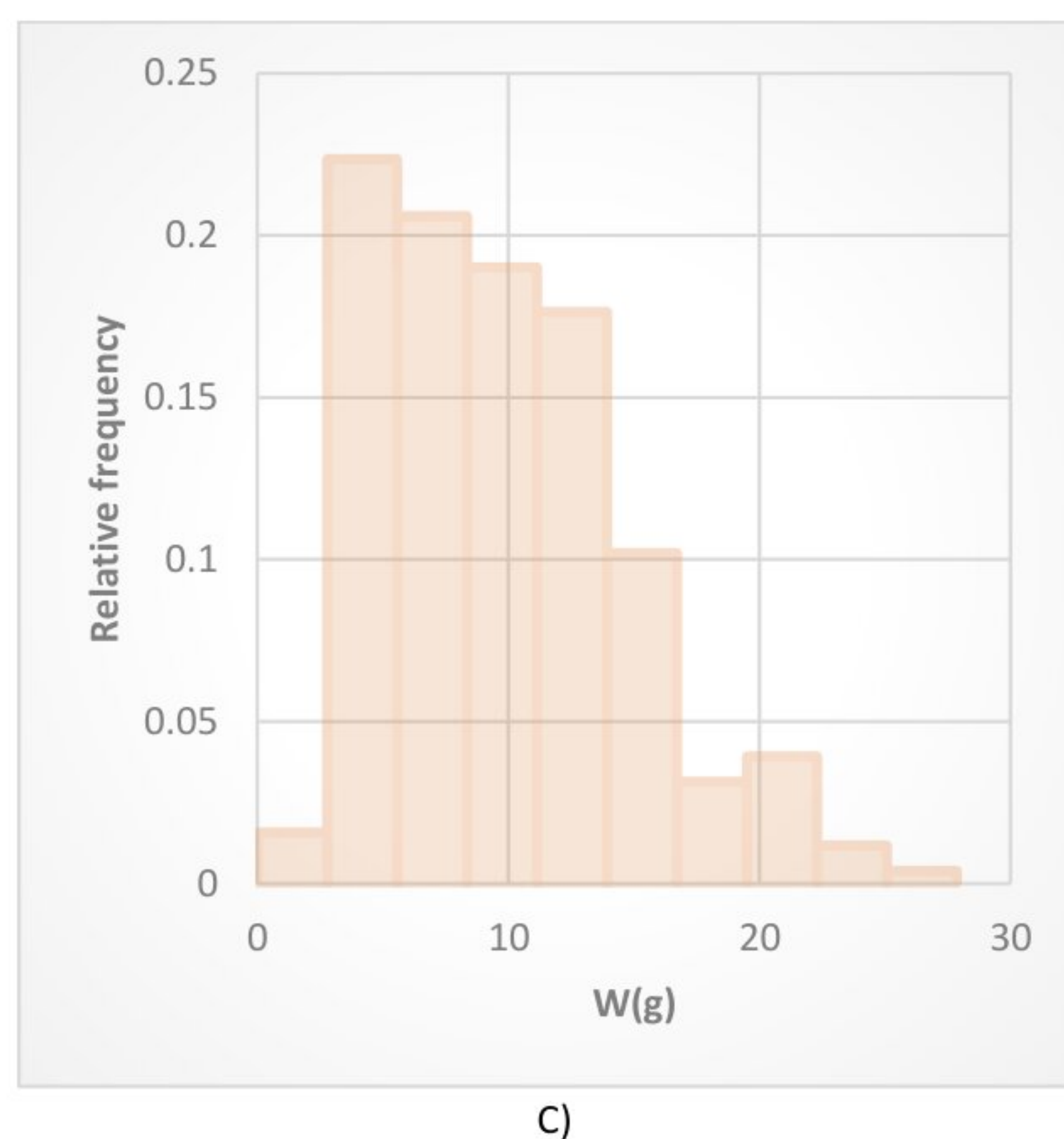


Figure 22 Weight structure of *M. merlangus* catches by sex: A) female, B) male and C) undetermined specimens;

The GSI index varies in females between 0.002 - 5.075, with an average value of 0.37, while in males the index is lower and we observe values of 0.008 - 2.158, an average of 2.23 (Fig.23).

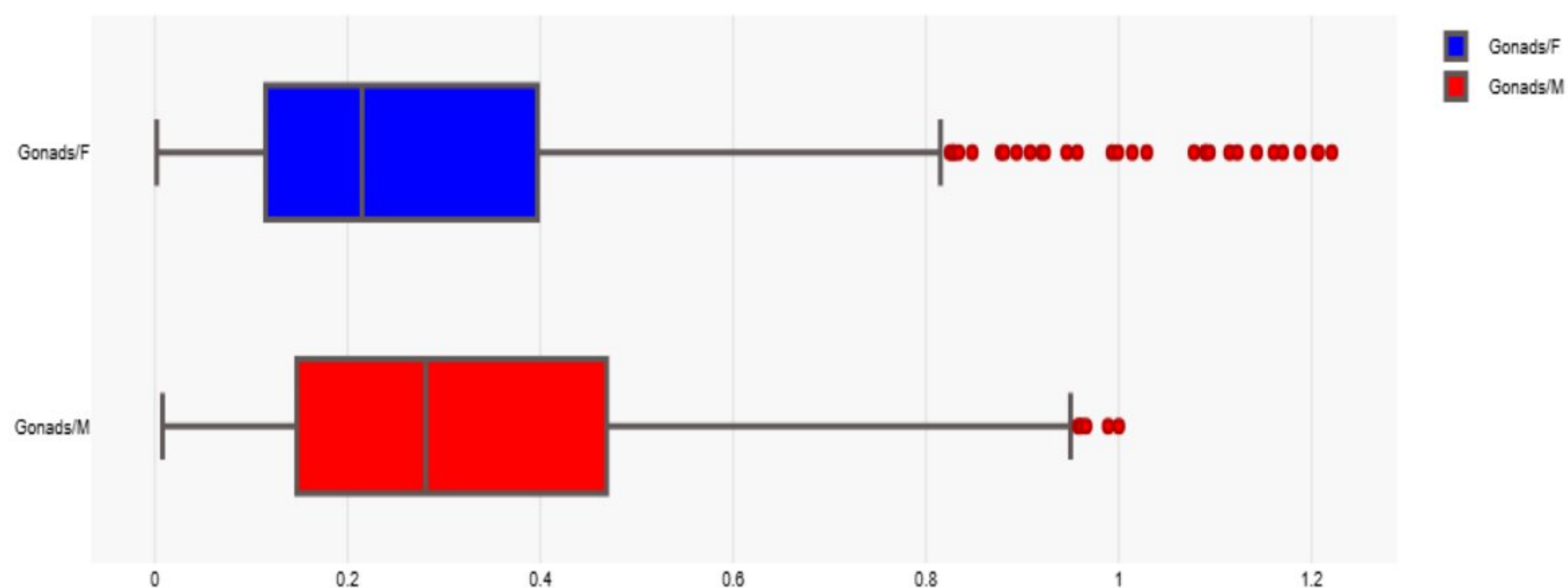


Figure 23 Gonadosomatic index (GSI) by sex of *M. merlangus*. Box-plot representation showing the median as a vertical line, the interquartile range and the acceptable minimum and maximum values, with individual points indicating outliers.

High abundance is observed at a depth of 45-65 m, (Fig.24). Specimens with a size of 11.0 cm - 14.5 cm predominate. The established ratio between female, male and indeterminate sex individuals is - **46.76%: 24.78%: 28.46%**.

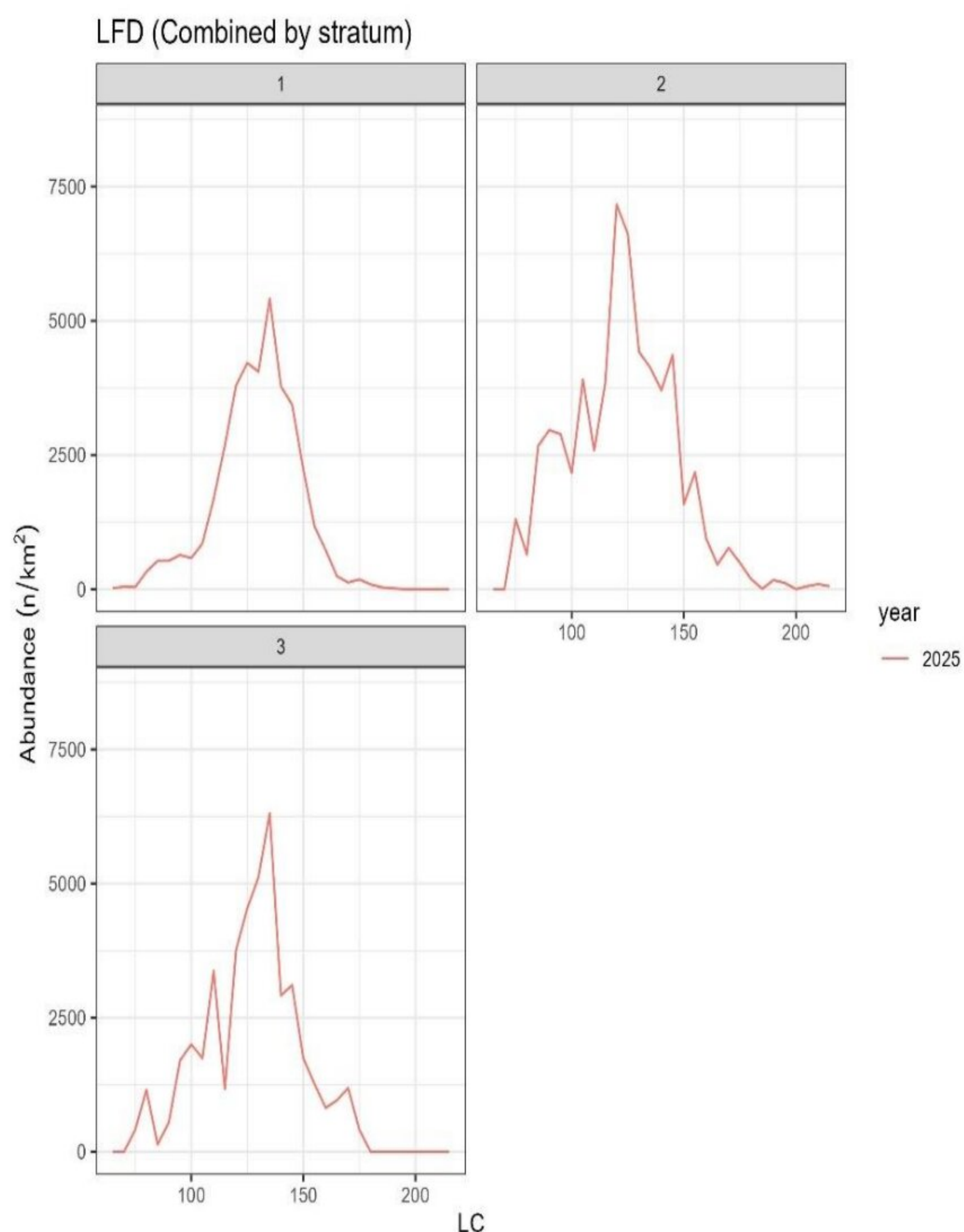


Figure 24 Abundance (n/km^2) by length classes (LC,mm) and depth strata (1, 2 and 3) for VII-VIII 2025;

Mean relative biomass (kg/km^2) and abundance (n/km^2) distribution on a coordinate grid for whiting is shown in Fig. 25.

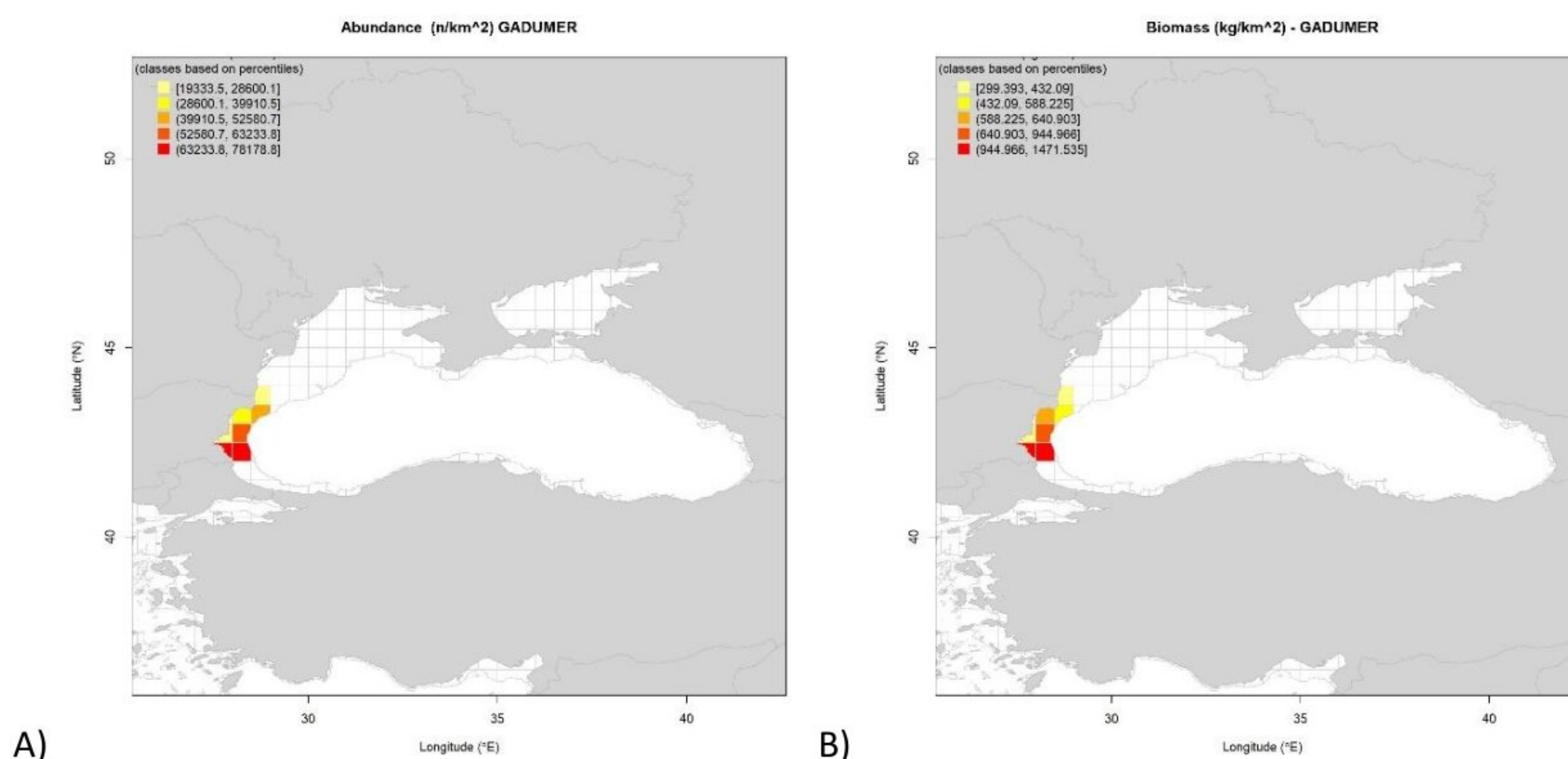


Figure 25 Distribution of mean A) relative biomass (kg /km²) and B) abundance (n/km²) of *M. merlangus* in July-August 2025, according to the BioIndex version 3.3;

The whiting biomass in the entire studied area in front of the Bulgarian coast of the Black Sea was estimated at **7243.3** tonnes (Table 4). The abundance in the studied area was estimated at **455.67*10³** specimens.

