# 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 autumn-winter season of 2024.***

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

**2025**

Co-funded by the European Union

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The present study was conducted by a team of specialists from the Institute of Fishery Resources (IFR) – Varna, Agricultural Academy, under contract № 146/10.03.2023 with the Executive Agency for Fisheries and Aquaculture (EAFA), for turbot stock assessment in the Bulgarian Black Sea waters during the autumn-winter period of 2024.

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 25 November - 19 December 2024 in the Bulgarian Black Sea waters on board of 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**

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***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.***

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# *BOTTOM TRAWL SUREVY FOR STOCK ASSESSMENT OF REFERENCE BOTTOM SPECIES IN BULGARIAN BLACK SEA SECTOR DURING AUTUMN-WINTER SEASON OF 2024*






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## LIST OF *FIGURES IN THE TEXT*






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# *BOTTOM TRAWL SURVEY FOR REFERENCE STOCK ASSESSMENT IN BULGARIAN BLACK SEA SECTOR DURING AUTUMN WINTER SEASON OF 2024*

## 1. Results from the National Bottom Trawl Surveys in November-December 2024

During 25 November - 19 December 2024**,** under contract number 146/10.03.2023 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 100 m of the shoreline.

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



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the 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.

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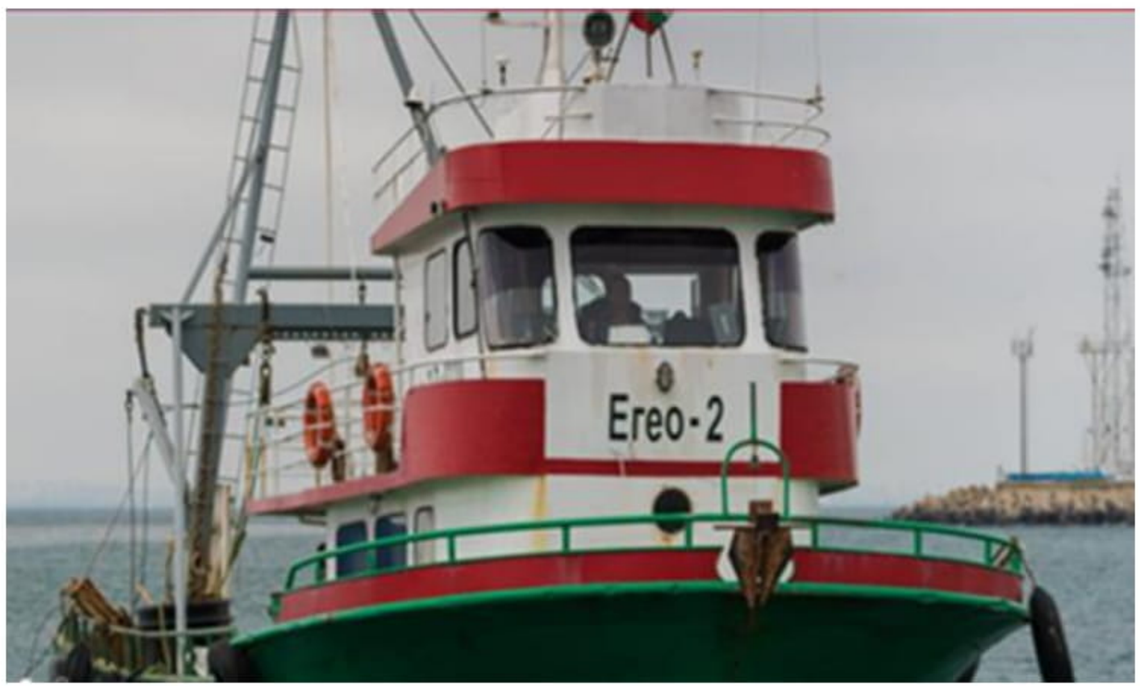


**Picture 1.** *Fishing ship*

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;



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***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.



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Stratified sampling

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/km$^2$) 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/km$^2$, kg/km$^2$);
- Abundance index (individual/km$^2$);
- 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 Nm$^2$ (or 85.8569 m$^2$). 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 km$^2$ (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.



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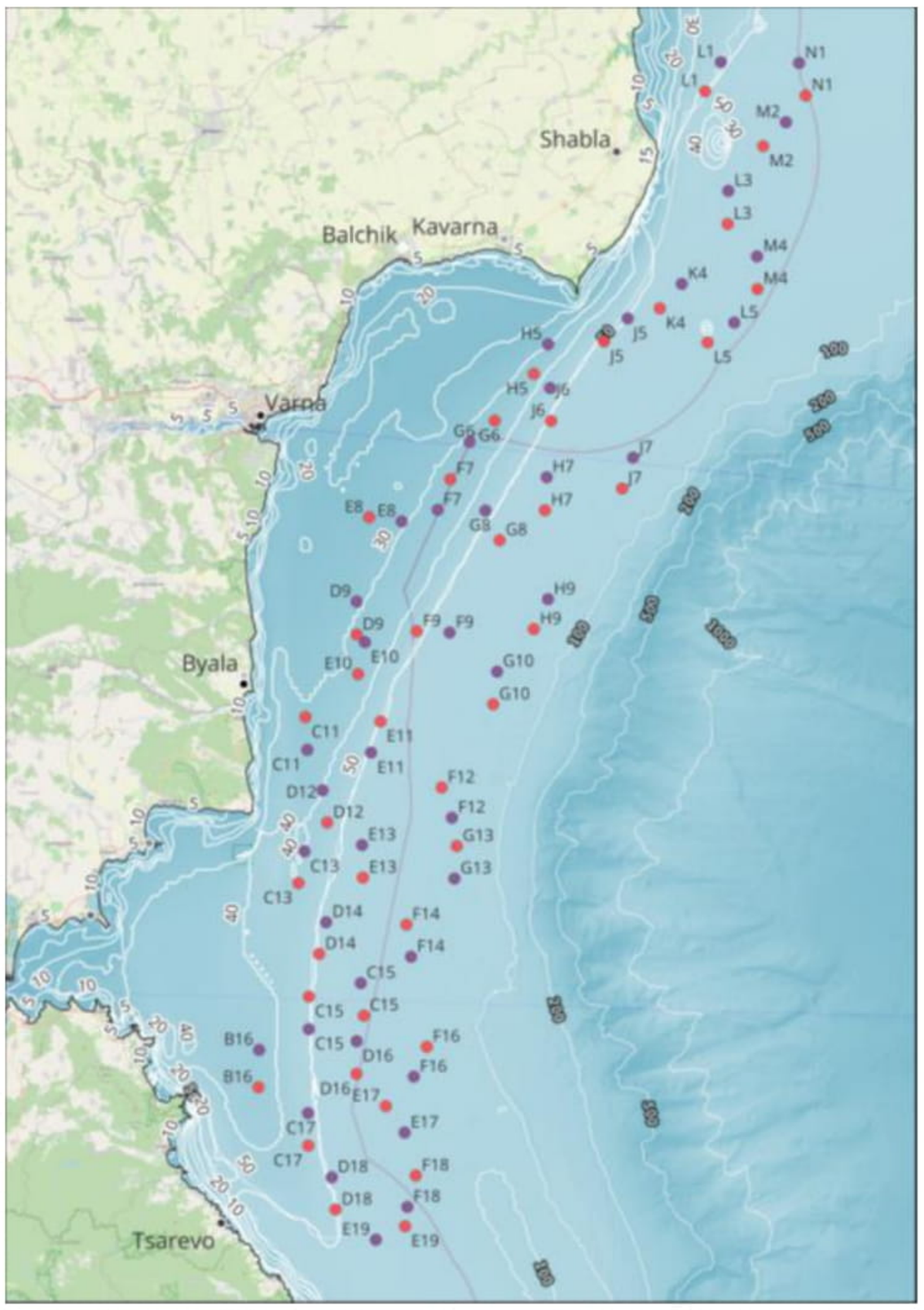


Figure 1 *Map of the surveyed sectors.*

## 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



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individuals of both sexes were calculated, and the percentage distribution by size class (TL, cm) was determined.

During the autumn-winter season of 2024, 131 stomachs were analyzed to determine the food spectrum of turbot, and a total of 94 stomachs from additional species - *Squalus acanthias, Raja clavata, Merlangus merlangus and Pomatomus saltatrix*. 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



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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)

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=TAn$wing_opening/10000000*TAn$distance assignment of each haul to one of the five stratification MEDITS depth strata is performed according to the haul mean depth =(TAn$shooting_depth+TAn$hauling_depth)/2.

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

***Biomass and abundance indices (kg/km$^2$, n/km$^2$)***

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:

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

xi, j is the weight of individuals caught in the individual hauls of the stratum and Ai, j is the corresponding swept area. Variance was calculated using the following formula:

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



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

$$I = \sum_{i=1}^{N} Wi\,\bar{X}i$$

Wi 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:

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

where fi 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:

$$\text{s.d.} = \sqrt[2]{Var(I)}$$

and the Coefficient of Variation is.

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



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

$$CPUE = yield/effort$$

***Maximum sustainable yield***

Gulland's formula for virgin stock is

$$MSY = 0.5 * M * Bv$$

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

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

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

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

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

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

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

***TAC - total allowable catch, Prediction models***

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

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



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

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.

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

Jones' length-based cohort analysis:

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

***Age and growth***

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

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

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

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

The length – weight relationship 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: $K = 100*(W/L^3)$, where: W - weight, L - length.



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***Natural mortality (M)***

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

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

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

L∞, W∞ and k – parameters in von Bertalanffy's equation; T°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 in XI-XII 2024, the following activities were conducted:

- 40 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 291 specimens of turbot, 9 european flounder, 148 thornback ray and 60 spiny dogfish specimens (Pictures 4 and 5);



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***Pictures 3.*** *Bottom trawling yield*

The constant presence of *S. maximus species was found* in almost all bottoms trawls at a depth of 50-75 m., when catching - at least 2-5 specimens of trawls were found (when fishing ≠ 0). At depths of 75to 100 meters, the average recorded catch is low, and at 15-50 meters, the average catch of turbot is increasing. In the seven sectors, the highest catch was obtained, which ranges between 31.81-41.93 g / trawl.

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***Pictures 4.*** *Catch of turbot (Scophthalmus maximus) and accompanying species - Merlangius merlangus (whiting), Dasyatis pastinaca (common stingray), Raja clavata (thornback ray), spiny dogfish (Squalus acanthias) and Trigla lucerna (tub gurnard);*

During the study, 60 specimens of the spiny dogfish (*Squalus acanthias*) were caught and measured. Their size ranged from 31 cm (0.08 kg) to 148 cm (16.88 kg) (Photo 4). Additionally, a relatively high number of whiting (*Merlangius merlangus euxinus*) and *Raja clavata* were caught. Other related species included the Gobiidae, scorpion fish (*Scorpaena porcus*) and red mullet (*Mullus barbatus*).



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

***<u>Comments on the biomass of Scophthalmus maximus in the Bulgarian waters by strata</u>***

Trawling at a depth of up to 30 m covered only three stations, and because of their small number, they were grouped together with the stations preformed up to 50 m; thus, statistical analysis was conducted for stratum 15–50 m. The biomass of the three shallow stations (at a depth < 30 m) reached respectively - 203 kg/km$^2$, 453 kg/km$^2$ и 168 kg/km$^2$, with abundance - 119 ind/km$^2$, 204 ind/km$^2$ and 103 ind/km$^2$. High catches on small stations depth are realized in front of Shkorpilovci (Table 1, Fig. 2).

The average relative biomass is higher in the stratum at 50-75 - 429 kg/km$^2$, with an average abundance of 204 ind/km$^2$. In the 15-50 m stratum, the average relative biomass is lower at 203 kg/km$^2$, with an average abundance of 98 ind/km$^2$ (refer to Table 1, Fig. 2, and Fig. 3).

**<u>Information on the yields by stratum is provided below.</u>**

***<u>Stratum 15-50 m</u>***

In this stratum, the average relative biomass value ranges from 0 - 453 kg/km$^2$, with an



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average of 203 kg/km$^2$ (Tab. 1, Figs. 2 and 3). Their abundance varies between 0 and 204 individuals/km$^2$, with an average – of 98 specimens/km$^2$ (Tab.2).

***Stratum 50 -75 m***

The average value of relative biomass per year in this stratum is high and is 73.2 and 760 kg /km$^2$, with an average of 429 kg/km$^2$ (Tab. 1, Figs. 2 and 3). Abundance has values between 51 and 324 ind/km$^2$, with an average of 204 ind/km$^2$ (Tab.2).

***Stratum 75-100 m***

In this stratum, the average value of relative biomass has high values and ranges between-0-269 kg/km$^2$, with an average of - 106.7 kg/km$^2$ (Tab. 1, Figs. 2 and 3), and the average cost of abundance is 53.06 ind./ km$^2$ (Tabs.2).

Table 1

***Relative biomass of turbot (kg/km2) by stratum, November - December 2024.***

| *15 - 50 м* | | *50 – 75 м* | | *75-100 м* | |
|---|---|---|---|---|---|
| *No. station* | *kg/км$^2$* | *No. station* | *kg/км$^2$* | *No. station* | *kg/км$^2$* |
| **40** | 203 | **39** | 543 | **28** | 26 |
| **22** | 453 | **29** | 709 | **36** | 189 |
| **23** | 168 | **10** | 366 | **19** | 269 |
| **1** | 266 | **38** | 325 | **37** | 57 |
| **24** | 59 | **30** | 557 | **16** | 210 |
| **4** | 360 | **26** | 760 | **18** | 209 |
| **2** | 277 | **35** | 73 | **21** | 0 |
| **11** | 89 | **15** | 337 | **31** | 0 |
| **12** | 0 | **6** | 230 | **20** | 0 |
| **13** | 285 | **34** | 167 | | |
| **7** | 184 | **33** | 586 | | |
| **3** | 430 | **9** | 571 | | |
| **5** | 261 | **17** | 585 | | |



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| | | | | | |
|---|---|---|---|---|---|
| **8** | 241 | **27** | 203 | | |
| **14** | 123 | | | | |
| **32** | 0 | | | | |
| **25** | 53 | | | | |
| **Total** | **3453.9** | **Total** | **6012** | **Total** | **960** |
| **Average** | **203** | **Average** | **429** | **Average** | **107** |
| **Standard error** | **34** | | **57** | | **37** |
| **Median** | **203** | | **455** | | **57** |
| **Standard deviation** | **138** | | **214** | | **110** |
| **Sample variance** | **19161** | | **45824** | | **12184** |

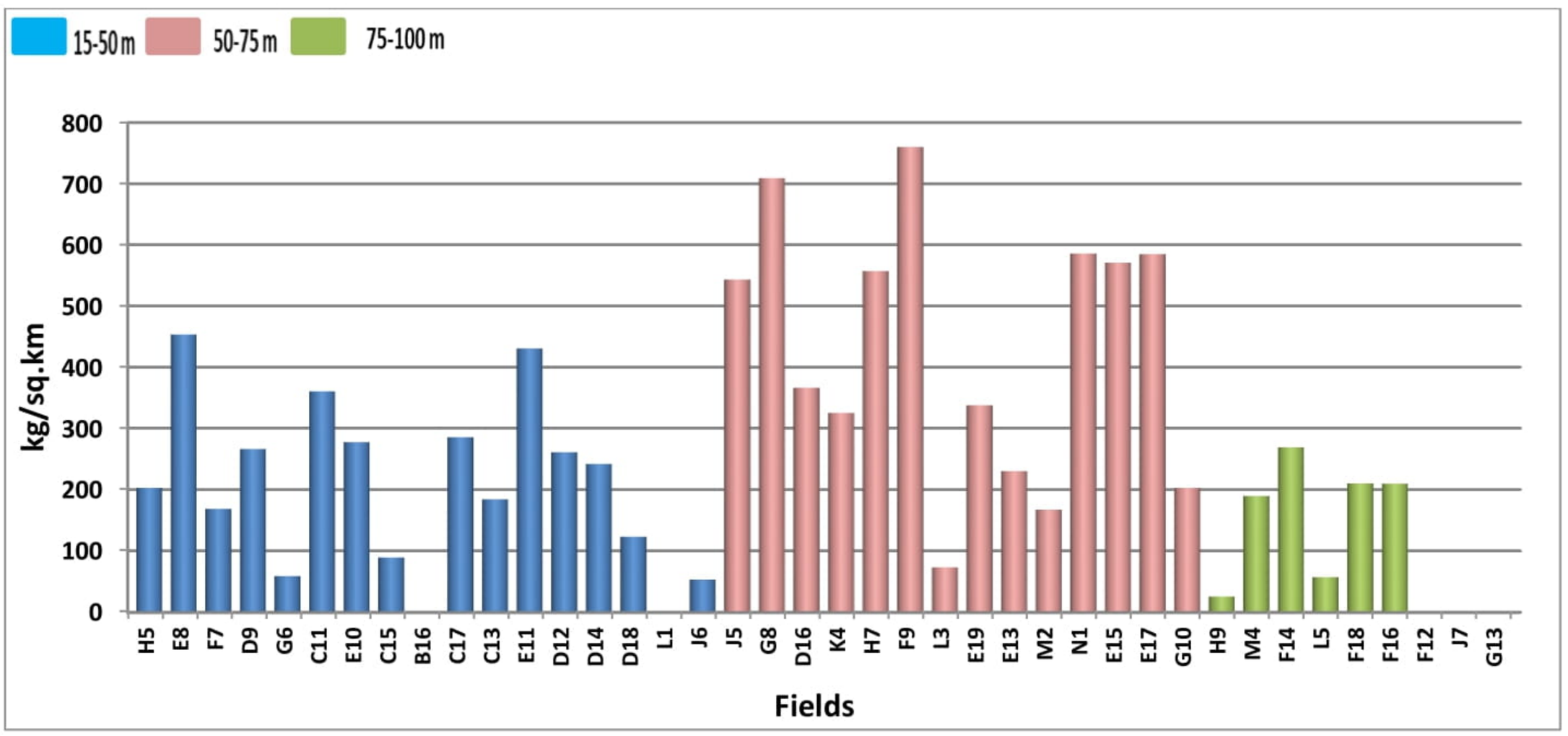


**Figure 2** *Relative biomass (kg/km$^2$) of S. maximus by strata off the Bulgarian Black Sea coast, XI-XII 2024*

Table 2 presents detailed data on turbot abundance by strata in November - December 2024.



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Table 2

**Abundance of *S. maximus* by stratum in November - December 2024.**

| *15 - 50 м* | | *50 – 75 м* | | *75-100 м* | |
|---|---|---|---|---|---|
| ***No. station*** | ***No. Ind./km2*** | ***No. station*** | ***No. Ind./km2*** | ***No. station*** | ***No. Ind./km2*** |
| **40** | 119 | **39** | 256 | **28** | 17 |
| **22** | 204 | **29** | 321 | **36** | 85 |
| **23** | 103 | **10** | 153 | **19** | 170 |
| **1** | 138 | **38** | 171 | **37** | 34 |
| **24** | 17 | **30** | 239 | **16** | 102 |
| **4** | 154 | **26** | 313 | **18** | 69 |
| **2** | 140 | **35** | 51 | **21** | 0 |
| **11** | 34 | **15** | 154 | **31** | 0 |
| **12** | 0 | **6** | 103 | **20** | 0 |
| **13** | 137 | **34** | 85 | | |
| **7** | 86 | **33** | 259 | | |
| **3** | 188 | **9** | 324 | | |
| **5** | 137 | **17** | 273 | | |
| **8** | 102 | **27** | 155 | | |
| **14** | 85 | | | | |
| **32** | 0 | | | | |
| **25** | 17 | | | | |
| **Total** | **1660** | **Total** | **2858.1** | **Total** | **478** |
| **Average** | **98** | **Average** | **204** | **Average** | **53** |
| **Standard error** | **16** | | **24** | | **20** |
| **Median** | **103** | | **205** | | **34** |
| **Standard deviation** | **64** | | **91** | | **59** |
| **Sample variance** | **4125** | | **8296** | | **3441** |

## 3.2. Catch per unit effort (CPUE)

The catches, from a total of 40 trawls, are distributed as follows:



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- 10 trawls (25 %), catch 0-4.99 kg on a trawl;
- 5 trawls (12.5%), catch 5.0-10.99 kg on a trawl;
- 25 trawls (62.5%), catch 11.0-41.93 kg on a trawl;

Stratum < 30 m; 3 trawls:

- 3 trawls, catch 9.99-27.00 kg.

Stratum 31-50 m; 14 trawls:

- 4 trawls, catch-0.1-4.99 kg on trawl;
- 2 trawls, catch-5.0-10.0 kg on trawl;
- 8 trawl, catch-10.0-25.99 kg on trawl;

Stratum 50-75 m; 14 trawls:

- 1 trawls, catch 0-4.99 kg on trawl;
- 1 trawls, catch 5.0-9.99 kg on trawl;
- 2 trawls, catch 10.0-15.99 kg on trawl;
- 10 trawls, catch 16.0-42.99 kg on trawl;

Stratum 75-100 m; 9 trawls:

- 5 trawls, catch 0-4.99 kg on trawl;
- 4 trawls, catch 10.0-15.00 kg on trawl;

The data on catch per unit effort (CPUE) during the expedition in XI-XII/2024 were presented in Table 3 and Fig.3.

**Table 3**

**The sampling stations, coordinates and CPUE (kg/trawl) in November - December 2024**

| № | Field | Starting coordinates | | Depth (m) | Speed (Nm) | Trawling time (min) | Catch turbot | |
|---|---|---|---|---|---|---|---|---|
| | | ϕ | λ | | | | № | Kg |
| **1** | D9 | 4258.34 | 2804.87 | 28 | 31.5 | 2.4 | 60 | 8 |
| **2** | E10 | 4254.8 | 2805.627 | 33.5 | 36 | 2.4 | 60 | 8 |
| **3** | E11 | 4249.654 | 2805.087 | 40 | 43 | 2.4 | 60 | 11 |
| **4** | C11 | 4248.094 | 2759.623 | 32 | 34 | 2.4 | 60 | 9 |
| **5** | D12 | 4243.656 | 2801.66 | 40 | 43 | 2.4 | 60 | 8 |
| **6** | E13 | 4239.558 | 2805.565 | 59 | 63 | 2.4 | 60 | 6 |
| **7** | C13 | 4239.2 | 2759.666 | 40.5 | 42.5 | 2.4 | 60 | 5 |



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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **8** | D14 | 4234.476 | 2800.84 | 48.5 | 49 | 2.4 | 60 | 6 |
| **9** | E15 | 4228.712 | 2805.341 | 66 | 67 | 2.4 | 60 | 19 |
| **10** | D16 | 4224.336 | 2804.577 | 63 | 53 | 2.4 | 60 | 9 |
| **11** | C15 | 4228.422 | 2756.18 | 40 | 39 | 2.4 | 60 | 2 |
| **12** | B16 | 4223.1 | 2750.282 | 37 | 39 | 2.4 | 60 | 0 |
| **13** | C17 | 4217.936 | 2755.432 | 39 | 40 | 2.4 | 60 | 8 |
| **14** | D18 | 4211.492 | 2800.226 | 44 | 49 | 2.4 | 60 | 5 |
| **15** | E19 | 4209.196 | 2806.835 | 58 | 62 | 2.4 | 60 | 9 |
| **16** | F18 | 4211.65 | 2810.54 | 74 | 80 | 2.4 | 60 | 6 |
| **17** | E17 | 4216.727 | 2806.754 | 66 | 67 | 2.4 | 60 | 16 |
| **18** | F16 | 4221.683 | 2810.518 | 80 | 81 | 2.4 | 60 | 4 |
| **19** | F14 | 4230.794 | 2810.329 | 78 | 79 | 2.4 | 60 | 10 |
| **20** | G13 | 4236.72 | 2815.48 | 87 | 89 | 2.4 | 60 | 0 |
| **21** | F12 | 4240.754 | 2814.749 | 86 | 84 | 2.4 | 60 | 0 |
| **22** | E8 | 4304.507 | 2806.366 | 25 | 29.5 | 2.4 | 60 | 12 |
| **23** | F7 | 4306.337 | 2810.689 | 29 | 30.5 | 2.4 | 60 | 6 |
| **24** | G6 | 4312.049 | 2816.777 | 30 | 33.5 | 2.4 | 60 | 1 |
| **25** | J6 | 4312.415 | 2825.142 | 49 | 50 | 2.4 | 60 | 1 |
| **26** | F9 | 4255.778 | 2811.046 | 46.5 | 58.5 | 2.4 | 60 | 17 |
| **27** | G10 | 4252.211 | 2815.054 | 73 | 68.5 | 2.4 | 60 | 9 |
| **28** | H9 | 4256.785 | 2820.441 | 79.5 | 76.5 | 2.4 | 60 | 1 |
| **29** | G8 | 4302.97 | 2818.812 | 55.5 | 51 | 2.4 | 60 | 19 |
| **30** | H7 | 4306.425 | 2821.272 | 53 | 56 | 2.4 | 60 | 14 |
| **31** | J7 | 4309.45 | 2830.067 | 77 | 84 | 2.4 | 60 | 0 |
| **32** | L1 | 4337.128 | 2841.271 | 50 | 49.5 | 2.4 | 60 | 0 |
| **33** | N1 | 4339.855 | 2850.86 | 55 | 65 | 2.4 | 60 | 15 |
| **34** | M2 | 4334.49 | 2849.329 | 64.5 | 64 | 2.4 | 60 | 5 |
| **35** | L3 | 4329.517 | 2843.342 | 61 | 61 | 2.4 | 60 | 3 |
| **36** | M4 | 4324.142 | 2846.657 | 76 | 77 | 2.4 | 60 | 5 |
| **37** | L5 | 4319.8 | 2843.55 | 78.5 | 79 | 2.4 | 60 | 2 |
| **38** | K4 | 4323.267 | 2836.026 | 52.5 | 54 | 2.4 | 60 | 10 |
| **39** | J5 | 4319.668 | 2833.088 | 52 | 50.5 | 2.4 | 60 | 15 |
| **40** | H5 | 4318.05 | 2824.314 | 26 | 21 | 2.4 | 60 | 7 |



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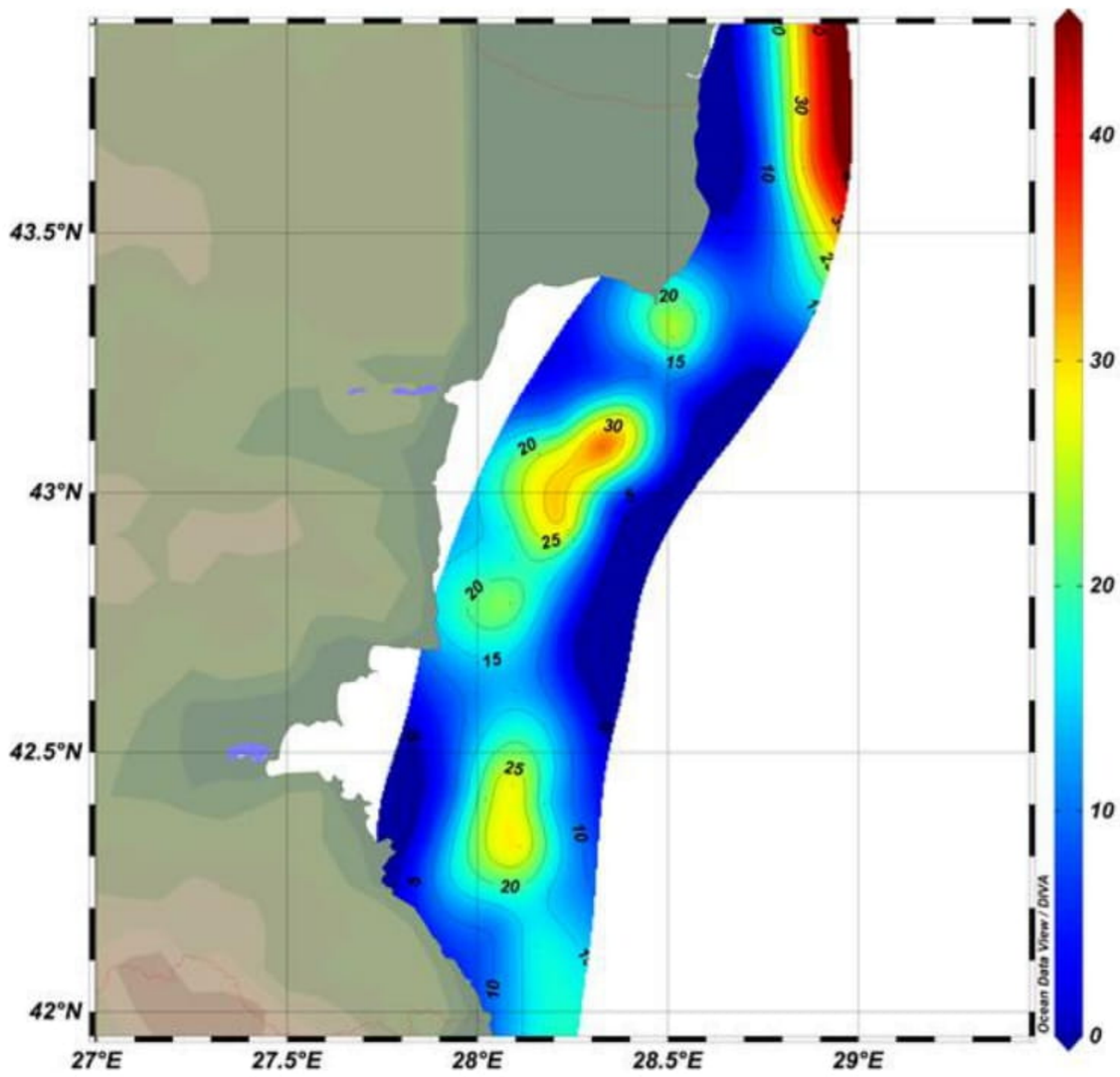


