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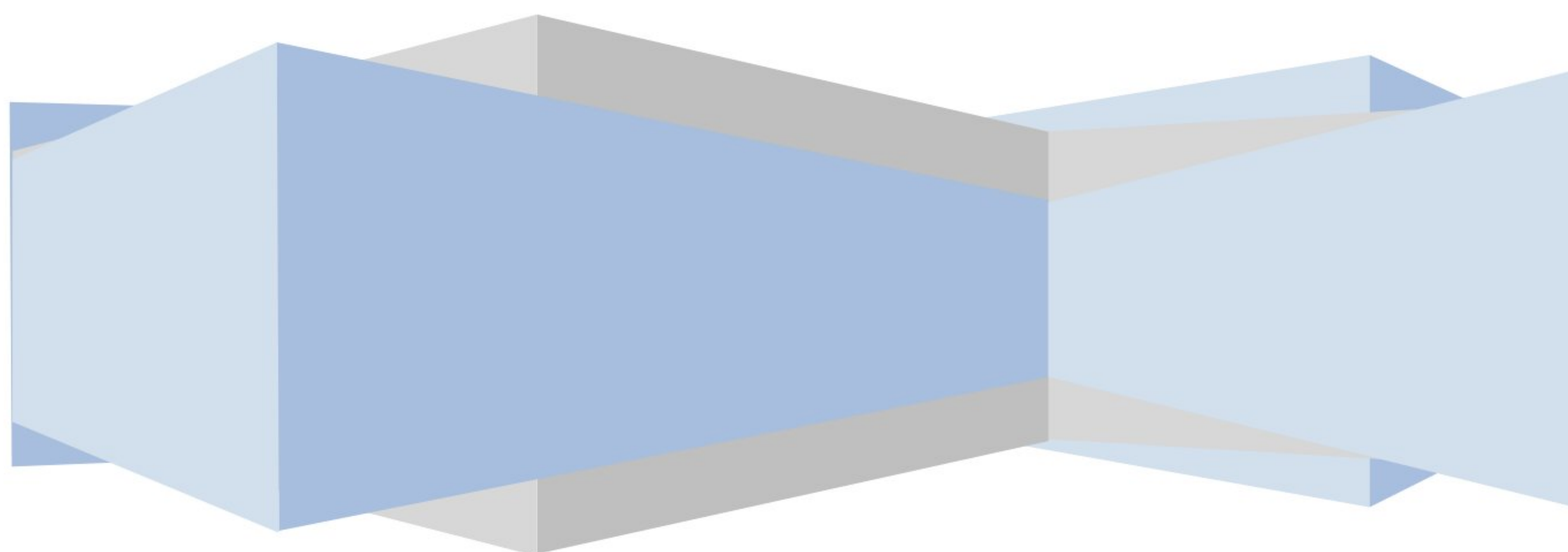
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PELAGIC TRAWL SURVEYS IN THE BULGARIAN MARINE AREA, OCTOBER– NOVEMBER 2025

SCIENTIFIC REPORT



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Project No. 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", financed by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Fund for maritime, fisheries and aquaculture fund.



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This study was carried out thanks to the financial support of the European Commission under REGULATION (EU) 2017/1004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008 (recast), the National Agency for Fisheries and Aquaculture – Ministry of Agriculture, Bulgaria and Institute of Oceanology – Bulgarian Academy of Sciences, Varna, Bulgaria.

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The survey was carried out in October–November 2025 in the Bulgarian Black Sea area on board of F/V Lefer in execution of the National Program of Bulgaria for data collection.



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1. Material and Methods

Pelagic trawl survey was accomplished following the National Programs for Data Collection in the Fisheries sector of Bulgaria. The study was conducted in October–November 2025, in the Bulgarian Black Sea area, enclosed between Durankulak and Ahtopol ($42^{\circ}05'$ and $43^{\circ}45'$ N and $27^{\circ}55'$ and $29^{\circ}55'$ E), with a total length of the coastline of 370 km (Fig. 1.1).



Figure 1.1. Location of the stations in October–November 2025.

The Pelagic Trawl survey (PT) was accomplished on board of Fishing Vessel “Lefer” (Fig. 1.2). The main characteristics of the ship are given below:

- IMO: 8862686
- MMSI: 207139000
- Call sign: LZHC
- Flag: Bulgaria [BG]
- AIS Vessel Type: Other

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- Gross Tonnage: 68
Length Overall / Breadth Extreme: 23 m / 6 m
Crew: 5



Figure 1.2. Photo of the Fishing Vessel “Lefer”.

During the survey, a total of 36 trawls were carried out. The trawling was performed during the day with a duration of 30–40 minutes, depending on the hydro-meteorological conditions, at an average speed of 2.7 knots (variation in the range 2.7–2.9).

The dimensions of the pelagic trawl employed are as follows:

- Type of pelagic trawl 50/27/27 m
- Length of the head rope – 27 m
- Length of the ground rope – 27 m
- Horizontal spread of trawl – 12 m
- Vertical spread of trawl – 12 m
- Mesh size of the net – 12 mm
- Effective part of wing spread – 27 m
- Pelagic doors – 3 m²

The following types of data were collected:

- Coordinates and duration of each trawl;

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- Total catch weight;
- Separation of catches by species;
- Composition of by-catch.

The biological analysis is based on the biomass of the species found during the study. Additionally, an analysis of the distribution and abundance of the other species caught as by-catch is presented.

1.1. Sampling design

In order to determine the abundance of the reference species (*Sprattus sprattus*) in the Bulgarian part of the Black Sea, a standard stratified survey methodology was used (Gulland, 1966). The study area is divided into three subgroups depending on depth: **Stratum 1** (15–30 m), **Stratum 2** (30–50 m), and **Stratum 3** (50–100 m). The research area in Bulgarian waters was further divided into 128 non-overlapping polygons of equal size, located at depths between 15 and 100 m. Sampling was conducted at 36 randomly selected sites using pelagic trawling.

Each field is a rectangle with dimensions 5' latitude x 5' longitude and an area of approximately 62.58 km² (measured using GIS), which is large enough to allow trawling for a corresponding duration in the meridional direction. The fields are grouped into larger units—referred to as layers—whose geographic and depth boundaries are determined by the distribution and density of the species observed during the survey. Only one trawl was conducted in each field, lasting between 30 and 40 minutes at a speed of 2.7–2.9 knots (Picture 1.1.1.).



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Picture 1.1.1. Catch in trawl.

1.2. Onboard sample processing

The specimens processed during the survey are presented in Table 1.2.1.

Table 1.2.1. Number of processed individuals.

Species	Number
sprat	1000
whiting	1200
red mullet	1200
horse mackerel	1500
anchovy	7

The data from each trawl included measurements of the following parameters (Gulland, 1966):

- Depth, measured using the vessel's echo sounder;
- GPS coordinates of start and end haul points;
- Haul duration;
- Abundance of species caught;

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- Weight of the total sprat catch;
- Abundance and weight of other species;
- Species composition of the by-catch.

A 4% formaldehyde solution prepared with seawater was used to preserve the stomach contents.

1.3. Laboratory analyses

The processing of the samples collected on board continued under laboratory conditions, focusing on determining the age and nutritional composition of the stomach contents of sprat. Age was determined based on the analysis of otoliths under a binocular microscope. The dietary spectrum was assessed by sorting the stomach contents into taxonomic groups, identified to the lowest possible taxonomic level.

1.4. Statistical analyses

Swept area method

This method is based on near-bottom trawling (the protrawled area), a widely used direct technique for estimating the instantaneous biomass of benthic organisms (Fig. 1.4.1, 1.4.2).

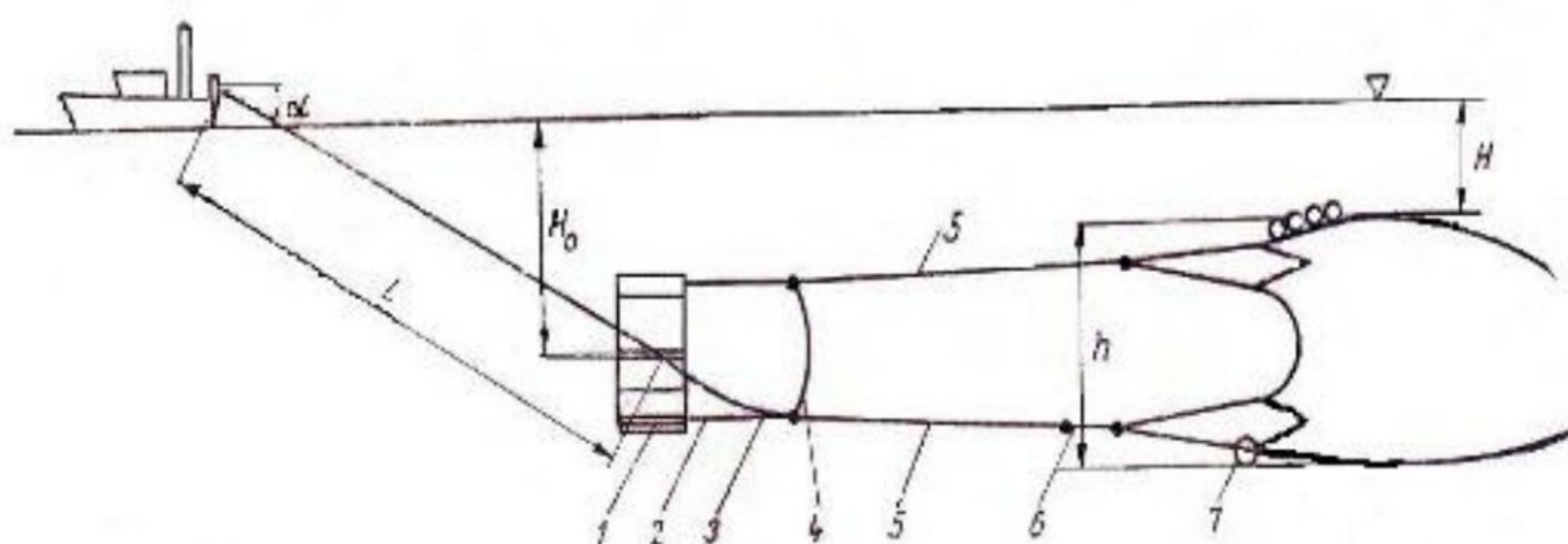


Figure 1.4.1. Scheme of the trawl, used in the Swept area method (according to Grudev et al., 1981) 1 – trawl door; 2 – conjections; 3 – transitional wire; 4 – compensator; 5 – wires; 6 – extension cord; 7 – deepener.

In Figure 1.4.2. the scheme of the so-called bathy-pelagic trawl for catching sprat is represented.