Catch per unit effort (CPUE) on dogfish (*Squalus acanthias*)

The distribution of the CPUE (kg/h) of *S. acanthias* is shown in Tab. 8 and Fig.18 (A).

Table 8

Results from CPUE (kg/h) on dogfish (*S. acanthias*) in July-August 2025

No	Field	Depth (m)		Catch (Kg/h)
1	G6	31	35	0
2	F7	27	30.5	44.05
3	E8	28	26	22.85
4	L1	48.5	50.5	0
5	N1	57	63	0
6	M2	64	68	0
7	L3	65	65	0
8	M4	75	76	8.54
9	L5	79	80	26.99
10	K4	69	69	0
11	J5	58	62	0
12	H5	20	30	0
13	J6	57	63.5	0
14	J7	78	84	0
15	H7	57	60	0
16	G8	55	49	16.91
17	H9	71	77	0
18	G10	78	69	0
19	F9	53.5	60.5	0
20	E10	36	36	50.72
21	D9	30.5	28.5	0.26
22	E11	51	50	0
23	F12	79	83	26.77
24	G13	87	86.5	17.65
25	E13	74	75	19.37
26	C11	32	34.5	0
27	D12	40	43	0
28	C13	40.5	43	0
29	D14	54	57	0
30	C15	44	41.5	0
31	B16	37.5	37	0
32	C17	41	43	0

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

33	D18	54	55	0
34	E19	60.5	62	5.19
35	F18	73	79	12.39
36	E17	65	62	0
37	D16	57	61	0
38	E15	66.5	66	0

The main biological parameters of *S. acanthias* are presented in Fig.26, 27 and 28. A large part of the caught females are between 127-132 cm in size (Fig. 26, A), and the males are smaller in size 112-119 cm, (Fig. 26, B). The catch is dominated by males 60% and females by 40%.

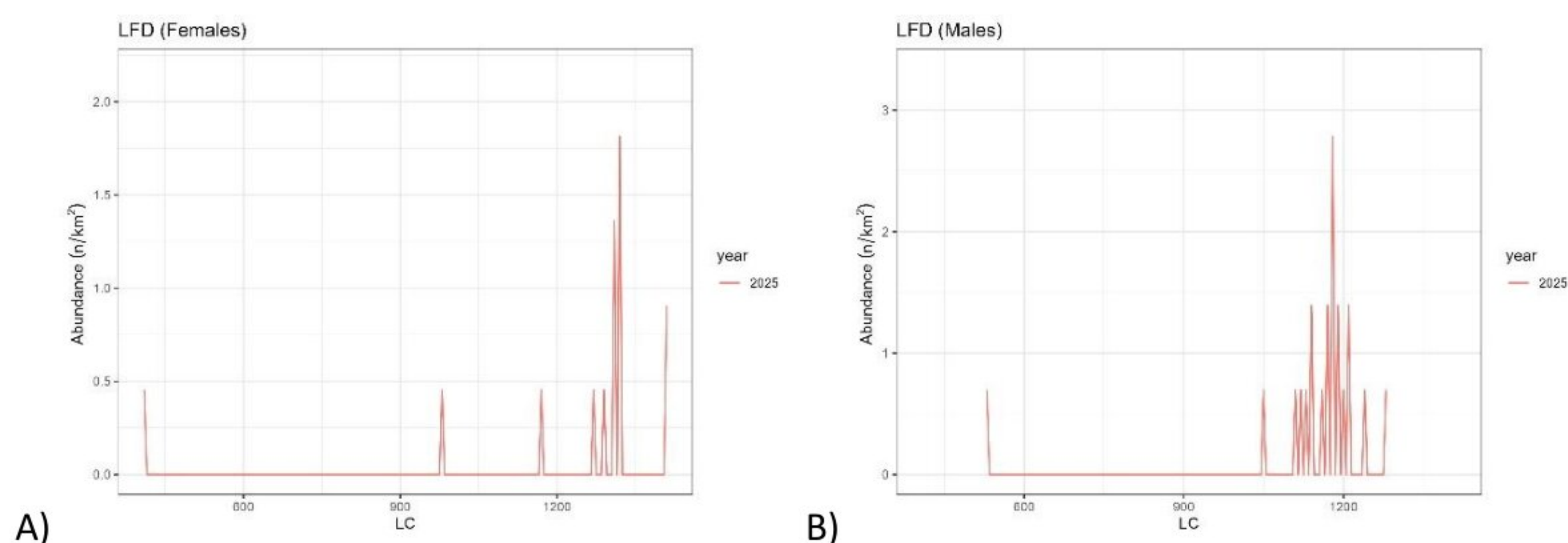


Figure 26 Abundance (n/km²) and length classes (LC, mm) of *S. acanthias* catches by sex, A) female and B) male specimens;

The female specimens captured weighed between 260 and 13100 grams, with an average weight of 8677.14 grams (Fig. 27, A). In contrast, the male specimens weighed less, ranging from 780 to 8540 grams, with an average weight of 6200.48 grams (Fig. 27, B).



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

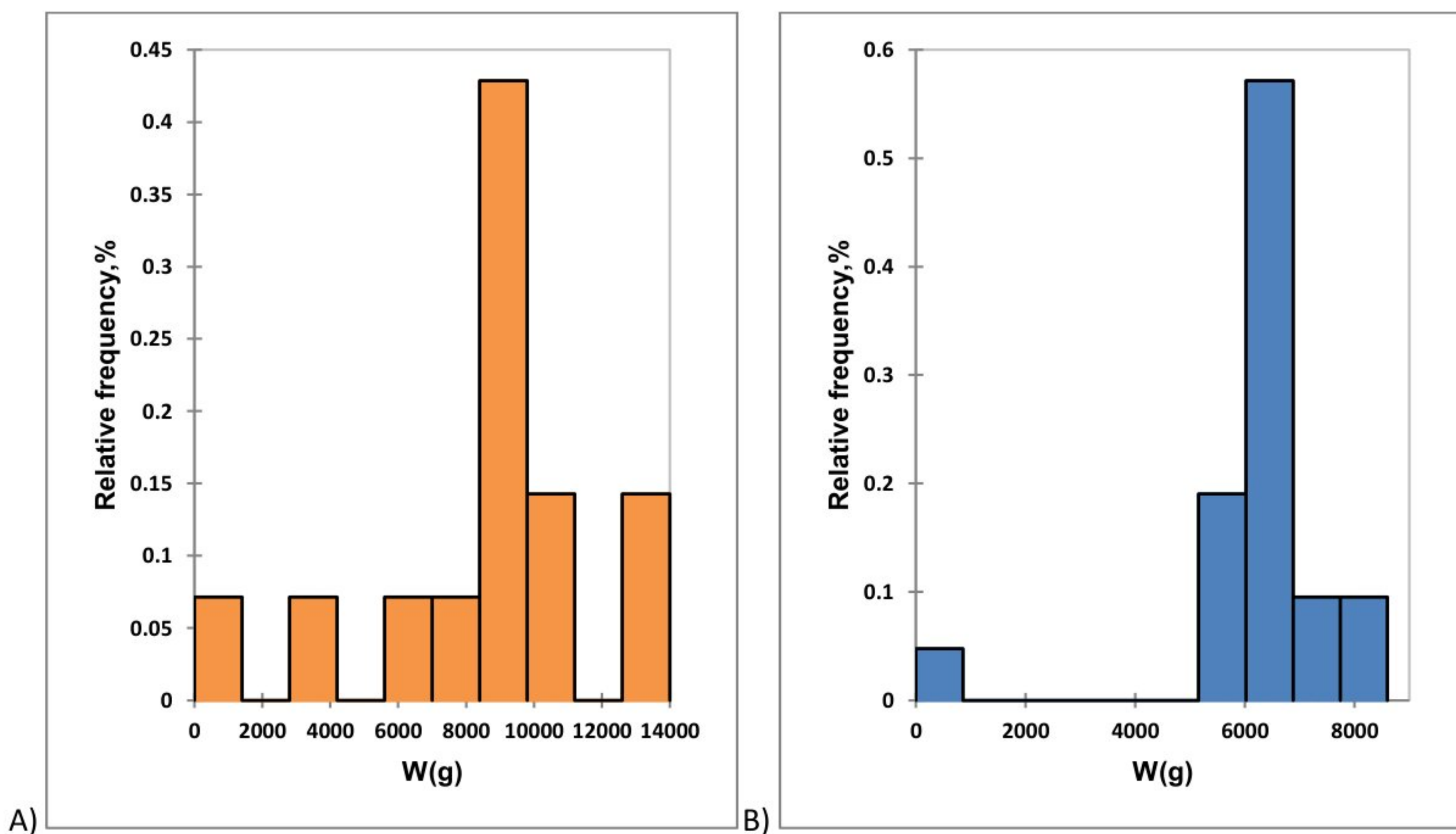


Figure 27 Weight structure of *S. acanthias* by sex, A) female and B) male specimens;

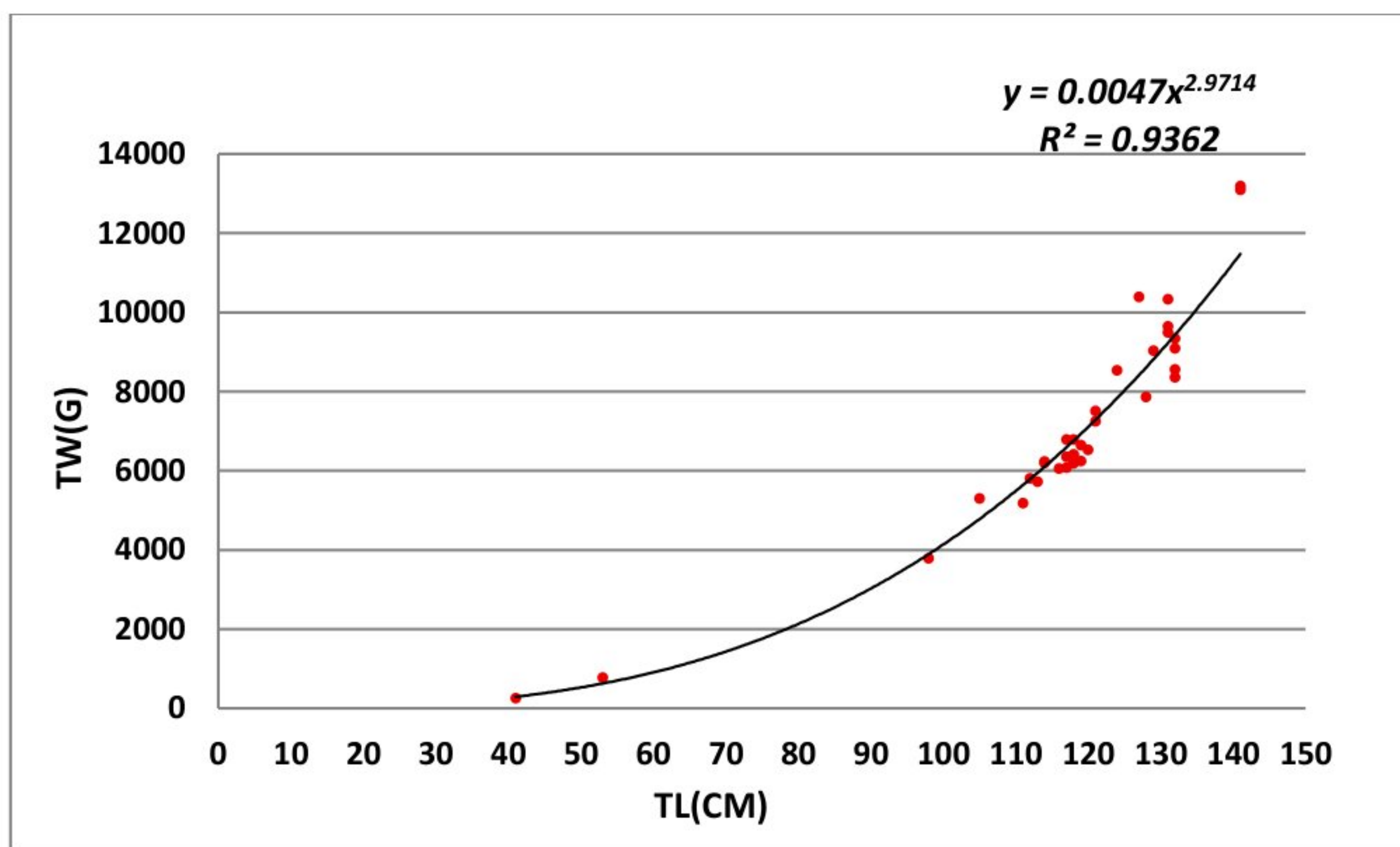


Figure 28 *S. acanthias*: Length-weight relationships VII-VIII, 2025;

www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

The most abundant dogfish bycatch was caught at depth of 35-75 m, (Fig. 29).