**Figure 3** *Distribution of catch per unit effort (CPUE, kg/h).*

## 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.



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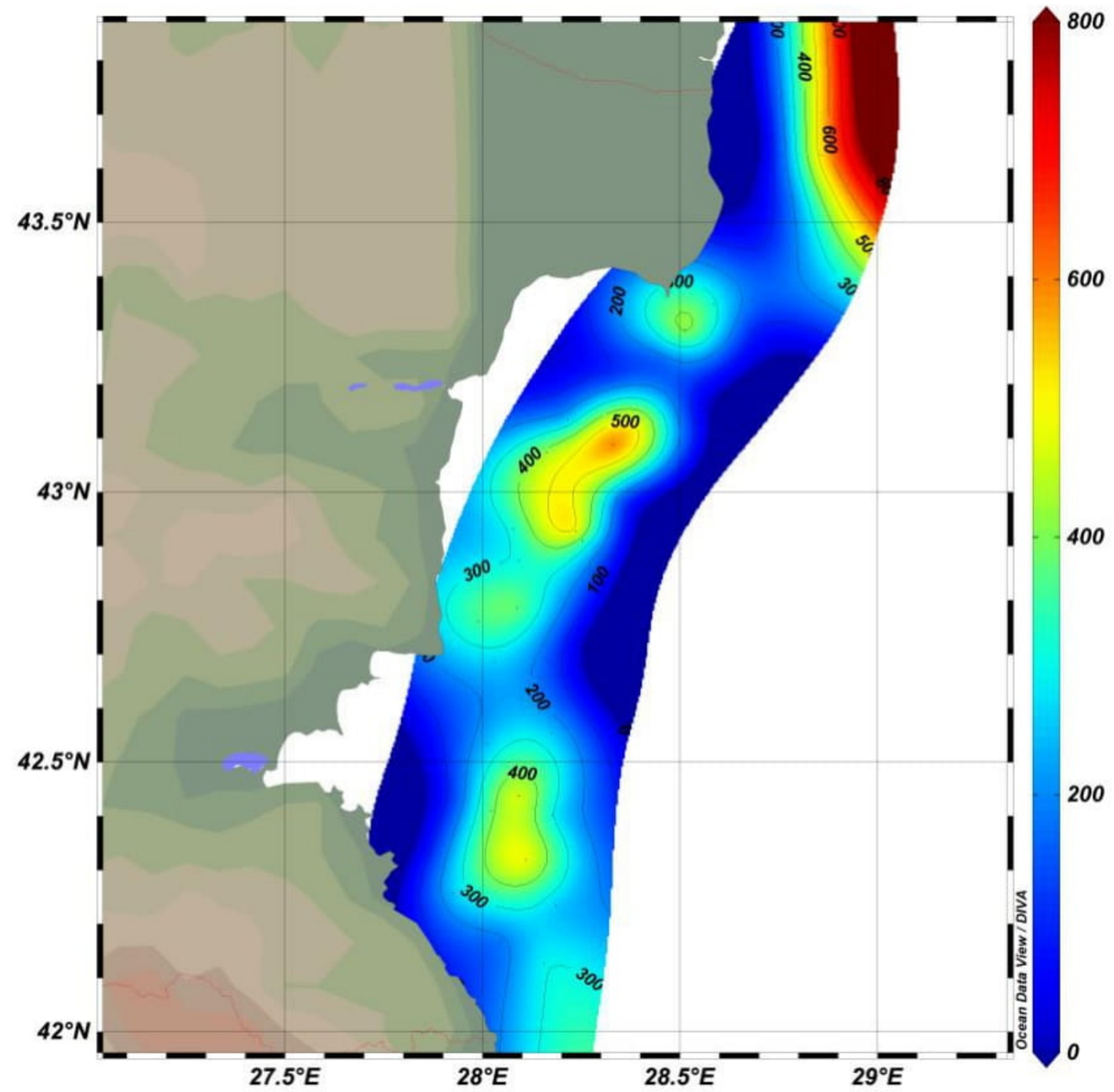


*Figure 4 Distribution of the relative biomass (kg/km$^2$) of S. maximus in November - December, 2024.*

In four fields in the Bulgarian Black Sea area, relatively high biomass levels were recorded, ranging from 585 - 760 kg/km$^2$. These levels were observed in the north-south direction, before Durankulak-Shabla (f.N1) at a depth of 55 - 65 m, in front of Varna - Byala at a depth of 46 - 58 m (f. G8 and F9), and at Primorsko at a depth of 66 - 67m (E17) (Figs. 2 and 4).



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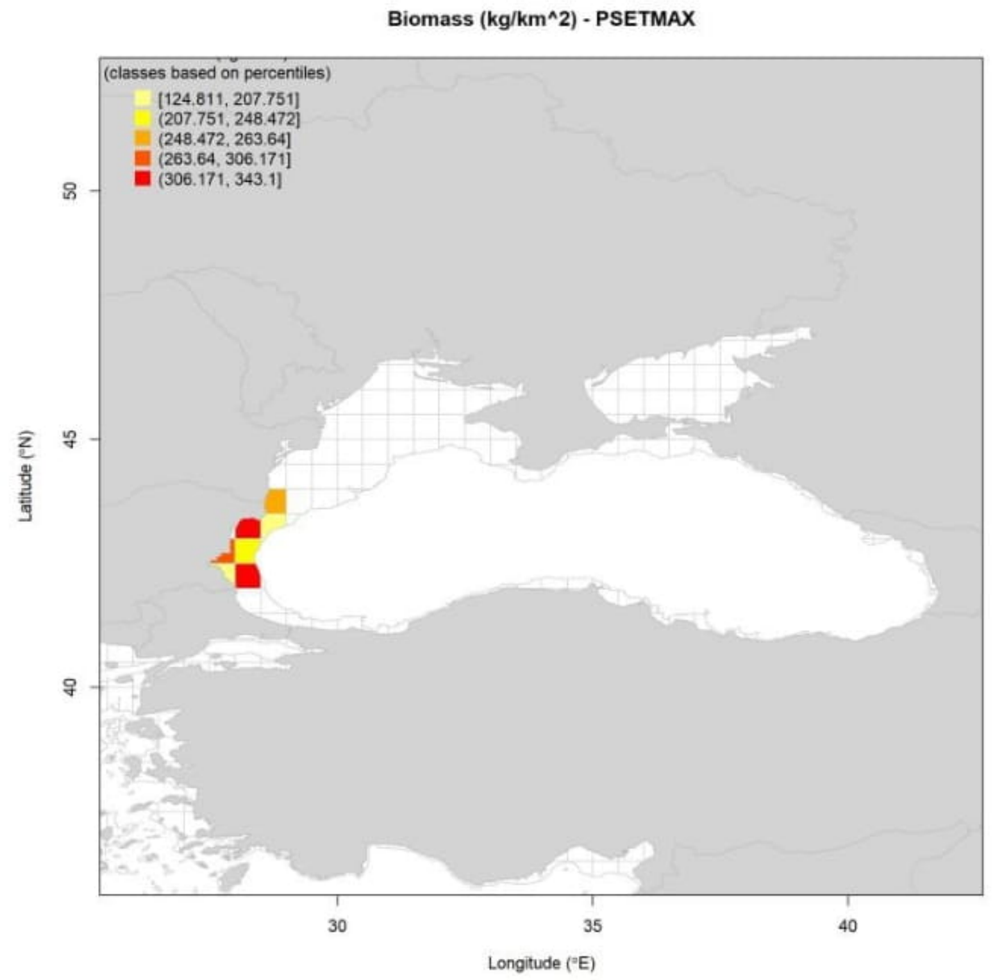


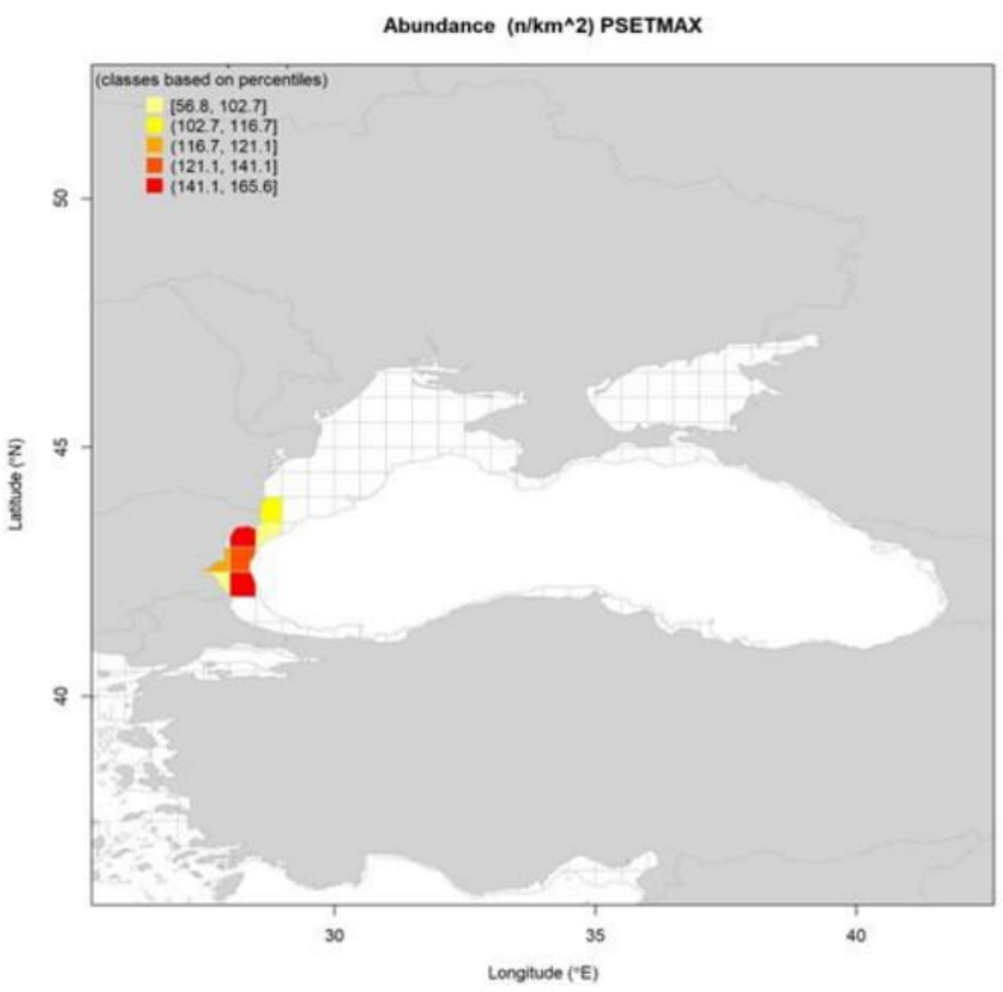


**Figure 5** *Distribution of the relative mean biomass (kg / km2) and abundance (n / km2) of S. maximus in November - December 2024 using BioIndex version 3.3.*

Table 4

***A) Abundance and biomass per fields and B) standard deviations overall for all fields, of turbot in the Bulgarian waters area during November - December 2024.***

**A)**

| *No. Station* | *Field* | *t/km²* | *No. ind./km²* |
|---|---|---|---|
| **1** | **D9** | 0.266 | 138 |
| **2** | **E10** | 0.277 | 140 |
| **3** | **E11** | 0.430 | 188 |
| **4** | **C11** | 0.360 | 154 |
| **5** | **D12** | 0.261 | 137 |
| **6** | **E13** | 0.230 | 103 |
| **7** | **C13** | 0.184 | 86 |
| **8** | **D14** | 0.241 | 102 |
| **9** | **E15** | 0.571 | 324 |
| **10** | **D16** | 0.366 | 153 |
| **11** | **C15** | 0.089 | 34 |
| **12** | **B16** | 0.000 | 0 |
| **13** | **C17** | 0.285 | 137 |
| **14** | **D18** | 0.123 | 85 |
| **15** | **E19** | 0.337 | 154 |
| **16** | **F18** | 0.210 | 102 |
| **17** | **E17** | 0.585 | 273 |
| **18** | **F16** | 0.209 | 69 |
| **19** | **F14** | 0.269 | 170 |
| **20** | **G13** | 0.000 | 0 |
| **21** | **F12** | 0.000 | 0 |
| **22** | **E8** | 0.453 | 204 |
| **23** | **F7** | 0.168 | 103 |
| **24** | **G6** | 0.059 | 17 |
| **25** | **J6** | 0.053 | 17 |
| **26** | **F9** | 0.760 | 313 |
| **27** | **G10** | 0.203 | 155 |



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| | | | |
|---|---|---|---|
| 28 | H9 | 0.026 | 17 |
| 29 | G8 | 0.709 | 321 |
| 30 | H7 | 0.557 | 239 |
| 31 | J7 | 0.000 | 0 |
| 32 | L1 | 0.000 | 0 |
| 33 | N1 | 0.586 | 259 |
| 34 | M2 | 0.167 | 85 |
| 35 | L3 | 0.073 | 51 |
| 36 | M4 | 0.189 | 85 |
| 37 | L5 | 0.057 | 34 |
| 38 | K4 | 0.325 | 171 |
| 39 | J5 | 0.543 | 256 |
| 40 | H5 | 0.203 | 119 |
| **Total** | | **10.43** | **4995.71** |
| **Average** | | **0.261** | **124.89** |

**B)**

| | *t/км²* | *№ ind./км²* |
|---|---|---|
| **Standard error** | 0.033 | 14.94 |
| **Median** | 0.220 | 111.32 |
| **Standard deviation** | 0.207 | 95 |
| **Sampling dispersion** | 0.043 | 8932 |

The turbot biomass in the entire studied area in front of the Bulgarian coast of the Black Sea was estimated at **2875.55** tonnes (Table 4). The abundance in the studied area was estimated at **1378.69*10$^3$** specimens (Table 4).

## 3.4. Size structure

The information about the size structure of the turbot population was based on biometric measurements of 291 turbot specimens and included data on the absolute and standard length and individual weight (pic.5).

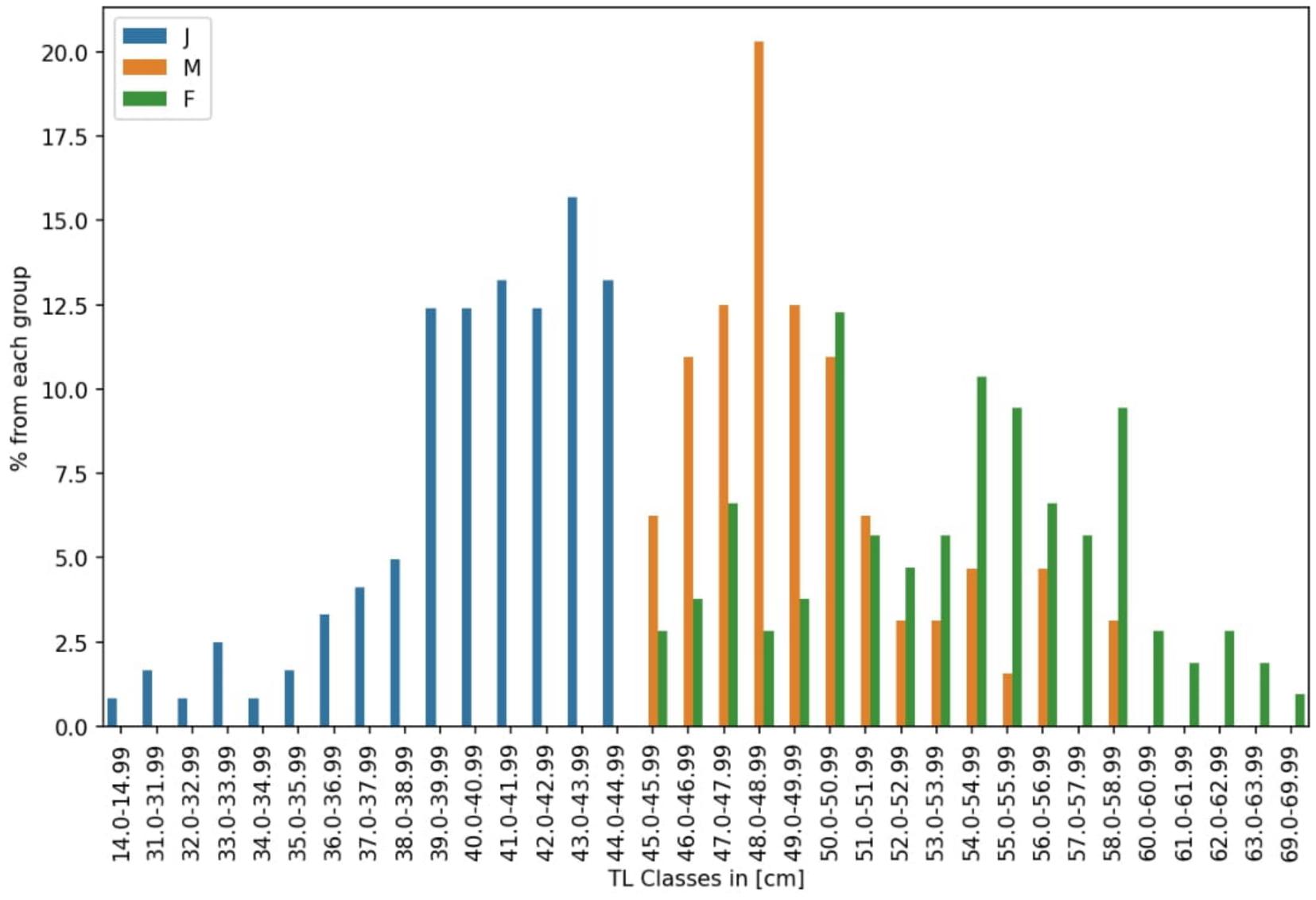


**Figure 6** *Length structure of S. maximus caught by sex.*

The total length ranges from 14 to 69 cm, with a weight between 70 and 5600 g. The totals catch on the reaches 606.94 kg. Of the total number - 291, with 40 have sizes between 14.0 and 39.5 cm (13.75%), 81 specimens - between 40.00 and 44.55 cm (27.84%), 61 - in the range between 45 and 49.5 cm (20.96%), and 109 - in the range between 50.0 and 69.0 cm (37.46%).

Specimens over 45.0 cm predominate in the total catch – 58.42% /170 individuals/, and, those below 45.0 cm are 121 / 41.58%/, female individuals dominate 36.43 % /106 specimens/ over males 21.99 % /64 individuals/.



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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/km$^2$) and the distribution of undersized individuals and those of standard length.

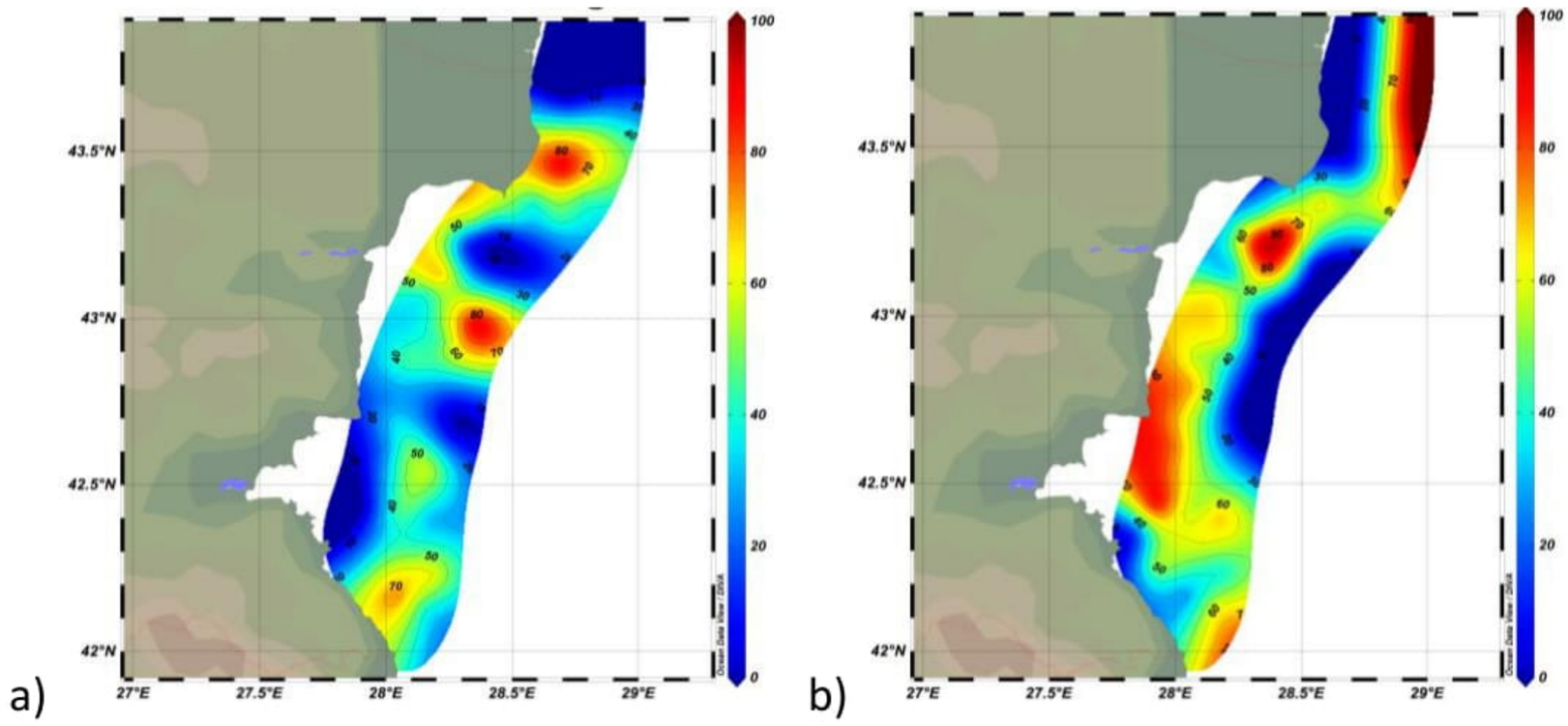


**Figure 7** *Percentage distribution of the S. maximus abundance (ind/km$^2$), a) undersized individuals and b) standard length.*

The relative turbot biomass by size class is shown in Fig. 8, indicating high biomass for two length classes - those 46-50 cm and 54-58 cm.



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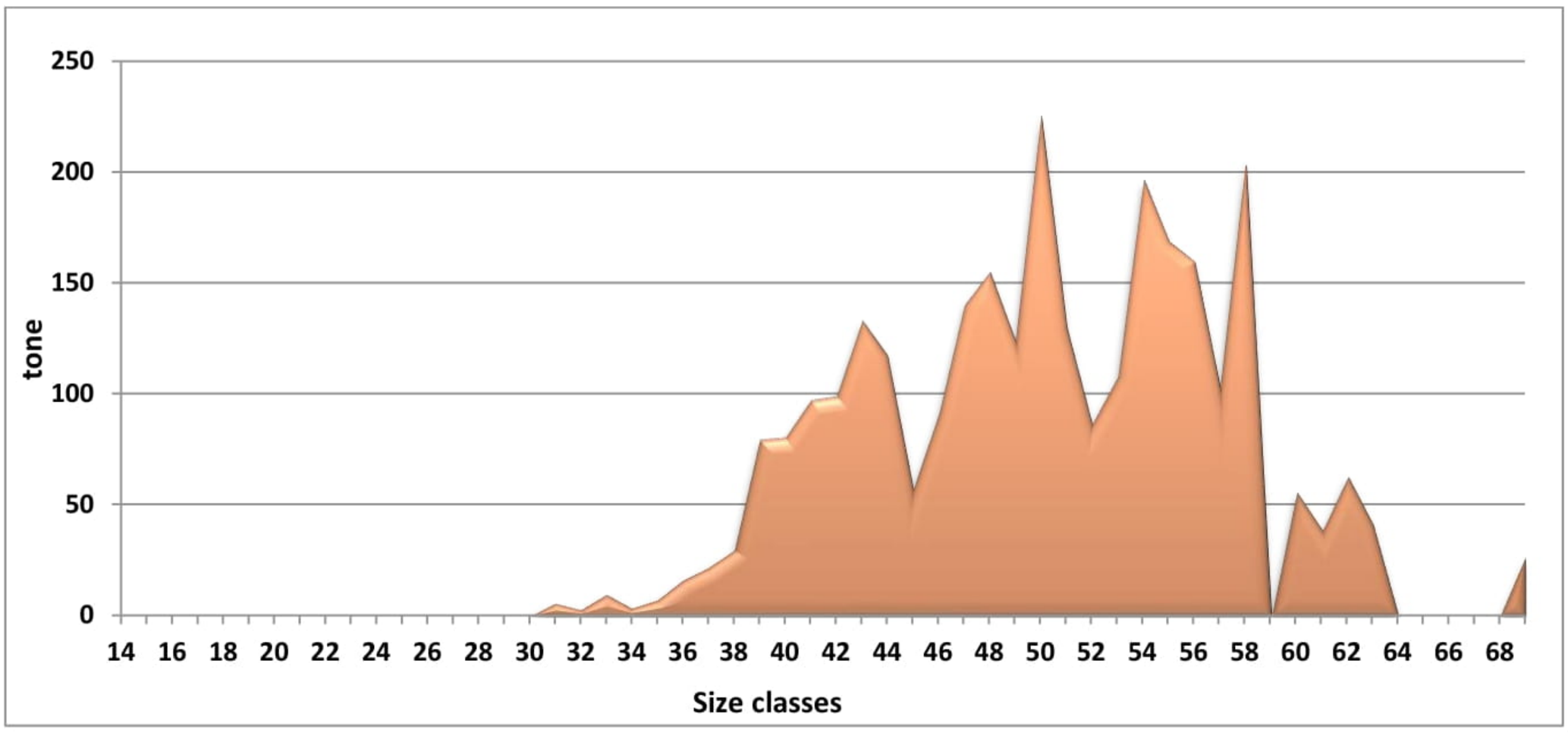


**Figure 8** *Biomass by mean size classes of S. maximus.*

## 3.5. Age structure

The age composition of the turbot was established through the analysis of 170 pairs of otoliths. The age structure of the turbot encompasses specimens ranging from 0 to 8 years old, with a predominance of 2 (16.49%), 3 (37.11%), and 4 (20.27%) year-olds, collectively accounting for 73.88%. This is followed by 5-year-old specimens, which represent 16.15% (fig. 9).

During the autumn-winter season of 2024, specimens exceeding 45 cm (58.42%) are more prevalent than those measuring under 45 cm (41.58%).

Specimens aged 6, 7, and 8 years are recorded in the catches.