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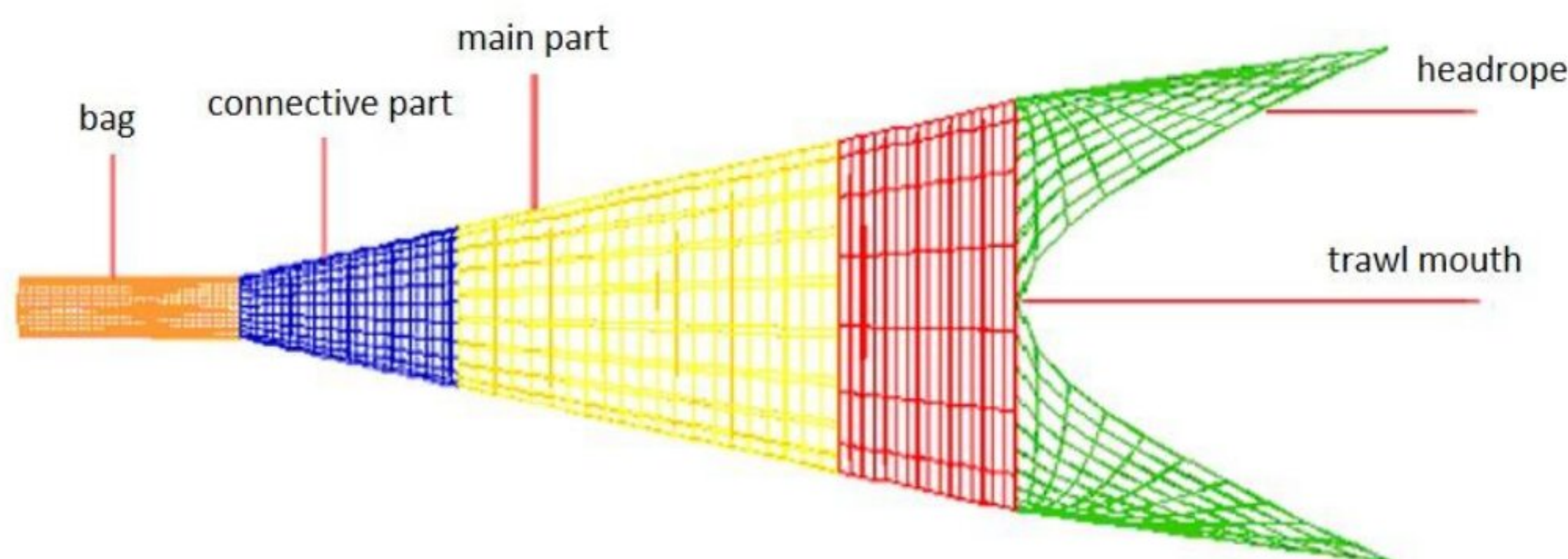


Figure 1.4.2. Scheme of bathy-pelagic trawl for sprat catch.

The main point of the method: the trawl doors are designed to drag along the seafloor for defined distance. Trawling area is calculated as follows:

$$(1) \quad a = D * h * X2$$

$$D = V * t$$

(where: a – trawling area, V – trawling velocity, h* X2 – trawl door distance, t – trawling duration (h), D – dragged distance on the seafloor;

$$(2) \quad D = 60 * \sqrt{(Lat_1 - Lat_2)^2 + (Lon_2 - Lon_1) * \cos(0.5 * (Lat_1 + Lat_2))}$$

$$(3) \quad D = \sqrt{VS^2 + CS^2 + 2 * VS * CS * \cos(dirV - dirC)},$$

where, VS is vessel velocity, CS – present velocity (knots), dirV vessel course (degrees), and dirC – present course (degrees).

Stock biomass is calculated using catch per unit area, as a fraction of catch per unit effort from the dragged area:

$$(4) \quad \left(\frac{C_{w/t}}{a/t}\right) = C_{w/a} \text{ kg / sq.km}$$

where: Cw/t – catch per unit effort, a/t – trawling area (km²) per unit time;

Stock biomass of the given species per each stratum could be calculated as follows:

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$$(5) \quad B = (\overline{C_{w/a}}) * A$$

where: $\overline{C_{w/a}}$ - mean CPUA for total trawling number in each stratum, A- area of the stratum.
The variance of biomass estimate for each stratum is (equation 4):

$$(6) \quad VAR(B) = A^2 * \frac{1}{n} * \frac{1}{n-1} * \sum_{i=1}^n [Ca(i) - \overline{Ca}]^2$$

The total area of the investigated region is equal to the sum of areas of each stratum:

$$A = A1 + A2 + A3$$

Average weighted catch per whole aquatic territory is calculated as follows:

$$(7) \quad \overline{Ca}(A) = Ca1 * A1 + Ca2 * A2 + Ca3 * A3 / A$$

where: Ca1- catch per unit area in stratum 1, A1 – an area of stratum 1, etc., A- size of total area.

Accordingly, total stock biomass for the whole marine area:

$$(8) \quad B = \overline{Ca}(A) * A$$

where: $\overline{Ca}(A)$ - average weighted catch per whole investigated marine area, A – total investigated marine area.

Estimation of Maximum Sustainable Yield (MSY)

The Gulland's formula for virgin stocks is used:

$$(9) \quad MSY = 0.5 * M * B_v$$

where: M – coefficient of natural mortality; B_v – virgin stock biomass.

A relative yield-per-recruit model with uncertainties:



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$$(10) \quad Y'/R = E * U^{M/k} \left\{ 1 - \frac{3U}{(1+m)} + \frac{3U^2}{(1+2m)} - \frac{U^3}{(1+3m)} \right\}$$

where: $U = 1 - (L_c/L_\infty)$

$m = (1-E)/(M/k) = k/Z$

$E = F/Z$ – exploitation coefficient

Converted catch curve

Several methods are available for estimating total mortality (Z) from length-frequency data. Reliable estimates of Z can be obtained from the mean length of a representative sample or from the slope of a cumulative Jones' plot. A variety of approaches have been developed to analyze length-frequency data, which serve as the functional equivalent of age-structured catch curves. These "length-converted catch curves" are based on assumptions similar to those used in age-structured catch curve analyses.

1.5. Age estimation

Calcified structures (CS) are commonly used to determine age. Aging in fish means the presence of CS visible as opaque and transparent areas. Calcified age-determining structures in fish are various: otoliths (statoliths), dorsal vertebrae, spines, and opercular bones. In some species, so called "sagittae" are used. The most important aspects (difficulties, extraction, storage, method of preparation, criteria for age determination) regarding age analysis are discussed by species. Otoliths play a role in balance, movement, and sound perception. They are most commonly used for age determination, growth and mortality studies. In bony fish, otoliths are the primary CS for age determination and are widely used in ichthyology. On the other hand, when analyzing O_2 isotopes, both species migrations and stock identification are determined. Otoliths serve as balance in space and as hearing organs for fish. Based on the shape and size of the otoliths, the feeding habits of the fish are also determined (Kasapoglu and Duzgunes, 2014). Researchers used reference collections and photographs of otoliths in publications to aid identification (Picture 1.5.1). Otoliths have a characteristic shape that is highly specific but varies greatly among species.



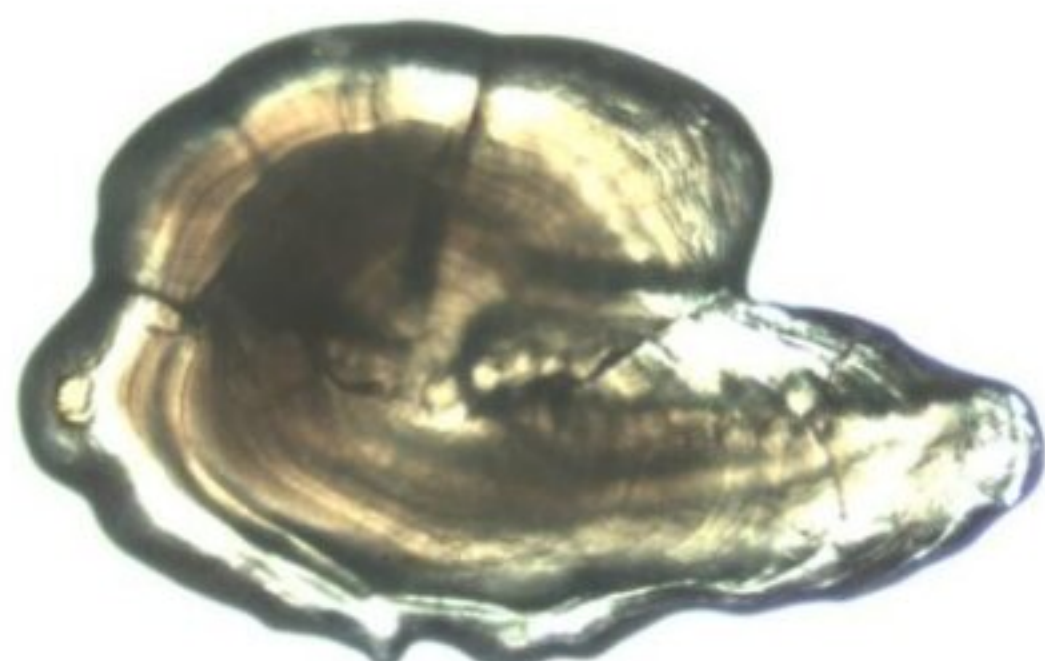
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6 cm (0+)



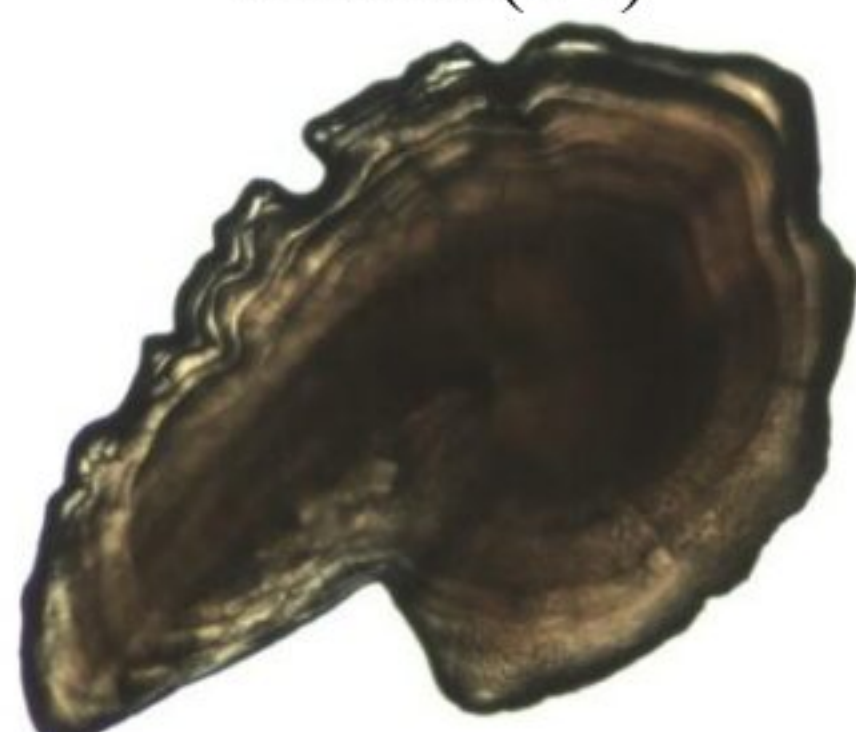
7.5 cm (1+)



8.2 cm (1+)



9 cm (2+)



9.5 (3+)



10.7 (4+)

Picture 1.5.1. Otoliths of sprat.