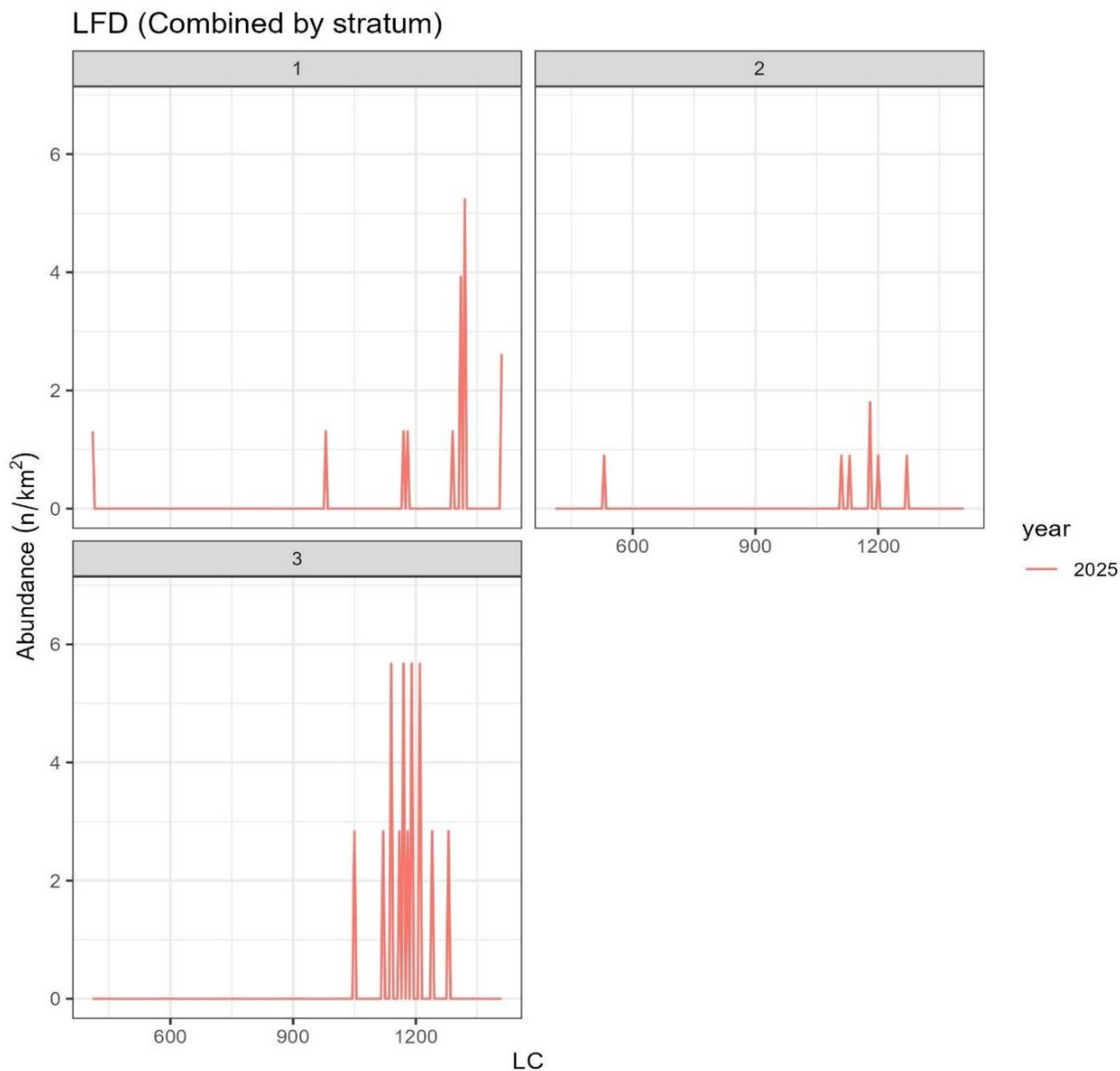


Figure 29 Abundance (n/km^2) by length classes (LC,mm) and depth strata (1, 2 and 3), VII-VIII 2025;

Biomass by haul (kg/km²)

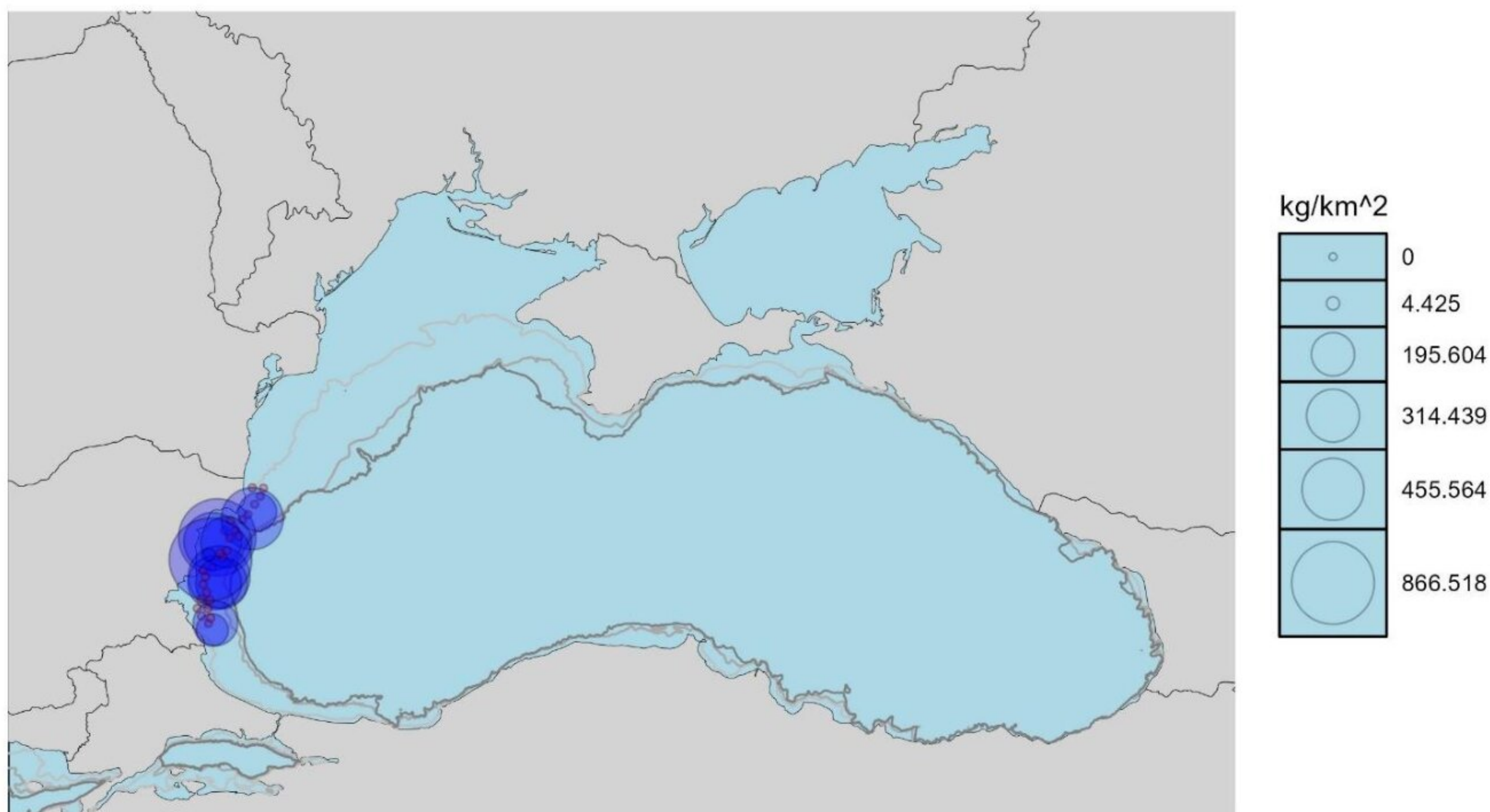


Figure 30 Distribution of the relative biomass by hauls (kg / km²) of *S. acanthias* in VII-VIII 2025 according to BioIndex version 3.3.

The maximum biomass index of dogfish for VII-VIII in the Bulgarian water area reaches **866.51 kg/km²**(Fig. 30).

Estimating the biomass and abundance of a species accurately is challenging due to their highly dispersed distribution, which poses significant challenges. Therefore, estimating biomass based on CPUE July-August not be accurate. The dogfish biomass in the entire studied area in front of the Bulgarian coast was estimated at **1724.72 tonnes**. During the study period, the total abundance in the Bulgarian water area was estimated to be **239.84*10³** individuals.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Catch per unit effort (CPUE) on thornback ray (*Raja clavata*)

The distribution of the CPUE (kg/h) of *Raja clavata* is shown in Tab. 9, and Fig.18 (C).

Table 9

Results of CPUE (catch per unit effort kg/h) of red fox (*R. clavata*) by month, July-August 2025

No	Field	Depth (m)		Catch (Kg/h)
1	G6	31	35	0
2	F7	27	30.5	1.66
3	E8	28	26	0
4	L1	48.5	50.5	0
5	N1	57	63	0.35
6	M2	64	68	2.12
7	L3	65	65	3.03
8	M4	75	76	6.22
9	L5	79	80	0
10	K4	69	69	0
11	J5	58	62	1.6
12	H5	20	30	0
13	J6	57	63.5	0
14	J7	78	84	3.73
15	H7	57	60	0
16	G8	55	49	7.66
17	H9	71	77	2.76
18	G10	78	69	5.29
19	F9	53.5	60.5	5.41
20	E10	36	36	1.1
21	D9	30.5	28.5	0
22	E11	51	50	0.35
23	F12	79	83	8.31
24	G13	87	86.5	11.17
25	E13	74	75	11.358
26	C11	32	34.5	0
27	D12	40	43	0
28	C13	40.5	43	0

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

29	D14	54	57	0
30	C15	44	41.5	0
31	B16	37.5	37	0.22
32	C17	41	43	0.3
33	D18	54	55	2.52
34	E19	60.5	62	36.69
35	F18	73	79	6.14
36	E17	65	62	1.56
37	D16	57	61	3.94
38	E15	66.5	66	15.885

The main biological parameters of *Raja clavata* are presented in Fig.31, 32 and 33. The caught female specimens are 31-79 cm in size and weigh 220-2890 g (Fig. 31 A and Fig.32 A), and the following values were recorded for males - 41-90 cm and 340-4140 g, (Fig. 31 B and Fig. 32 B). Female specimens predominate in the catch, 55.88 %, and males 44.12%.

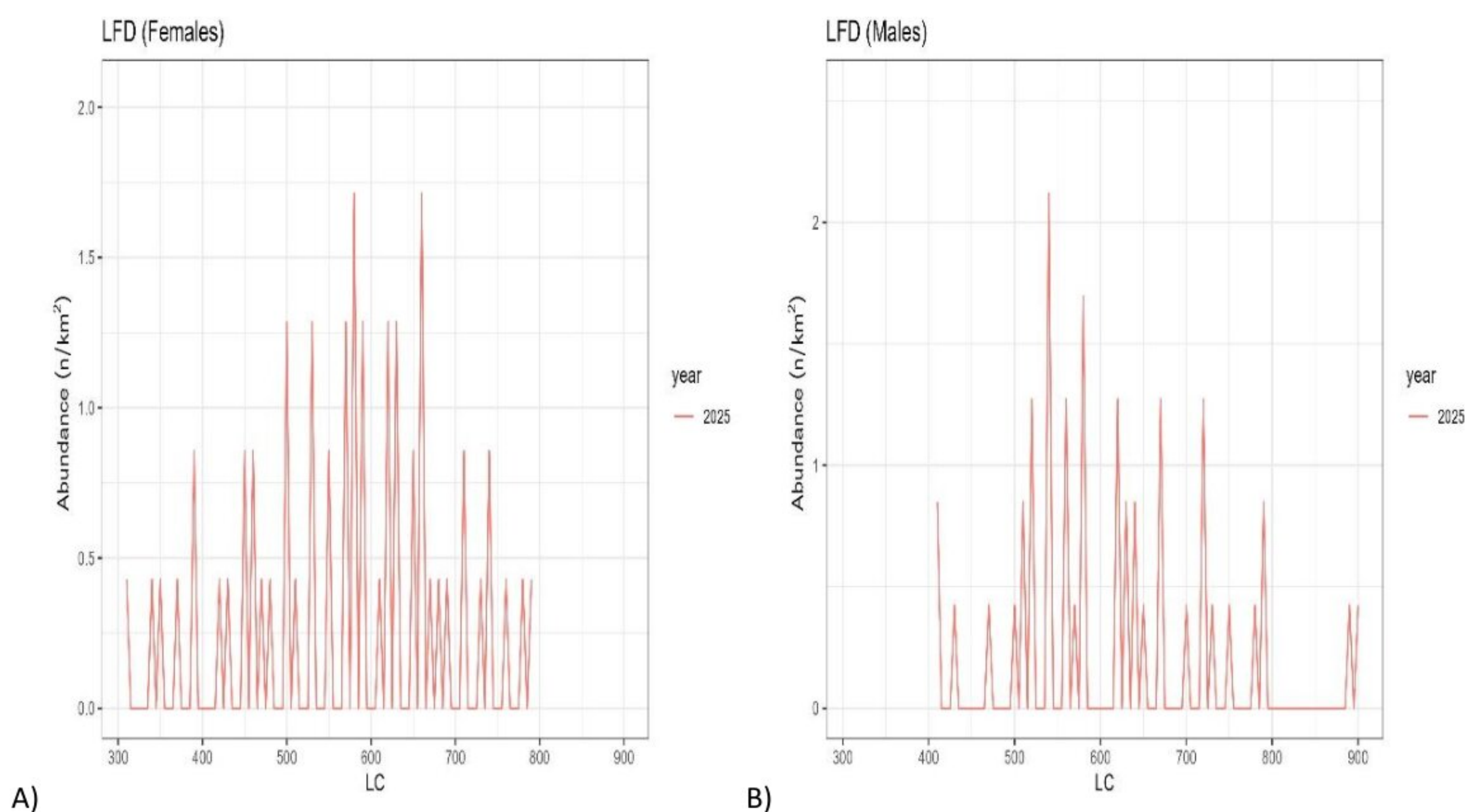


Figure 31 Abundance (n/km²) and length classes (LC, mm) of *Raja clavata* by sex, A) female, and B) male specimens;

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

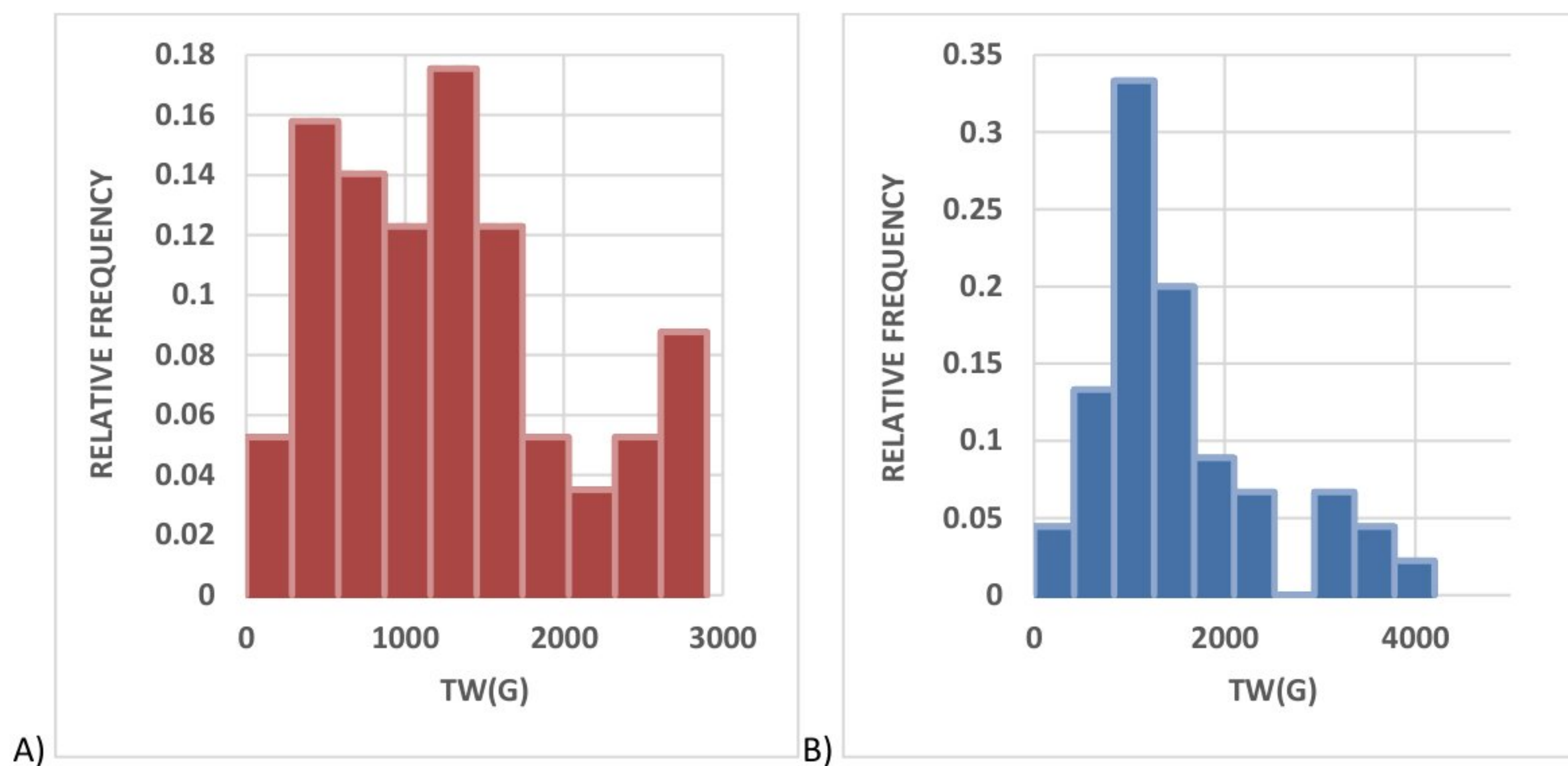


Figure 32 Weight structure by sex of *Raja clavata* catches, A) female and B) male specimens;