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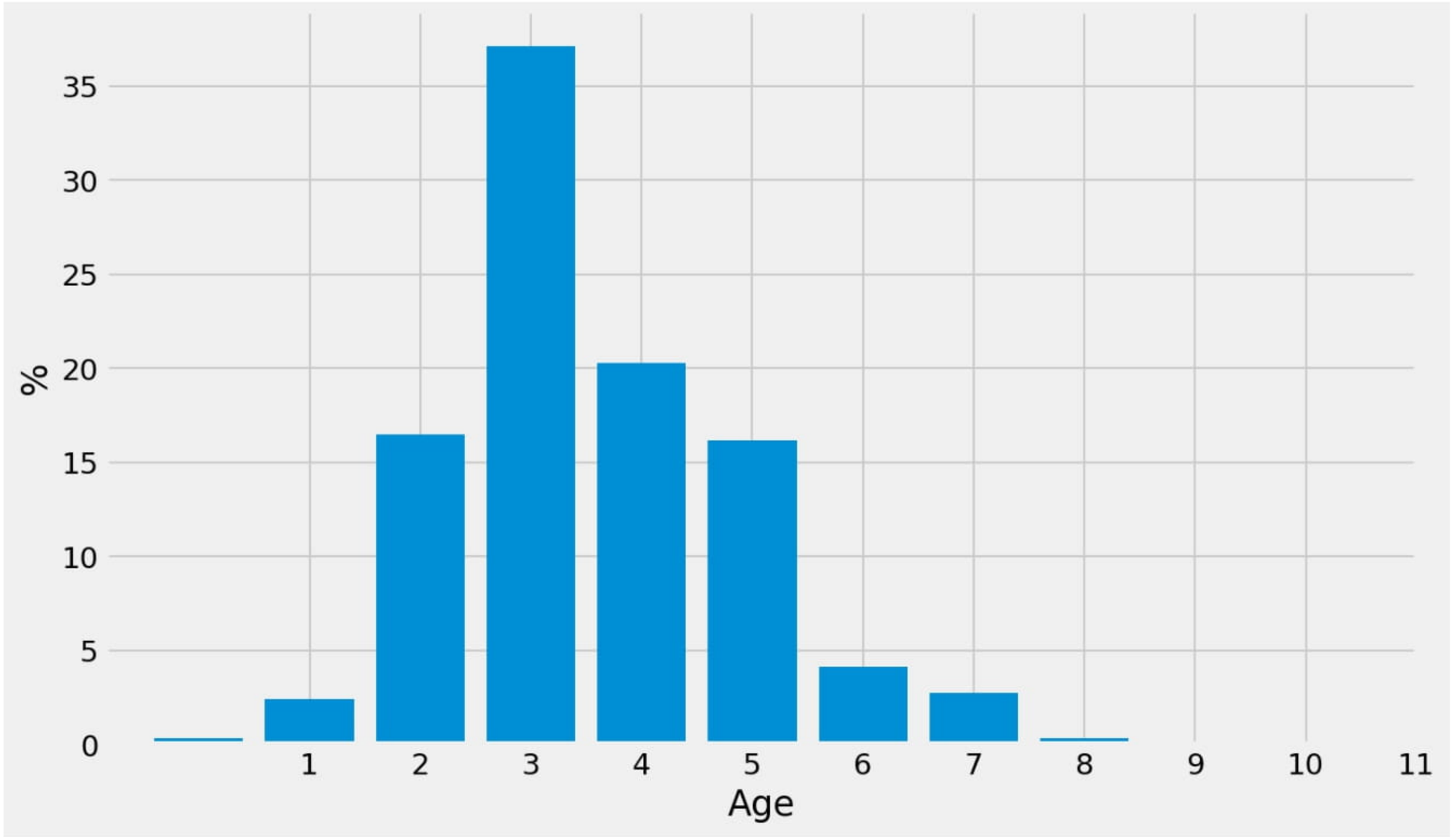


*Figure 9 Age structure of turbot in November - December, 2024.*

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

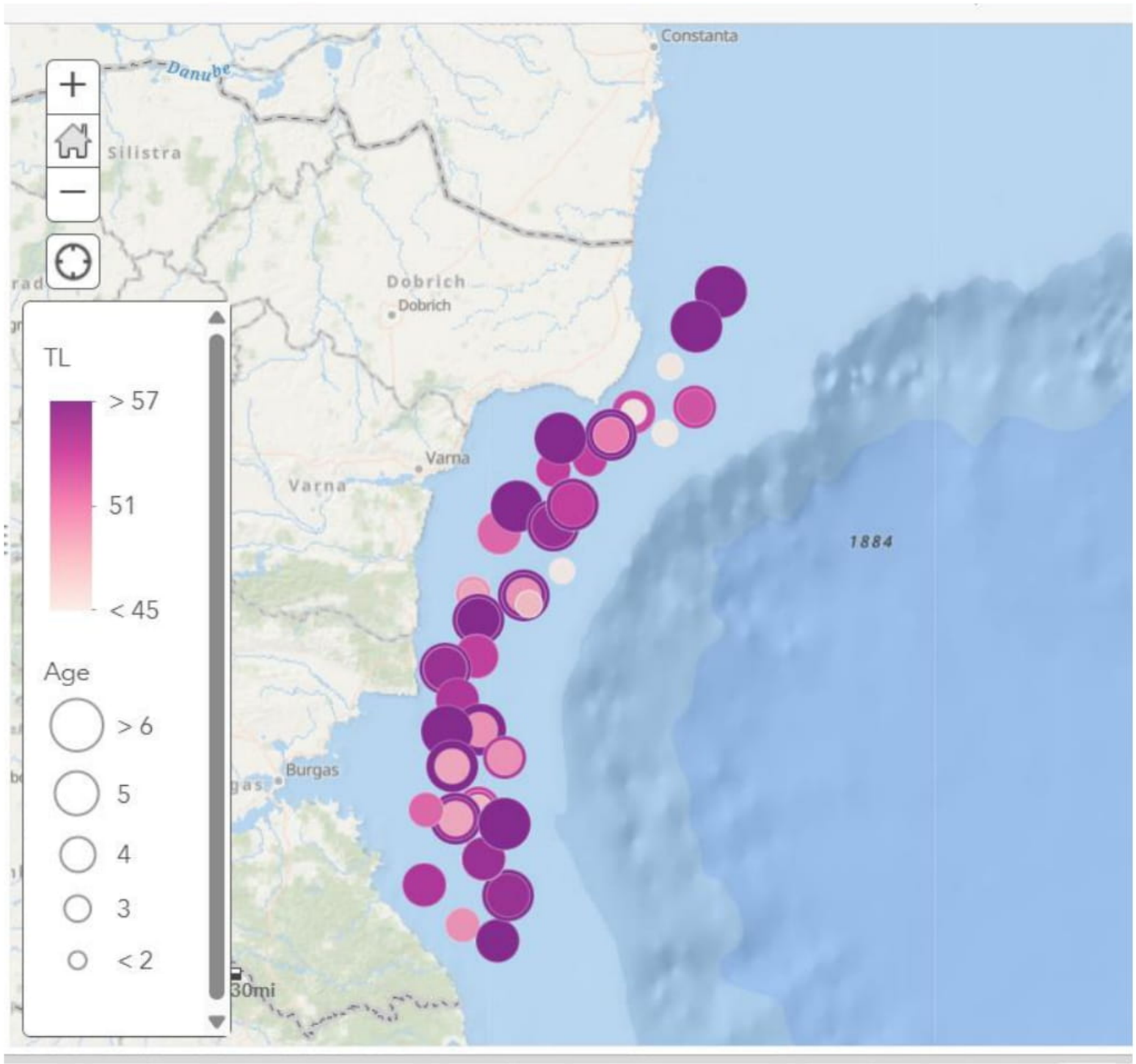


*Figure 10 Spatial distribution by ages and lengths of S. maximus.*

## 3.6. Biological parameters of *S. maximus*

To establish the rate of turbot growth in the Bulgarian waters of the Black Sea during the autumn-winters season of 2024, 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 t0 were estimated (see Table 5). The values of these parameters in the von Bertalanffy equation were computed as follows:



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Table 5

**Von Bertalanffy parameters and L-W dependence.**

| sex | Linf (mm) | k | t0 | a | b |
|---|---|---|---|---|---|
| F | 881.8249 | 0.1338 | -2.2136 | 0.000080 | 2.77 |
| M | 764.5957 | 0.1719 | -2.0267 | 0.000037 | 2.89 |
| C | 822.272 | 0.1555 | -2.0305 | 0.01934 | 2.99 |

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

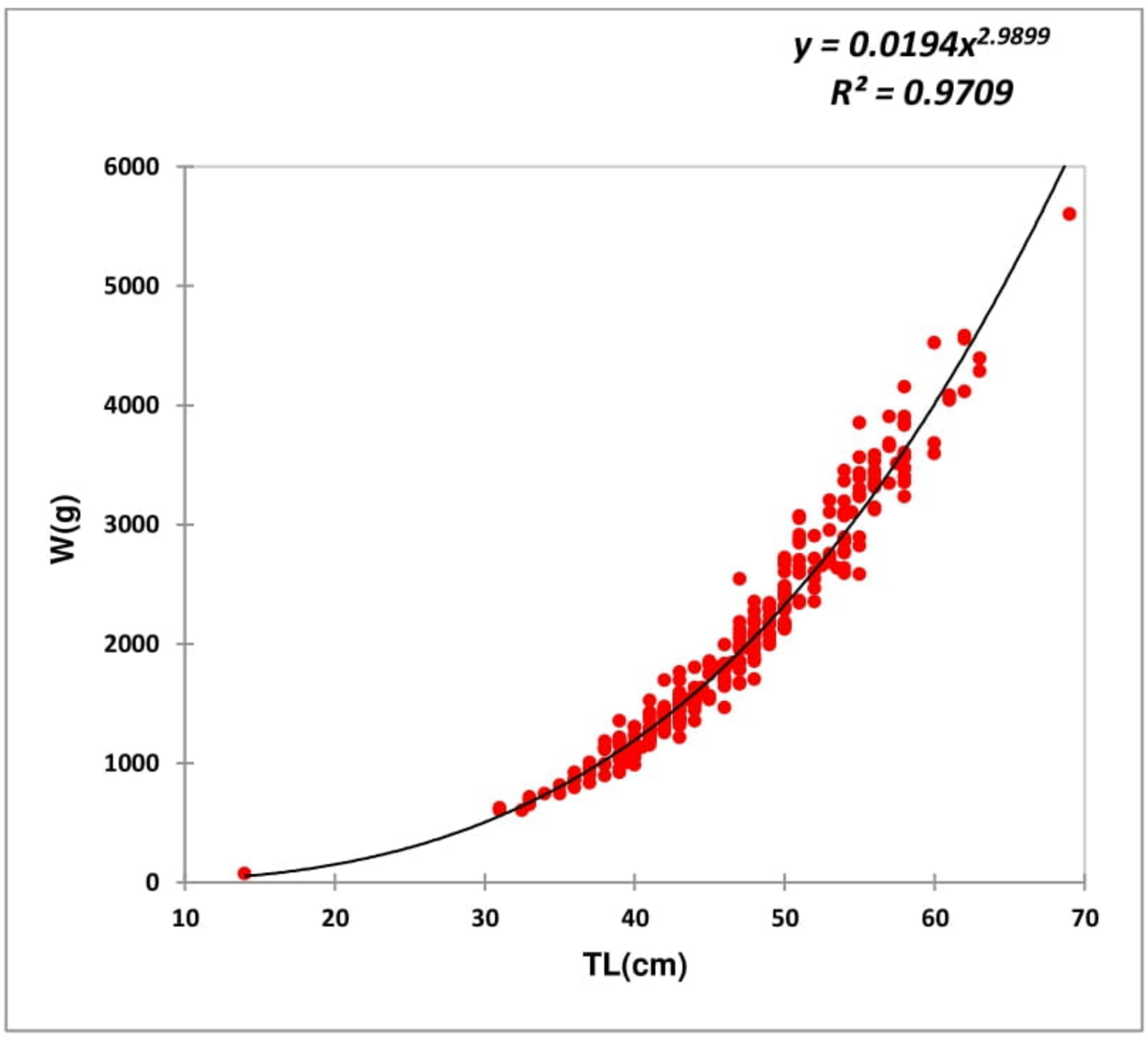


**Figure 11** *S. maximus: Length-weight relationships in November - December, 2024.*

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.



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

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

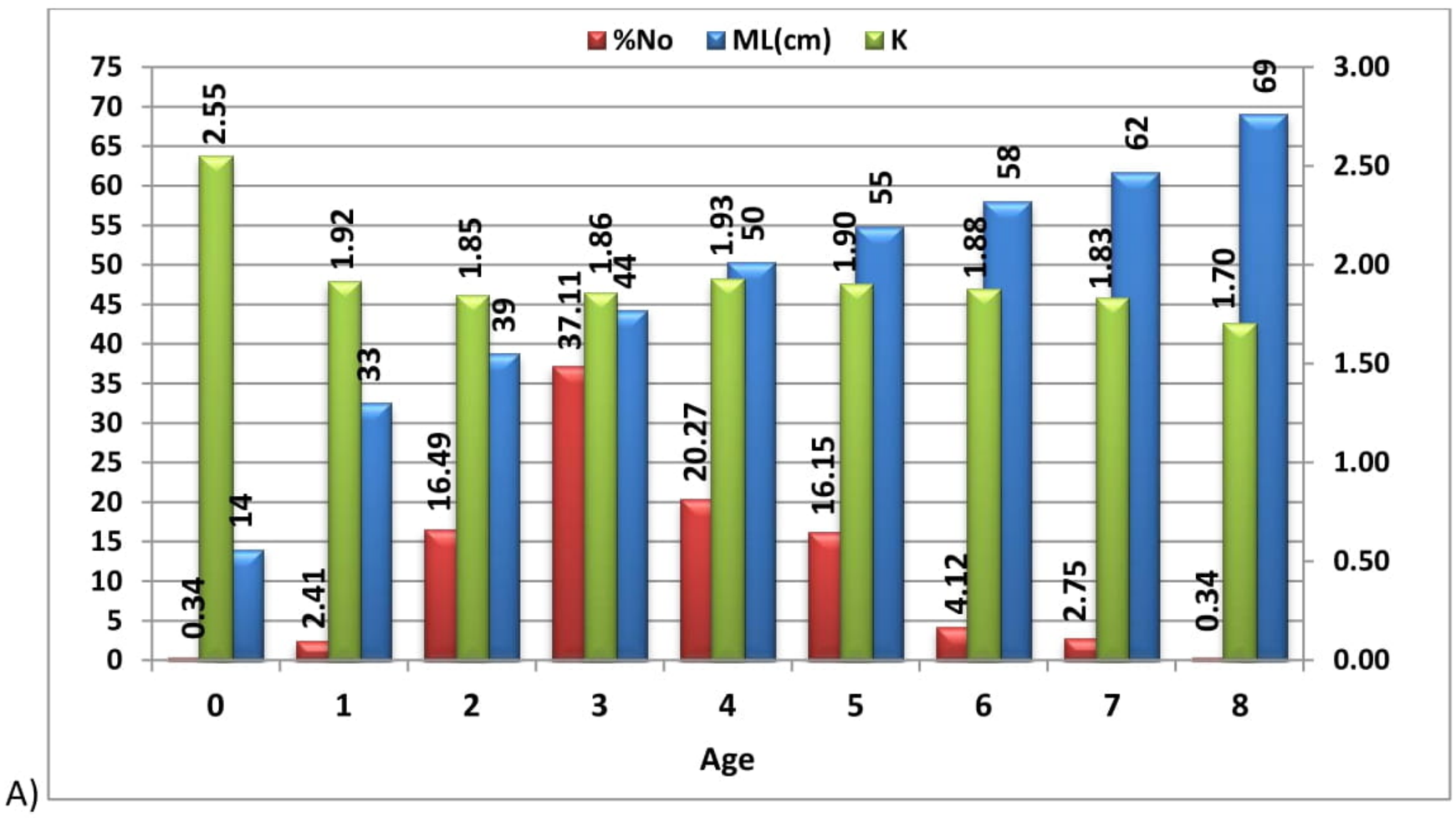
$\log(-t_0) = -0.3922 - 0.2752*\log L_\infty - 1.038*\log k$

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

Considering that water temperature was 8 °C during the study period, the coefficient of natural mortality (M) for both sexes was: 0.4.

## 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).




A)



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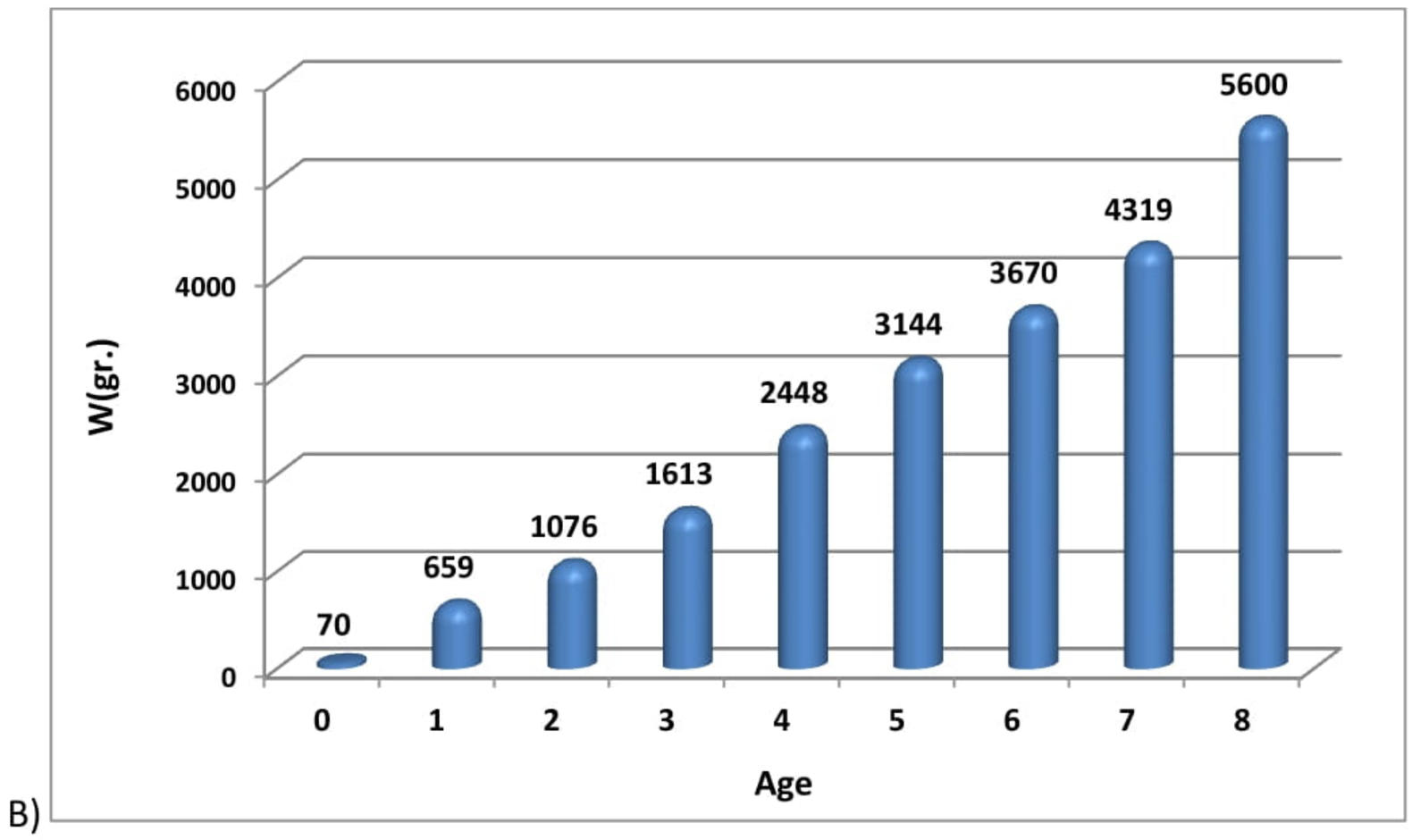


*Figure 12 Percentage distribution and relation between the average length (ML) and coefficient of Fulton (K) by age groups (A) and an average weight (g) of turbot by age groups (B).*

## 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 autumn-winter season of 2024 reveals that immature individuals constitute for 41.58 % of the total catch, while sexually mature individuals represent 58.42 %. Females comprise 36.43%, and males constitute 21.99%. The sex ratio of sexually mature individuals is 62.35% females and 37.65% males.

Among the 40 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 8 areas (Fig. 13).



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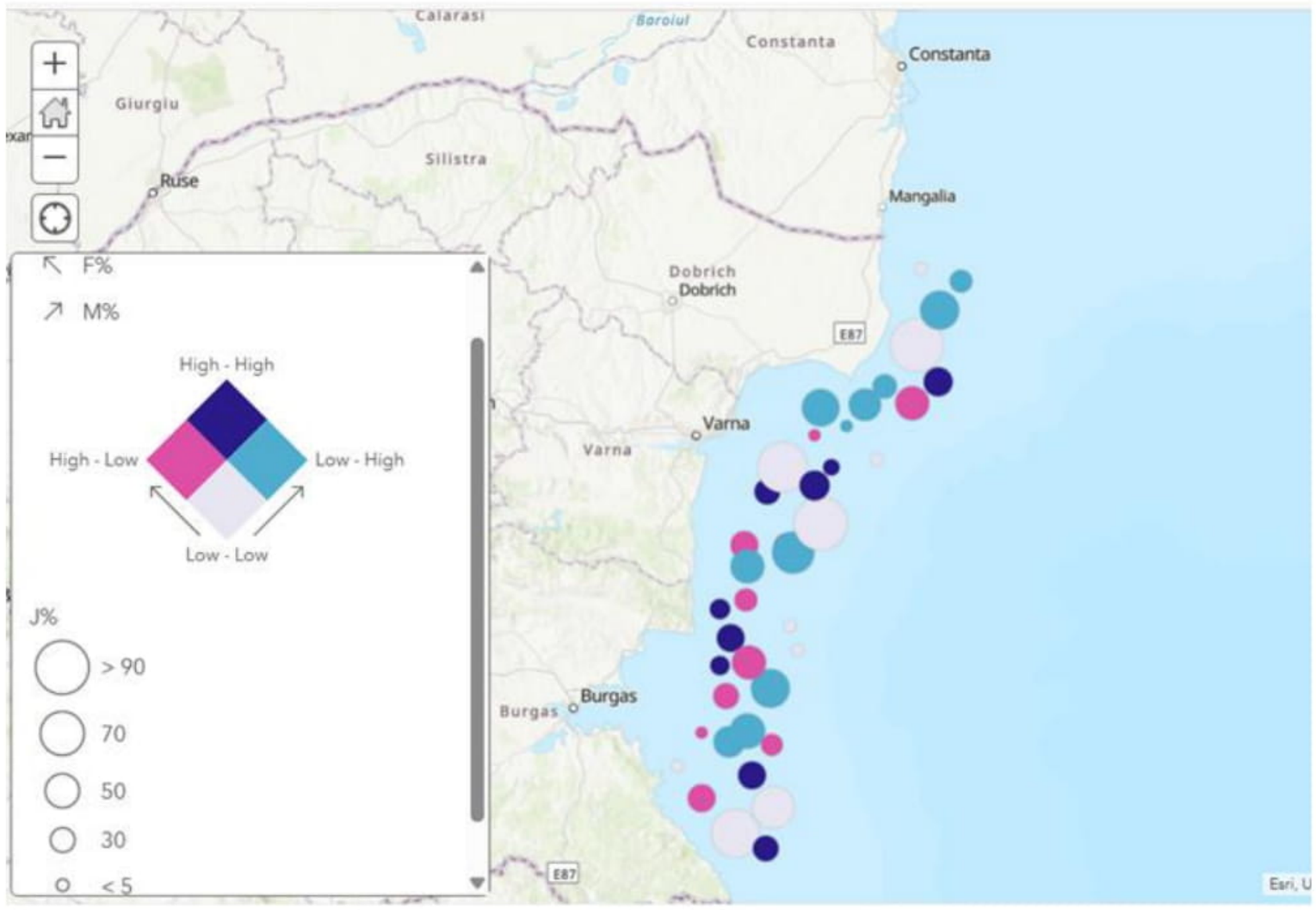


**Figure 13**. *Sex structure of S. maximus in November - December 2024: distribution by station (female, male, and juvenile specimens are indicated by purple, blue and grey, dark blue, presence of both sexes, and juveniles).*

Male specimens are mainly found at depths ranging from 45 to 56 meters, while female specimens are observed in significant numbers at depths between 35 and 50 meters. Juvenile individuals are primarily concentrated in the area Shabla, Varna and in front of Tsarevo, specifically at depths of 61 to 79 meters.

Female specimens are predominantly located in the regions of Varna, near C. Emine-Primorsko village. In contrast, a larger concentration of male specimens has been identified in the C. Kaliakra - Varna area.



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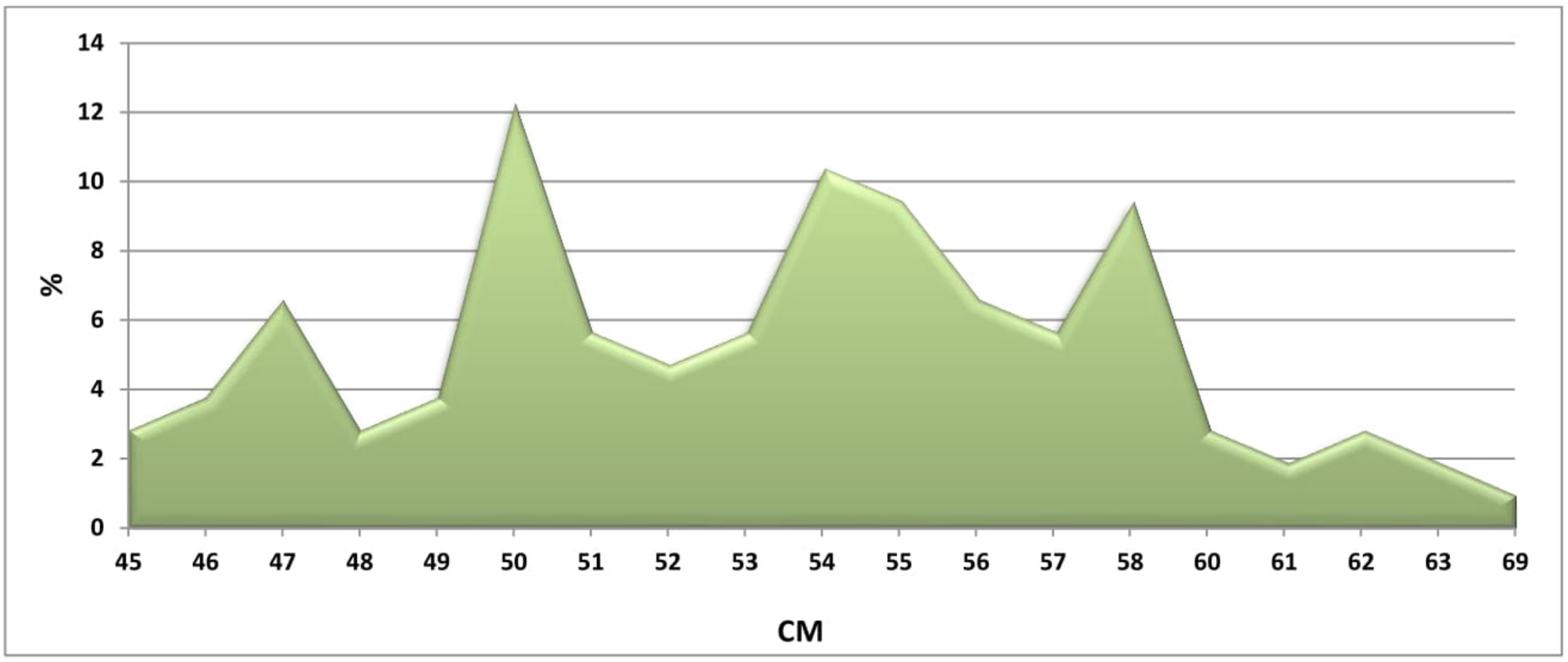


**Figure 14** *Female specimens: Percentage distribution by length classes.*

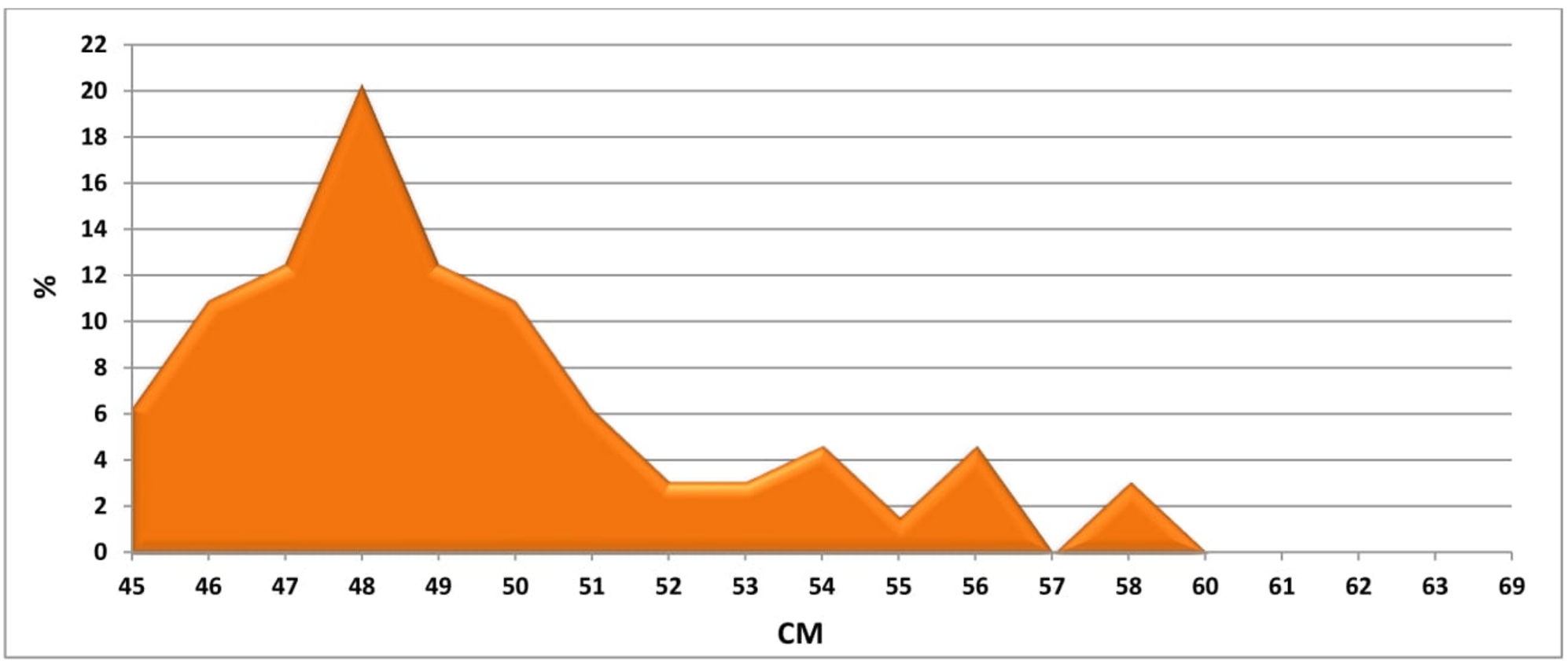


**Figure 15** *Male specimens: Percentage distribution by length classes.*

The distribution by sex and size groups shows that female specimens predominantly fall within the size range of 54 to 58 cm, accounting for 41.50% of the measured female population (Fig. 14). All individuals measuring between 60 cm and 69 cm are female, accounting for 10.37% of the total population.