Otoliths are three types, located on the left and right sides of the head in semi rings: “sagitta” in the sacculus, “lapillus” in the lagenar, and “asteriscus” in the utricular channels. The location, size, and shape of these three types differ by species, the largest is “sagitta” and the smallest is “asteriscus”. So, “sagitta” is the one that is mostly used in age determination of bony fishes. Other reasons for using otoliths to determine age are:

- Their formation in the embryonic phase, which shows all the changes in the life cycle of the fish.
- Their presence in fish which have no scales.
- Achieving better results than those of scale analysis, especially when it comes to older fish.

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- No recovery or regeneration.
- Having the same structure in all the individuals of the same species (Jearld, 1983).

On the other hand, their disadvantages are the need to dissect the fish and some problems in age determination due to crystal-like formations by irregular CaCO_3 accumulations on the otoliths.

1.5.1. Preparation for otolith extraction

It is very important to have a representative sample from which the otoliths will be extracted, and their number depends on the size of the respective species. For smaller species, fewer otoliths are taken. According to availability, 5 specimens from each size group are set aside for age determination. For each fish total length (± 0.1 cm), total weight (± 0.01 g), sex, maturation stage (I–V), and gonad weight (± 0.01 g) are recorded.

Sagittal otoliths of each fish are removed by cutting the head over the eyes after all individual measurements. The fish is then rinsed and placed in 96% ethyl alcohol to remove organic debris and finally stored with a sample number for other operational information.

1.5.2. Preparation of the otoliths for the age determination

Otoliths are placed in small black convex laboratory glasses containing 96% ethyl alcohol for age determination under a binocular stereo microscope with side and top illumination (Polat and Beamish, 1992). The magnification used depends on the size of the otolith, with $4\times$ magnification being optimal for sprat.

1.5.3. Age determination and analysis of annual rings

The first step is to identify the location of the center and the first age ring. The observation of consecutive rings, whether continuous or not, is then essential. It is important to determine whether the fish is still growing or has reached the end of its growth period by examining the characteristics of the otolith's outer ring to see if it is opaque or hyaline. After these steps, the otoliths can be read following standardized protocols, which are very important for providing accurate age data, determining realistic population parameters, and reduce abnormal procedures and biases through standardized age reading criteria.

Isometric growth is observed in the sprat's left and right otoliths. These are small, transparent structures (Fig. 1.5.3.1). They feature distinct summer and winter rings, along with a central core. Additionally, spring rings—opaque—and late autumn rings—hyaline—are considered during age determination (Pisil, 2006).



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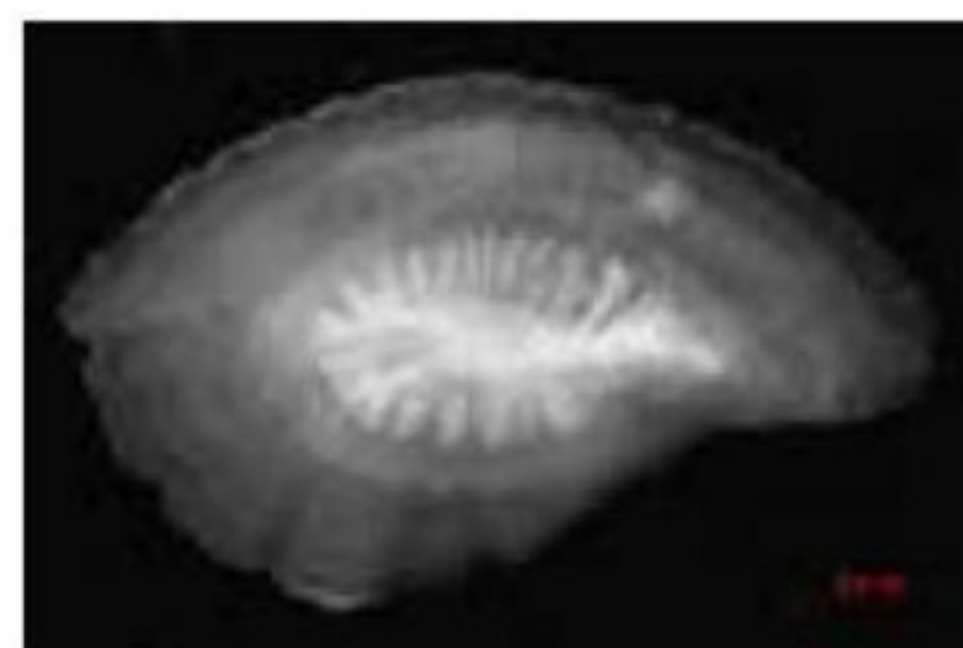
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Sprattus sprattus



Merlangius merlangus



Trachurus mediterraneus



Mullus barbatus

Figure 1.5.3.1. Sprat, whiting, horse mackerel, and red mullet otoliths.

1.5.4. Age reading protocol for sprat

1. The dissected otoliths are rinsed, treated with 96% ethyl alcohol, and stored dry.
2. Age determination is performed by an expert by immersing the entire otolith in 96% ethyl alcohol, then placing it in a convex glass under reflected light against a dark background.
3. Magnification is selected based on the size of the otolith. The aim is to avoid increasing magnification excessively, as this may reveal rings that are not representative for age determination in larger otoliths. A magnification of 4× is optimal for visualizing the hyaline zones in sprat otoliths.
4. Otolith are observed from their distal surface.
5. January 1st of the respective year is considered the hatching date for sprat.
6. A central point surrounded by hyaline rings forms after the yolk sac and the initiation of free feeding. The next opaque ring is known as "first year growth". This ring retains its circular

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shape in the postrostrum region. Together with this ring and the next hyaline ring, they form a "V" shape in the rostrum and are accepted as first-year rings.

7. Small, continuous concentric rings near the true hyaline ring as part of the same age mark. These may appear as either very small opaque rings within the hyaline band or as small hyaline rings near the outer edge of an opaque ring.
8. Sprat and some other short-lived species exhibit very rapid growth, particularly in their first years. After the second year, the width of the growth rings narrows significantly, which should be considered when counting rings in older specimens.

The number of small and weak hyaline rings—known as false rings—in the opaque region is generally low, and distinguishing them from true age rings is relatively easy. However, when numerous and indistinguishable, such otoliths should not be used.

1.6. Sex and maturity estimation

1.6.1. Maturity stages

It is very important to use standardized maturity scales for sprat (and all species) to assess sampling strategies and determine the appropriate timing for accurate maturity classification in both sexes. In sprat, the small gonad size and batch spawnings of multiple egg cohorts over an extended period pose significant challenges for standardizing the maturity scale.

According to ICES (2011), standardized sexual maturity scale for sprat includes six stages for both males and females (Fig. 1.6.1.1, Table 1.6.1.1).

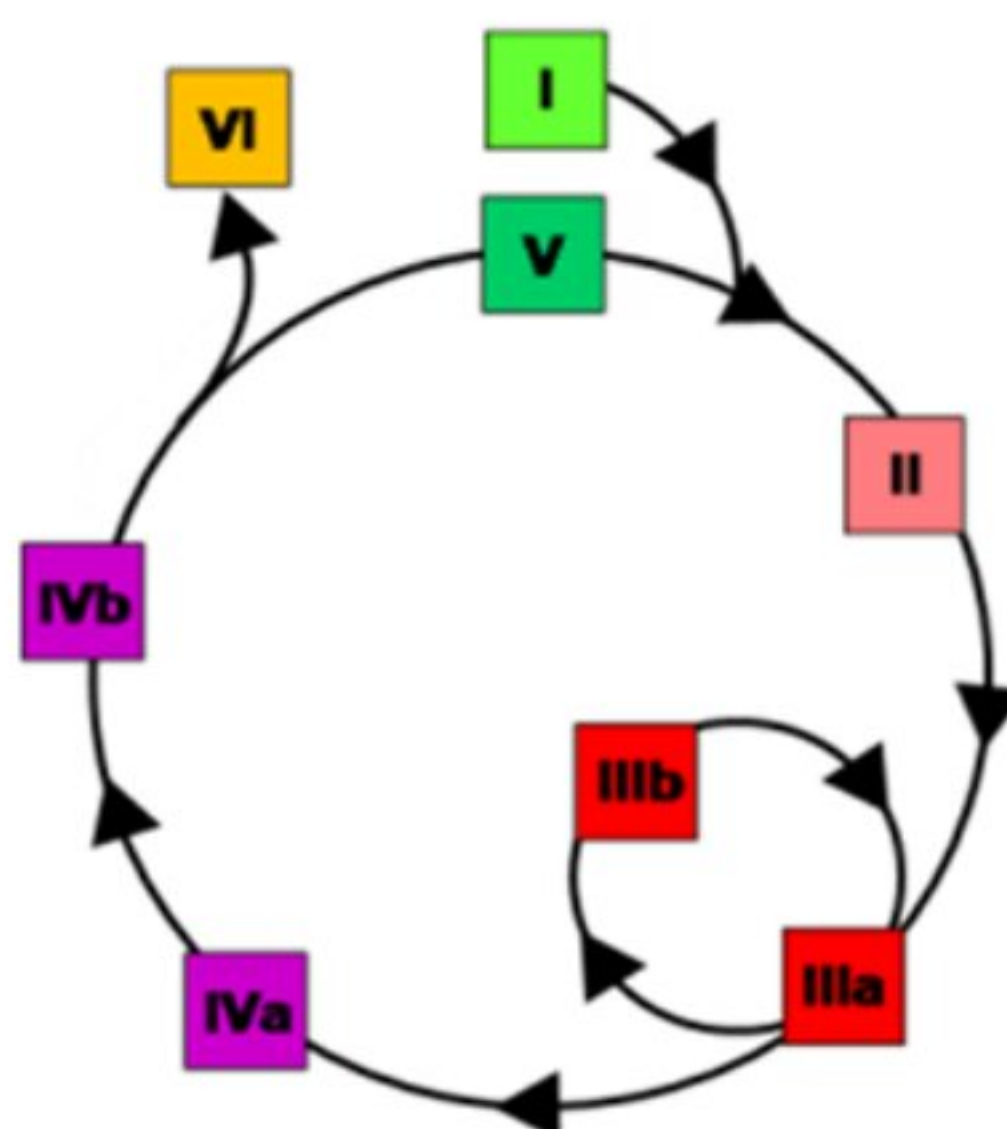


Figure 1.6.1.1. Scale with six maturity stages in sprat (Name of the stages are given in Table 1.6.1.1).



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In particular, specimens without visible gland development were grouped into the "Immature" and "Preparation" categories. The spawning stage was subdivided into an inactive spawning stage (maturation and re-maturation, characterized by visible gamete development) and an active spawning stage, indicated by the presence of hydrated eggs. Integrating maturation and re-maturation into the spawning stage allows for more accurate identification of maturing and spawning individuals within the population.

Table 1.6.1.1. Macroscopic and histological characteristics of gonad developmental stages.