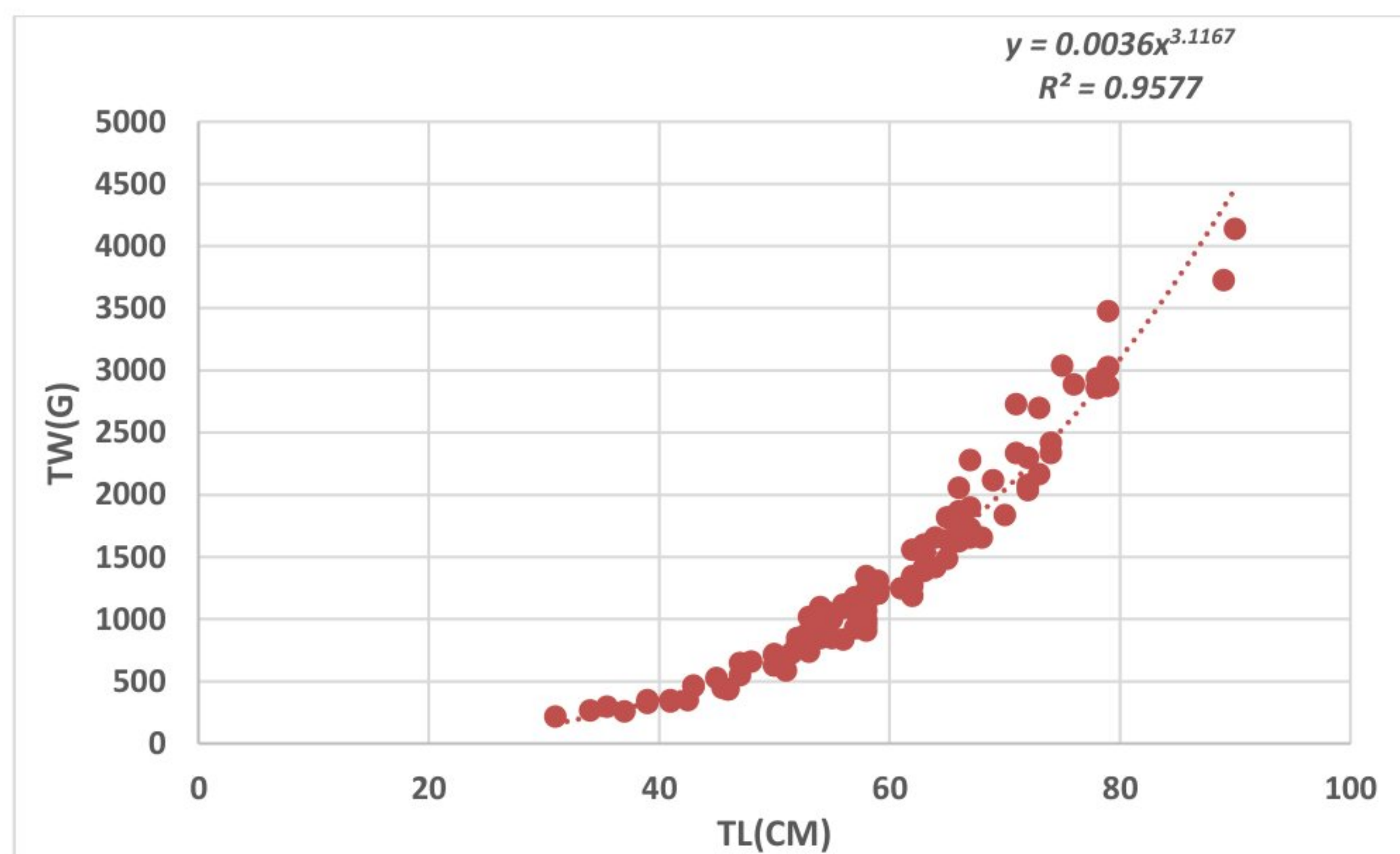


Figure 33 *Raja clavata*: Length-weight relationships VII-VIII, 2025;

www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

At a depth of 60-85 m, a high catch of thornback ray was recorded, and at this depth catch specimens with lengths between 50 - 65 cm (Fig. 34).

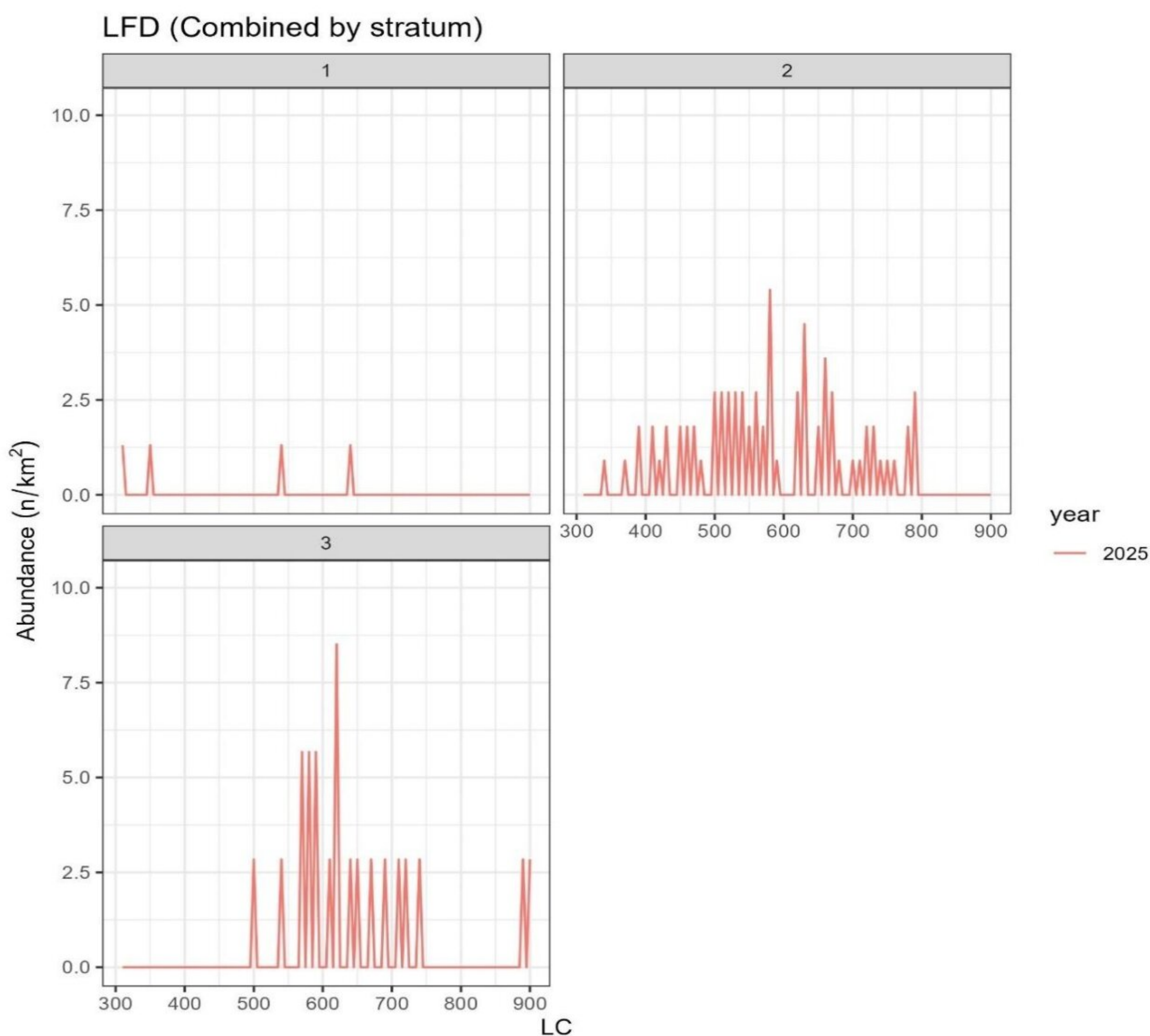


Figure 34 Abundance (n/km^2) by length classes (LC, mm) and depth strata (1, 2 and 3) for VII-VIII 2025;

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

Mean relative biomass (kg/km²) and abundance (n/km²) distribution on a coordinate grid for thornback ray is shown in Fig. 35.

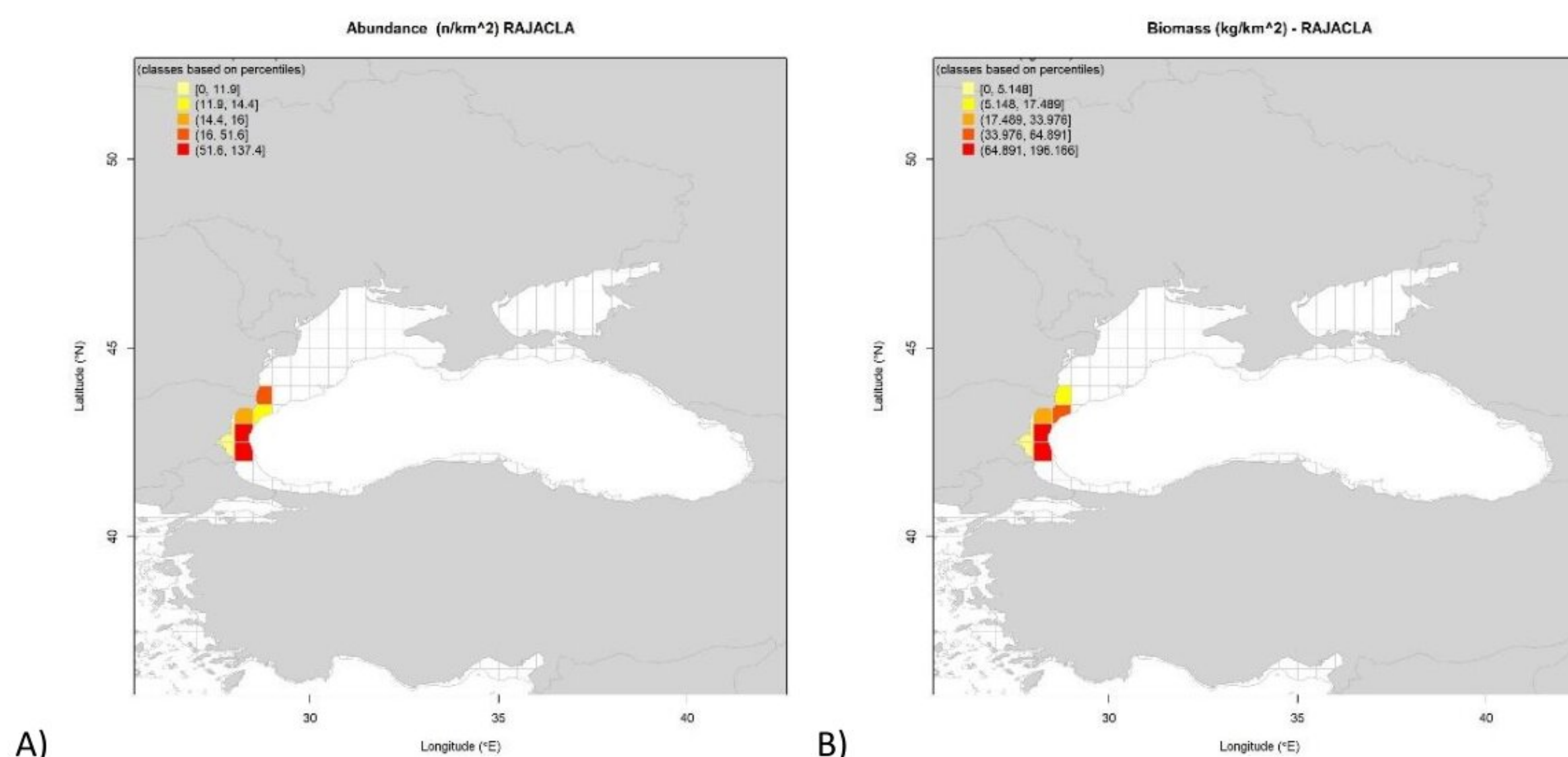


Figure 35 Distribution of mean A) relative biomass (kg /km²) and B) abundance (n/km²) of *Raja clavata* in VII-VIII 2025, according to the BioIndex version 3.3;

The thornback ray biomass in the entire studied area in front of the Bulgarian coast of the Black Sea was estimated at **731.14** tonnes. The abundance was estimated at **535.08*10³** specimens.

4. Food spectrum of *S. maximus*

During the spring-summer season of 2025, 104 stomachs were analyzed to determine the diet spectrum of turbot. Nutritional components were found in 45.19% of the examined specimens, while 54.81% were without stomach content, indicating a lower percentage of feeding fish during this period. General statistical data for the measured biological parameters are shown in Table 10.

Table 10

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

	L (cm)	W (g)	Stom. content (gr)	ISF
Number	47.00	47.00	47.00	47.00
Sum	2439.50	121.69	341.92	14.1867
Min	44.50	1.37	0.74	0.021023
Mean	51.90	2.589149	7.27	0.301845
Max	65.00	5.10	18.84	0.902551
Std. dev	5.66	0.89	5.27	0.224659
Median	50.00	2.27	6.79	0.231481
Kurtosis	-0.82	0.23	-0.64	-0.38
Skewness	0.58	0.98	0.64	0.69
Std. Err.	0.83	0.13	0.77	0.03

The mean fullness index of the turbot stomachs reaches $0.302 \% \text{ BW} \pm 0.03 \text{ SE}$ (Table 10). ISF (% BW) values for the spring-summer season of 2025 are shown on Fig. 36.