For male specimens, the largest group-comprising - 67.18 % 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

The data on the weight distribution of the turbot population in Bulgarian waters of the Black Sea for the year 2024 were collected from an analysis of 291 individuals, with each specimen's weight recorded. The analysis revealed that the majority of specimens had an average weight of 2085.70 g (see Fig. 16).

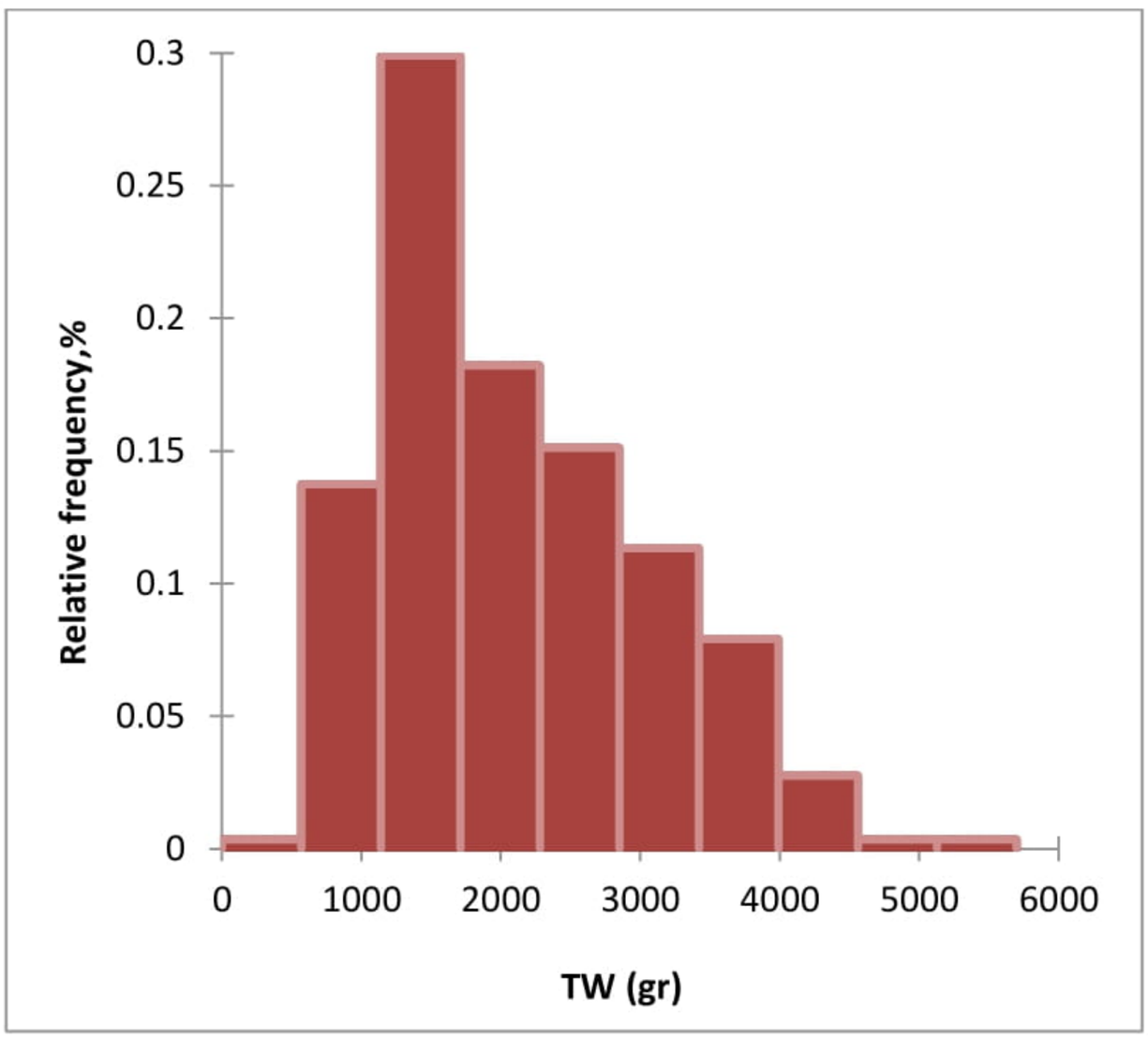


**Figure 16** *Weight structure of S. maximus catches.*

Immature specimens weigh between 80.0 and 1800.0 grams, with an average weight of 1225.207 grams. Female specimens range from 1560.0 to 5600.0 grams, averaging 2952.7 grams.



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Male specimens weigh between 1460.0 to 3600.0 grams, with an average weight of 2276.56 grams (see Fig. 17, A, B, and C).

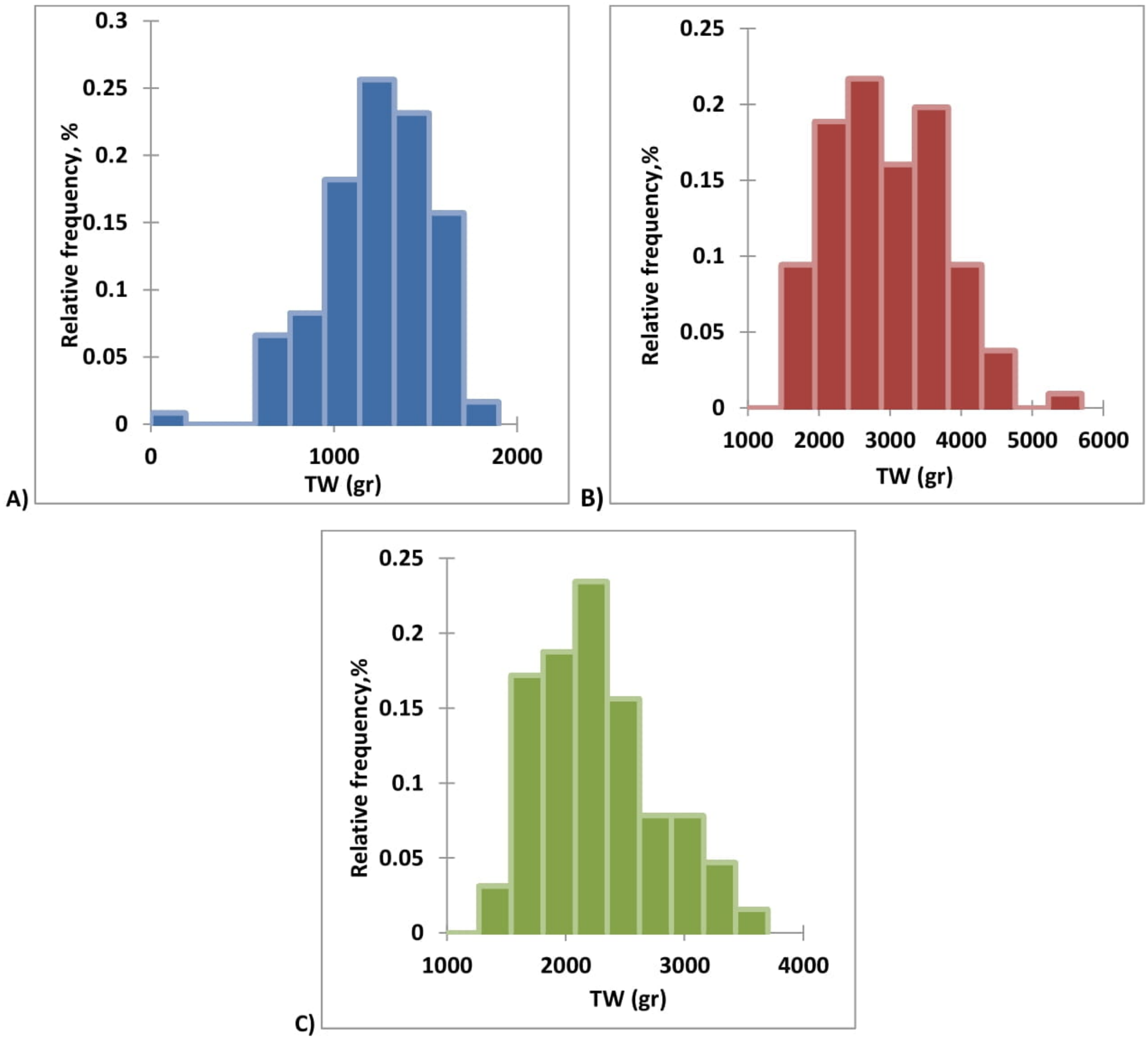


**Figure 17** *Weight structure of S. maximus catches by sex: A) immature specimens, B) female and C) male specimens;*



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## 3.9. Other reference species

During bottom survey in the autumn-winters season of 2024, 60 specimens of sharks (*Squalus acanthias*), 148 specimens of thornback ray (*Raja clavata*), and 9 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. |
| ***Squalus acanthias*** | 60 | 31 | 148 | 97 | 0.08 | 16.88 | 4.97 |
| ***Raja clavata*** | 148 | 33 | 94 | 62.26 | 0.2 | 5.48 | 1.69 |
| ***Platichthys flesus luscus*** | 9 | 22 | 33 | 25.83 | 0.14 | 0.52 | 0.272 |
| ***M.merlangus*** | 1300 | 9.8 | 21.3 | 13.6 | 0.007 | 0.0753 | 0.02144 |

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 the species *S. acanthias* are primarily observed between Byala and n. Emine (28-43 m and 78-89 m). Clusters of *Pl. flesus* are located in the central region of the Bulgarian coast in front of Varna, at depths of 51 - 55 m. Representatives of the species *R. clavata* are noted in front of Primorsko at depths of 39 - 40 m. Specimens of the species *M. merlangus* are prevalent, with a significant concentration observed in the southern region in from the C. Emine to Tsarevo (66-89 m).

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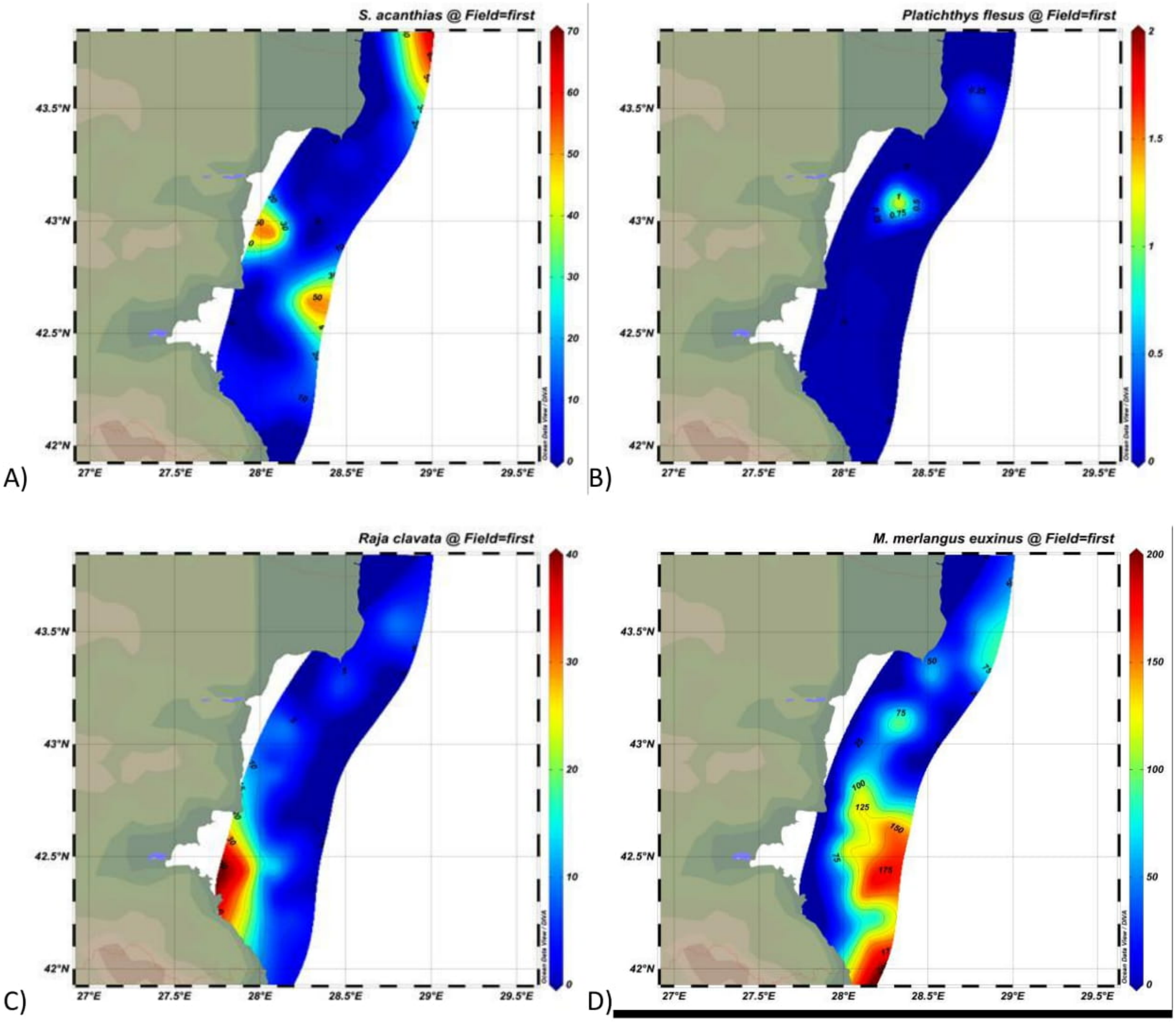


**Figure 18** *Location of stations with bycatch from A) spiny dogfish (S. acanthias), B) flounder (Pl. flesus), C) thornback ray (R. clavata) and D) whiting (M. m. euxinus).*



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## 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, November - December 2024**

| № | Field | Depth (m) | | Catch (Kg/h) |
|---|---|---|---|---|
| 1 | D9 | 28 | 31.5 | 40 |
| 2 | E10 | 33.5 | 36 | 70 |
| 3 | E11 | 40 | 43 | 140 |
| 4 | C11 | 32 | 34 | 10 |
| 5 | D12 | 40 | 43 | 140 |
| 6 | E13 | 59 | 63 | 110 |
| 7 | C13 | 40.5 | 42.5 | 10 |
| 8 | D14 | 48.5 | 49 | 160 |
| 9 | E15 | 66 | 67 | 120 |
| 10 | D16 | 63 | 53 | 42 |
| 11 | C15 | 40 | 39 | 37 |
| 12 | B16 | 37 | 39 | 0 |
| 13 | C17 | 39 | 40 | 10 |
| 14 | D18 | 44 | 49 | 40 |
| 15 | E19 | 58 | 62 | 160 |
| 16 | F18 | 74 | 80 | 42.5 |
| 17 | E17 | 66 | 67 | 180 |
| 18 | F16 | 80 | 81 | 190 |
| 19 | F14 | 78 | 79 | 110 |
| 20 | G13 | 87 | 89 | 170 |
| 21 | F12 | 86 | 84 | 60 |
| 22 | E8 | 25 | 29.5 | 20 |
| 23 | F7 | 29 | 30.5 | 50 |
| 24 | G6 | 30 | 33.5 | 0 |
| 25 | J6 | 49 | 50 | 0 |



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| | | | | |
|---|---|---|---|---|
| **26** | F9 | 46.5 | 58.5 | 80 |
| **27** | G10 | 73 | 68.5 | 3 |
| **28** | H9 | 79.5 | 76.5 | 2 |
| **29** | G8 | 55.5 | 51 | 120 |
| **30** | H7 | 53 | 56 | 80 |
| **31** | J7 | 77 | 84 | 1 |
| **32** | L1 | 50 | 49.5 | 1 |
| **33** | N1 | 55 | 65 | 40 |
| **34** | M2 | 64.5 | 64 | 60 |
| **35** | L3 | 61 | 61 | 9 |
| **36** | M4 | 76 | 77 | 80 |
| **37** | L5 | 78.5 | 79 | 3 |
| **38** | K4 | 52.5 | 54 | 50 |
| **39** | J5 | 52 | 50.5 | 90 |
| **40** | H5 | 26 | 21 | 0 |

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

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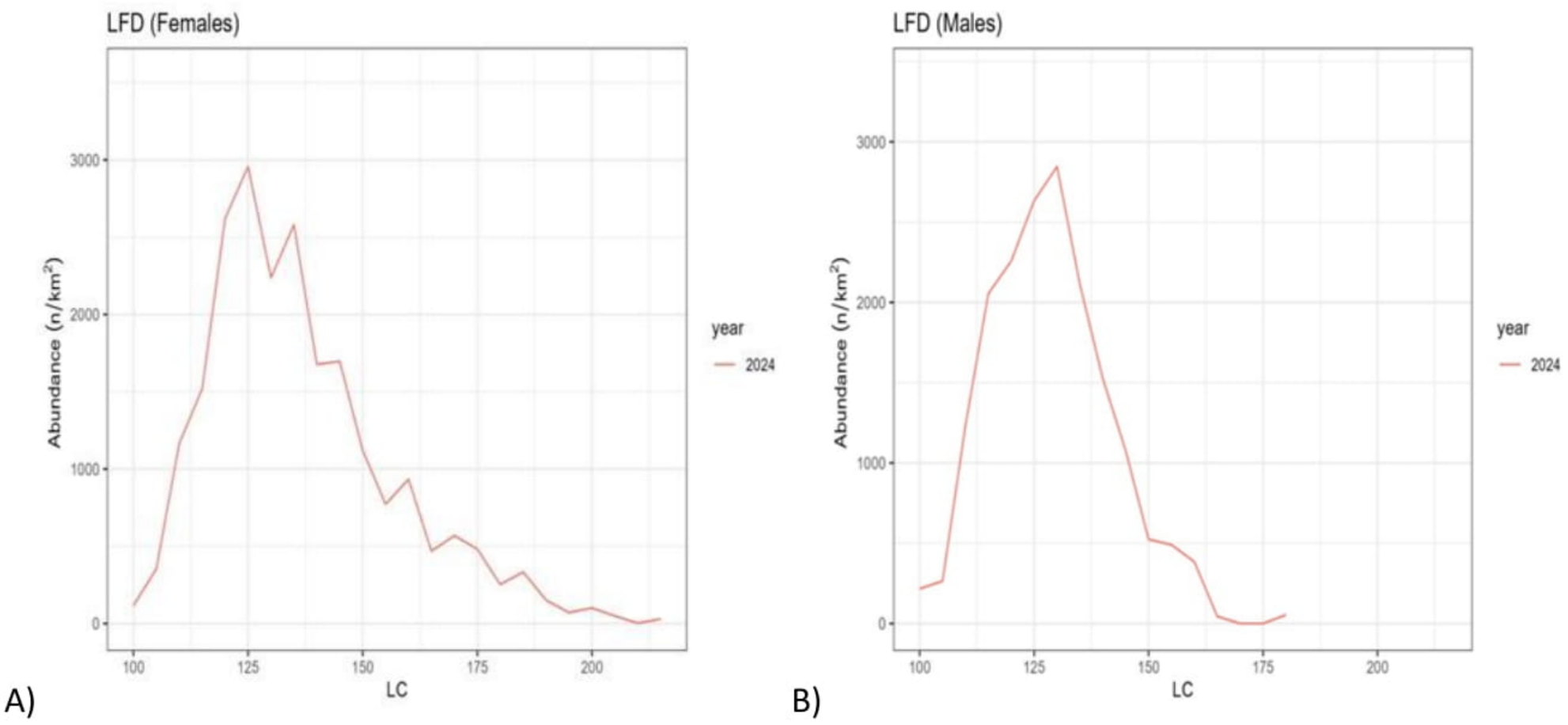


***Figure 19*** *Length classes (LC, mm) of M.merlangus catch by sex: A) female, B) male.*

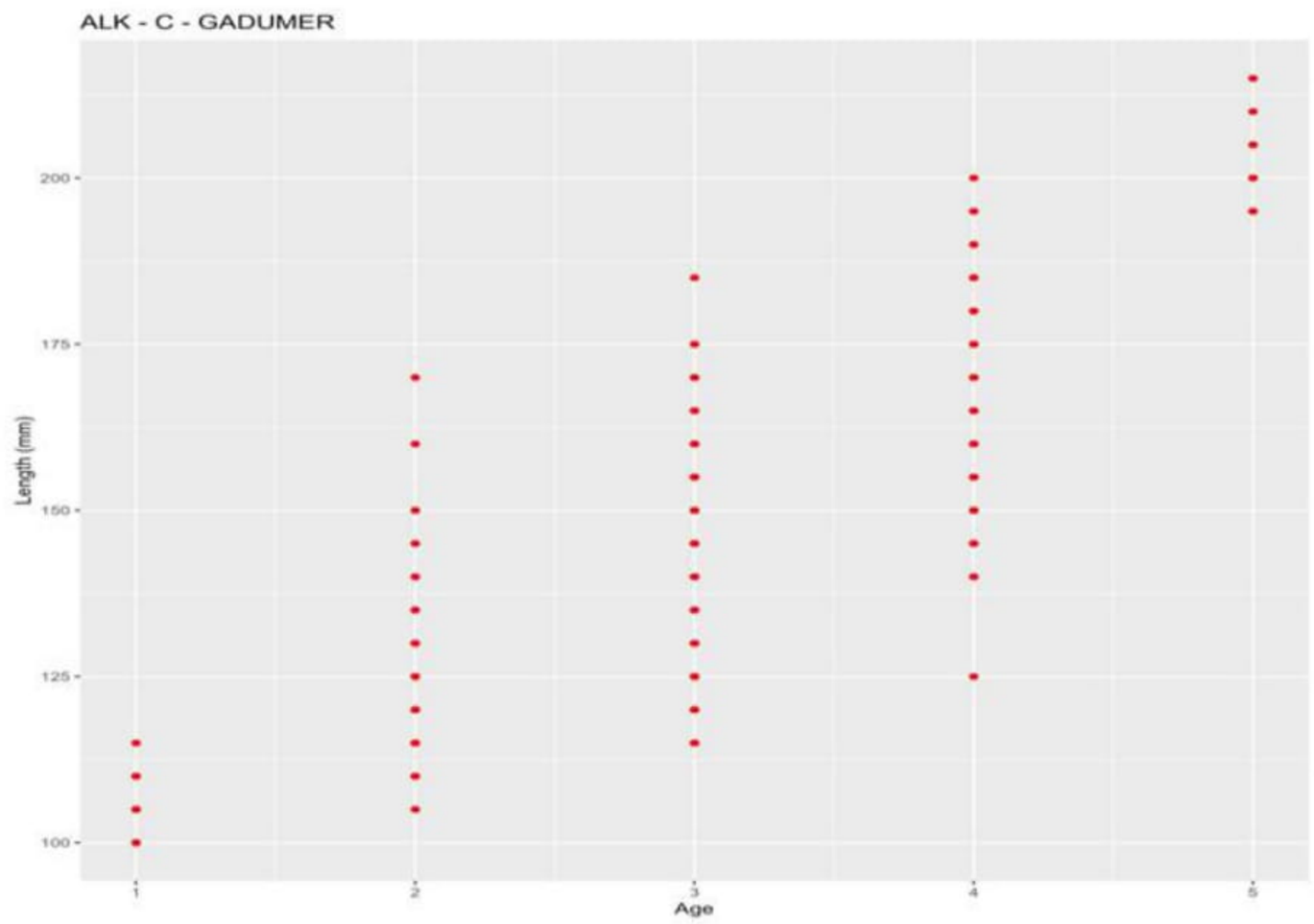


***Figure 20*** *M. merlangus: Age-size relationships.*



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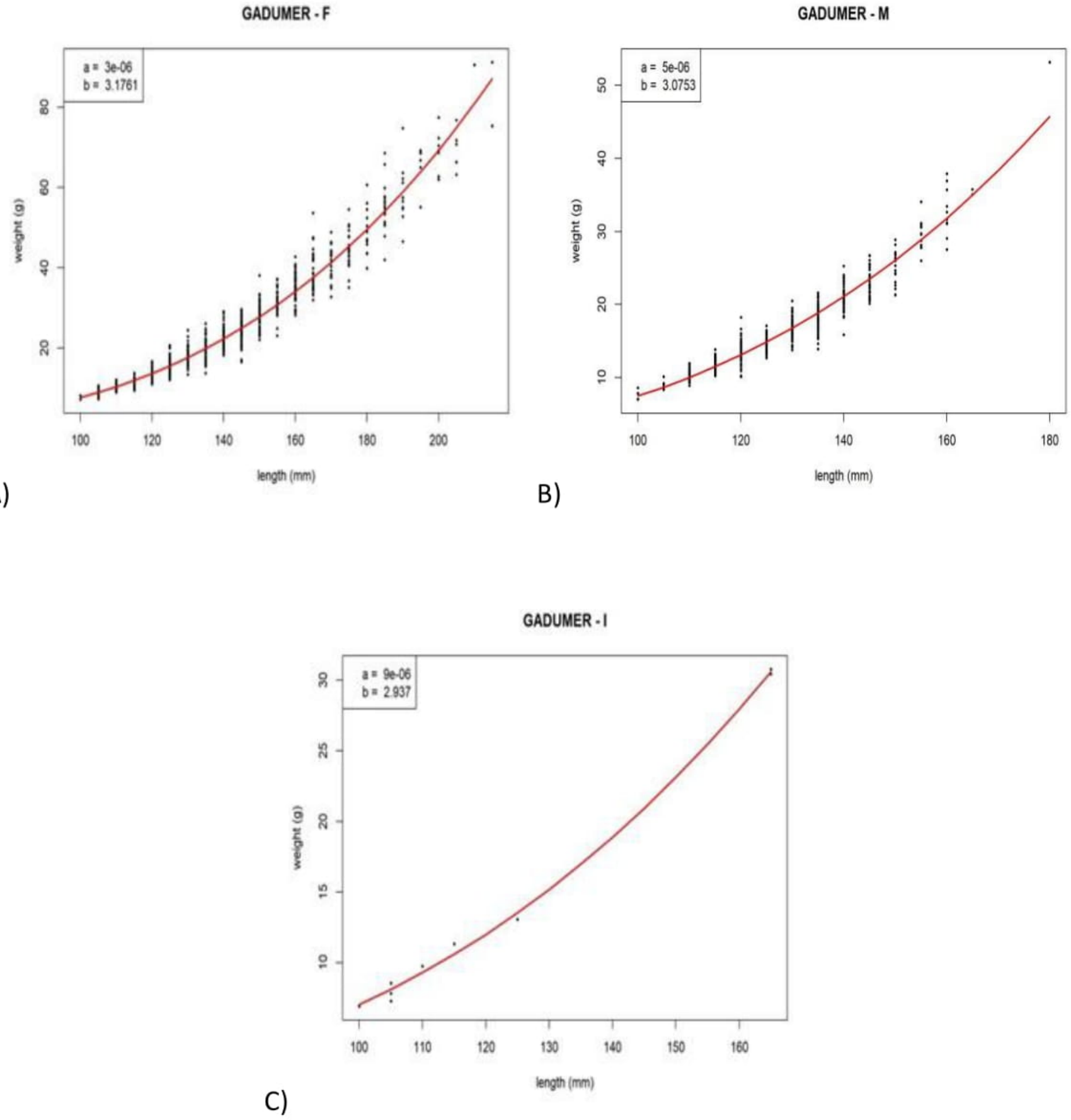