Stages	Macroscopic Characteristics	Histological characteristics
<i>FEMALES (OG: Oogonia, PG1: Early previtellogenic oocytes, PG2: Late previtellogenic oocytes, CA: Cortil alveoli oocytes, VT1: Early vitellogenic oocytes, VT2: Mid vitellogenic oocytes, VT3: Late vitellogenic oocytes, HYD: Hydrated oocytes, POF: Postovulatory follicles, SSB: Spawning stock biomass).</i>		
<i>I-Immature</i>	<i>Juvenile: ovaries threadlike and small; transparent to wine red and translucent in color; sex difficult to determine; distinguishable from testes by a more tubular shape; oocytes not visible to the naked eye</i>	<i>OG+/-PGI</i>
<i>II. Preparation</i>	<i>The transition from immature to early maturing; oocytes not visible to the naked eye; ovaries yellow-orange to bright red; ovaries occupy up to half of the abdominal cavity. This stage is not included in SSB.</i>	<i>PG1, PG2, CA</i>
<i>III. Spawning</i> <i>a. Inactive</i>	<i>Maturing and re-maturing: yolked opaque oocytes visible to the naked eye; ovaries change from semi-transparent to opaque yellow-orange or reddish as more oocytes enter the yolk stage; ovaries occupy at least half of the body cavity; re-maturing ovaries may be red to grey-red or purple in color and less firm than an ovary maturing the first batch, few hydrated oocytes may be left</i>	<i>PG1, PG2, CA, VT1, VT2, VT3, +/- POF</i>
<i>b. Active</i>	<i>Spawning active. Hydrated eggs are visible among yolked opaque oocytes; hydrates oocytes may be running; ovaries fill the body cavity; overall color varies from yellowish to reddish.</i>	<i>PG1, PG2, CA, VT1, VT2, VT3, HYD, POF</i>
<i>IV.a. Cessation</i>	<i>Baggy appearance; bloodshot; grey-red translucent in color; atretic oocytes appear as opaque irregular grains; few residual eggs may remain</i>	<i>PG1, PG2, POF, atretic oocytes, residual HYD</i>
<i>IV.b. Recovery</i>	<i>Ovaries appear firmer and membranes thicker than in sub-stage IV.a; these characteristics together with the slightly larger size distinguish this stage from the virgin stage; ovaries appear empty and there are no residual eggs; transparent to wine red translucent in color</i>	<i>PG1, PG2, atretic VT oocytes</i>
<i>V. Resting</i>	<i>Ovaries appear more tubular and firmer; oocytes not visible to the naked eye; transparent or grey-white to wine red with well-developed blood supply; this stage leads to stage II.</i>	<i>PG1, PG2 +/- atretic oocytes</i>
<i>VI. Abnormal</i>	<i>a) infection; b) intersex - both female and male tissues can be recognized; c) one lobe degenerated; d) stone roe (filled with connective tissue); e) other</i>	<i>Abnormal tissue</i>
<i>MALES (SG: Spermatogonia; PS: Primary spermatocytes; SS: Secondary spermatocytes; ST: Spermatids; SZ: Spermatozoa; SSB: Spawning stock biomass)</i>		

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I. Immature	Juvenile: Testes threadlike and small; white-grey to grey-brown; difficult to determine sex, but distinguishable from ovaries by a more lanceolate shape (knife-shaped edge of the distal part of the lobe).	SG, PS
II. Preparation	The transition from immature to mature: Testes easily distinguishable from ovaries by lanceolate shape; sperm development not visible; reddish grey to creamy translucent in color; testes occupy up to ½ of the abdominal cavity; this stage is not included in SSB.	SG, PS, SS, potentially few ST
III. Spawning a. Inactive	Maturing and re-maturing: Testes occupy at least half of the body cavity and grow to almost the length of the body cavity; the empty sperm duct may be visible; color varies from reddish light grey, creamy to white; edges may still be translucent at the beginning of the stage, otherwise opaque; re-maturing testes may be irregularly colored with reddish or brownish blotches and grey at the lower edge with partly whitish remains of sperm	SG, PS, SS, ST, SZ
b. Active	Spawning active: testes fill the body cavity; Sperm duct filled and distended throughout the entire length; sperm runs freely or will run from the sperm duct, if transected; color varies from light grey to white..	SG, PS, SS, ST, SZ
IV.a. Cessation	Baggy appearance (like an empty bag when cut open); bloodshot; grey to reddish-brown translucent in color; residual sperm may be visible in the sperm duct.	SG, PS, atretic SS, ST and SZ
IV.b. Recovery	Testes appear firmer and the testes membrane appears thicker than in stage IVa due to contraction of the testes membrane; these characteristics together with the slightly larger size distinguish this stage from the virgin stage; testes appear empty and no residual sperm is visible in the sperm duct; reddish grey to greyish translucent in color.	SG, PS, potentially SS, atretic SZ
V. Resting	Testes appear firmer, development of a new line of germ cells; grey in color; this stage leads to stage II.	SG, PS, SS
VI. Abnormal	a) infection; b) intersex - both female and male tissues can be recognized; c) one lobe degenerated; d) other.	e.g. oocytes visible among spermatogenic tissues

1.7. Batch fecundity

All fish were measured to the nearest 1 mm in total length (TL) and weighed to the nearest 1 gram. The gonads were examined under a microscope for external characteristics such as hardness and color to determine the stage of maturity. The sex ratio was also calculated in this study as the number of males / the number of females (Simon et al., 2012). Females were identified through macroscopic observation of a mature ovary (Laevastu, 1965). Fecundity rates can vary considerably during the short spawning season—starting low, peaking during peak spawning, and declining again toward the end. Batch fecundity of sprat was determined using the Hydrated Oocyte Method (Hunter et al., 1985). Fat, hydrated females were used. After

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sampling, their body cavity was opened and preserved in a buffered formalin solution (Hunter et al., 1985). The ovary-free female weight and the ovary weight were recorded. Three tissue samples of approximately 50 mg were taken from different parts of the ovary, and their exact weights were measured. The number of hydrated oocytes in each of the three subsamples was then counted under a binocular microscope. Hydrated oocytes are easily distinguished from other oocyte types by their large size, translucent appearance, and wrinkled surface resulting from formalin preservation. Batch fecundity was estimated based on the average number of hydrated oocytes per unit weight of the three subsamples.

Gonadosomatic Index (GSI) is determined monthly. GSI is calculated as:

$$GSI = \frac{GW}{SW} \times 100$$

where GW is gonads weight and SW is somatic weight (represents the BW without GW).

For the estimation of sprat growth rate, the von Bertalanffy growth function (1938) is used, (according to Sparre, Venema, 1998):

$$(11) \quad L_t = L_{\infty} \left\{ 1 - \exp[-k(t - t_0)] \right\}$$

$$(12) \quad W_t = W_{\infty} \left\{ 1 - \exp[-k(t - t_0)] \right\}^n$$

Where: L_t , W_t are the length and weight of the fish at age t years; L_{∞} , W_{∞} – asymptotic length and weight, k – curvature parameter, t_0 – the initial condition parameter.

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

$$(13) \quad W_t = qL_t^n$$

where q – condition factor, constant in a length-weight relationship; n – constant in a length-weight relationship.

Coefficient of natural mortality (M), Pauly's empirical formula (1979, 1980) is applied:

$$(14) \quad \log M = -0.0066 - 0.279 * \log L_{\infty} + 0.6543 * \log k + 0.4634 * \log T^{\circ}C$$

$$(15) \quad \log M = -0.2107 - 0.0824 \log W_{\infty} + 0.6757 \log K + 0.4627 \log T^{\circ}C$$

Where: L_{∞} , W_{∞} and κ – parameters in von Bertalanffy growth function, $T^{\circ}C$ – an average annual temperature of the water (environmental parameter of the studied species).



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1.8. Maximum Sustainable Yield (MSY)

The maximum sustainable yield was estimated as follows:

$$B_{msy} = 0.5 * B(t)$$

According to FAO (1995), following the precautionary approach:

$$B_{pr} (2/3MSY)$$

1.9. Planktivorous fish species feeding

The study on the diet of planktivorous fish (sprat and horse mackerel) in the western Black Sea was based on stomach-content analyses of 67 sprat specimens and 80 horse mackerel specimens collected between 27.10. –14. 11.2025.

During this period, data on the composition and quantity of mesozooplankton in the marine environment were collected, as this group of organisms forms the main food base for the fish species studied.

The coordinates of the study area and descriptions of the data are presented in Table 1.9.1.

Table 1.9.1. Study areas in October–November 2025.

Date	Trawl №	Coordinates		Depth (m)	Temperature (°C)
		Latitude	Longitude		
27.10.2025	T3	43.1178	28.2420	33	16.75
27.10.2025	T5	43.2093	28.4236	17	16.33
27.10.2025	T7	43.3315	28.3062	17	15.85
28.10.2025	T11	43.3943	28.9197	85	15.57
28.10.2025	T13	43.2921	28.2365	17	15.73
29.10.2025	T15	42.9952	27.9158	24.4	15.04
29.10.2025	T18	42.8665	28.1471	49	16.44
08.11.2025	T24	42.6401	27.7583	27	14.71
09.11.2025	T26	42.2638	28.1526	75	15.71
09.11.2025	T28	42.3686	28.0257	49	15.85
12.11.2025	T30	42.4592	27.7903	36	15.05
12.11.2025	T32	42.5711	27.7767	33	14.72
14.11.2025	T38	42.5169	27.7428	35	14.69

From the trawl catch, approximately 10 live fish specimens were separated and fixed in 10% formaldehyde solution. Under laboratory conditions, the absolute length (TL, with an accuracy of 0.1 cm) and weight (with an accuracy of 0.01 g) of the collected specimens were measured.

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The stomachs of the studied organisms were weighed using an analytical balance (accuracy: 0.0001 g). The food mass of each fish specimen was calculated as the difference between the weights of the full and empty stomachs.

To determine the species composition and number of food objects, stomach contents were examined under a microscope. Prey biomass in fish stomachs was calculated by multiplying the number of zooplankton organisms by their individual weights.

The following indices were defined:

1. Index of stomach fullness (ISF) as a percentage of body mass: $(\text{weight of stomach contents} / \text{weight of fish body}) \times 100$
2. Index of relative importance (IRI; PINKAS et al., 1971): $\text{IRI} = (N + M) \times \text{FO}$, where N is the proportion of the taxon (species) of the prey in the food by number, M 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).

Zooplankton samples were collected from the entire water layer (surface–bottom) with a plankton net with an inlet diameter of $d = 36$ cm and an aperture of $150 \mu\text{m}$ and fixed on board the ship with a 4% formalin-seawater solution (Korshenko & Aleksandrov 2013). The zooplankton species composition was determined according to the Manuals for the Black and Azov Seas (Mordukhai-Boltovsky et al., 1968) and the quantity in a Bogorov chamber according to the methodology of Korshenko and Aleksandrov (2013).

2. Results

2.1. Species diversity

A total of 28 species were identified during the study, including 19 fish, 3 crustaceans, 2 molluscs, and 3 macrozooplankton species. The most common species in the trawl catches (based on presence/absence) were *Sprattus sprattus* (9.5%), *Merlangius merlangus* (19.22%), *Mullus barbatus* (20.05%), and *Trachurus mediterraneus* (44.21%). Other species, such as *Alosa immaculata*, *Neogobius melanostomus*, *Gobius niger*, *Mesogobius batrachocephalus*, *Zosterisessor ophiocephalus*, *Raja clavata*, *Dasyatis pastinaca*, *Pegusa lascaris*, *Aphia minuta*, *Uranoscopus scaber*, *Trachinus draco*, *Scophthalmus maximus*, *Squalus acanthias*, *Chelidonichthys lucerna*, *Acipenser gueldenstaedtii*, and *Acipenser stellatus*, had a negligible presence in the catches.