ISF

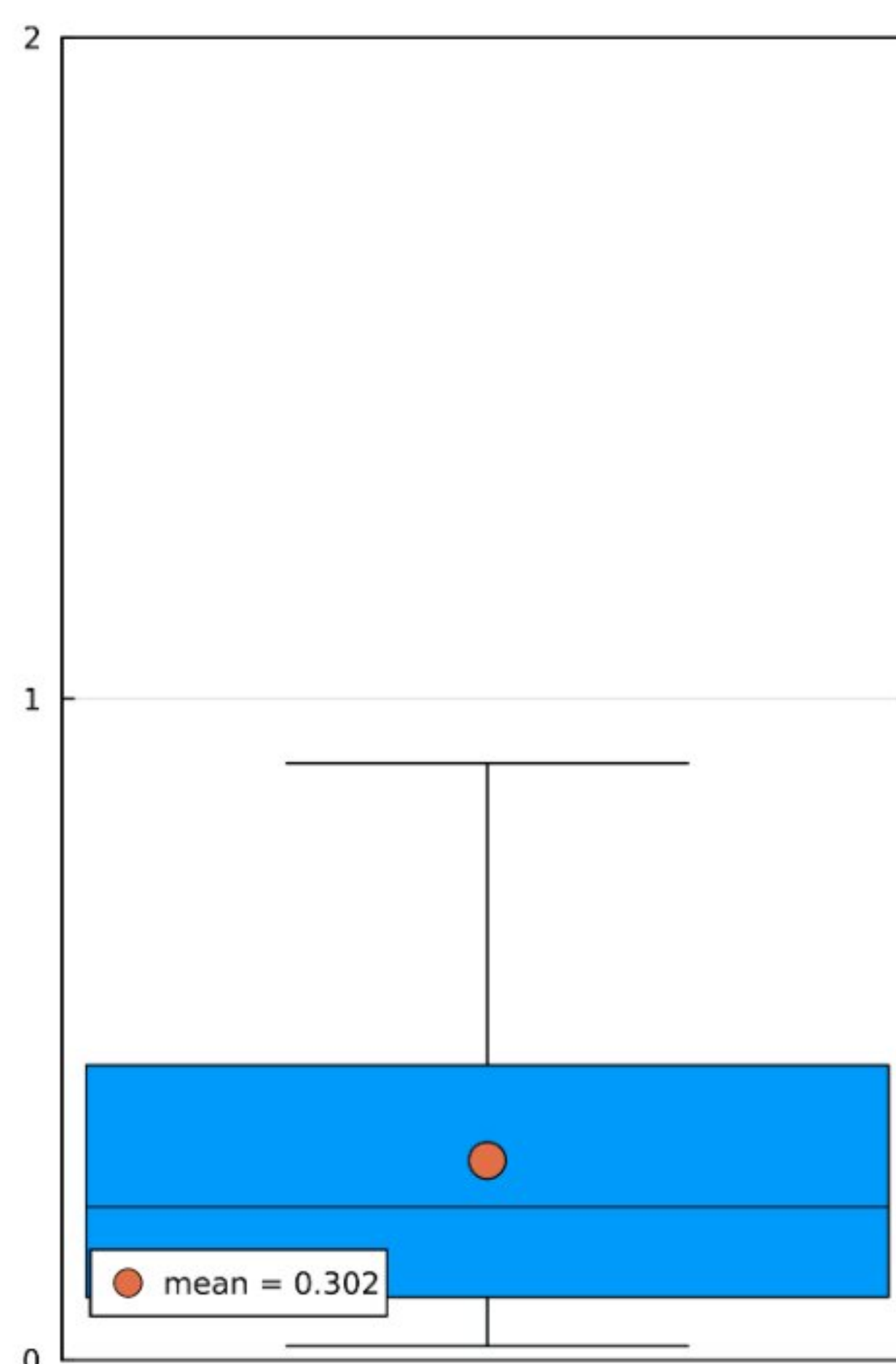


Figure 36 Box-plot: ISF (% BW) values during the spring-summer of 2025

The spatial distribution of the stomach fullness index of turbot (Fig. 37) shows higher values in the central and northern areas off the Bulgarian coast of the Black Sea.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

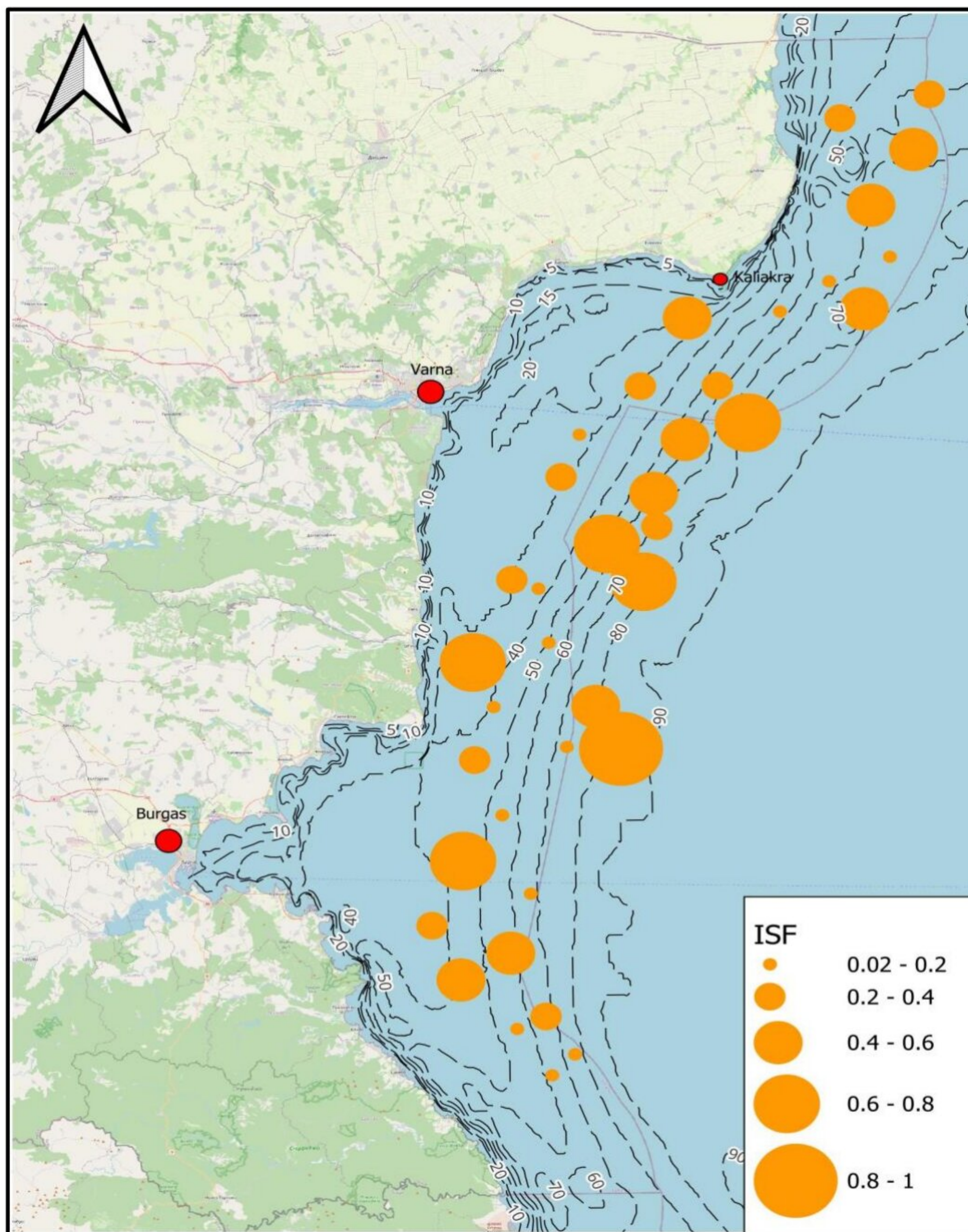


Figure 37 Spatial distribution of the turbot stomach fullness index (ISF, % BW) during the spring-summer season 2025

www.eufunds.bg

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

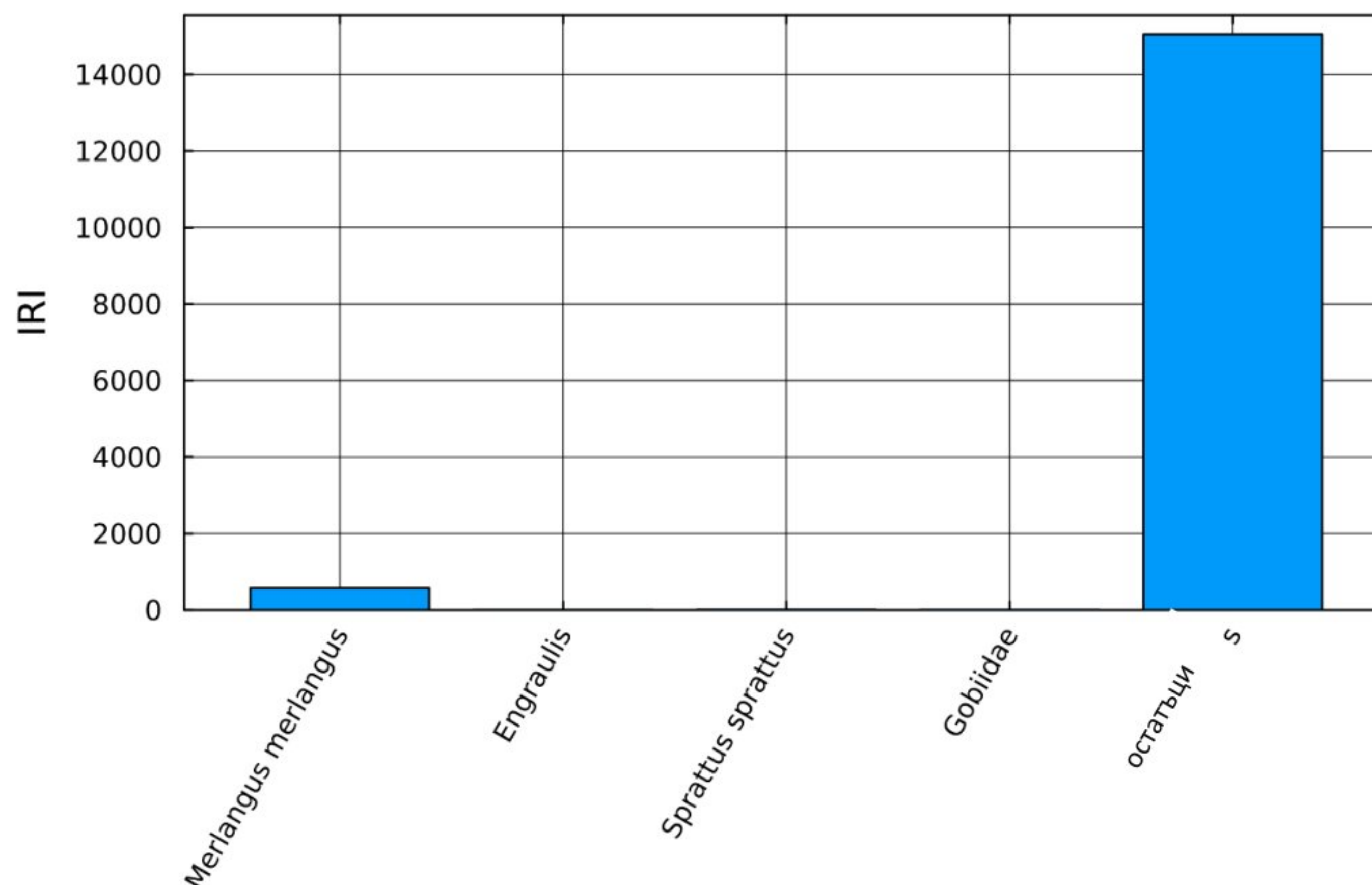


Figure 38 IRI values by species for the spring-summer season of 2025 – Turbot.

Table 11

Qualitative composition of turbot diet during the study period					
Species	FO	CN	CB	IRI	IRI %
<i>Merlangus merlangus</i>	21.28	12.41	14.69	576.67	3.69
<i>Engraulis encrasicolus</i>	2.13	1.06	0.63	3.6	0.02
<i>Sprattus sprattus</i>	2.13	2.13	2.13	9.05	0.06
Gobiidae	2.13	1.06	1.39	5.23	0.03
<i>Remains</i>	91.49	83.33	81.16	15049.12	96.2

During the study period, the highest IRI value was for processed content – 15049.12 (96.20%). Only one taxonomic group was identified, with fish being dominant (IRI = 594.95; 3.80%). Within the fish group, whiting (*Merlangus merlangus*) traditionally prevailed, with IRI = 576.67 (3.69%).

The percentage distribution of the different taxonomic groups according to % IRI is shown in Fig.39.

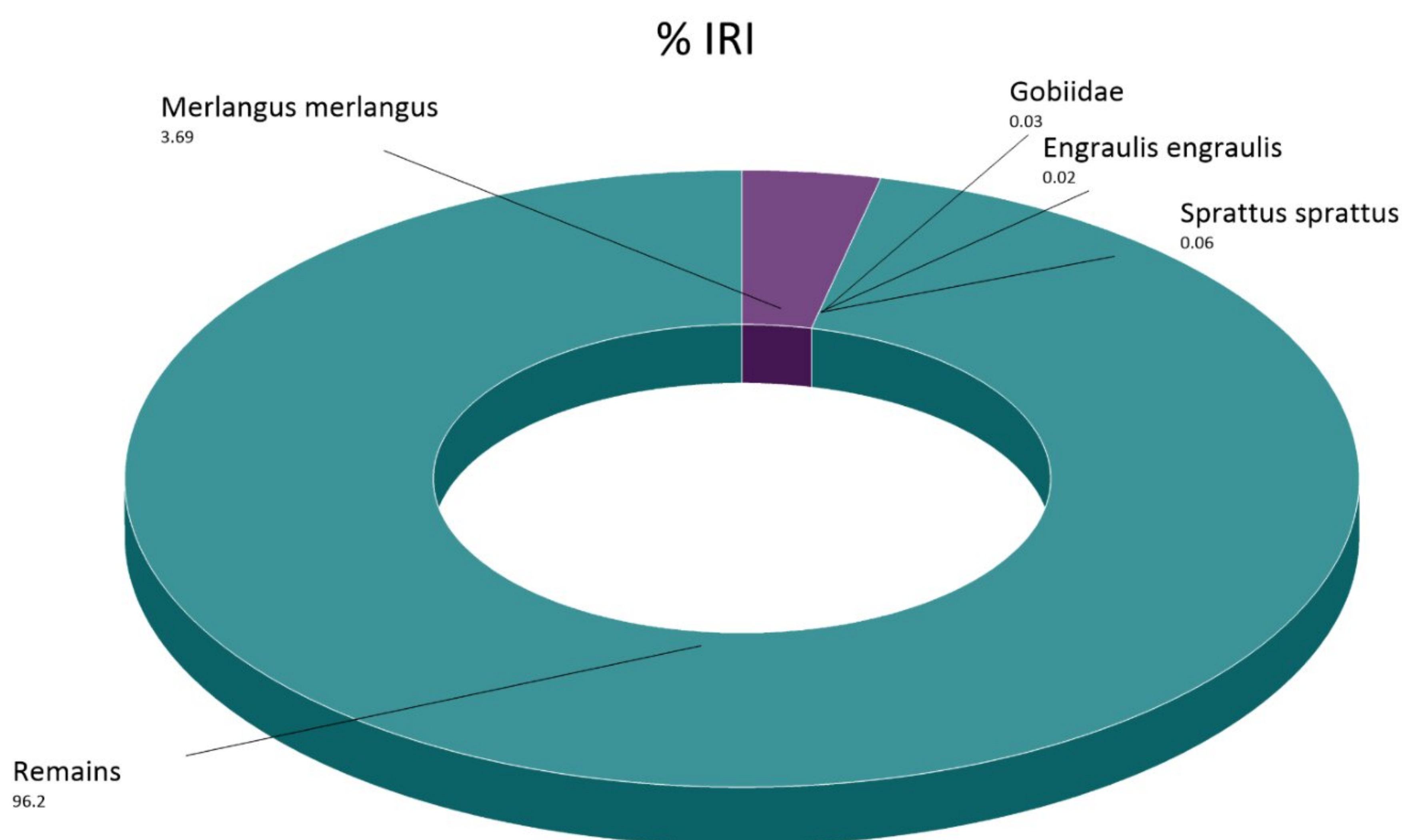


Figure 39 Percentage shares by groups (% IRI) in the turbot diet spectrum during the spring-summer season of 2025



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Additional species, diet spectrum

Along with the analyzed turbot stomachs, during the spring-summer season of 2025 the following fish species were examined to analyze their dietary spectrum: *Squalus acanthias*, *Raja clavata*, and *Merlangus merlangus*.