***Figure 21*** *M. merlangus: Length-weight relationships by sex, A) female, B) male and C) indeterminate, November - December, 2024.*



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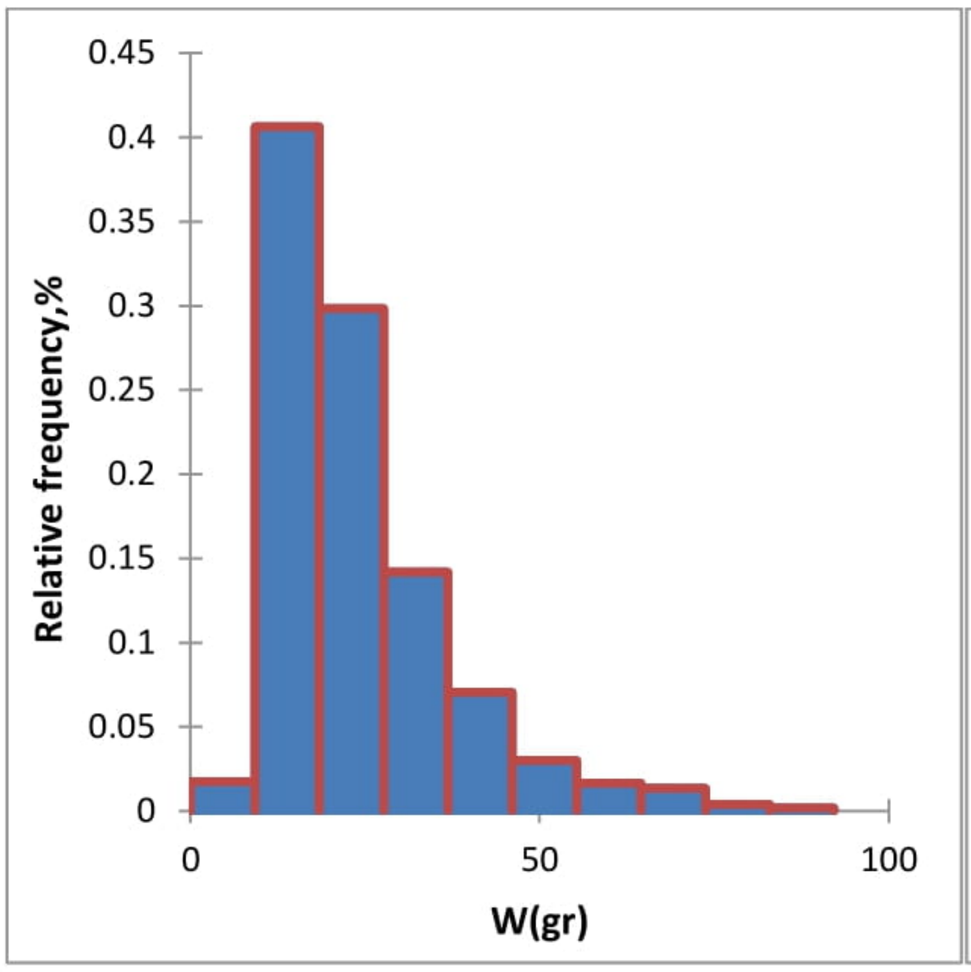
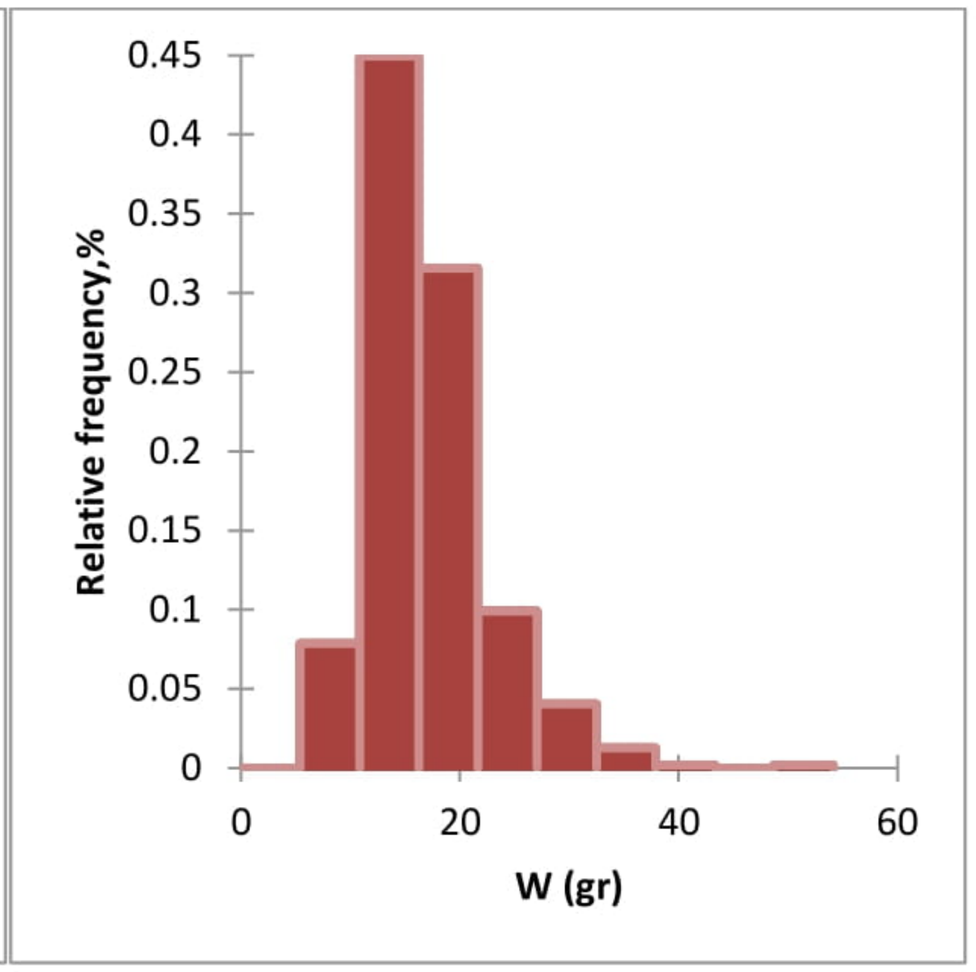
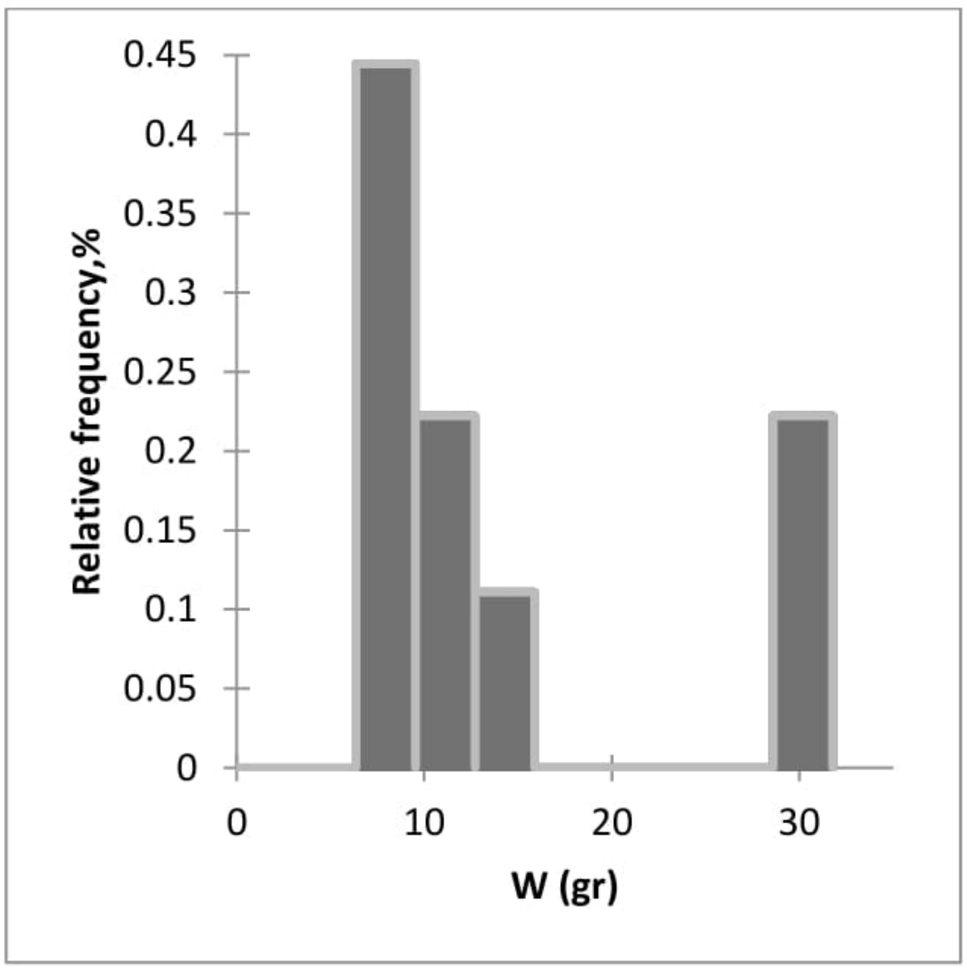



A)




B)




C)

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

The GSI index varies on female specimens: 0.338 - 33.867, with an average – 6.621, while in males the index is lower, and we observe values from 0.197-15.748, and an average – 3.144 (Fig.23). Fecundity was determined between 1.02 and 64.21 (mean: 15.24±10.53) according to 500 gonads examined.

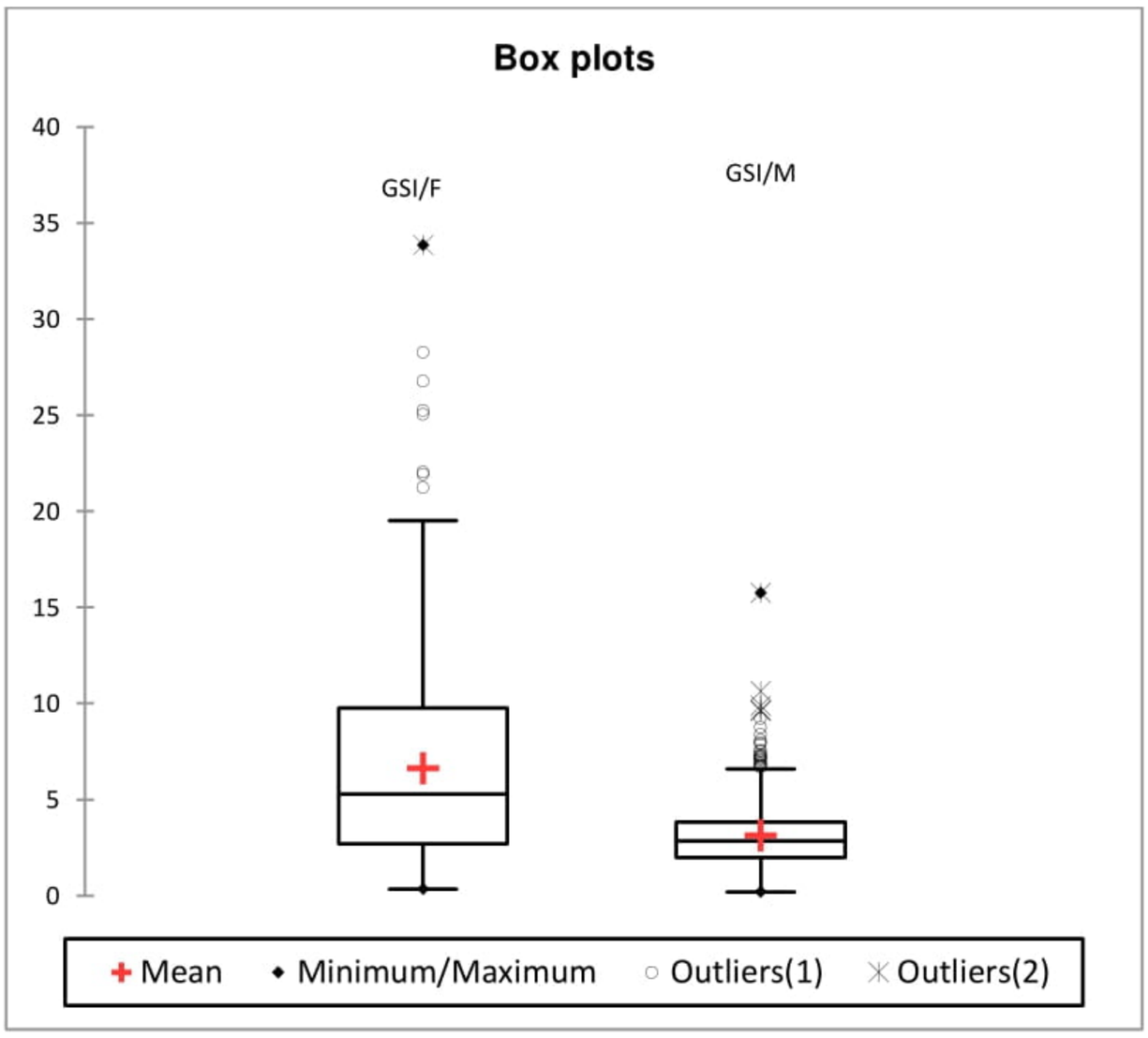



*Figure 23 Gonadosomatic index (GSI) by sex of M. merlangus. Box-plot: the horizontal line is the median; the upper and lower bars show the maximum and minimum range of the data, excluding outliers.*

A high abundance was observed at depth of 45-75 m,(Fig.24). Dominant specimens with sizes of 12.0 cm - 13.5 cm. The established ratio of female, male, and indeterminate individuals is - **65.16%:34.28%:0.57%.**



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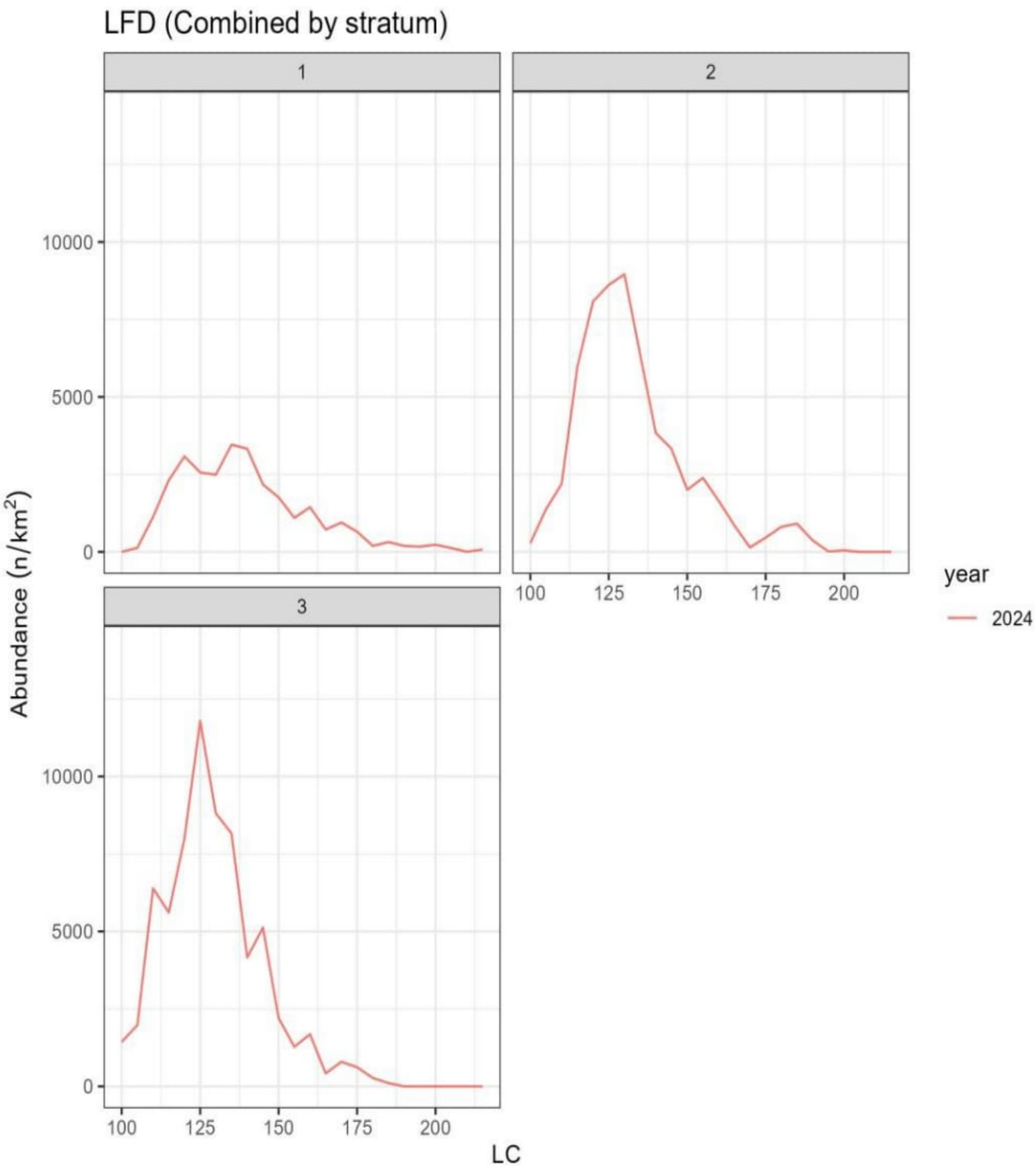


*Figure 24 Abundance (n/km2) by length classes (LC,mm) and depth strata (1, 2 and 3) for XI-XII 2024;*

Mean relative biomass (kg/km2) and abundance (n/km2) distribution on a coordinate grid for whiting is shown in Fig. 25.



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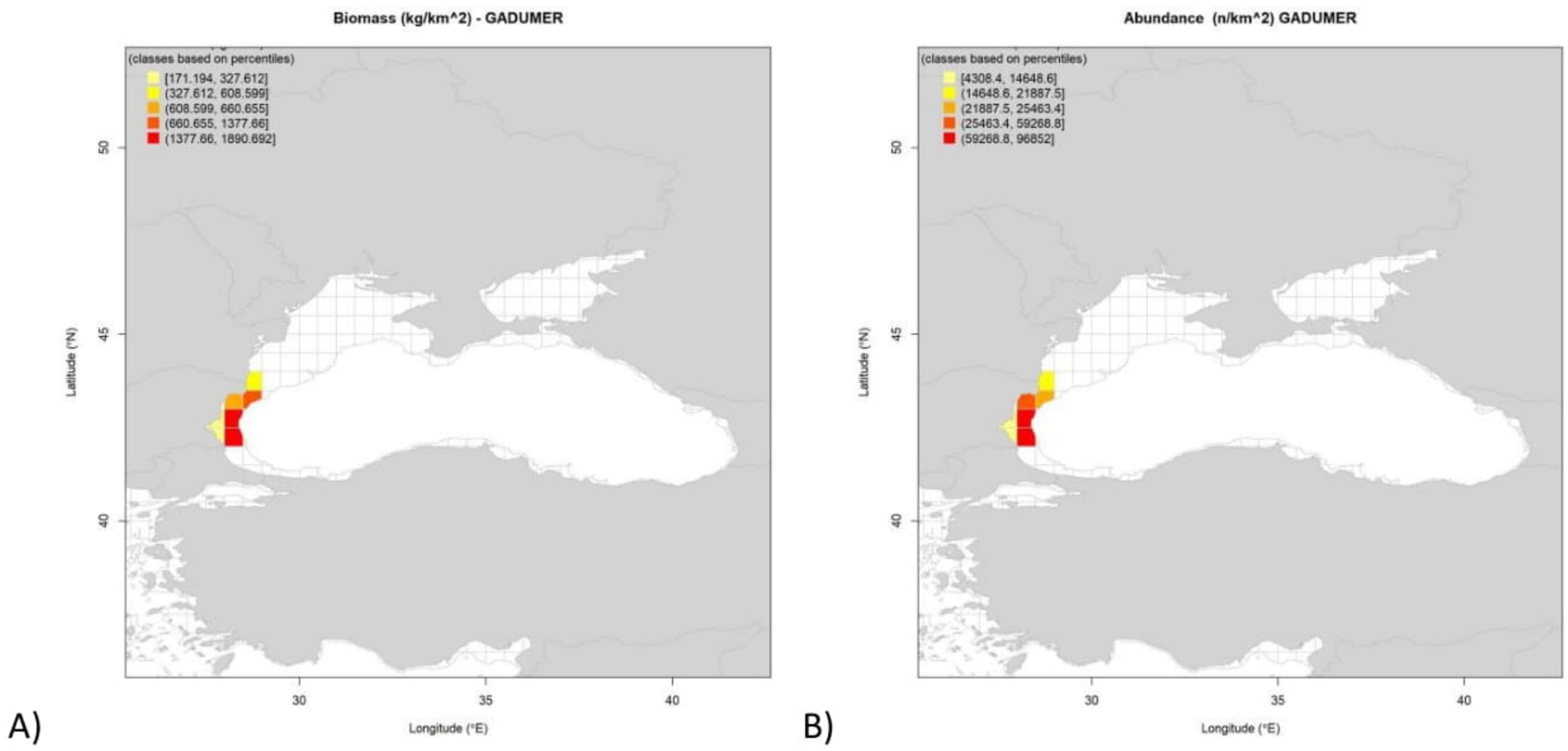


*Figure 25 Distribution of mean A) relative biomass (kg /km2) and B) abundance (n/km2) of M. merlangus in November - December 2024, according to the BioIndex version 3.3;*

The whiting biomass in the entire studied area in front of the Bulgarian coast of the Black Sea was estimated at **12949.93** tonnes (Table 4). The abundance in the studied area was estimated at **604.009*10$^{6}$** 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).



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Table 8

**Results from CPUE (kg/h) on dogfish (*S. acanthias*) in November - December 2024**

| № | Field | Depth (m) | | Catch (Kg/h) |
|---|---|---|---|---|
| 1 | D9 | 28 | 31.5 | 66.98 |
| 2 | E10 | 33.5 | 36 | 13.33 |
| 3 | E11 | 40 | 43 | 12 |
| 4 | C11 | 32 | 34 | 0 |
| 5 | D12 | 40 | 43 | 0.4 |
| 6 | E13 | 59 | 63 | 17.23 |
| 7 | C13 | 40.5 | 42.5 | 3.11 |
| 8 | D14 | 48.5 | 49 | 0 |
| 9 | E15 | 66 | 67 | 0 |
| 10 | D16 | 63 | 53 | 0 |
| 11 | C15 | 40 | 39 | 0 |
| 12 | B16 | 37 | 39 | 6.18 |
| 13 | C17 | 39 | 40 | 4.77 |
| 14 | D18 | 44 | 49 | 7.07 |
| 15 | E19 | 58 | 62 | 0 |
| 16 | F18 | 74 | 80 | 12.14 |
| 17 | E17 | 66 | 67 | 6.5 |
| 18 | F16 | 80 | 81 | 0 |
| 19 | F14 | 78 | 79 | 12.05 |
| 20 | G13 | 87 | 89 | 60.13 |
| 21 | F12 | 86 | 84 | 20.1 |
| 22 | E8 | 25 | 29.5 | 0 |
| 23 | F7 | 29 | 30.5 | 0 |
| 24 | G6 | 30 | 33.5 | 0 |
| 25 | J6 | 49 | 50 | 0 |
| 26 | F9 | 46.5 | 58.5 | 0 |
| 27 | G10 | 73 | 68.5 | 0 |
| 28 | H9 | 79.5 | 76.5 | 0 |
| 29 | G8 | 55.5 | 51 | 5.56 |
| 30 | H7 | 53 | 56 | 0 |



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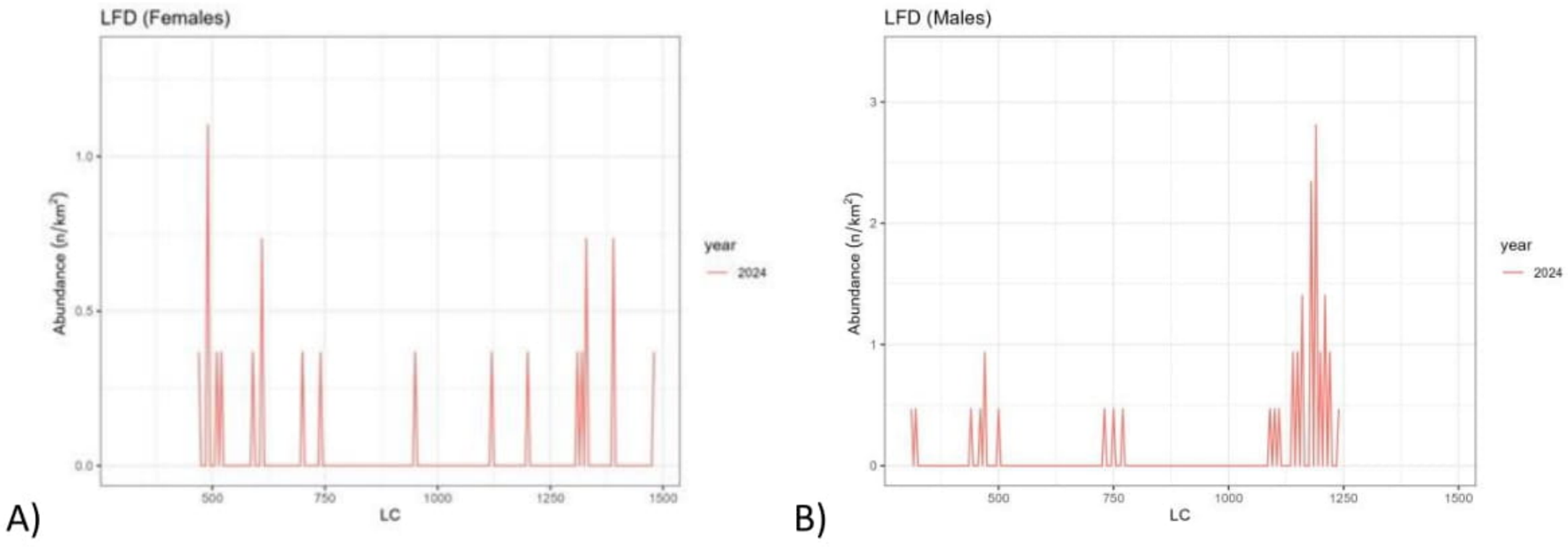
| | | | | |
|---|---|---|---|---|
| **31** | J7 | 77 | 84 | 0 |
| **32** | L1 | 50 | 49.5 | 0 |
| **33** | N1 | 55 | 65 | 35.46 |
| **34** | M2 | 64.5 | 64 | 0 |
| **35** | L3 | 61 | 61 | 3.21 |
| **36** | M4 | 76 | 77 | 6.45 |
| **37** | L5 | 78.5 | 79 | 0 |
| **38** | K4 | 52.5 | 54 | 0 |
| **39** | J5 | 52 | 50.5 | 5.49 |
| **40** | H5 | 26 | 21 | 0 |

The main biological parameters of *S. acanthias* are presented in Fig.26, 27 and 28. A large part of the captured female specimens with a size between 45-95 cm (Fig. 26, A), and males are bigger, 106-124 cm, (Fig. 26, B). Males predominate in the catch specimens 65%, and females are 35%.