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2.2. Horse mackerel (*Trachurus mediterraneus*)

2.2.1. Distribution

Horse mackerel is a migratory species along the Bulgarian coast. It is a carnivorous fish and plays an important role in the food chain, serving as prey for larger predators such as turbot and dolphins. Horse mackerel was significantly represented in the catches in October–November 2025.

2.2.2. Horse mackerel biomass by strata

The total area surveyed was 8010.24 km², and the total biomass of horse mackerel was estimated at 5629 tonnes (Table 2.2.2.1; Table 2.2.2.2; Fig. 2.2.2.1; Fig. 2.2.2.2). The densest aggregations were observed off the coast of Balchik and in Kavarna. The highest biomass was recorded in the 15–30 m depth stratum (4200 tonnes) followed by 784 tonnes (30–50 m) and 1.24 tonnes (50–100 m).



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Biomass (tons) of Horse Mackerel - Second Expedition'2025

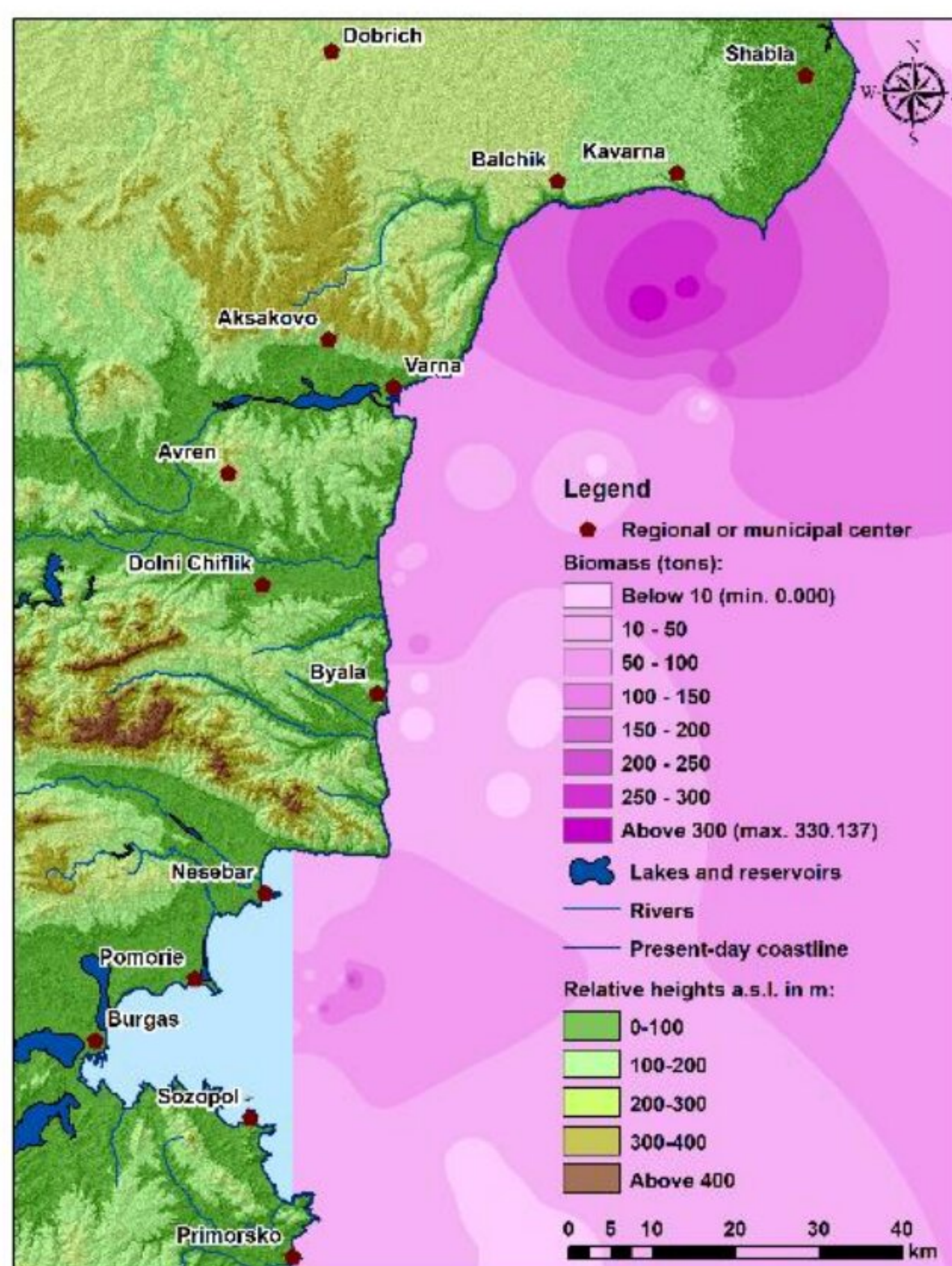


Figure 2.2.2.1. Horse mackerel biomass by strata, October–November 2025.

Table 2.2.2.1. Swept area method for stock survey in October–November 2025 – average values of catch per unit area (CPUA), biomass (kg), A_x – area and number of fields.

CPUA, average	Strata (m)	Biomass (kg)	A_x Surface	Number of stations
2033.79	15-30	4200.06	2065,14	33
784.55	30-50	1423.82	1814,82	29
1.24	50-100	5.12	4130,28	66
		5629	8010,24	128



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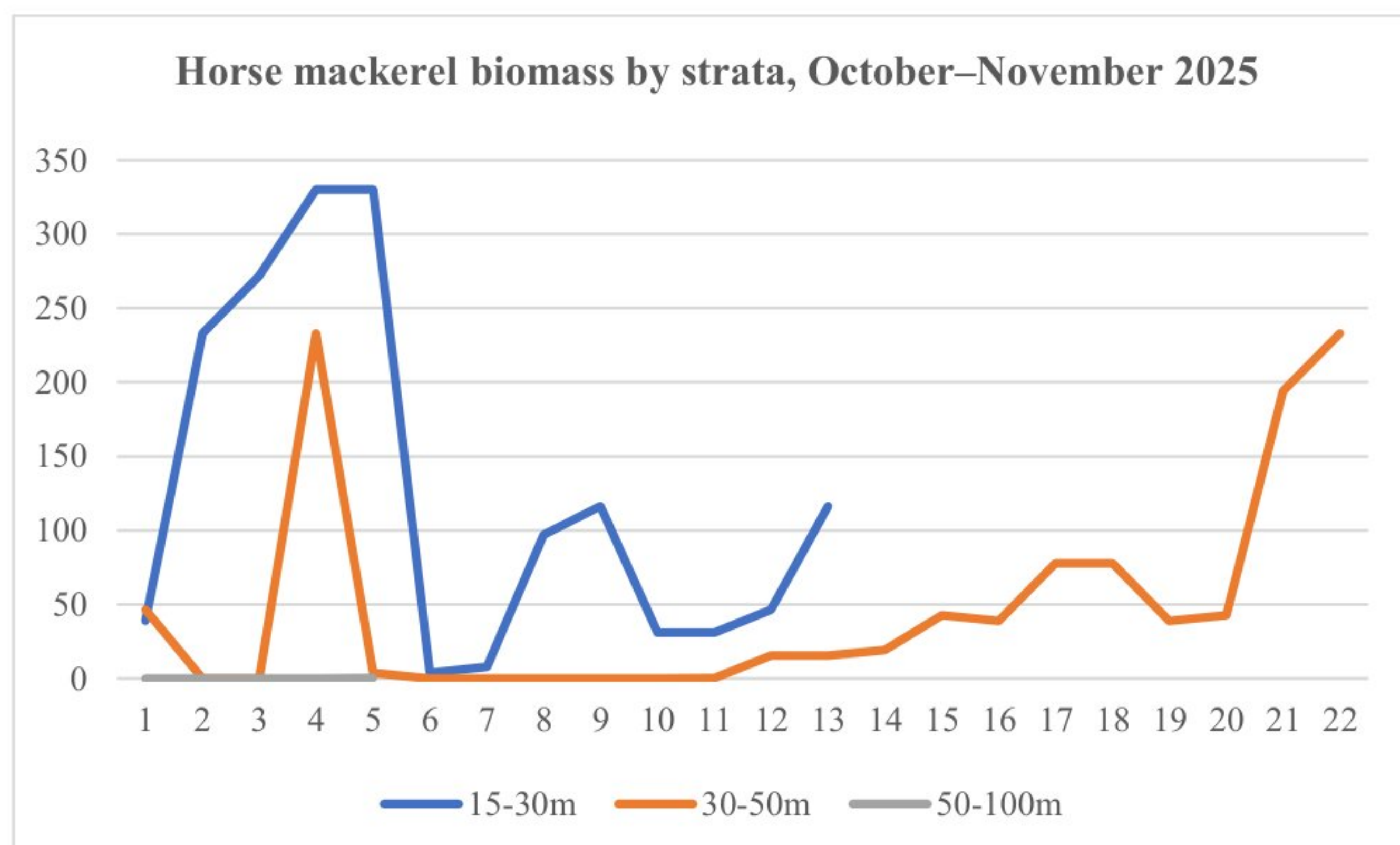


Figure 2.2.2.2. Horse mackerel biomass (kg) by strata in October–November 2025.

Table 2.2.2.2. Descriptive statistics of horse mackerel CPUA indices (t) in October–November 2025.

	15-30 m	30-50 m	50-100 m
Average	2033.79	784.5454	1.24128
Standard error	539.6061	252.1973	1.24128
Median	1551.6	279.288	0
Mode	5275.44	0	0
Standard deviation	1945.578	1182.91	2.775586
Variation	3785272	1399277	7.70388
Excess	-1.00287	2.405306	5
Asymmetry	0.779791	1.860426	2.236068
Range	5213.376	3723.84	6.2064
Minimum	62.064	0	0
Maximum	5275.44	3723.84	6.2064

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Amount	26439.26	17260	6.2064
Number	13	22	5
Greatest Value (1)	5275.44	3723.84	6.2064
Smallest value (1)	62.064	0	0
Confidence level (95.0%)	1175.701	524.473	3.446346

2.2.3. Catch per unit area (CPUA)

Horse mackerel was recorded at the highest densities in the waters off Balchik, Kavarna, and Burgas Bay (Fig. 2.2.3.1).

The highest values of CPUA were registered in the 15–30 m depth layer, reaching 1241 kg.km^{-2} , with an average value of 512 kg.km^{-2} . In the 30–50 m $124\text{--}869 \text{ kg.km}^{-2}$ and 50–100 m depth layers, the species was recorded with very low values of 3.41 kg.km^{-2} (Fig. 2.2.3.1).