Piked dogfish (*Squalus acanthias*) – Of the 7 stomachs analyzed to determine the diet spectrum, 6 specimens contained stomach contents (85%). General statistical data for the measured biological parameters are presented in Table 12.

Table 12

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

	L (cm)	W (gr)	Stom. content	ISF
Number	6	6	6	6
Sum	720	41820	172.86	2.33656
Min	113	5730	5.27	0.0792481
Mean	120	6970	28.81	0.389427
Max	128	7870	109	1.38501
Std. dev	4.89898	756.28	39.6746	0.495131
Median	120	7025	12.82	0.201324
Kurtosis	-0.285	-0.704246	1.05872	0.987227
Skewness	0.301869	-0.520156	1.71227	1.6729
Std. Err.	2	308.75	16.1971	0.202136

The mean value of the ISF (stomach fullness) reaches $0.389 \% \text{ BW} \pm 0.20 \text{ SE}$ (Table 12).

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Thornback ray (*Raja clavata*) – A total of 13 stomachs were analyzed, with stomach contents present in 12 specimens (92%). General statistical data for the measured biological parameters are presented in Table 13.

Table 13

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

	L (cm)	W (gr)	Stom. content	ISF
Number	12	12	12	12
Sum	786.00	21475.00	85.60	6.47
Min	56.00	1000.00	1.23	0.06
Mean	65.50	1789.58	7.13	0.54
Max	90.00	4140.00	25.51	2.16
Std. dev	10.73	953.29	6.95	0.61
Median	60.50	1385.00	5.44	0.39
Kurtosis	0.18	1.10	2.06	2.06
Skewness	1.10	1.45	1.58	1.63
Std. Err.	3.10	275.19	2.01	0.18

The mean value of the ISF (stomach fullness) reaches 0.54% BW $\pm$ 0.18 SE (Table 13).

Whiting (*Merlangus merlangus*) – Of the 80 stomachs examined, 9 contained stomach contents. The mean value of the ISF (stomach fullness) reached 4.23% BW $\pm$ 1.11 SE. General statistical data for the measured biological parameters are presented in Table 14.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

Table 14

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

	L (cm)	W (gr)	Stom. content	ISF
Number	9	9	9	9
Sum	117.80	120.42	5.01	38.07
Min	12.00	9.51	0.05	0.53
Mean	13.09	13.38	0.56	4.23
Max	14.60	19.06	1.37	11.81
Std. dev	0.87	3.19	0.40	3.34
Median	13.10	12.25	0.54	3.20
Kurtosis	-0.89	-0.95	0.01	1.04
Skewness	0.45	0.65	0.78	1.29
Std. Err.	0.29	1.06	0.13	1.11

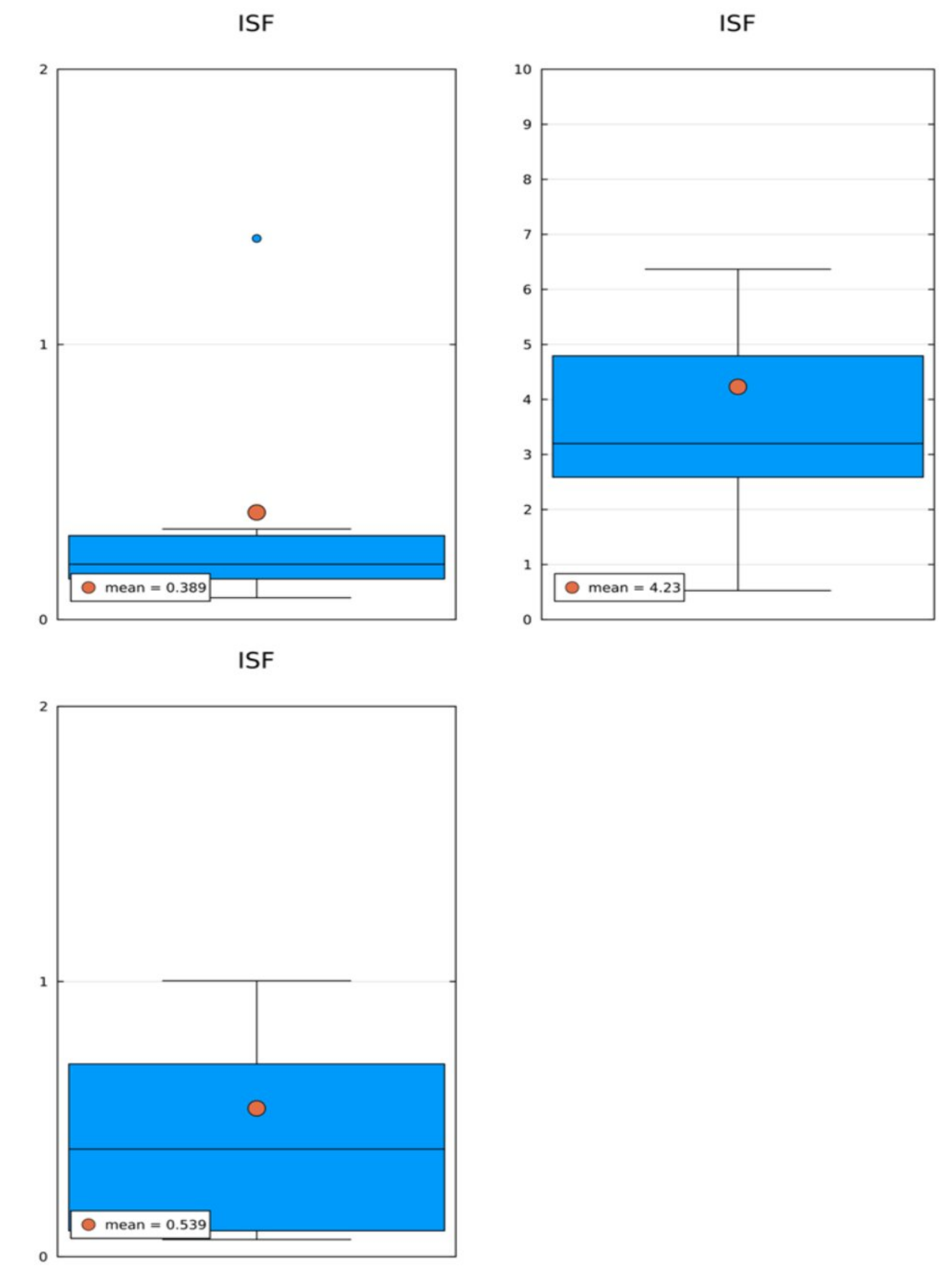


Figure 40 Box-plot: ISF values for a) *Squalus acanthias*, b) *Raja clavata*, c) *Merlangus merlangus*.

The qualitative composition of the diet of *Squalus acanthias*, *Raja clavata*, and *Merlangus merlangus* is presented in Tables 15, 16, and 17.

Table 15

Qualitative composition *Squalus acanthias* diet for the period of research

Species	FO	CN	CB	IRI	IRI %
Merlangus merlangus	150.00	44.44	45.36	13470.89	65.35
Sprattus sprattus	83.33	22.22	18.48	3392.18	16.46
Dolphin meat	66.67	6.67	9.94	1107.44	5.37
Remains	50.00	26.67	26.21	2643.81	12.83

Table 16

Qualitative composition of *Raja clavata* diet for the period of research

Species	FO	CN	CB	IRI	IRI %
Merlangus merlangus	16.67	8.33	8.33	277.78	1.7
Polybius vernalis	50.00	12.5	5.56	903.16	5.53
Remains	91.67	79.17	86.1	15149.77	92.77

Table 17

Qualitative composition of *Merlangus merlangus* diet for the period of research

Species	FO	CN	CB	IRI	IRI %
<i>Sprattus sprattus</i>	33.33	33.33	33.33	2222.22	20.0
Remains	66.67	66.67	66.67	8888.89	80.0

The results of the qualitative analysis show that *Squalus acanthias* feeds mainly on whiting (*Merlangus merlangus*), which accounts for IRI = 13470.89 (63.35%), while ground content forms IRI = 2643.81 (12.83%). In the diet of *Raja clavata*, species from two taxonomic groups were recorded - fish with IRI = 277.78 (1.70%) and Decapoda with IRI = 903.16 (5.53%). For *Merlangus merlangus*, only one taxonomic group was observed, namely fish with IRI = 2222.22 (20%). For this species, food remains content had the highest value, IRI = 8,888.89 (80.00%). The IRI values of the individual species forming the stomach contents of *Squalus acanthias*, *Raja clavata*, and *Merlangus merlangus* during the spring-summer of 2025 are presented in Figures 41, 42, and 43.

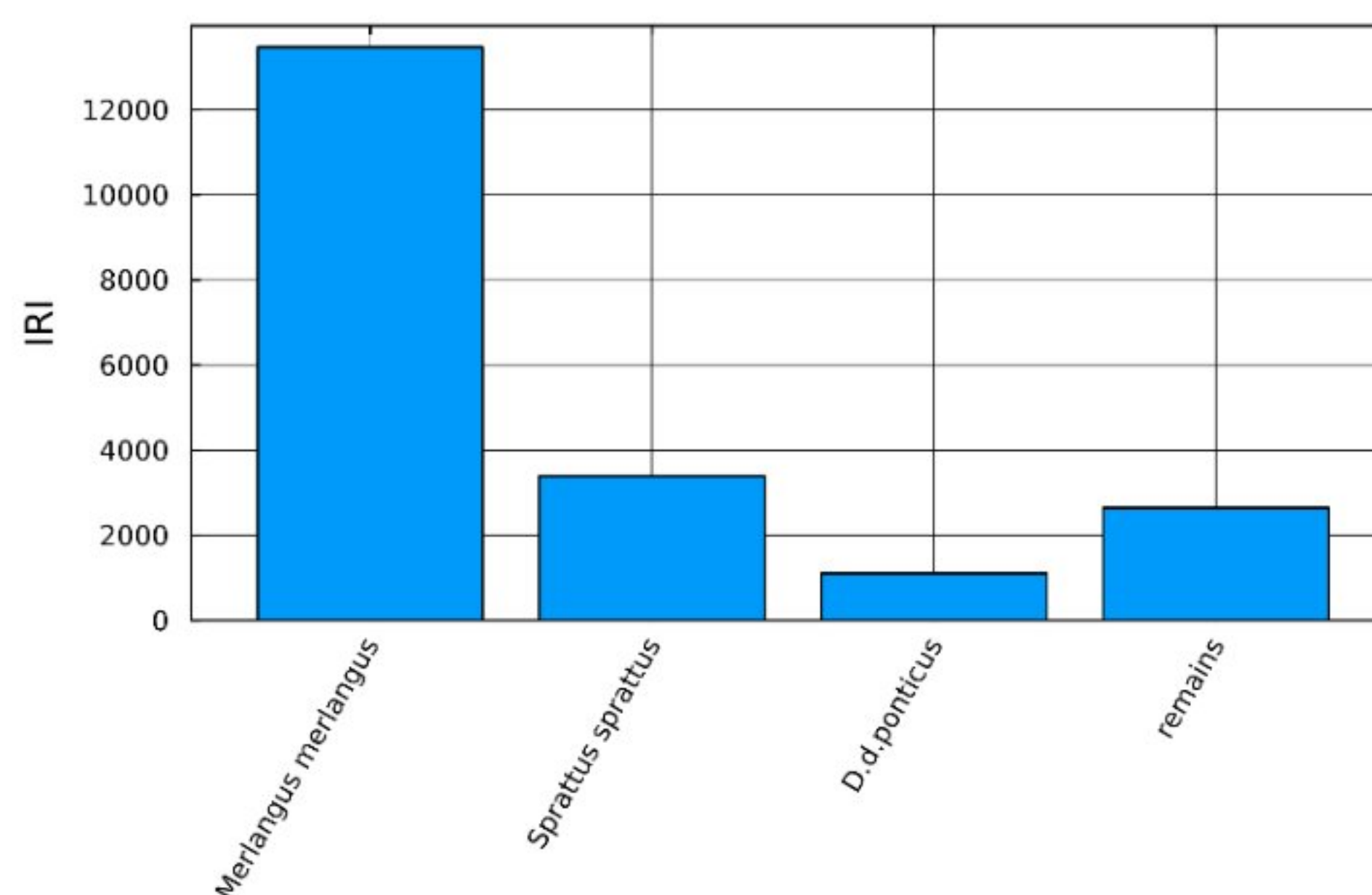


Figure 41 IRI values by species for the spring-summer season of 2025 - *Squalus acanthias*;

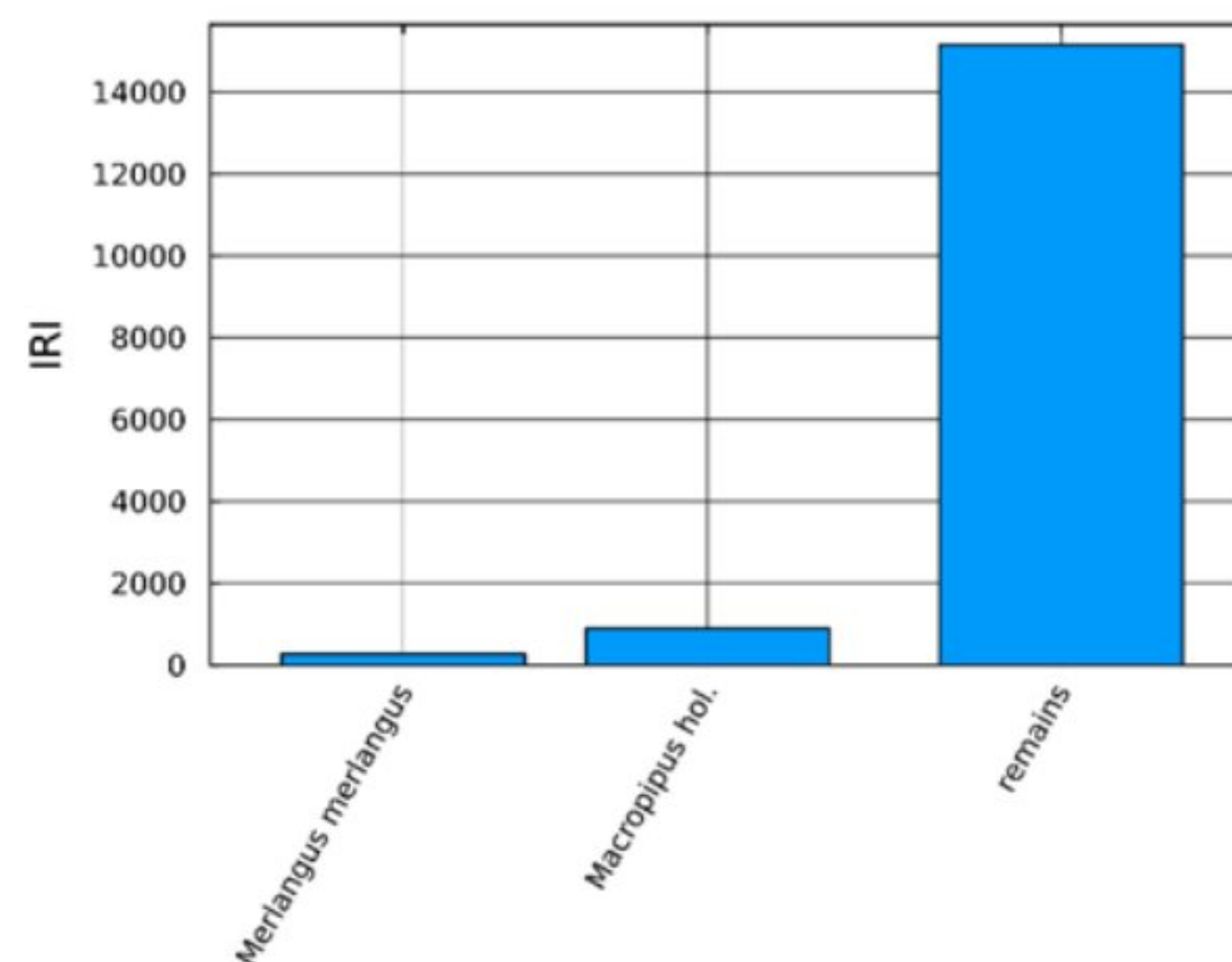


Figure 42 IRI values by species for the spring-summer season of 2025 – *Raja clavata*;