A) B)

***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 340 and 16880 grams, with an average weight of 5062.38 grams (Fig. 27, A). In contrast, the male specimens weighed less, ranging from 80 to 7360 grams, with an average weight of 4919.23 grams (Fig. 27, B).

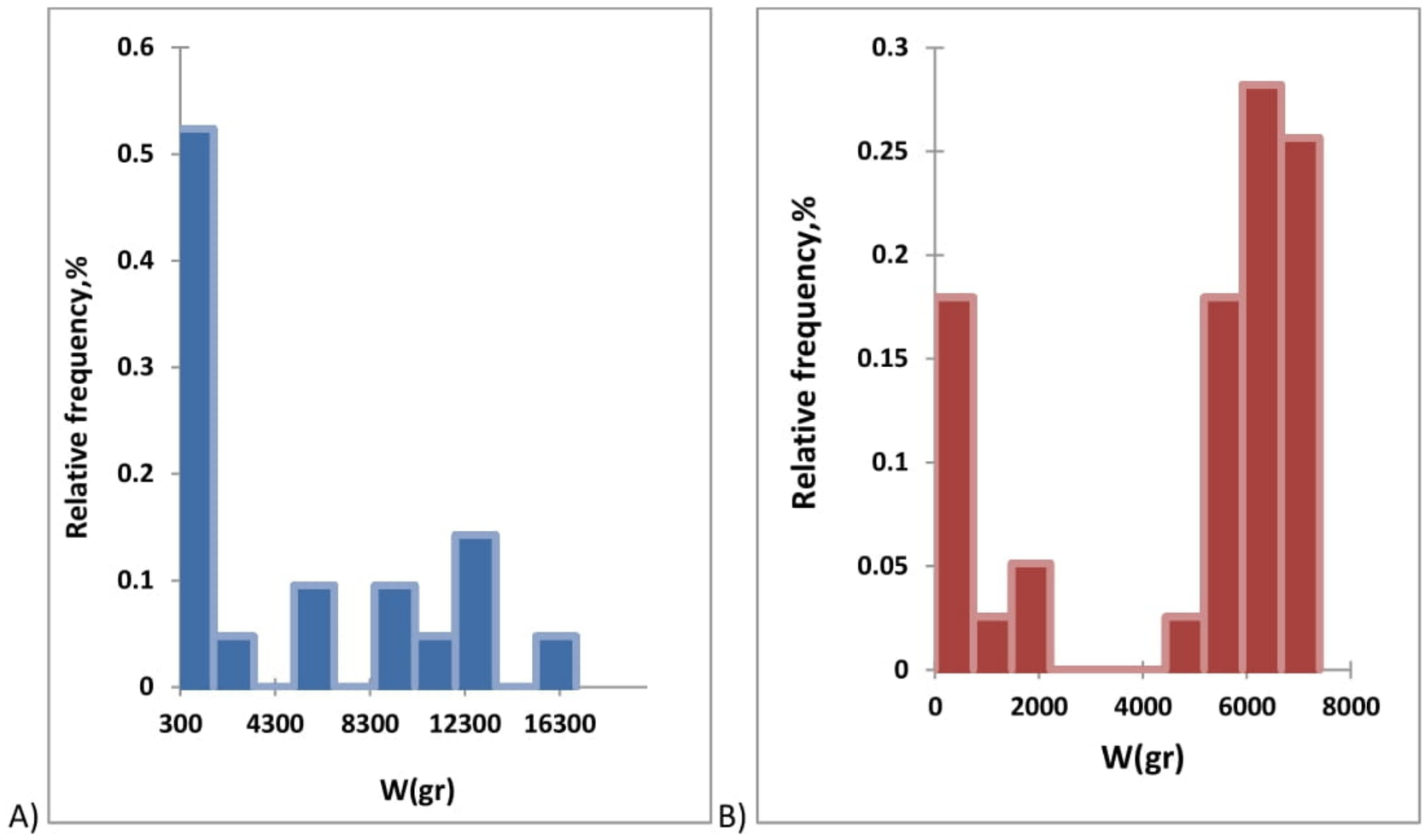



**Figure 27** *Weight structure of S. acanthias by sex, A) female and B) male specimens;*

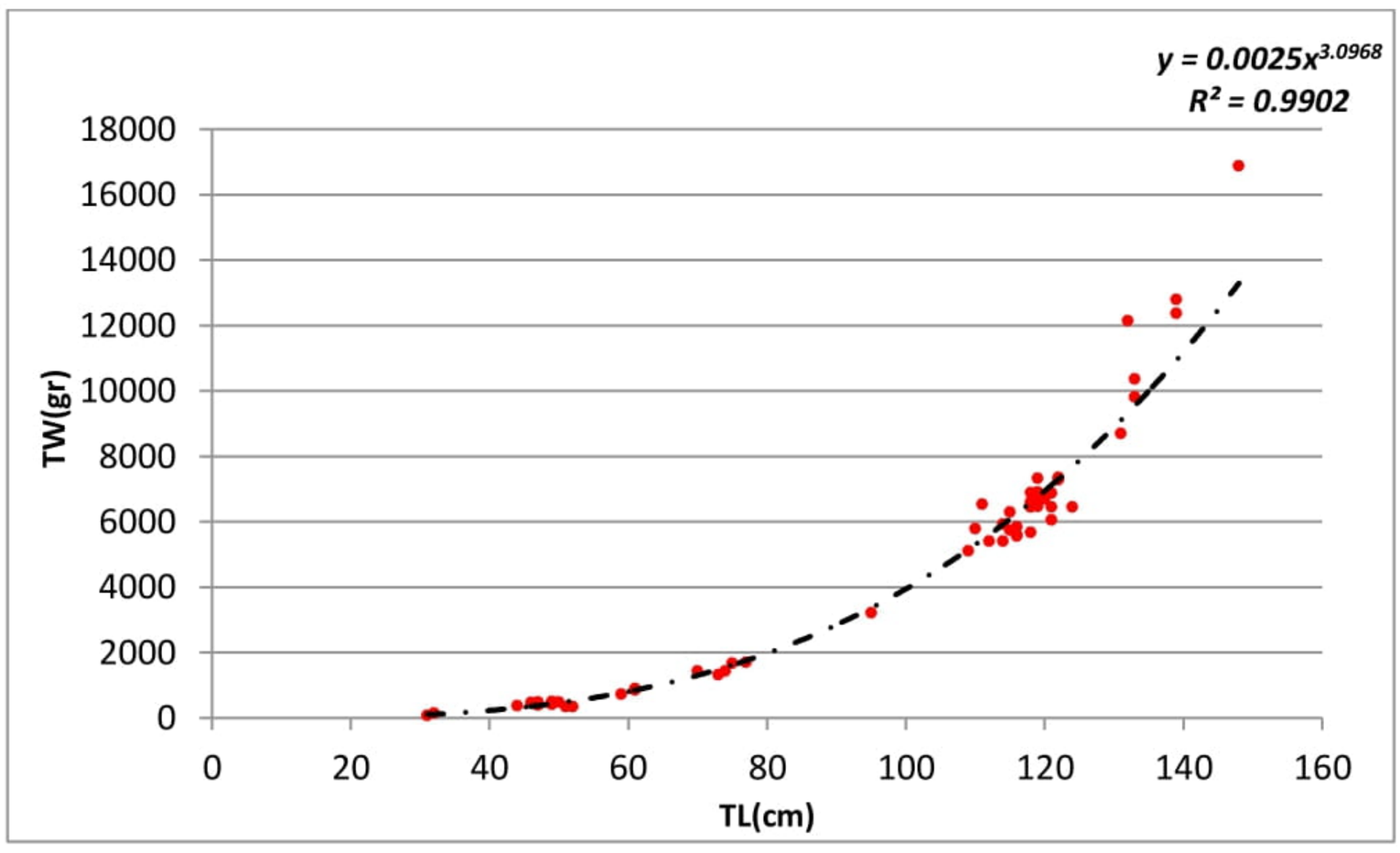



***Figure 28*** *S. acanthias: Length-weight relationships XI-XII, 2024;*

The most abundant dogfish bycatch was caught at depth of 28-31.5 and 87-89 m, (Fig. 29).



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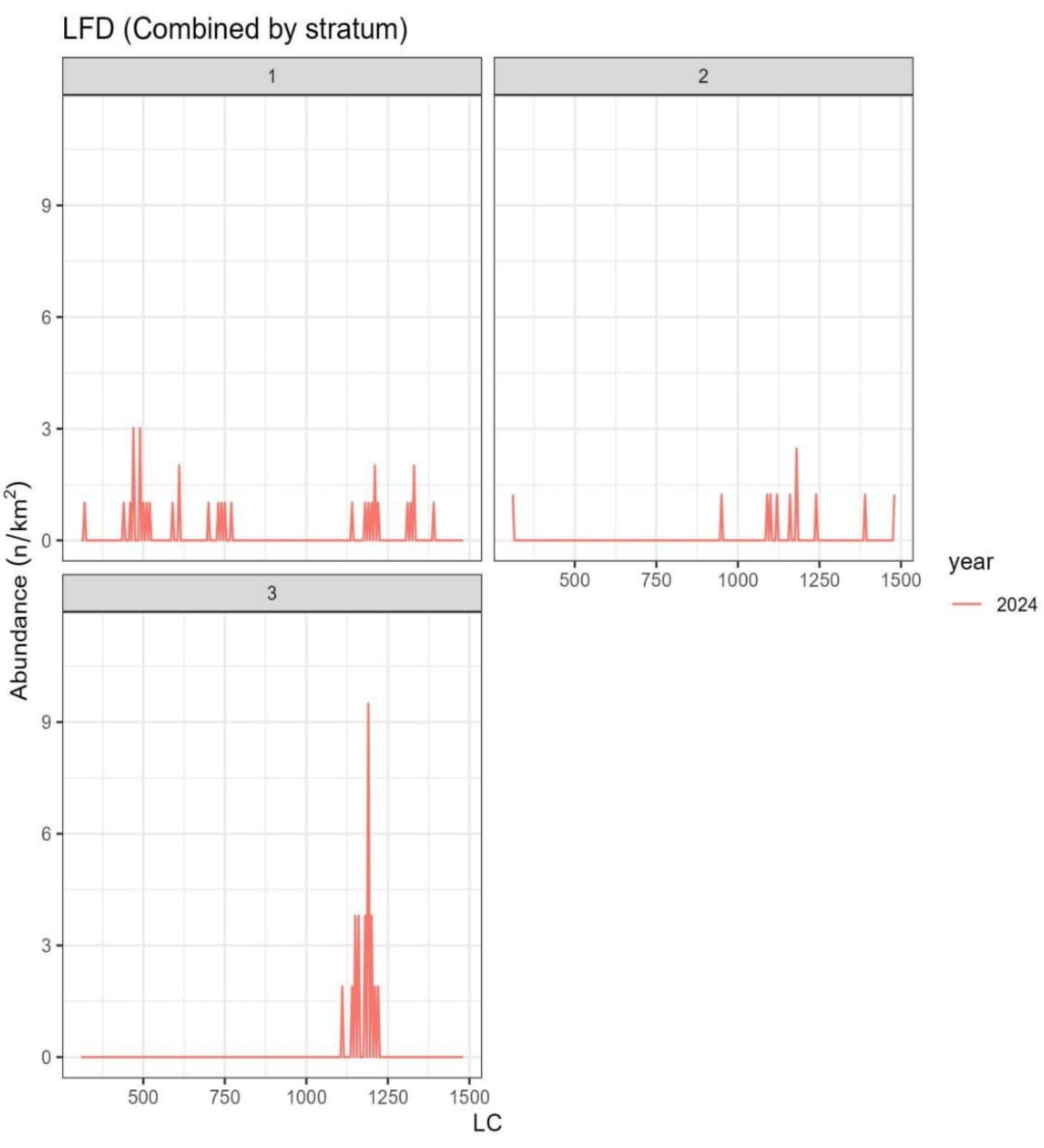


*Figure 29 Abundance (n/km2) by length classes (LC,mm) and depth strata (1, 2 and 3), XI-XII 2024;*


**Figure 30** *Distribution of the relative biomass by hauls (kg / km2) of S. acanthias in XI-XII 2024 according to BioIndex version 3.3.*

The maximum biomass index of dogfish for XI-XII in the Bulgarian water area reaches **1156.57** kg/km$^2$(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 may not be accurate. The dogfish biomass in the entire studied area in front of the Bulgarian coast was estimated at **1579.22** tonnes. During the study period, the total abundance in the Bulgarian water area was estimated to be **317.79 *10$^3$** individuals.

## 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).



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Table 9

**Results of CPUE (catch per unit effort kg/h) of red fox (R. clavata) by month, November - December 2024**

| № | Field | Depth (m) | | Catch (Kg/h) |
|---|---|---|---|---|
| 1 | D9 | 28 | 31.5 | 1.68 |
| 2 | E10 | 33.5 | 36 | 11.93 |
| 3 | E11 | 40 | 43 | 2.4 |
| 4 | C11 | 32 | 34 | 10.13 |
| 5 | D12 | 40 | 43 | 4.69 |
| 6 | E13 | 59 | 63 | 0 |
| 7 | C13 | 40.5 | 42.5 | 10.3 |
| 8 | D14 | 48.5 | 49 | 9.2 |
| 9 | E15 | 66 | 67 | 20.37 |
| 10 | D16 | 63 | 53 | 3.55 |
| 11 | C15 | 40 | 39 | 37.95 |
| 12 | B16 | 37 | 39 | 32.65 |
| 13 | C17 | 39 | 40 | 24.33 |
| 14 | D18 | 44 | 49 | 8.2 |
| 15 | E19 | 58 | 62 | 4.11 |
| 16 | F18 | 74 | 80 | 7.36 |
| 17 | E17 | 66 | 67 | 0 |
| 18 | F16 | 80 | 81 | 1.1 |
| 19 | F14 | 78 | 79 | 6.09 |
| 20 | G13 | 87 | 89 | 0 |
| 21 | F12 | 86 | 84 | 0 |
| 22 | E8 | 25 | 29.5 | 11.64 |
| 23 | F7 | 29 | 30.5 | 0 |
| 24 | G6 | 30 | 33.5 | 1.15 |
| 25 | J6 | 49 | 50 | 7.8 |
| 26 | F9 | 46.5 | 58.5 | 4.8 |
| 27 | G10 | 73 | 68.5 | 0 |
| 28 | H9 | 79.5 | 76.5 | 0 |
| 29 | G8 | 55.5 | 51 | 1.19 |
| 30 | H7 | 53 | 56 | 0.51 |
| 31 | J7 | 77 | 84 | 0 |
| 32 | L1 | 50 | 49.5 | 0 |

| | | | | |
|---|---|---|---|---|
| **33** | N1 | 55 | 65 | 4.72 |
| **34** | M2 | 64.5 | 64 | 11.18 |
| **35** | L3 | 61 | 61 | 3.68 |
| **36** | M4 | 76 | 77 | 0 |
| **37** | L5 | 78.5 | 79 | 0 |
| **38** | K4 | 52.5 | 54 | 2.05 |
| **39** | J5 | 52 | 50.5 | 6.64 |
| **40** | H5 | 26 | 21 | 0 |

The main biological parameters of *Raja clavata* are presented in Fig.31, 32 and 33. The caught female specimens are 33-94 cm in size and weigh 200-5480 g (Fig. 31 A and Fig.32 A), and the following values were recorded for males - 34-90 cm and 210-4800 g, (Fig. 31 B and Fig. 32 B). The female and male ratio in the catch was approximately equal, at 49.3% and 50.7% respectively.

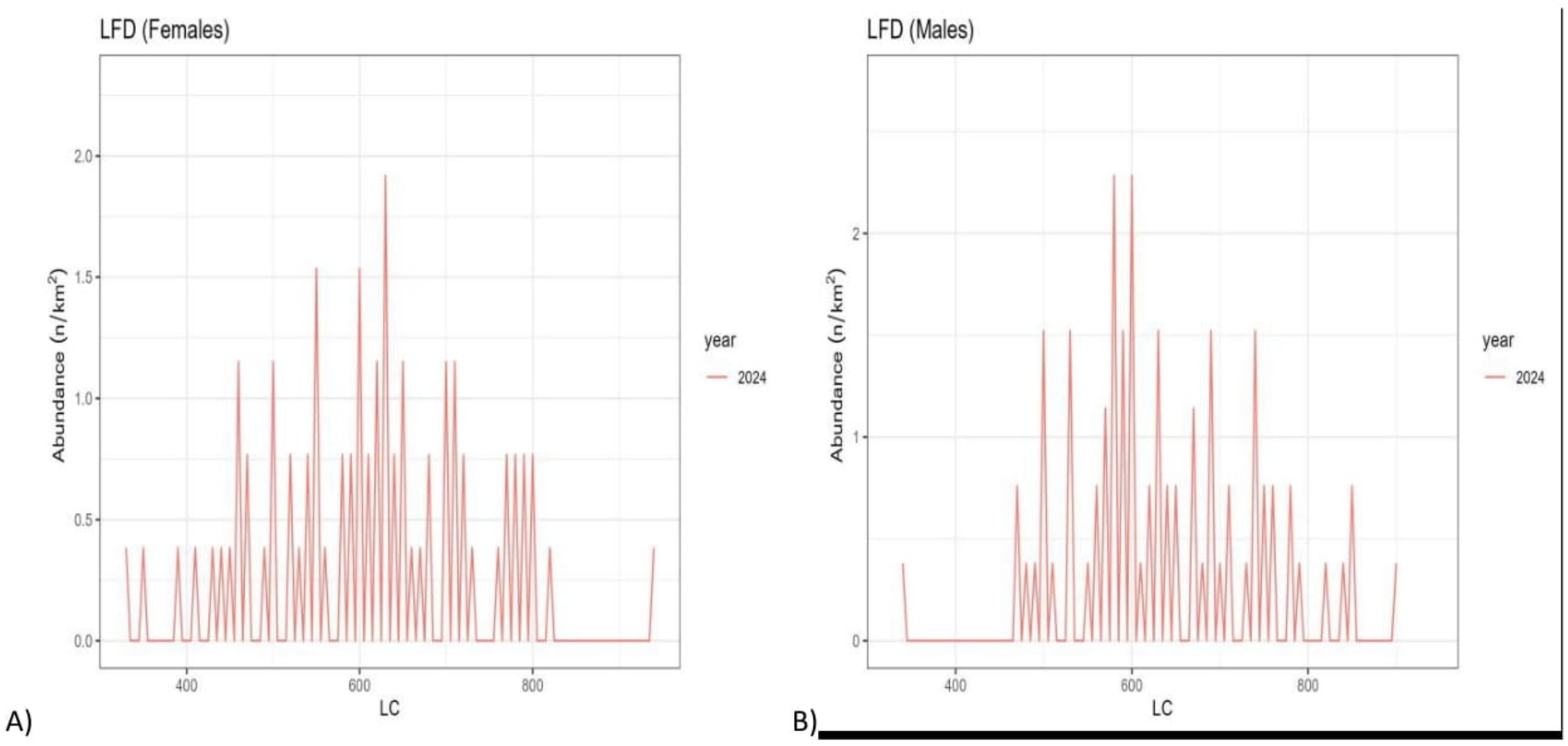


**Figure 31** *Abundance (n/km2) and length classes (LC, mm) of Raja clavata by sex, A) female, and B) male specimens;*



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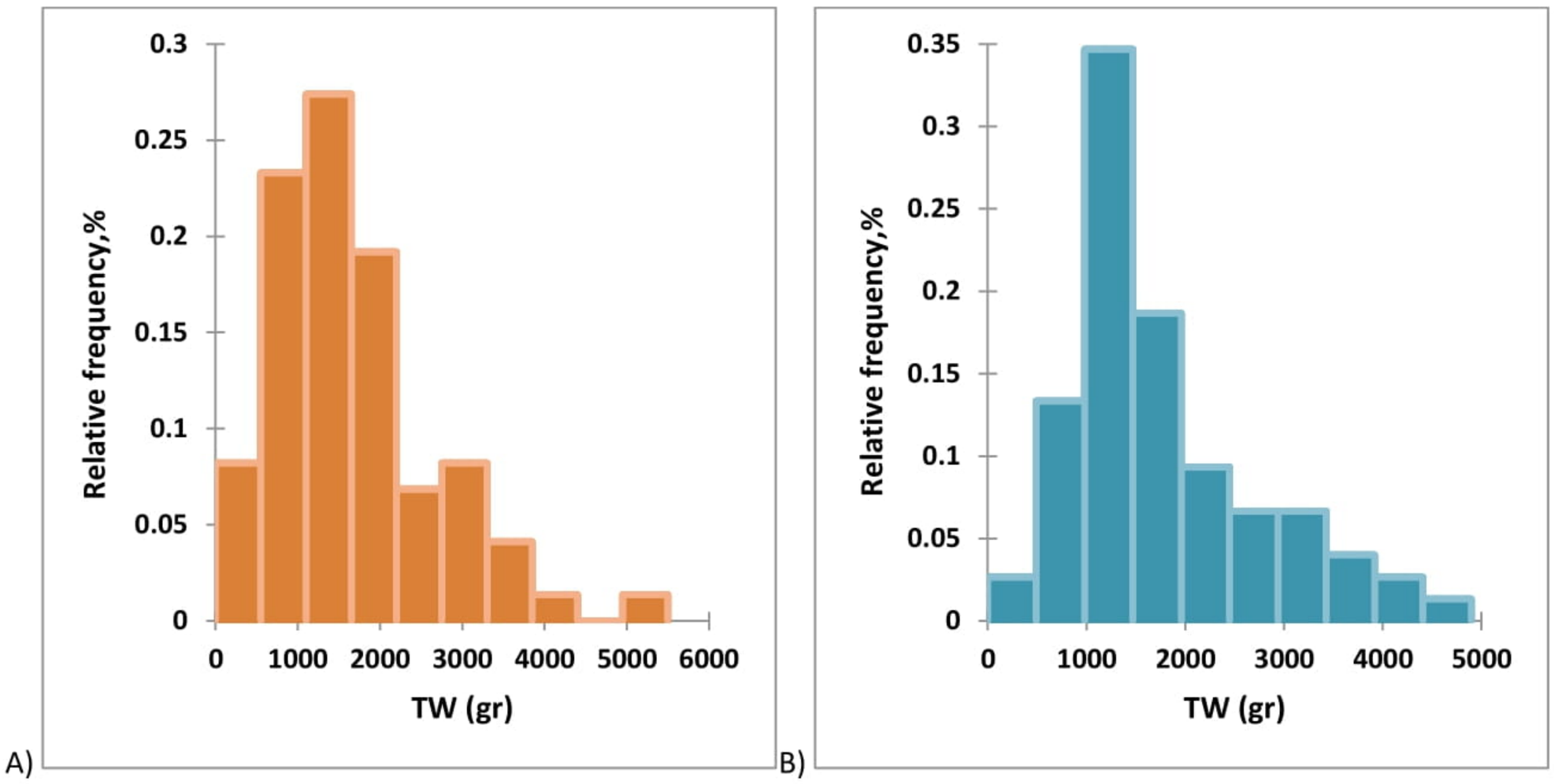


**Figure 32** *Weight structure by sex of Raja clavata catches, A) female and B) male specimens;*

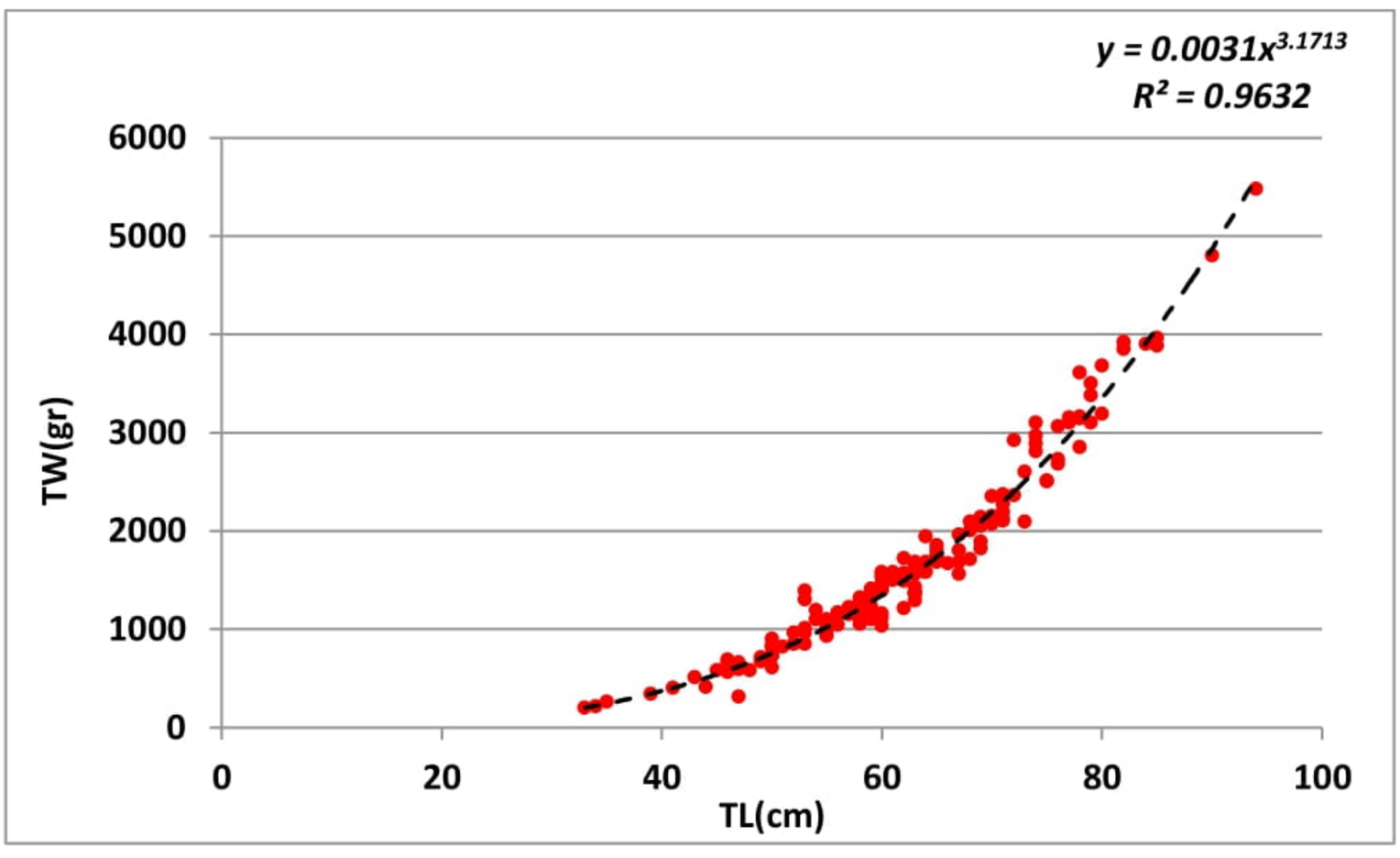


**Figure 33** *Raja clavata: Length-weight relationships XI-XII, 2024;*



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At a depth of 15-50 m, a high catch of thornback ray was recorded, and at this depth catch specimens with lengths between 33 - 85 cm (Fig. 34).