**CPUA (kg/km^2) of Horse Mackerel
- Second Expedition'2025**

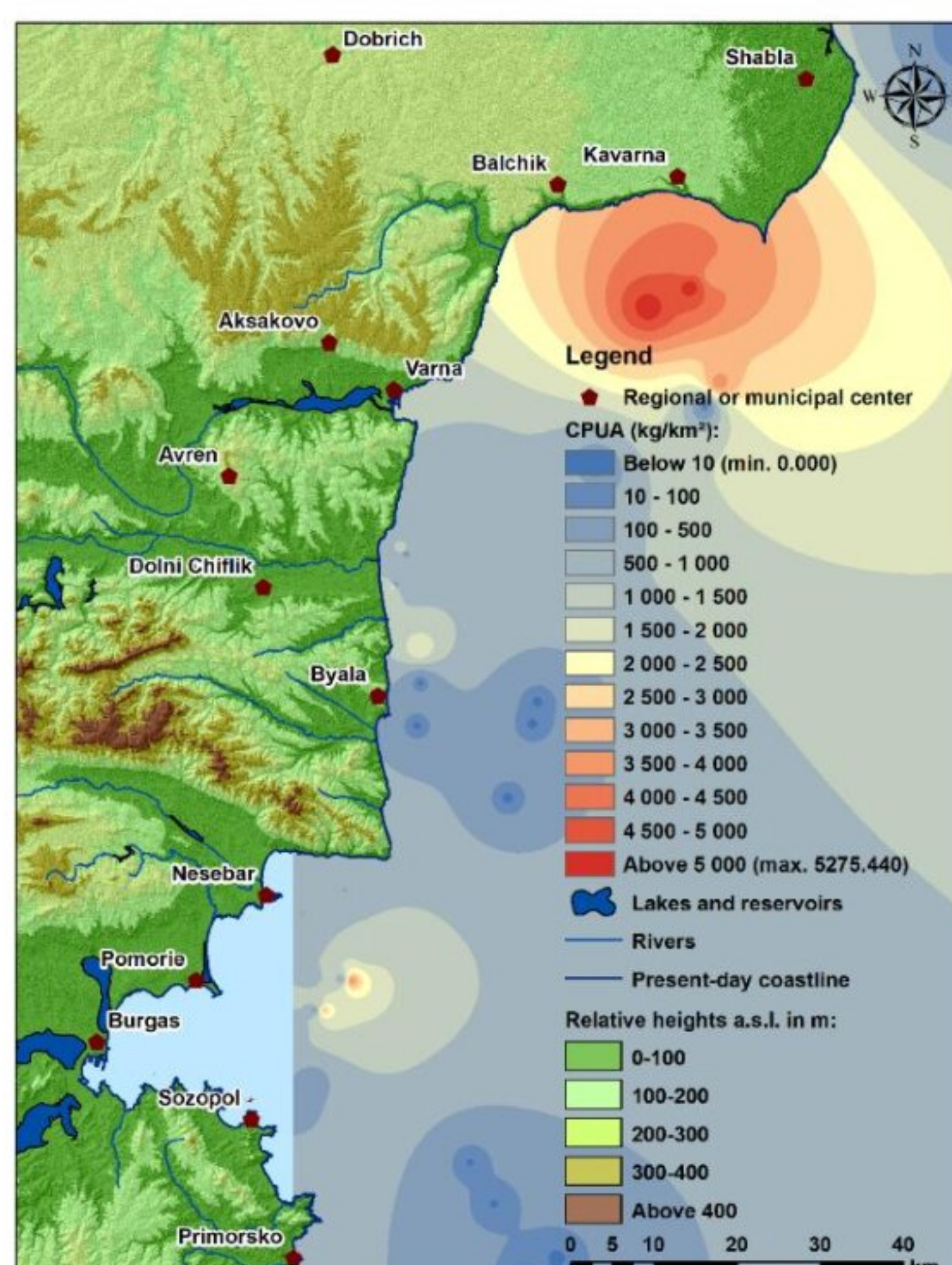


Figure 2.2.3.1. Catch per unit area (CPUA kg.km^{-2}), October–November 2025.

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2.2.4. Catch per unit effort (CPUE)

The catch per unit effort (CPUE) for the species is presented graphically in Figure 2.2.4.1. The highest CPUE values (kg.h^{-1}) were observed in front of Kavarna and Balchik, followed by Burgas Bay.

CPUE (kg/h) of Horse Mackerel - Second Expedition'2025

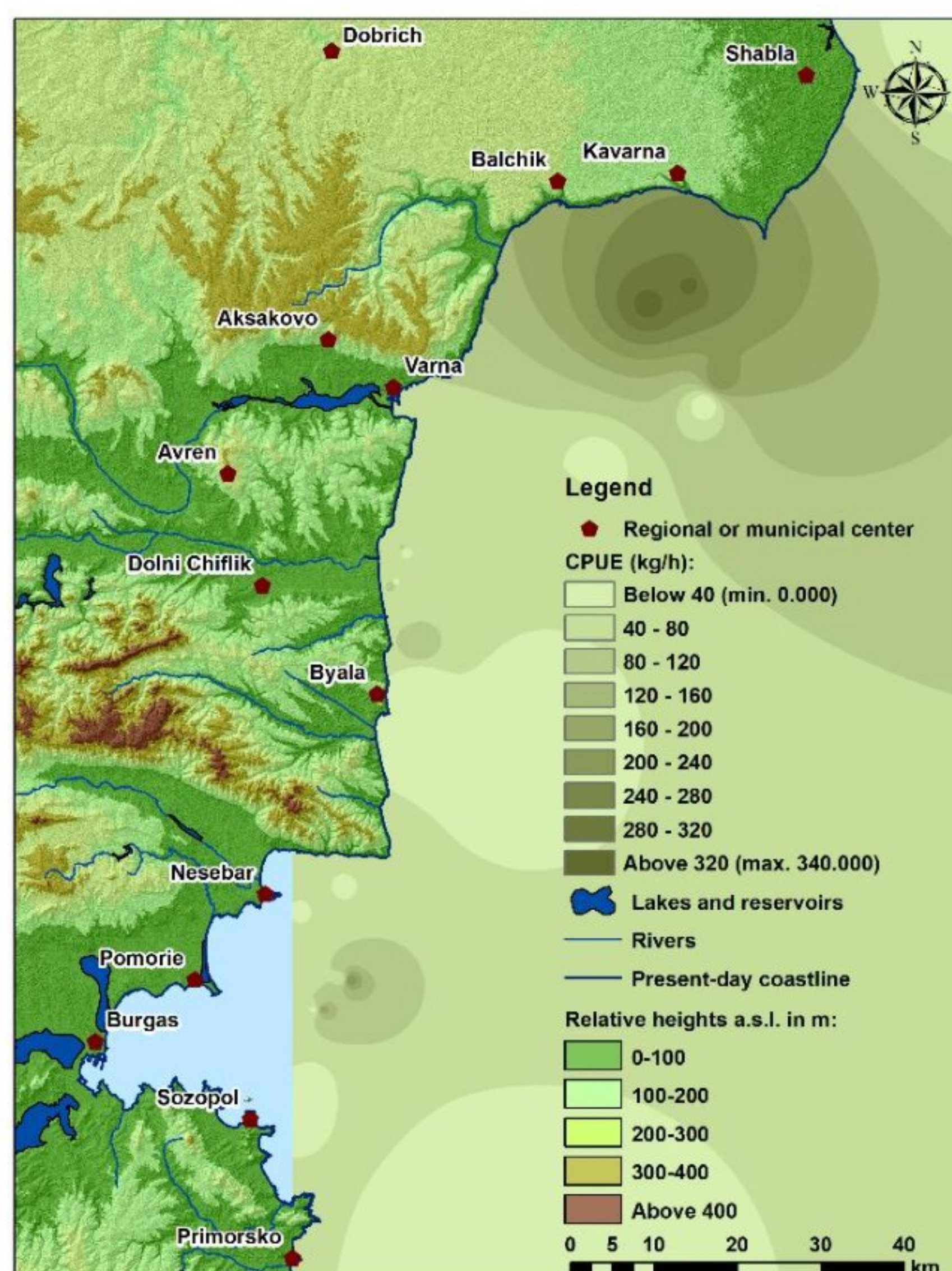


Figure 2.2.4.1. Catch per unit effort (CPUE kg.h^{-1}) for horse mackerel by strata.



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2.2.5. Length-weight relationship

The length-weight relationship in horse mackerel is described by the model $W = 0.009 \cdot L^{2.77}$, allometric growth coefficient < 3 , the resulting nonlinear length-weight relationship model has a high degree of determination ($R^2 = 0.97$) (Fig. 2.2.5.1.).

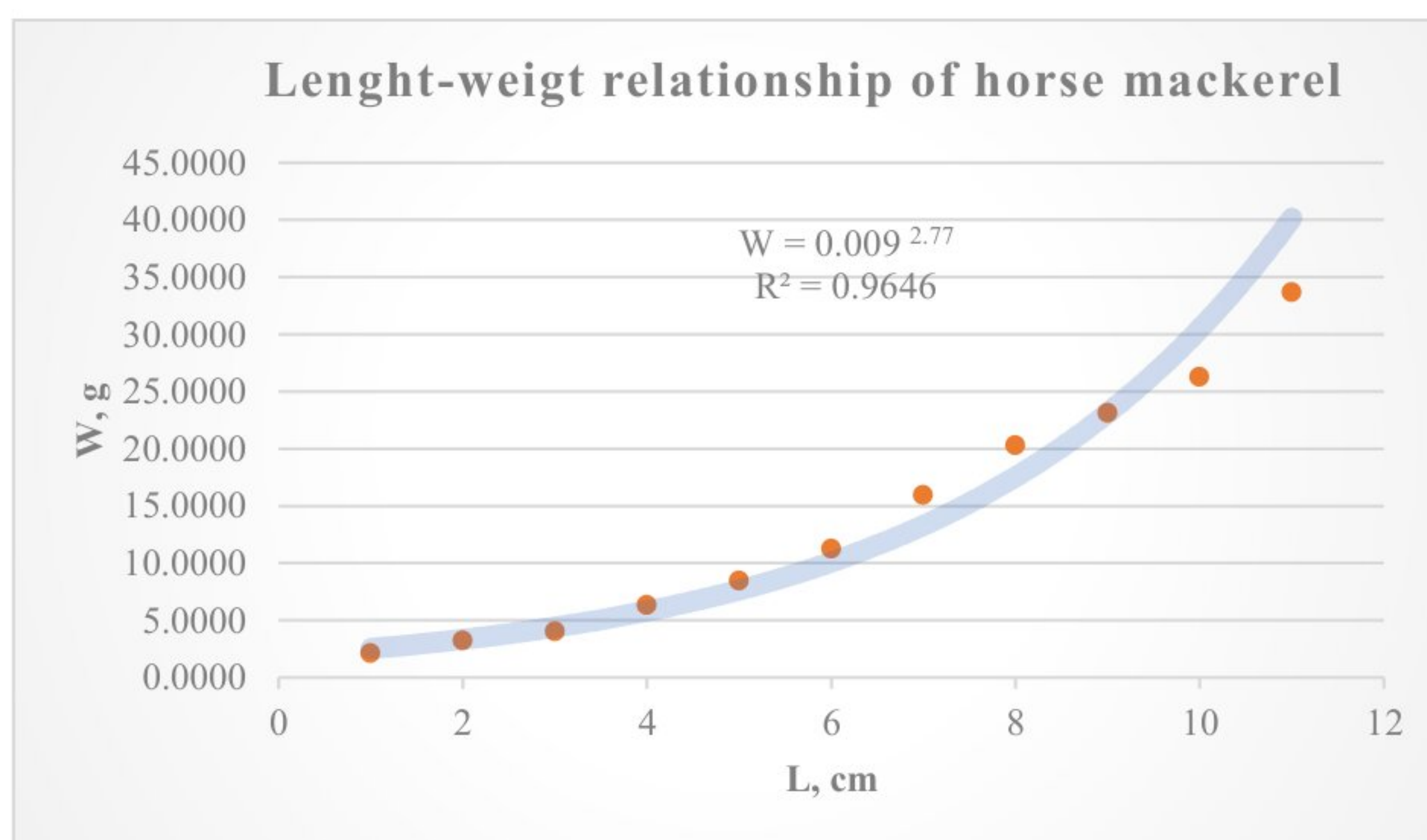


Figure 2.2.5.1. Length-weight relationship of horse mackerel in October–November 2025.