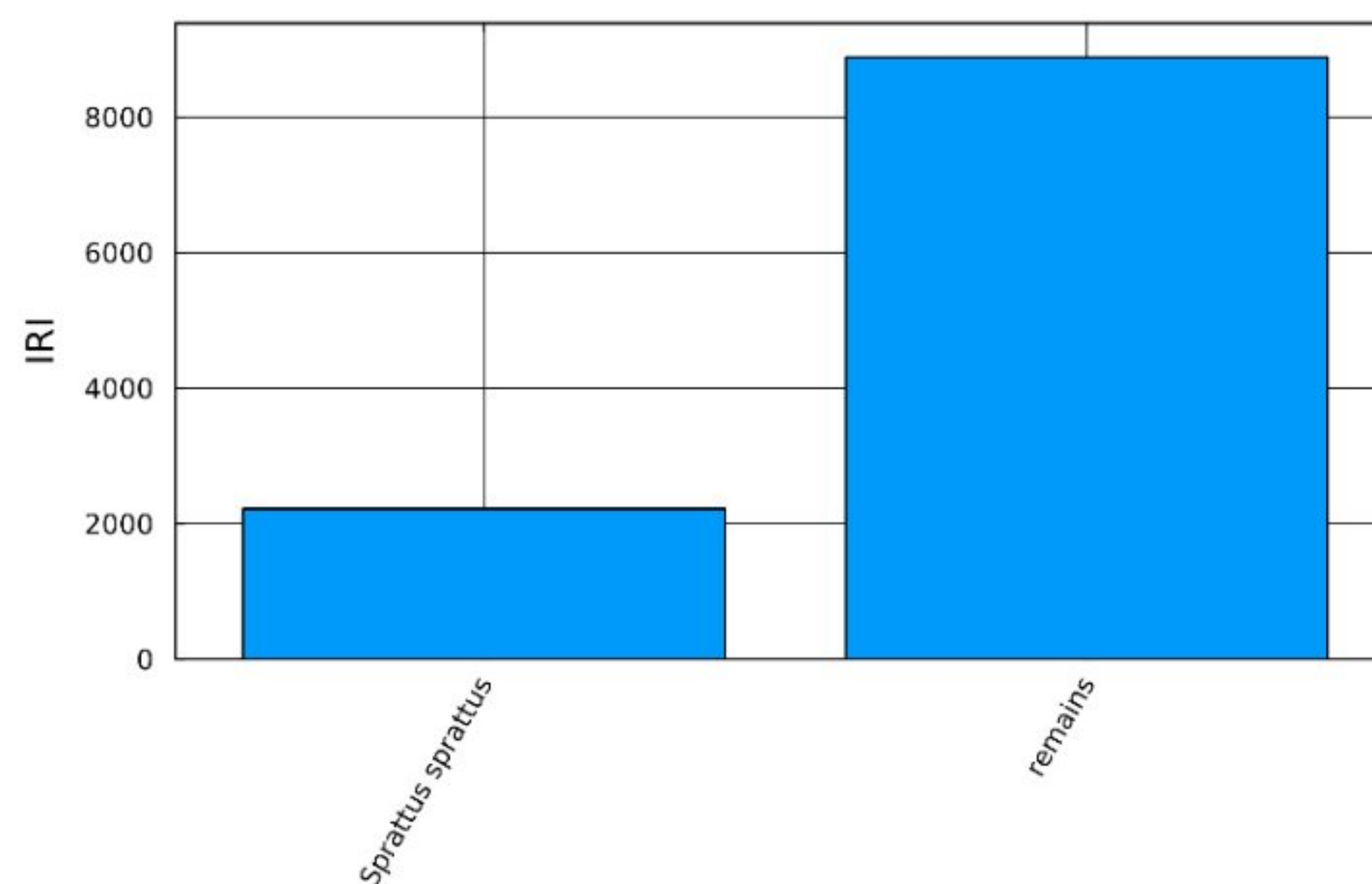


Figure 43 IRI values by species for the spring-summer season of 2025 - *Merlangus merlangus*;

5. Fecundity

The fecundity of 25 females was determined in July-August 2025. The average body weight was **3.34** kg, average total body length - **57.56** cm, and the average age - **6** years (Fig.44).

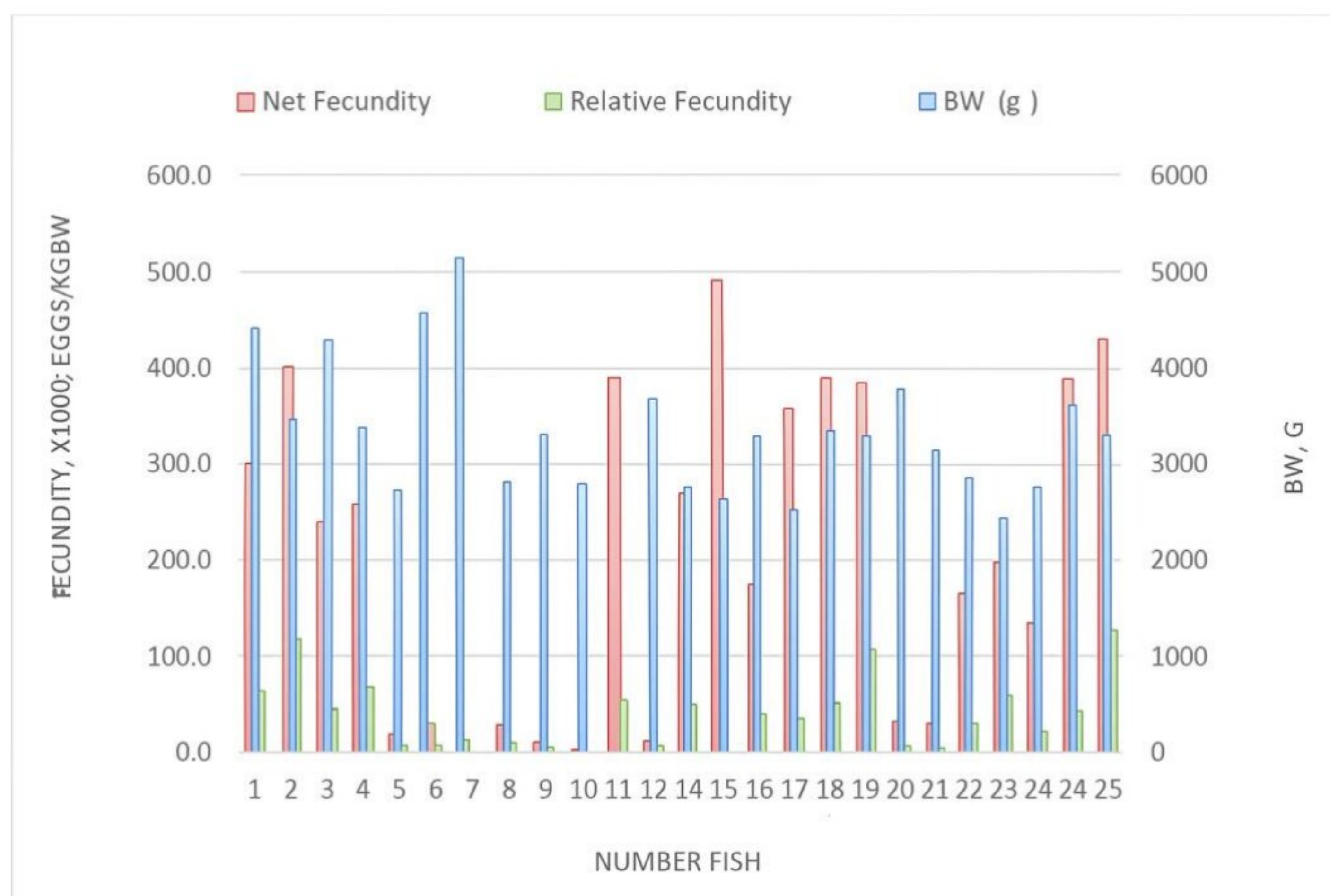


Figure 44 Absolute and relative fecundity of female turbot, July-August 2025;

The absolute fecundity for July-August 2025 is 221 943.5 caviar grains, and the relative fecundity is 67 644.2 caviar grains (Tab. 18).

Table 18

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

Values for absolute and relative fecundity of turbot V 2025.

Indicator	Average values
Number of female fish	25
Full body length, TL (cm)	57.56
Body weight, BW (g)	3 426
Absolute fecundity ($\times 10^3$), eggs/ individual	221 943.5
Relative fecundity ($\times 10^3$), eggs /kg BW	67 644.2
Age, year	6

The established fecundity (221,943.5 caviar/individual) is almost 10 times lower according to literature data - Aydin & Sahin, 2011 (2,554,500 caviar/individual), 9 times lower than Aydin et al. 2019 (2,400,000 caviar/individual) and 6 times lower than the one found in a study of the IRA, Plovdiv from 2022 (1,698,957 caviar/individual). This is due to the fact that the samples from the cited studies were taken immediately before the breeding season or during breeding, while in the present study the samples were taken at the end of July.

The current results for turbot fecundity are very close in value to those established by IFR - Varna (269 920.1 caviar) in 2023 and the samples were also taken after the end of the breeding season, in July.

----- www.eufunds.bg -----

Weather conditions during the survey

During the expedition activity, the dominant direction of the wind was - west, northeast and southeast, with a strength between 1-2^o Bf - along the coast and 2-3^o Bf - in the open sea.

In the spring-summer season of 2025, the conditions were normal for carrying out a trawl photo to assess turbot stocks in the Bulgarian waters of the Black Sea.

6. Conclusions and recommendations

From the collected information and results obtained from the trawl survey in spring-summer, 2025 the following conclusions and recommendations can be made:

- The turbot biomass in the entire studied area in front of the Bulgarian coast of the Black Sea was estimated at **1945.75** tonnes (Table 4). The abundance in the studied area was estimated at **897.56*10³** specimens (Table 4).
- The recommended **MSY (maximum sustainable yield)** for Bulgaria will be calculated and incorporated into the autumn-winter report, encompassing data from both trawl surveys conducted in the spring-summer and the autumn-winter season of 2025.
- The size structure of the turbot population, in the Bulgarian Black Sea zone included length classes from **20** cm to **74** cm were observed, with weights varying between **130** g and **7100** g. The average weight of the turbot was estimated at **2167.82** g. Individuals measuring less than 45 cm constituted 26.21% of the total population, while those exceeding 45 cm accounted for 73.79%.
- The age composition of the population included age classes from 1 to 10 years, with a predominant presence of 3-year-olds (29.61%), 4-year-olds (25.73%) and 5 -year-olds (19.42%), collectively accounting for 74.76%. This is followed by 6-year-old specimens, which represent 10.19%.

----- www.eufunds.bg -----



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

- The established ratio of female, male, and immature individuals in the catch is **42.23%: 31.55%: 26.21%**.
- The recorded fecundity of turbot in July-August 2025 is **221 943.5** caviar grains per individual. Current turbot fecundity results are nearing those observed in 2023, which recorded 269 920.1 spawn per individual, also sampled in July.
- *M. merlangus* is widespread, with higher concentrations observed in the south between Primorsko and Tsarevo at a depth of 45 - 65. The average biomass index (CPUE) of *M. merlangus* is 42.11 kg/h, with the highest indicators ahead of the southern coasts (up to 200 kg/h), and catches are dominated by size classes of 10.5 – 15.5 cm, with female specimens dominant.
- Specimens of the species *S. acanthias* are observed mainly between Varna-Byala (27-36 m) only female specimens and in front of Klayakra and Emine (79-83 m) concentration of male specimens; accumulation of *Pl. flesus* occurs in the northern part of the Bulgarian coast in front of Kavarna and in front of the central part of the coast of Varna, at a depth of 60-68 m. Representatives of the species *R. clvata* are observed in front of Primorsko-Tsarevo at depths of 60 - 75 m.
- The whiting biomass in the entire studied water area off the Bulgarian coast of the Black Sea is estimated at **7243.3** tonnes, with an abundance of approximately **455.67** thousand specimens. The calculated biomass of the thornback ray in the same area is **475.71** tonnes, and its abundance is estimated at **535.08** thousand specimens. Accurate estimation of biomass and abundance for these species is challenging due to their patchy and highly scattered distribution. Consequently, the CPUE biomass estimation method July-August yield inaccuracies. The current biomass of the dogfish in this water area is estimated at **1724.72** tonnes. For the studied period, the total abundance for the entire area was estimated at **239.84** thousand individuals.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

- In the summer season of 2025, 104 stomachs were analyzed to determine the diet spectrum of turbot and a total of 100 stomachs from additional species - *Squalus acanthias*, *Raja clavata*, and *Merlangus merlangus*. The qualitative composition of the turbot diet shows the presence of one taxonomic group - the dominant group - fish IRI= 594.95 (3.80%). Of the group of fish with the highest value, the IRI whiting = 576.67 (3.69%) traditionally prevails. For the study period, the ground content with the highest IRI value is 15049.12 (96.20%). The results of the qualitative analysis show that the species *Squalus acanthias* feeds mainly on whiting (*Merlangus merlangus*).), which forms IRI = 13470.89 (63.35%) and ground content IRI = 2643.81 (12.83%). In the diet of the species *Raja clavata*, species of two taxonomic groups were recorded - fish with IRI = 277.78 (1.70%) and Decapoda with IRI = 903.16 (5.53%). In the species *Merlangus merlangus*, only one taxonomic group was observed, respectively fish with an IRI = 2222.22 (20%). For this species, the ground content had the highest value IRI = 8888.89 (80.00%).