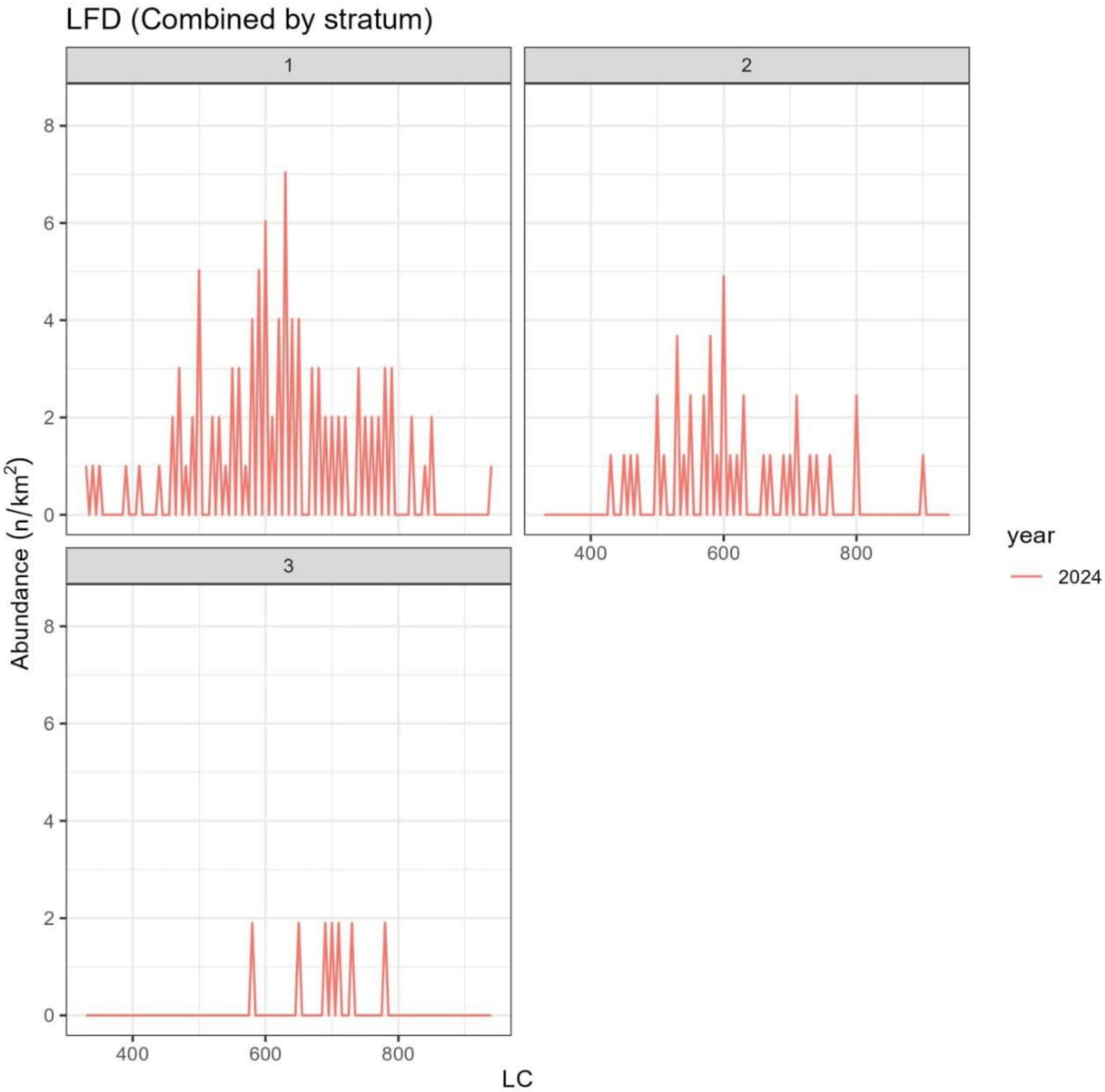


**Figure 34** *Abundance (n/km$^2$) by length classes (LC, mm) and depth strata (1, 2 and 3) for XI-XII 2024;*

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



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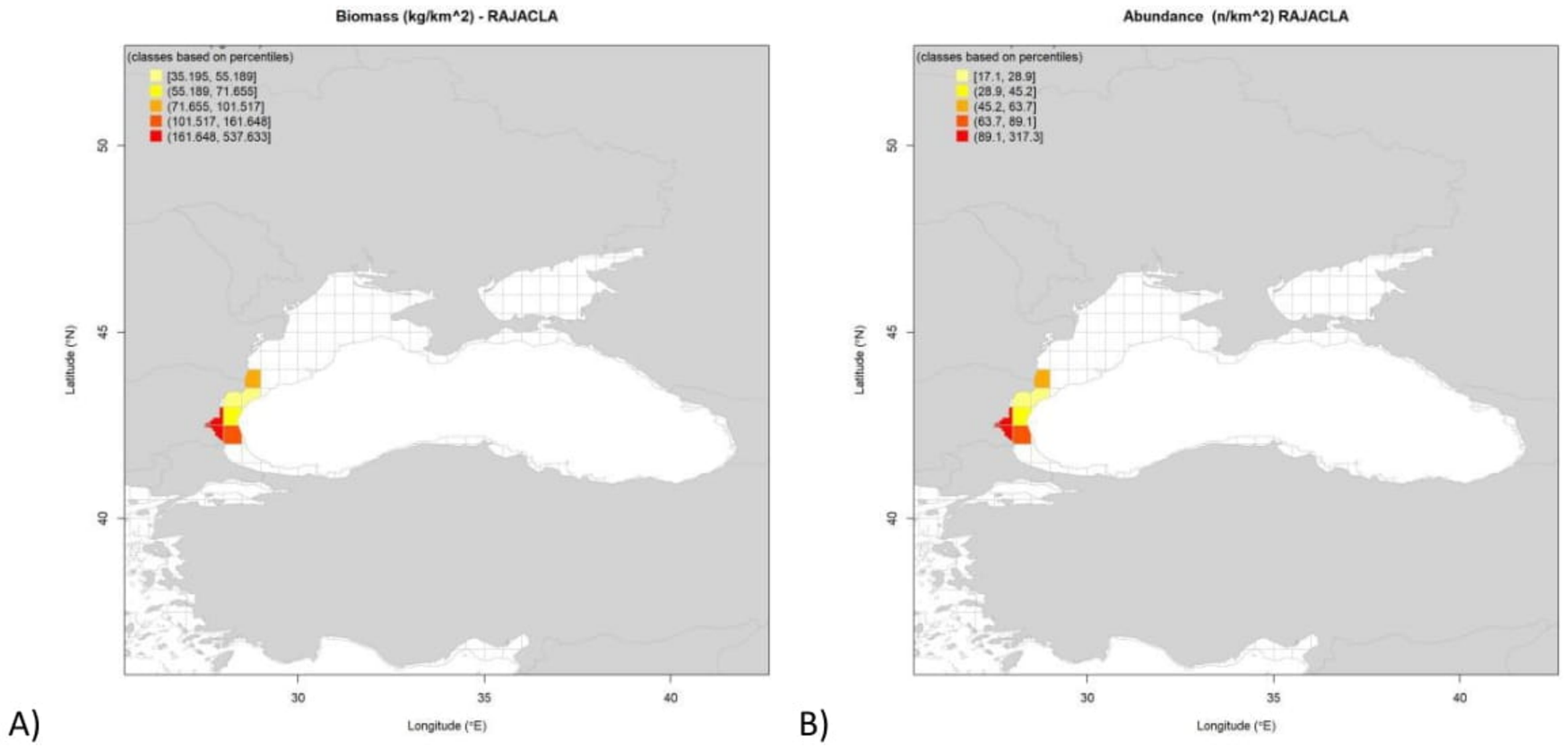


**Figure 35** *Distribution of mean A) relative biomass (kg /km2) and B) abundance (n/km2) of Raja clavata in XI-XII 2024, according to the BioIndex version 3.3;*

The thornback ray biomass in the entire studied area in front of the Bulgarian coast of the Black Sea was estimated at **1118.68** tonnes. The abundance was estimated at **658.57 *10$^3$** specimens.

## 4. Food spectrum of *S. maximus*

During the autumn season of 2024, 131 stomachs were analyzed to determine the diet spectrum of turbot. Nutritional components were found in 60.31% of the examined specimens, while 39.69% were without stomach content, indicating a higher percentage of feeding fish during this period. General statistical data for the measured biological parameters are shown in Table 10.



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Table 10

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

| | L (cm) | W (gr) | ST_cont | ISF |
|---|---|---|---|---|
| **Number** | 79 | 79 | 79 | 79 |
| **Sum** | 4100.50 | 215.03 | 1712.75 | 63.65 |
| **Min** | 40.00 | 1.10 | 1.99 | 0.06 |
| **Mean** | 51.91 | 2.72 | 21.68 | 0.81 |
| **Max** | 63.00 | 4.58 | 82.06 | 2.85 |
| **Std. dev** | 4.88 | 0.79 | 18.02 | 0.63 |
| **Median** | 51.00 | 2.66 | 14.87 | 0.62 |
| **Kurtosis** | -0.56 | -0.79 | 0.99 | 0.77 |
| **Skewness** | 0.22 | 0.26 | 1.22 | 1.16 |
| **Std. Err.** | 0.55 | 0.09 | 2.03 | 0.07 |

The mean fullness index of the turbot stomachs reaches 0.806 % BW ± 0.07 SE (Table 10). ISF (% BW) values for the summer season of 2024 are shown in Fig. 36.



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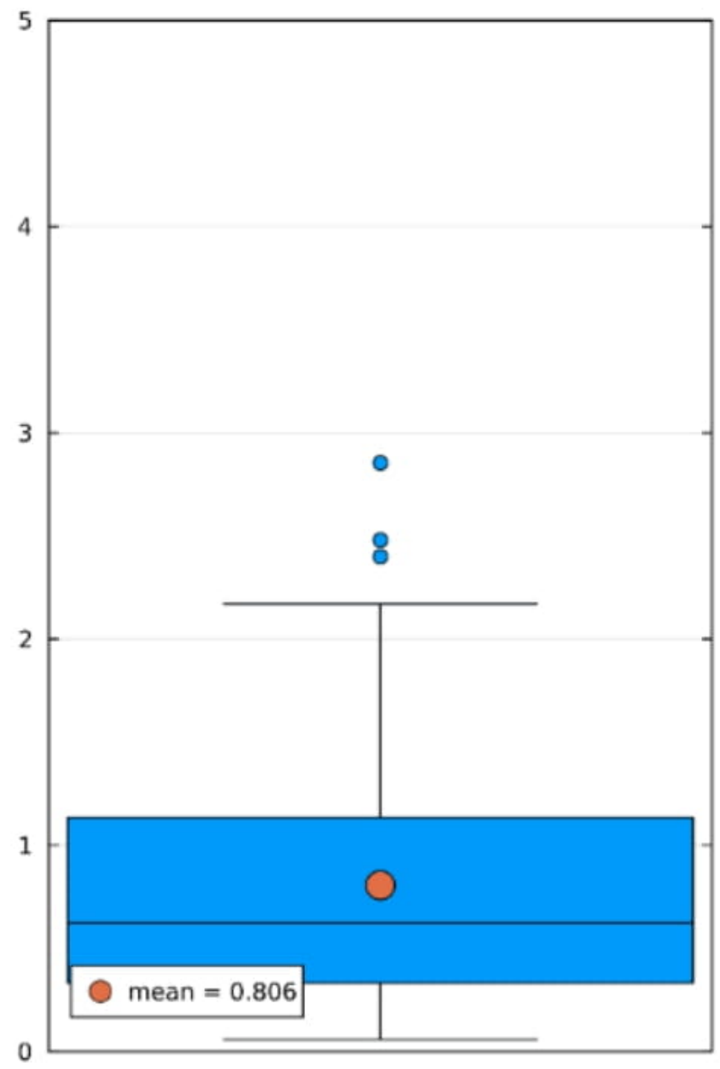


**Figure 36** Box-plot: ISF (% BW) values during the spring-summer of 2024.

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

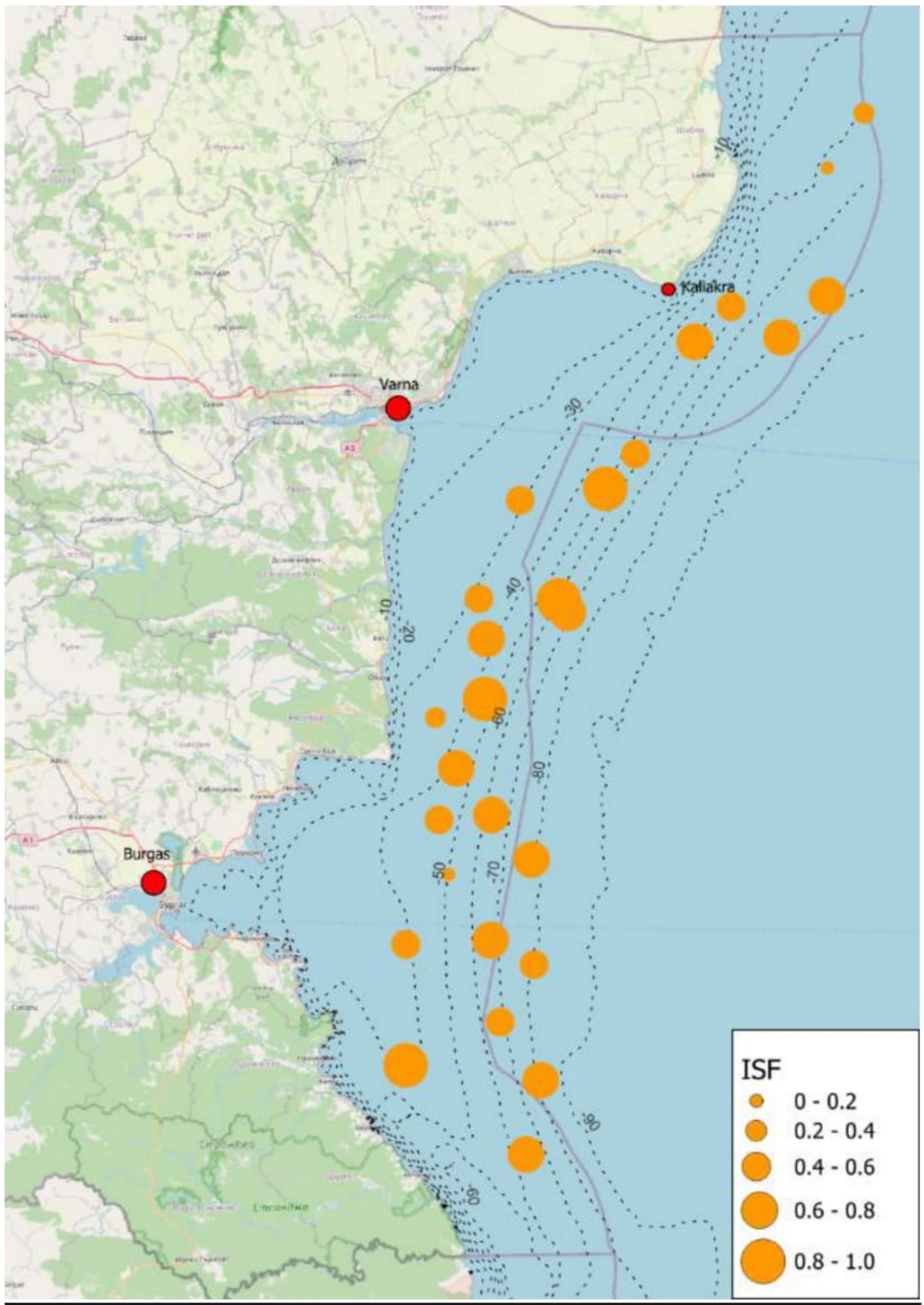


**Figure 37** Spatial distribution of the turbot stomach fullness index (ISF, % BW) during the spring-summer season of 2024.



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Table 11

**Qualitative composition of turbot diet during the study period.**

| Species | FQ | CN | CB | IRI | IRI % |
|---|---|---|---|---|---|
| **Merlangus merlangus** | 56.96 | 24.89 | 29.26 | 3084.9 | 23.98 |
| **Mullus barbatus** | 6.33 | 3.48 | 4.11 | 48.02 | 0.37 |
| **Engraulis encrasicolus** | 12.66 | 4.16 | 3.33 | 94.76 | 0.74 |
| **Sprattus sprattus** | 1.27 | 0.32 | 0.22 | 0.68 | 0.01 |
| **Alosa caspia** | 1.27 | 0.32 | 0.53 | 1.07 | 0.01 |
| **Trachurus mediterraneus** | 53.16 | 12.68 | 9.18 | 1162.65 | 9.04 |
| **Gobiidae** | 1.27 | 0.63 | 0.69 | 1.68 | 0.01 |
| **remains** | 79.75 | 53.52 | 52.68 | 8468.63 | 65.84 |

During the study period, the highest IRI value was for processed content – 8468.63 (65.84%). Only one taxonomic groups was identified - the dominant group being fish IRI=4393.75 (34.16%). Among the fish group, *Merlangus merlangus* traditionally predominates with the highest IRI=3084.90 (23.98%).



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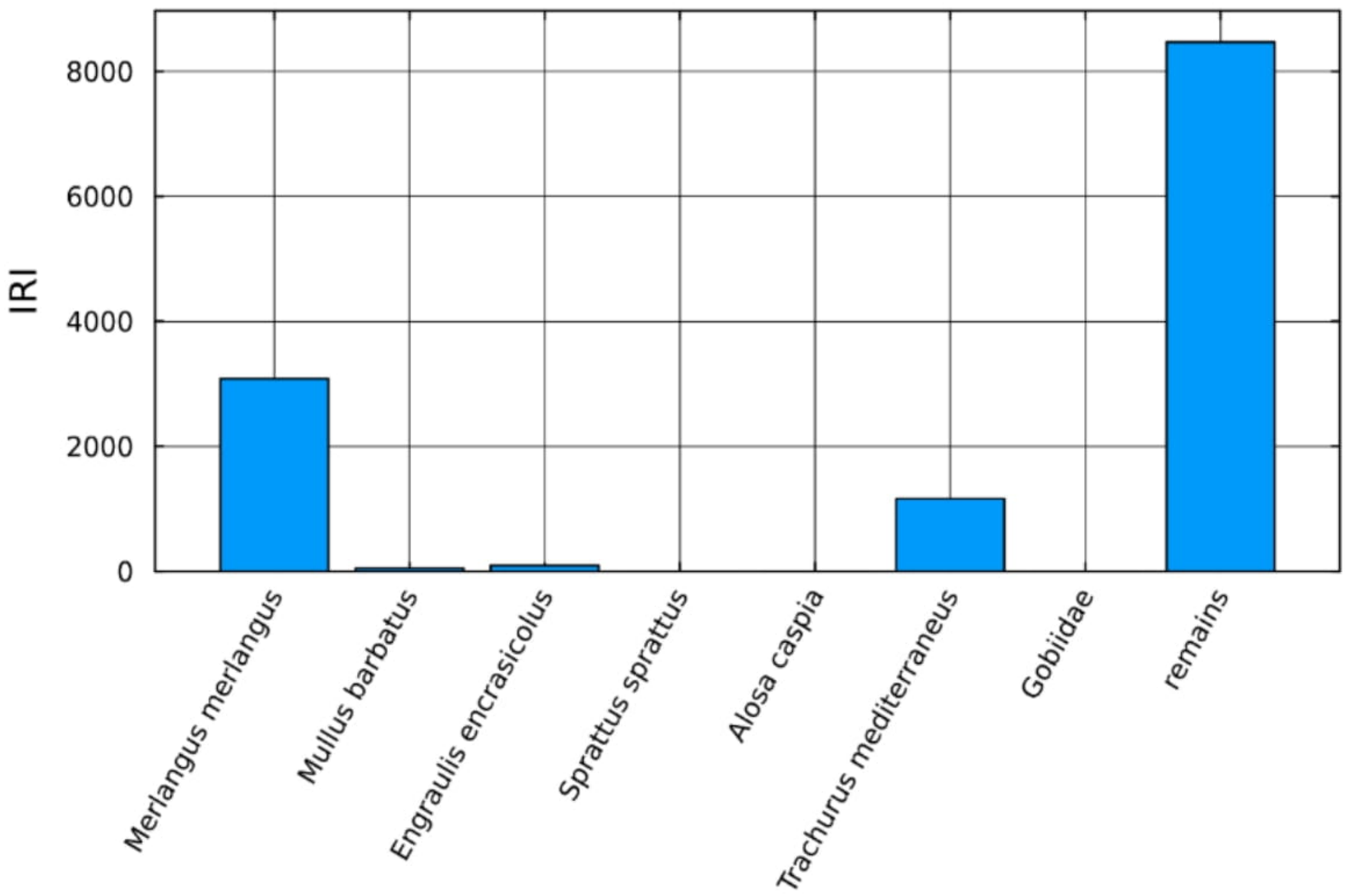


**Figure 38** IRI values by species during the autumn season of 2024;

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

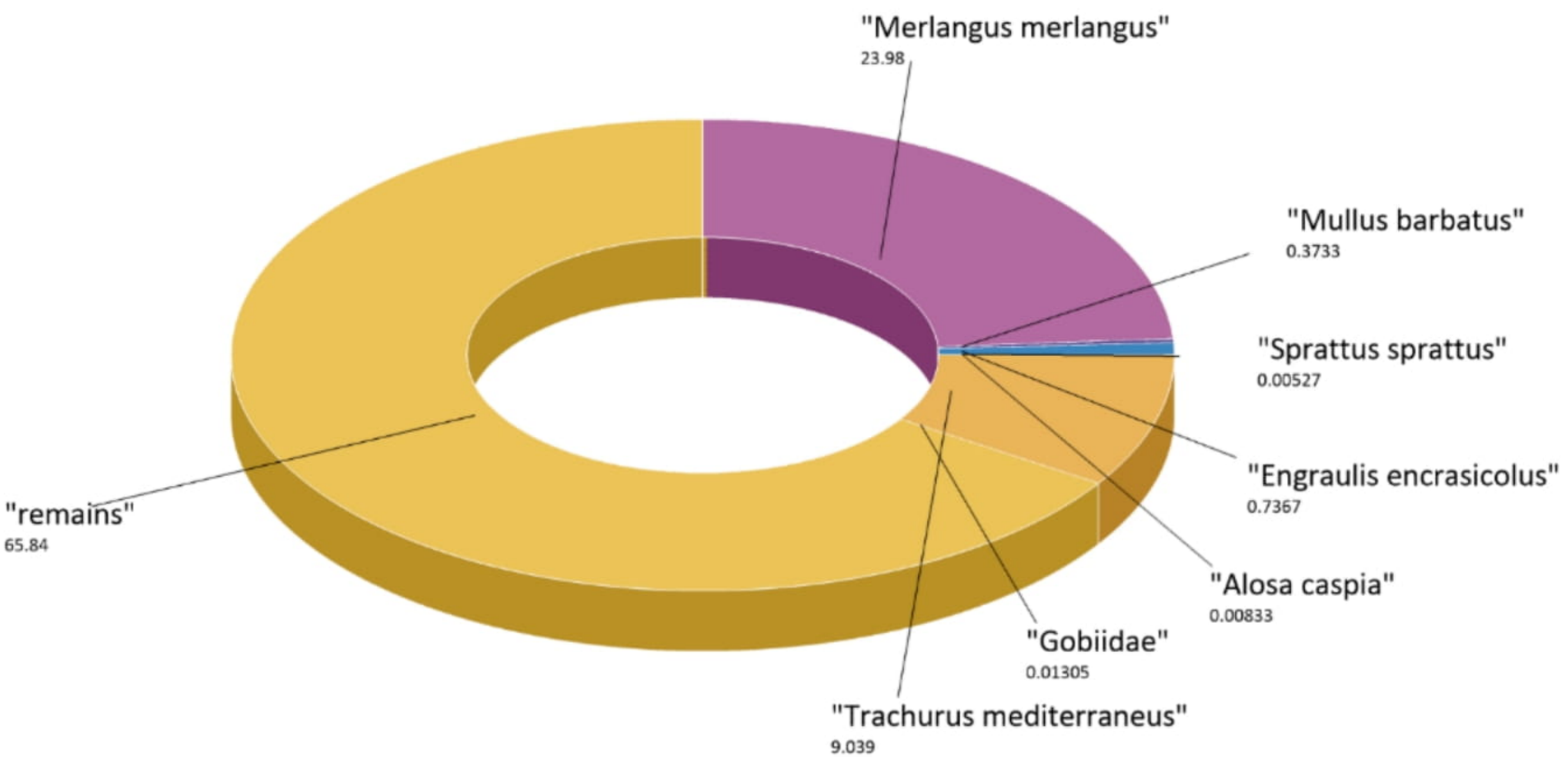


**Figure 39** Percentage shares by groups (% IRI) in the turbot diet spectrum during the autumn season of 2024.

## Additional species, diet spectrum

Along with the processed stomachs analyzed for the dietary spectrum of turbot during the autumn season of 2024, the dietary spectrum: of *Squalus acanthias*, *Pomatomus saltatrix*, *Raja clavata*, *Merlangus merlangus* and *Pomatomus saltatrix* were also examined.

**Piked dogfish *(Squalus acanthias)* –** Black Sea shark (Squalus acanthias) – From the 10 stomachs analyzed to determine the diet spectrum, 5 specimens had stomach content (50 %). General statistical data for the measured biological parameters are shown in Table 12.

Table 12

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

| | L (cm) | W (gr) | ST_cont | ISF |
|---|---|---|---|---|
| **Number** | 5 | 5 | 5 | 5 |
| **Sum** | 595.00 | 36660.00 | 155.24 | 2.01 |
| **Min** | 110.00 | 5560.00 | 0.97 | 0.01 |
| **Mean** | 119.00 | 7332.00 | 31.05 | 0.40 |
| **Max** | 132.00 | 12150.00 | 68.12 | 0.68 |
| **Std. dev** | 8.06 | 2733.69 | 25.71 | 0.27 |
| **Median** | 118.00 | 6500.00 | 34.91 | 0.52 |
| **Kurtosis** | -0.40 | 0.11 | -1.00 | -1.27 |
| **Skewness** | 0.77 | 1.39 | 0.31 | -0.51 |
| **Std. Err.** | 3.61 | 1222.54 | 11.50 | 0.12 |

The mean fullness index of the stomachs reaches 0.4 % BW ± 0.12 SE (Table 12).

**Thornback ray *(Raja Clavate)*** – 20 stomachs were analyzed, with stomach content found in 17 of them. General statistical data for the measured biological parameters are shown in Table 13.



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Table 13

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

| | L (cm) | W (gr) | ST_cont | ISF |
|---|---|---|---|---|
| **Number** | 17 | 17 | 17 | 17 |
| **Sum** | 1074.00 | 27810.00 | 232.21 | 15.11 |
| **Min** | 53.00 | 1010.00 | 1.46 | 0.08 |
| **Mean** | 63.18 | 1635.88 | 13.66 | 0.89 |
| **Max** | 76.00 | 3100.00 | 30.39 | 2.22 |
| **Std. dev** | 6.28 | 561.74 | 8.10 | 0.54 |
| **Median** | 63.00 | 1460.00 | 11.98 | 0.81 |
| **Kurtosis** | -0.78 | 0.57 | -0.32 | 0.36 |
| **Skewness** | 0.39 | 1.02 | 0.63 | 0.79 |
| **Std. Err.** | 1.52 | 136.24 | 1.96 | 0.13 |

The mean fullness index of the stomachs reaches 0.89% BW ± 0.13 SE (Table 13).

**Whiting *(Merlangus merlangus)*** – Whiting (Merlangus merlangus) - From the 40 stomachs analyzed, 20 had stomach content (50 %). The mean fullness index of the stomachs reaches 2.95% BW ± 0.72 SE. General statistical data for the measured biological parameters are shown in Table 14.



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Table 14

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

| | L (cm) | W (gr) | ST_cont | ISF |
|---|---|---|---|---|
| **Number** | 20 | 20 | 20 | 20 |
| **Sum** | 267.80 | 340.40 | 10.09 | 59.01 |
| **Min** | 11.20 | 10.05 | 0.02 | 0.11 |
| **Mean** | 13.39 | 17.02 | 0.50 | 2.95 |
| **Max** | 15.10 | 25.98 | 2.19 | 12.23 |
| **Std. dev** | 1.16 | 4.49 | 0.59 | 3.24 |
| **Median** | 13.60 | 17.27 | 0.26 | 1.57 |
| **Kurtosis** | -0.65 | -0.59 | 1.67 | 1.35 |
| **Skewness** | -0.52 | 0.21 | 1.53 | 1.40 |
| **Std. Err.** | 0.26 | 1.00 | 0.13 | 0.72 |

**Bluefish (***Pomatomus saltatrix)* – From the 24 stomachs analyzed, only 6 had stomach content (25%). The mean fullness index of the stomachs reaches 1.71 % BW ± 0.67 SE. General statistical data for the measured biological parameters are shown in Table 15.