The size structure of the horse mackerel stock is presented in Figure 2.2.5.2. The length distribution in the horse mackerel samples is bimodal (gaus), with 2 peaks – bell-shaped, as the most common lengths in the samples were in the range 10–13.5 cm. A peak was observed in the 10 cm size group (1500 ind.) (Фиг. 2.2.5.2).



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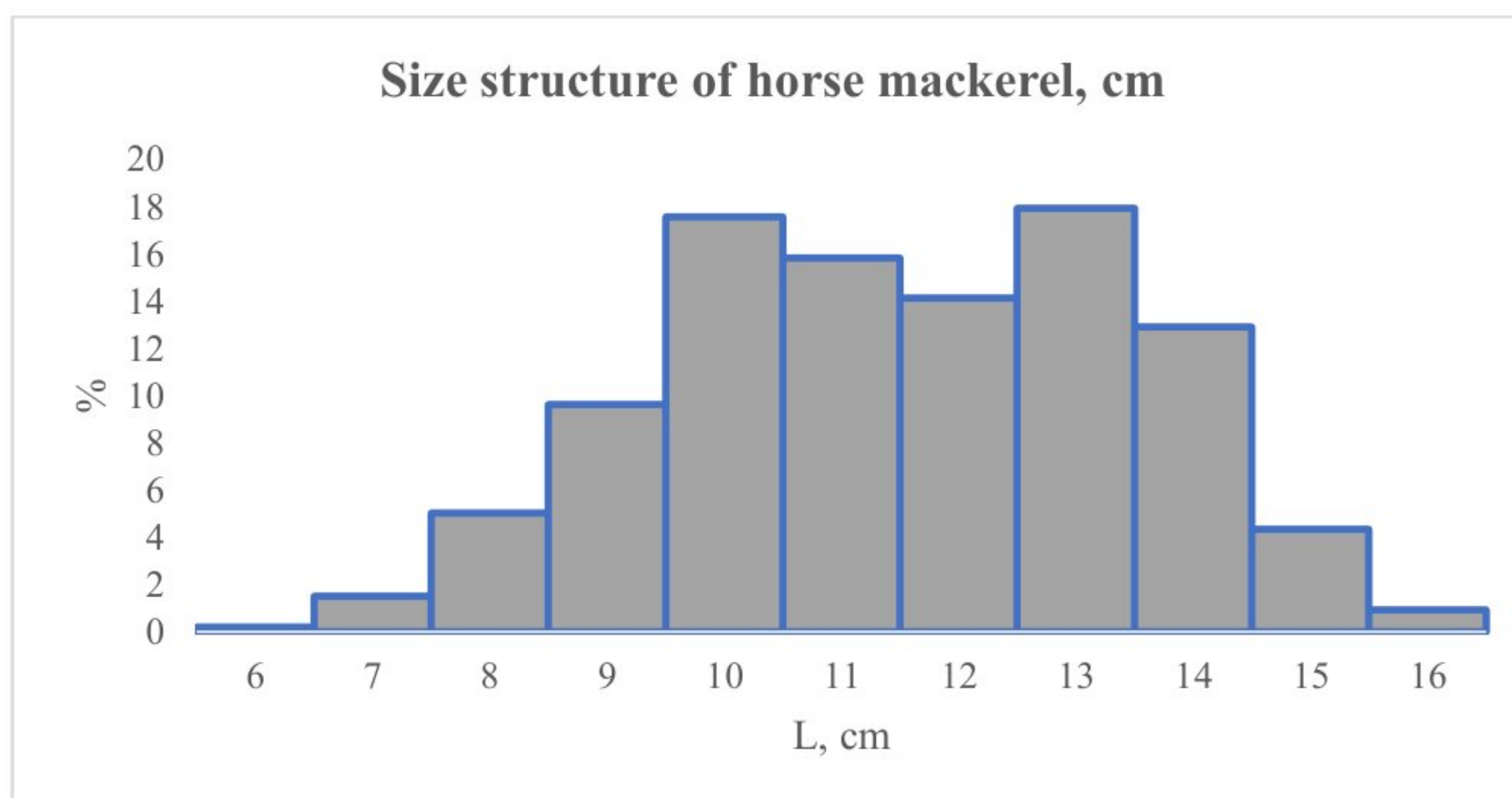


Figure 2.2.5.2. Size structure of horse mackerel in October–November 2025.

Average weight varied from 2.13 to 33.66 g (Fig. 2.2.5.3.).

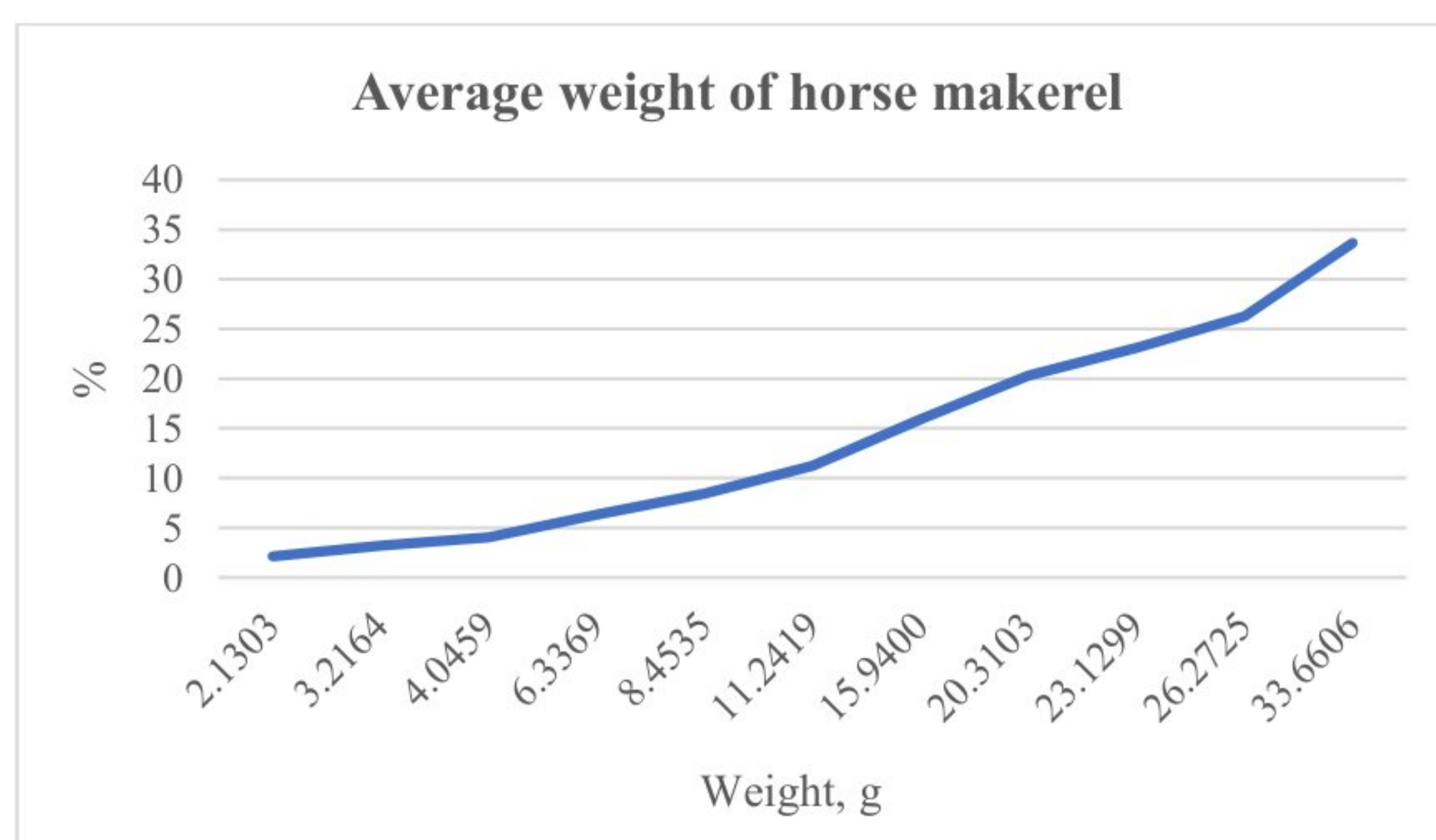


Figure 2.2.5.3. Weight structure of horse mackerel in October–November 2025.

The dominant age group of horse mackerel during the study period was 2-2+ years (31.5%), followed by age group 1-1+ years (9.8%). The replenishment was represented by 4.6%. The age structure of the horse mackerel varies from 0 to 5+ years, with a significant presence of the 3-3+years age group, comprising 19.66% of the total (Fig. 2.2.5.4.).