7. References

- Alverson, D. L., 1971.** Manual of methods for fisheries resource survey and appraisal. Part 1. Survey and charting of fishery resources. *FAO Fish. Tech. Pap.*, (102): 80 p.
- Avşar, D., 1998.** Balıkçılık Biyolojisi ve Populasyon Dinamiği. Çukurova Üniversitesi, Su Ürünleri Fakültesi. Ders Ders Kitabı No: 5, Baki Kitap Evi, Adana, 303s.
- Aydin, I. and Sahin, T. 2011.** Reproductive performance of turbot (*Psetta maxima*) in the Southern Black Sea Coast. *Turkish Journal of Zoology*, 35(1): 109-113.
- Aydin, I., Polat, H., Sahin, T. 2019.** Reproductive performance of wild and hatchery-reared Black Sea Turbot, *Psetta maxima*, in the Southern Black Sea *Turkish Journal of Fisheries and Aquatic Sciences*, 20 (5): 351:357.
- Bertalanffy, L. Von, 1934.** Untersuchungen über die Gesetzmäßigkeiten des Wachstums. 1. Allgemeine Grundlagen der Theorie. *Roux'Arch.Entwicklungs-mech.Org.*, 131: 613-653.
- Beverton, R. J. H. and S. J. Holt, 1957.** On the dynamics of exploited fish populations.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

Fish.Invest.Minist.Agric.Fish.Food.G.B. (2 Sea Fish.), 19: 533 p.

Beverton, R. J. H. and S. J. Holt, 1966. Manual of methods for fish stock assessment. Part 2. Tables of yield functions. Manuel sur les méthodes d'évaluation des stocks ichthyologiques. Partie 2. Tables de fonctions de rendement. Manual de métodos para la evaluación de los stocks de peces. Parte 2. Tablas de funciones de rendimiento. *FAO Fish.Tech. Pap. /FAO Doc.Tech. Pêches/FAO Doc Téc.Pesca*, (38) Rev. 1 : 67 p.

Beverton, R. J. H., and S. J. Holt, 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. *Rapp.P.-V. Réun.CIEM*, 140:67-83.

Bulgurkov, K., 1965. Food and distribution of industrial turbot (*Rhombus maeoticus* Pallas) in the southern region of the Bulgarian Black Sea coast. *Izv. of the Institute of Fisheries and Oceanography - Varna*, vol. VI, pp. 99-109.

Cadima, E. L., 2003. Fish stock assessment manual. *FAO Fisheries Technical Paper*. No. 393. Rome, 161p.

Cochran W.G., 1977. Sampling techniques (3rd edition). John Wiley & Sons, New York, USA, 428pp.

European Commission, Joint Research Centre, Mannini, A., The JRC MEDITS R script – A tool to analyse MEDITS data during STECF EWGs, Publications Office, 2020, <https://data.europa.eu/doi/10.2760/5799>.

Gulland, J. A., 1966. Manual of sampling and statistical methods for fisheries biology. Part I: Sampling methods. *FAO Manuals in Fisheries Science* No. 3, Rome.

Gulland, J. A., 1969. Manual of Methods for Fish Stock Assessment - Part 1. Fish Population Analysis. *FAO Manuals in Fisheries Science* No.4:154p.

Ivanov, L.S., M. Karapetkova, 1979. Dynamics of the stock of turbot (*Scophthalmus maeoticus* Pallas) from the Bulgarian Black Sea shelf and measures for their rational exploitation. I. Growth and mortality; II. Stocks and reproduction. *Hydrobiology*, 9, 3-14 and 15-28.

Jones R., 1981. The use of length composition data in fish stock assessment (with notes on VPA and cohort analysis). *FAO Fish.Circ.No* 734, 55 pp.

Mannini, A., 2020. European Commission, Joint Research Centre, The JRC MEDITS R script : a tool to analyse MEDITS data during STECF EWGs, Publications Office, <https://data.europa.eu/doi/10.2760/5799>

Marinov, K., M. Karapetkova, 1957. Distribution of turbot during the first months of 1955. *Scientific Papers of Scientific Research Inst. of Fisheries and Fisheries - Varna*, vol. I., Zemizdat, Sofia, 45-51 pages.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



- Martino, K., M. Karapetkova, 1957.** Distribution of turbot during the first months of 1955. Scientific annals of Research Institute of Fisheries and fish industry. – Varna, vol. I, Publ. Zemizdat, Sofia, 45-51 pp.
- Nash, R.D.M., Valencia, A.H., Geffen, A. J. 2006.** The origin of Fulton's condition factor – setting the record straight. *Fisheries* 31:5, 236-238.
- National Research Council 1998.** Improving Fish Stock Assessments. Washington, DC: The National Academies Press. <https://doi.org/10.17226/5951>.
- Pauly, D., 1980.** On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons.Int. Explor. Mer*, 39:175-192.
- Pauly, D., 1983.** Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical Paper No. 234, 52 p.
- Pavlova E., S. Stoykov, V. Mihneva, D. Gerdjikov, Klisarova D., S. Valchev, F. Tserkova, 2017.** "Stock assessment of turbot (*Scophthalmus maximus*) by swept area method in front of Bulgarian Black Sea coast during autumn – winter 2016". Project report for the National Agency of Fisheries and Aquaculture of Bulgaria to National Data Collection program for 2017, 36 pp.
- Pavlova E., S. Stoykov, V. Mihneva, D. Gerdjikov, Petrova D., F. Tserkova, S. Valchev T. Hubenova, A. Zaikov, L. Hadjinikolova, A. Ivanova, M. Gevezova, G. Rusenov, V. Maximov, G. Radu., 2016.** "Stock assessment of turbot (*Scophthalmus maximus*) by swept area method in front of Bulgarian Black Sea coast during autumn – winter 2015". Project report for the National Agency of Fisheries and Aquaculture of Bulgaria to National Data Collection program for 2016, 66 pp.
- Pavlova E., S. Stoykov, V. Mihneva, Klisarova D., D. Gerdjikov, F. Tserkova, S. Valchev, V. Maximov, G. Radu., 2017.** "Stock assessment of turbot (*Scophthalmus maximus*) by swept area method in front of Bulgarian Black Sea coast during spring-summer 2016". Project report for the National Agency of Fisheries and Aquaculture of Bulgaria to National Data Collection program for 2016, 44 pp.
- Pavlova E., S. Stoykov, V. Mihneva, S. Valchev, P. Penchev, D. Gerdjikov, Klisarova D., , F. Tserkova, 2017.** "Stock assessment of turbot (*Scophthalmus maximus*) by swept area method in front of Bulgarian Black Sea coast during spring-summer 2017". Project report for the National Agency of Fisheries and Aquaculture of Bulgaria to National Data Collection program for 2017, 40 pp.
- Pavlova E., S. Stoykov, V. Mihneva, S. Valchev, P. Penchev, D. Gerdjikov, Klisarova D., , F. Tserkova, 2018.** "Stock assessment of turbot (*Scophthalmus maximus*) by swept area method in front of Bulgarian Black Sea coast during autumn 2017". Project report for the National Agency of Fisheries and Aquaculture of Bulgaria to National Data Collection

----- www.eufunds.bg -----



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

program for 2017, 40 pp

Pavlova E., S. Stoykov, V. Mihneva, S. Valchev, P. Penchev, D. Gerdjikov, Klisarova D., F. Tserkova, 2018. "Stock assessment of turbot (*Scophthalmus maximus*) by swept area method in front of Bulgarian Black Sea coast during spring-summer 2018". Project report for the National Agency of Fisheries and Aquaculture of Bulgaria to National Data Collection program for 2018, 43 pp.

Petrova E., Stoykov S., Mihneva V., Valchev S., Georgiev K., Angelov G., Penchev Ph., Tserkova F., 2022. Bottom trawl surveys in the Bulgarian Black Sea Area, Spring-summer-Summer 2022, Report under Contract with the Executive Agency Fisheries and Aquaculture, Bulgarian Work Plan for data collection in the fisheries and aquaculture sectors 2022, p.64.

Petrova E., Stoykov S., Mihneva V., Valchev S., Penchev Ph., Tserkova F., 2019. Bottom trawl surveys in the Bulgarian Black Sea Area, Spring-summer 2019, Report under Contract with the Executive Agency Fisheries and Aquacultures, Program for data collection for fishing in 2019, p.48.

Petrova E., Stoykov S., Mihneva V., Valchev S., Penchev Ph., Tserkova F., 2020. Bottom trawl surveys in the Bulgarian Black Sea Area, autumn 2019, Report under Contract with the Executive Agency Fisheries and Aquacultures, Program for data collection for fishing in 2020, p.52.

Petrova E., Stoykov S., Mihneva V., Valchev S., Penchev Ph., Tserkova F., 2020. Bottom trawl surveys in the Bulgarian Black Sea Area, Summer 2020, Report under Contract with the Executive Agency Fisheries and Aquacultures, Program for Data collection for fisheries in 2020, p.53.

Petrova E., Stoykov S., Mihneva V., Valchev S., Penchev Ph., Tserkova F., 2021. Bottom trawl surveys in the Bulgarian Black Sea Area, Autumn-Winter 2020, Report under Contract with the Executive Agency Fisheries and Aquacultures, Program for Data collection for fisheries in 2021, p.46.

Petrova E., Stoykov S., Mihneva V., Valchev S., Penchev Ph., Tserkova F., 2021. Bottom trawl surveys in the Bulgarian Black Sea Area, spring-summer 2021, Report under Contract with the Executive Agency Fisheries and Aquacultures, Program for Data collection for fisheries in 2021, p.53.

Petrova E., Stoykov S., Mihneva V., Valchev S., Georgiev K., Angelov G., Penchev Ph., Tserkova F., 2022. Bottom trawl surveys in the Bulgarian Black Sea Area, Autumn-Winter 2021, Report under Contract with the Executive Agency Fisheries and Aquacultures, Program for Data collection for fisheries in 2022, p.59.

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

- Petrova E., Stoykov S., Mihneva V., Valchev S., Georgiev K., Angelov G., Penchev Ph., Tserkova F., 2023.** Bottom trawl survey and stock assessment of target species - turbot, spiny dogfish and whiting, and bycatch of thornback ray and other accompanying species off the Bulgarian Black Sea coast during the autumn-winter season of 2022, Report under Contract with the Executive Agency Fisheries and Aquaculture, Bulgarian Work Plan for data collection in the fisheries and aquaculture sectors 2022, p.92.
- Petrova E., Stoykov S., Mihneva V., Valchev S., Georgiev K., Penchev Ph., Tserkova F., 2023.** Bottom trawl survey and stock assessment of target species - turbot, spiny dogfish and whiting, and bycatch of thornback ray and other accompanying species off the Bulgarian Black Sea coast during the spring-summer season of 2023, Report under Contract with the Executive Agency Fisheries and Aquaculture, Bulgarian Work Plan for data collection in the fisheries and aquaculture sectors 2023, p.83.
- Petrova E., Stoykov S., Mihneva V., Valchev S., Georgiev K., Penchev Ph., Tserkova F., 2023.** Bottom trawl survey and stock assessment of target species - turbot, spiny dogfish and whiting, and bycatch of thornback ray and other accompanying species off the Bulgarian Black Sea coast during the autumn-winter season of 2023, Report under Contract with the Executive Agency Fisheries and Aquaculture, Bulgarian Work Plan for data collection in the fisheries and aquaculture sectors 2025, p.90.
- Petrova E., Stoykov S., Mihneva V., Valchev S., Hyusein A., Georgiev K., Penchev Ph., Tserkova F., 2024.** Bottom trawl survey and stock assessment of target species - turbot, spiny dogfish and whiting, and bycatch of thornback ray and other accompanying species off the Bulgarian Black Sea coast during the autumn-winter season of 2024, Report under Contract with the Executive Agency Fisheries and Aquaculture, Bulgarian Work Plan for data collection in the fisheries and aquaculture sectors 2025, p.89.
- Pinkas, L., M. S. Oliphant, I. L. K. Iverson. 1971.** Food habits of albacore, bluefin tuna and bonito in Californian waters. *California Fish Game* 152:1-105.
- Raykov, 2011.** Status, trends and environmental aspects of population dynamics of sprat (*Sprattus Sprattus* L.) Bulgarian sector of the Black Sea. PhD thesis, 210 p.
- Ricker, W. E., 1975.** Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Can.*, (191):382 p.
- Rikhter, J. A, V. N. Efanov, 1976** - On one of the approaches to estimation of natural mortality of fish population. *ICNAF* 76/VI/8, 12p.
- Sabatella, E., R. Franquesa, 2004.** Manual for fisheries sampling surveys: Methodologies for estimation of socio-economic indicators in the Mediterranean Sea. General Fisheries Commission for the Mediterranean. Studies and Reviews, No.73, FAO Rome, ISBN 1020-7236, 38 pp.
- Souplet, A., 1996.** Définition des estimateurs. In: Campagne internationale de chalutage démersal

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.



Co-funded by
the European Union



MINISTRY OF AGRICULTURE AND FOOD



MARITIME, FISHERIES AND
AQUACULTURE PROGRAMME

en Méditerranée (Médits 95). Vol. III. Indices de biomasse et distributions en tailles. Bertrand J. Coordonnateur général. Etude 94/047 IFREMER/CE, 94/011 IEO/CE, 94/057 SIBM/CE, 94/051 NCMR/CE

Sparre, P., S. C. Venema, 1992. Introduction to tropical fish stock assessment. Part1. *FAO Fisheries Technical Paper* No 306.1, Rome, 376 p.

Sparre, P., S. C. Venema, 1998. Introduction to tropical fish stock assessment. Part I: Manual. *FAO Fisheries Technical Paper*, 306/1, rev.2, DANIDA, Rome FAO. 407p. ISBN 92-5-103996-8.

Troadec, J. P., 1977. Méthodes semi-quantitatives d'évaluation. *FAO circ.Pêches*, (701) :131-141.

Tserkova, F., D. Petrova, E. Pavlova, S. Stoykov, V. Mihneva, T. Hubenova, A. Zaikov, L. Hadjinikolova, D. Terziyski, A. Ivanova, M. Gevezova, V. Maximov, G. Radu., 2015. "Stock assessment of turbot (*Psetta maxima*) by swept area method in front of Bulgarian Black Sea coast during autumn – winter 2014". Project report for the National Agency of Fisheries and Aquaculture of Bulgaria to the National Data Collection program for 2015, 56 pp.

Tserkova, F., D. Petrova, E. Pavlova, S. Stoykov, V. Mihneva, V. Maximov, G. Radu., 2015. Abundance of Turbot (*Psetta maxima* L.) along the Bulgarian Black Sea Coast in Autumn 2014. Ozhan, E.(Editor), 2015, *Proceedings of Twelfth International Conference on the Mediterranean Coastal Environment, MEDCOAST, 15*, 06-10 October 2015, Varna, Bulgaria, MEDCOAST, Mediterranean Coastal Foundation, Dalyan, Mugla, Turkey, vol 1, 419-430 p. ISBN: 978-605-85652-4-1.

Walford, L. A., 1946. A new graphic method of describing the growth of animals. *Biol. Bull. Mar. Biol. Lab. Woods. Hole*, 90:141-147.

Zengin, M., 2005. Report of the Assessment Methodologies for the Turbot Stock in the Black Sea; Proposals for Standardized Methodology and Implementation at the Regional Level. AG FOMR, BSC.

Zupa W., Casciaro L., Bitetto I., Spedicato M.T., 2023. BioIndex (3.3). Zenodo. <https://doi.org/10.5281/zenodo.8181238>

----- www.eufunds.bg -----

Project BG14MFPR001-1.002-0002 „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2025-2026“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.