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Table 15

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

| | L (cm) | W (gr) | ST_cont | ISF |
|---|---|---|---|---|
| **Number** | 6 | 6 | 6 | 6 |
| **Sum** | 98.40 | 158.89 | 2.67 | 10.28 |
| **Min** | 14.70 | 20.43 | 0.03 | 0.08 |
| **Mean** | 16.40 | 26.48 | 0.45 | 1.71 |
| **Max** | 17.40 | 37.48 | 1.04 | 4.03 |
| **Std. dev** | 0.96 | 6.34 | 0.46 | 1.64 |
| **Median** | 16.65 | 24.56 | 0.27 | 1.27 |
| **Kurtosis** | -0.27 | -0.52 | -1.52 | -1.45 |
| **Skewness** | -0.92 | 0.88 | 0.52 | 0.42 |
| **Std. Err.** | 0.39 | 2.59 | 0.19 | 0.67 |

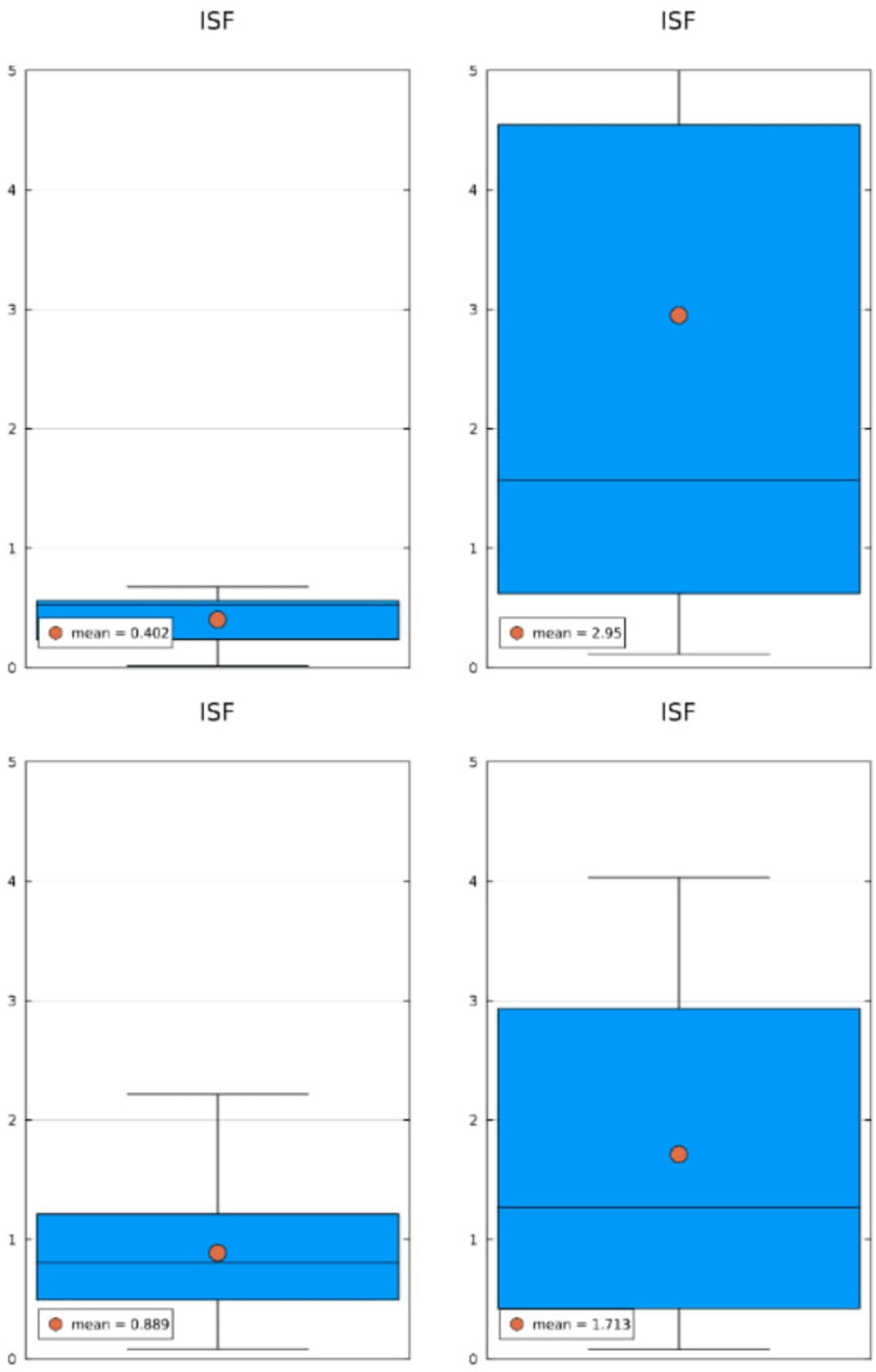


**Figure 40** *Box-plot: ISF values for a) Squalus acanthias, b) Raja clavata, c) Merlangus merlangus, autumn 2024; and d) Pomatomus saltatrix*

The quality composition of the food spectrum of *Squalus acanthias, Raja clavata and Merlangus merlangus* is presented in tables 16, 17 and 18. The quality composition of *Pomatomus saltatrix* consists only processed content.

Table 16

**Qualitative composition of piked dogfish diet during the study period.**

| Species | FQ | CN | CB | IRI | IRI % |
|---|---|---|---|---|---|
| ***Merlangus merlangus*** | 20 | 10 | 16.07 | 521.48 | 4.39 |
| **remains** | 80 | 60 | 49.96 | 8796.71 | 74.07 |
| **Dolphin meat** | 40 | 30 | 33.97 | 2558.69 | 21.54 |

Table 17

**Qualitative composition of thornback ray diet during the study period.**

| Species | FQ | CN | CB | IRI | IRI % |
|---|---|---|---|---|---|
| ***Trachurus mediterraneus*** | 29.41 | 12.75 | 14.06 | 788.51 | 5.96 |
| ***Mullus barbatus*** | 5.88 | 1.96 | 2.49 | 26.21 | 0.2 |
| **Gobiidae** | 5.88 | 2.94 | 4.43 | 43.37 | 0.33 |
| **Decapoda** | 29.41 | 16.67 | 14.96 | 930.12 | 7.03 |
| **remains** | 88.24 | 65.69 | 64.05 | 11447.53 | 86.49 |



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Table 18

**Qualitative composition of whiting diet during the study period.**

| Species | FQ | CN | CB | IRI | IRI % |
|---|---|---|---|---|---|
| ***Sprattus sprattus*** | 15 | 15 | 15 | 450 | 5.62 |
| **Gobiidae** | 5 | 5 | 5 | 50 | 0.62 |
| ***Engraulis encrasicolus*** | 5 | 5 | 5 | 50 | 0.62 |
| ***Palaemon elegans*** | 5 | 5 | 5 | 50 | 0.62 |
| **Decapoda** | 10 | 10 | 10 | 200 | 2.5 |
| **remains** | 60 | 60 | 60 | 7200 | 90 |

The results of the qualitative analysis indicate that the species *Squalus acanthias* predominantly feeds on dolphin meat, which constitute IRI = 2558.69 (21.54%) and Remains IRI = 8796.71 (74.07%). In the diet of *Raja clavata*, species from two taxonomic groups were recorded - fish with IRI = 858.09 (6.49%) and Decapoda with IRI = 930.12 (7.03%). For *Merlangus merlangus*, two taxonomic groups were also observed, respectively fish with IRI = 650.00 (6.86%) and crustaceans from Decapoda - IRI = 250.00 (3.12%). For this species, the processed content has the highest IRI = 7200.00 (90.00%). The IRI of *Pomatomus saltatrix* is calculated at IRI = 20000 (100 %). IRI values for the individual species making up the stomach content for the four species *Squalus acanthias, Raja clavata, and Merlangus merlangus* during the autumn of 2024 are reflected in Figures 41, 42, and 43.

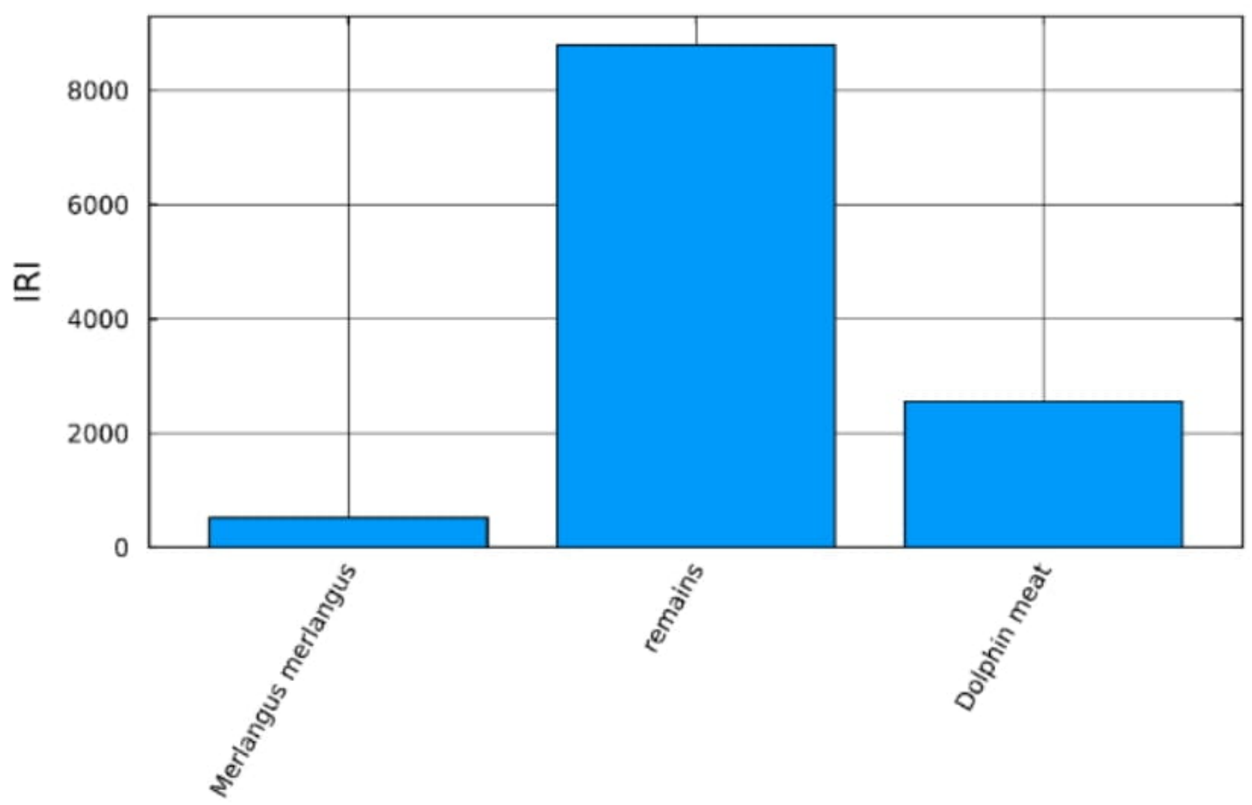


**Figure 41** *IRI values by species during the spring-summer season of 2024 - Squalus acanthias;*

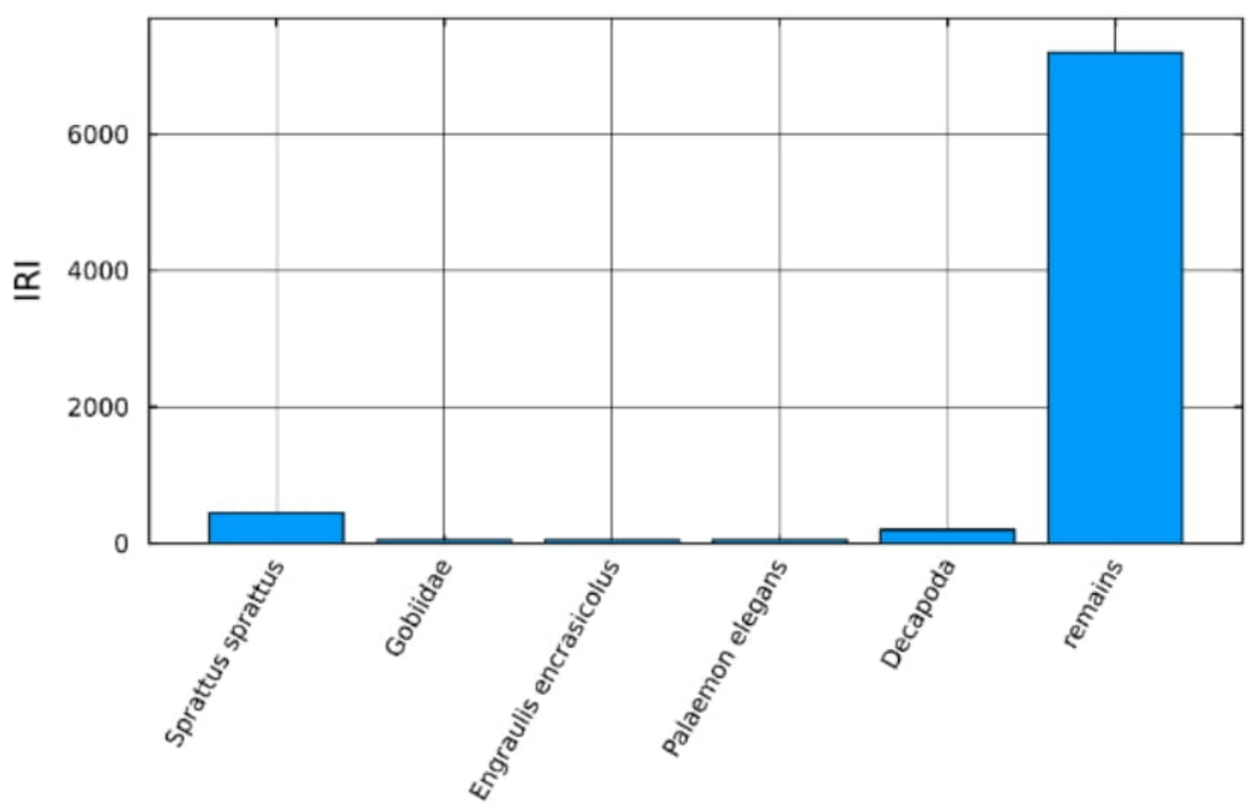


**Figure 42** *IRI values by species during the spring-summer season of 2024 – Raja clavata;*

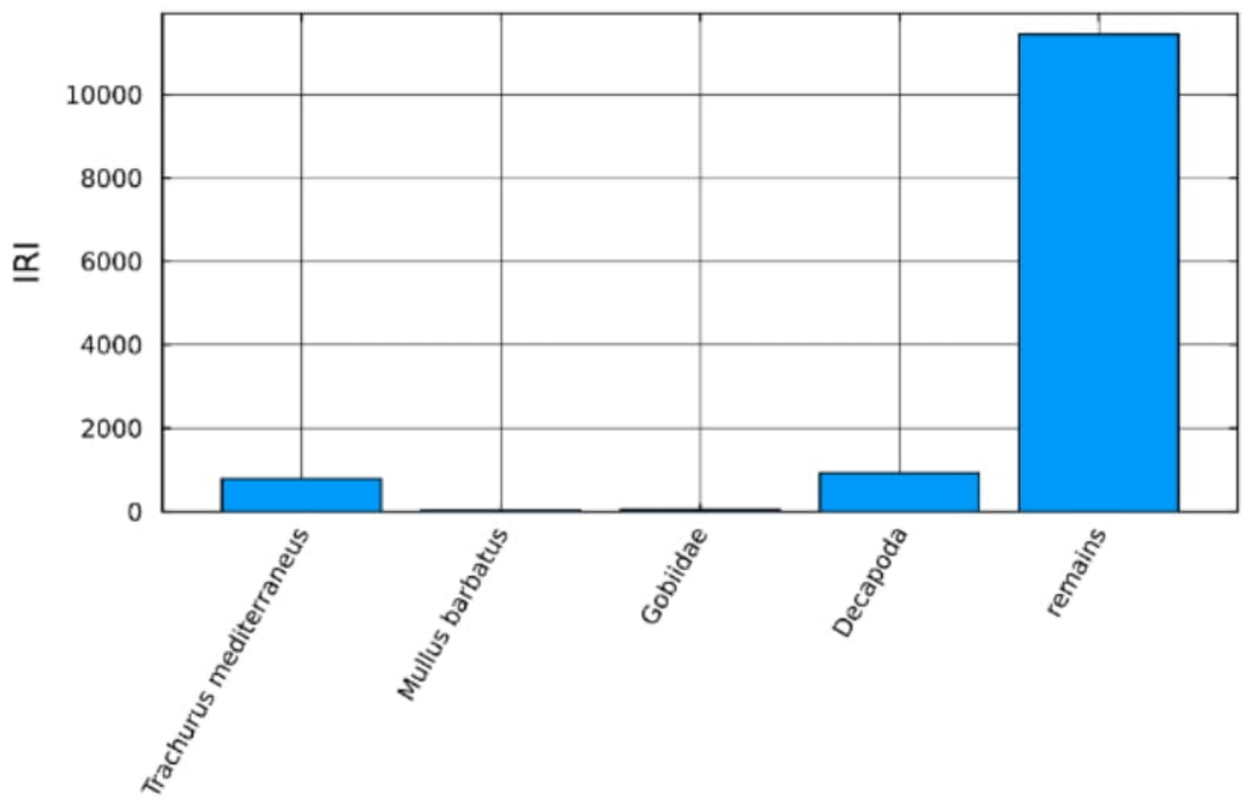


Figure 43 *IRI values by species during the spring-summer season of 2024 – Merlangus merlangus;*

## 5. Forecasts and opportunities for exploitation

The determination of MSY (maximum sustainable catch) in the autumn season of 2024 was made according to the formula of Gulland (1971): MSY = 0.5*M*Bv, and the natural mortality rate (M) was calculated according to the formula of Pauly (1979, 1980).With a value of M = 0.2, the quantity of MSY according to the Gulland method amounts to **287.6** t for the autumn-winter season of 2024.

Stock exploitation (E) is determined by the formula E = F/Z (Pauly, 1983) and varies according to the intensity of fishing activities (Avşar, 1998), so the population is under exploited at E < 0.5, at E = 0.5 it considers an optimal level of exploitation, a E >0.5 indicates over-exploitation of the stock. The calculated value of E = **0.5** (for the two studied seasons of 2024) is an indication of the optimal level of exploitation of the turbot stock .



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The values of the parameters in the von Bertalanffy equation for the two investigated seasons of 2024 were calculated: **a = 0.00002047, b = 2.97, q = -1.688, L∞ = 76.71, k = 0.191, to = -1.32** and a linear-weighted dependence for the entire period (Fig. 45).

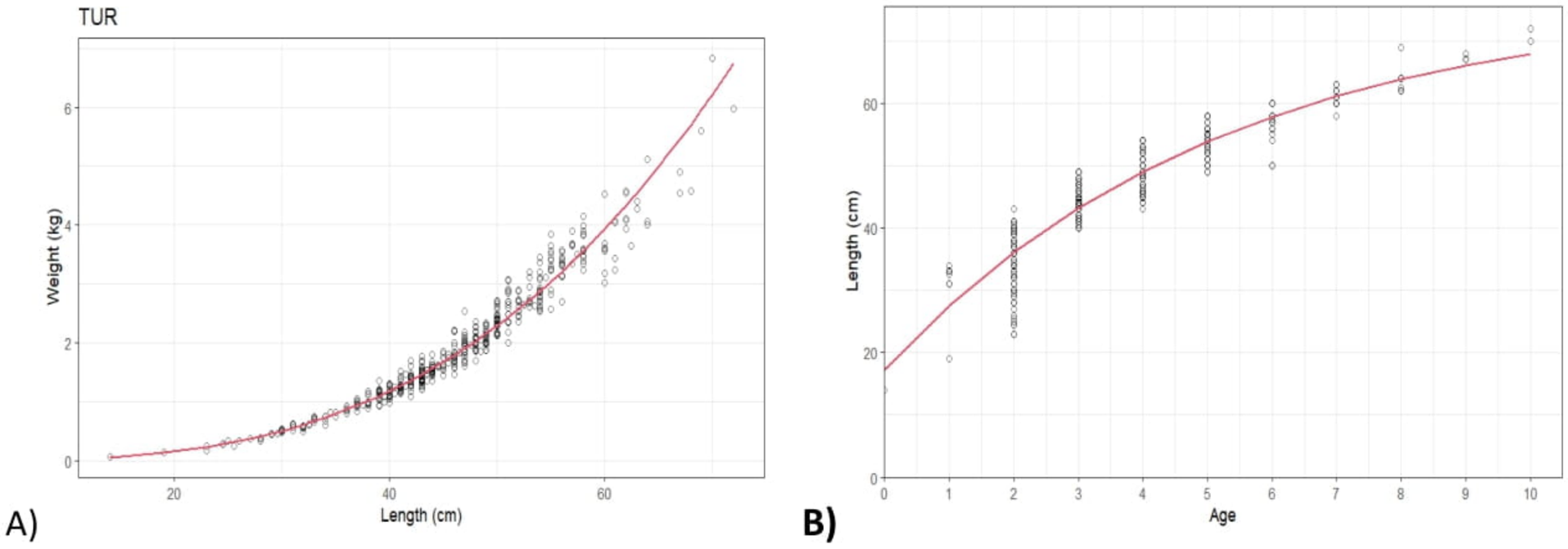


**Figure 44** *S. maximus A) length-weight and B) length-age relationships in 2024;*

## TAC (Total Allowable Catch)

Beverton & Holt, 1957 - Y/R catch-restocking relationship model is used to calculate total allowable catch. To determine the stock-replenishment relationship, the parameters: W∞, k, M, t0, tr. are used, and the model allows to determine Y/R at different input levels of the parameters F - fishing effort and Tc - optimal exploitation age and to assess the effect of their fluctuations. The results are presented in Fig.46, with increasing catch/recruitment values at F = 0.2, this is why the fishing mortality value should not exceed 0.2.



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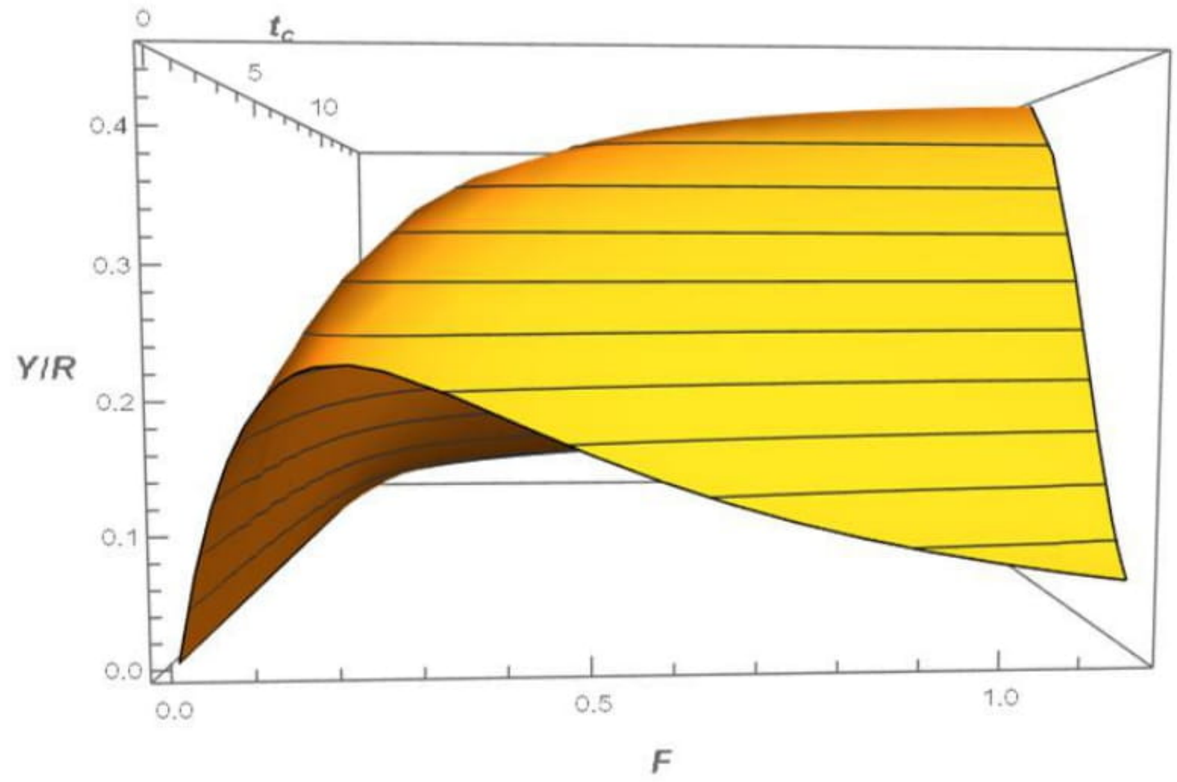


Figure 45 *Catch-replenishment dependence as a function of F at three different optimal operational ages;*

The dynamic model strategy for MSY does not account for variation in recruitment from year to year, so it should be used with caution in conjunction with other stock assessment analytical models involving linear or age-based virtual population analysis. It is necessary to use the so-called "ad hoc" - special approaches and application of TAC, as part of MSY - up to 2/3 of MSY(Raikov, 2011) or 1/2.When applied this method assumes that the total allowable catch of turbot can reach up to **144** tonnes in the Bulgarian waters of the Black Sea, calculated on the basis of data from the autumn season of 2024, but we must note that the percentage distribution of sexually mature specimens is 58.42 % for the winter season of 2024 and after recalculations based on this percentage, the total allowable catch should not exceed **84** tonnes.

***Weather conditions during the survey***

During the expedition activity, the dominant wind directions were West, Southwest, Northwest, Northeast and Southeast, exhibiting a force of 1-2 on the Beaufort scale along the coast and 2-3 in the open sea.

In the autumn-winter season of 2024, the field conditions were normal for conducting research activities for turbot stock assessment in the Bulgarian Black Sea waters.

## 6. Conclusions and recommendations

From the collected information and results obtained from the trawl survey in autumn-winter, 2024 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 **2875.55** tonnes (Table 4). The abundance in the studied area was estimated at **1378.7*10$^3$** specimens (Table 4).
- The recommended MSY (maximum sustainable catch) for Bulgaria should notexceed **287.6** tonnes, and the total allowable catch (TAC) can reach up to **84** tonnes as an acceptable amount for the Bulgarian Black Sea water area.
- The size structure of the turbot population, in the Bulgarian Black Sea zone included length classes from **14** cm to **69** cm were observed, with weights varying between **70** g and **5600** g. The average weight of the turbot was estimated at **2085.70** g. Individuals measuring less than 45 cm constituted 41.58 % of the total population, while those exceeding 45 cm accounted for 58.42%.
- The age composition of the population included age classes from 0 to 8 years, with a predominant presence of 2-year-olds (16.49%), 3-year-olds (37.11%), and 4-year-olds (20.27%), collectively accounting for 73.88%. This is followed by 5-year-old specimens, which represent 16.15%.



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- The established ratio of female, male, and immature individuals in the catch is **36.43%:21.99%:41.58%.**
- M. merlangus is widely distributed, with significant concentrations noted in the southern areas from N. Emine to Tsarevo (66-89 meters). The average biomass index (CPUE) for *M. merlangus* is 63.26 kg/h, with peak values recorded off the southern coast, reaching up to 190 kg/h. The catches predominantly consist of size classes measuring 10.5 to 15 cm, with a notable predominance of females.
- The spatial distribution of the target bottom cartilaginous fish species is as follows: *S. acanthias* are primarily observed between Byala and C. Emine (28-43 and 78.89 m); *Pl. flesus* clusters are located the central part of the Bulgarian coast in front of Varna, at depths of 51-55 m. Representatives of *R. clavata* are noted in front of Primorsko at depths of 39-40 m.
- The whiting biomass in the entire studied water area off the Bulgarian coast of the Black Sea is estimated at **12949.93** tonnes, with an abundance of approximately **604.009*10$^{6}$** million specimens. The calculated biomass of the thornback ray in the same area is **1118.7** tonnes, and its abundance is estimated at **658.6*10$^{3}$** thousand specimens. The current biomass of the dogfish in this water area is estimated at **1579.22** tonnes. For the studied period, the total abundance for the entire area was estimated at **317.79*10$^{3}$** individuals. 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 November - December yield inaccuracies.
- During the autumn season of 2024, 131 stomachs were analyzed to determine the diet spectrum of turbot. Nutritional components were found in 60.31% of the examined specimens, while 39.69% were without stomach content, indicating a higher percentage of feeding fish during this period. During the study period, the highest IRI value was for processed content – 8468.63 (65.84%). Only one taxonomic groups was identified - the dominant group being fish IRI=4393.75 (34.16%). Among the fish group, Merlangus



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merlangus traditionally predominates with the highest IRI=3084.90 (23.98%). Along with the processed stomachs analyzed for the dietary spectrum of turbot during the autumn season of 2024, the dietary spectrum: of *Squalus acanthias*, *Pomatomus saltatrix*, *Raja clavata*, *Merlangus merlangus* and *Pomatomus saltatrix* were also examined.

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