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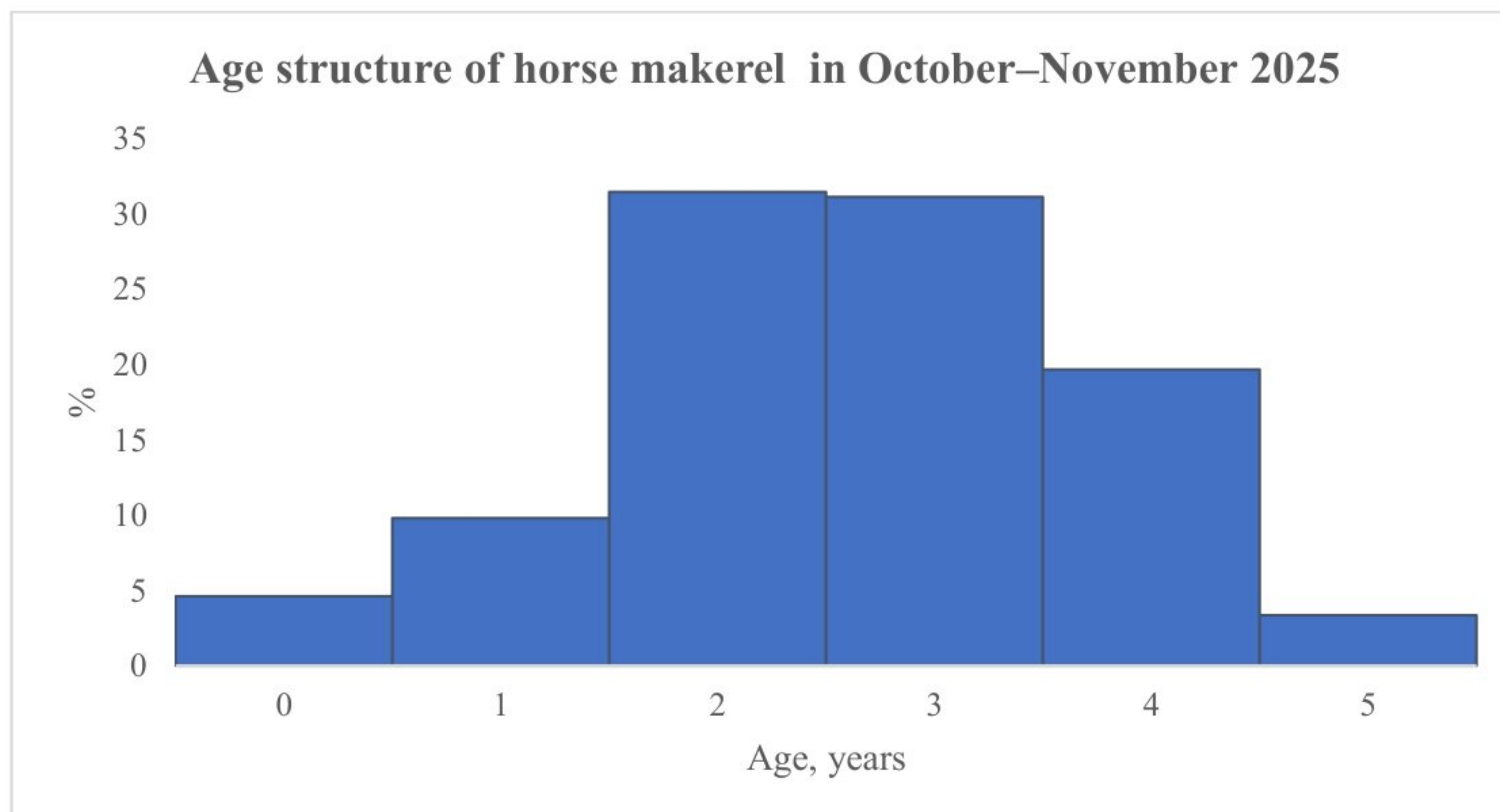


Figure 2.2.5.4. Age structure of horse mackerel in October–November 2025.

2.2.6. Individual growth

The growth parameters of horse mackerel (1500 ind.), calculated using the von Bertalanffy model, show an asymptotic length of 25.42 cm and higher values of the coefficient determining the rate of reaching the asymptote (Table 2.2.6.1.).

Table 2.2.6.1. Von Bertalanffy Growth Model (VBGF) for horse mackerel.

Species	Asymptotic length	Growth rate	Growth parameter	Growth coefficient	Allometric coefficient
<i>Trachurus mediterraneus</i>	$L_{\infty} = 25.42$	$K = 0.244$	$t_0 = -1.115$	$q = 0.006$	$n = 2.95$

2.2.7. Abundance and biomass by length and age classes

In October–November 2025, the 10.0 cm size class had the highest percentage representation in the catches (Fig. 2.2.7.1).



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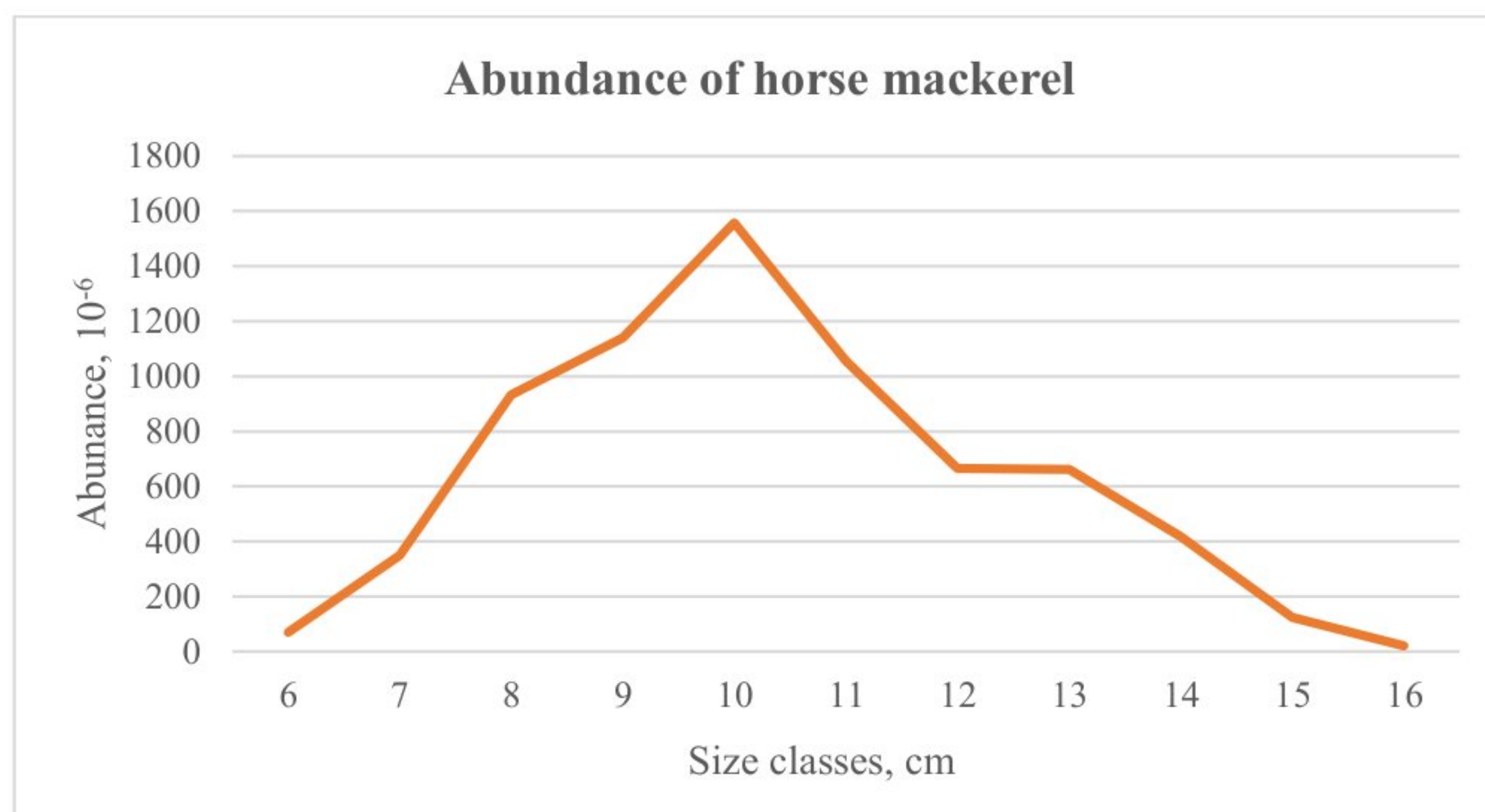


Figure 2.2.7.1. Abundance of horse mackerel by size classes in October–November 2025.

Analysis of the age structure of the catch showed that age groups 3–3+ and 4–4+ years had high abundance indices and dominated the catches (Fig. 2.2.7.2). The age groups recorded in the catches ranged from 0 to 4+ years.

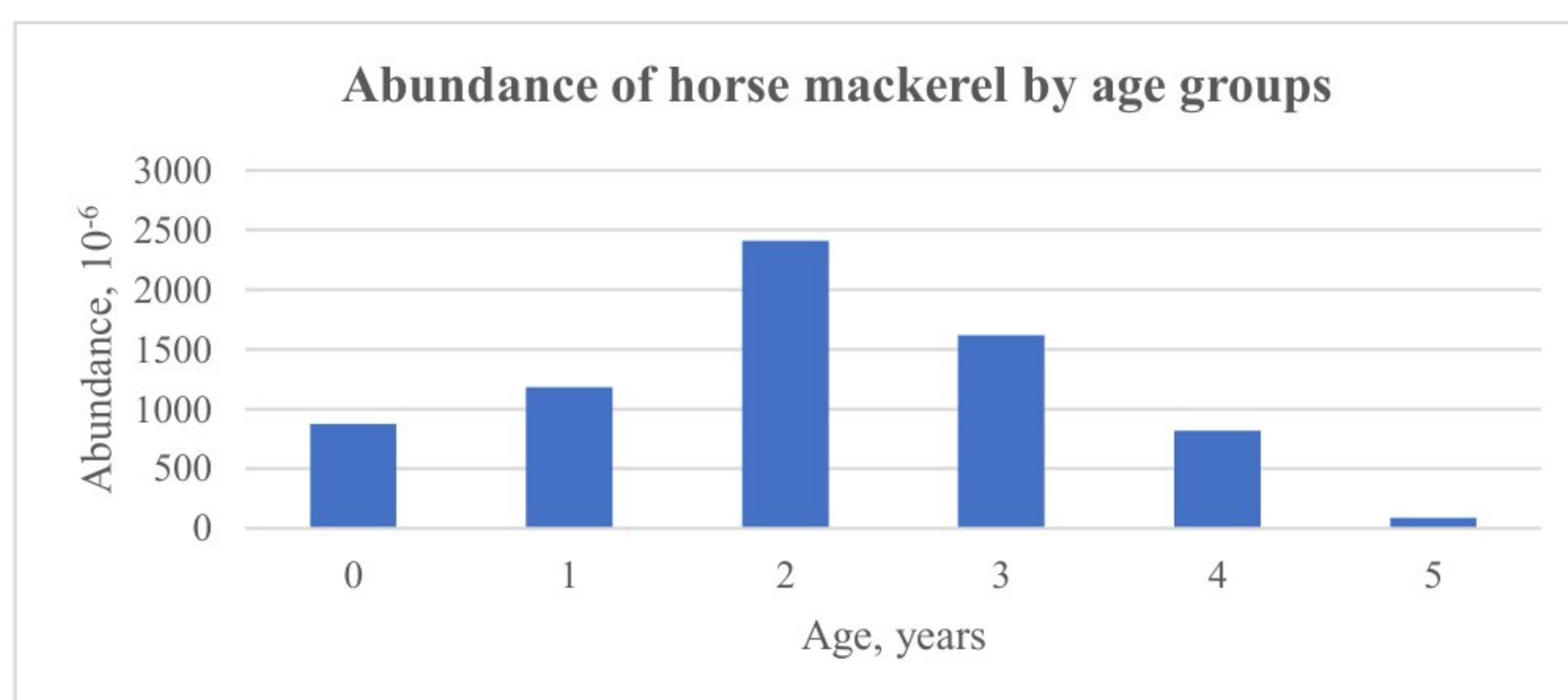


Figure 2.2.7.2. Abundance of horse mackerel by age groups in October–November 2025.

Biomass, similar to abundance, was dominated by the 10 cm size group, followed by the 13.5 cm size group (Fig. 2.2.7.3). Figure 2.2.7.4 presents the distribution of biomass by age group. In October–November 2025, age groups 1–1+ years had a significantly higher share in the catches compared to other age groups.



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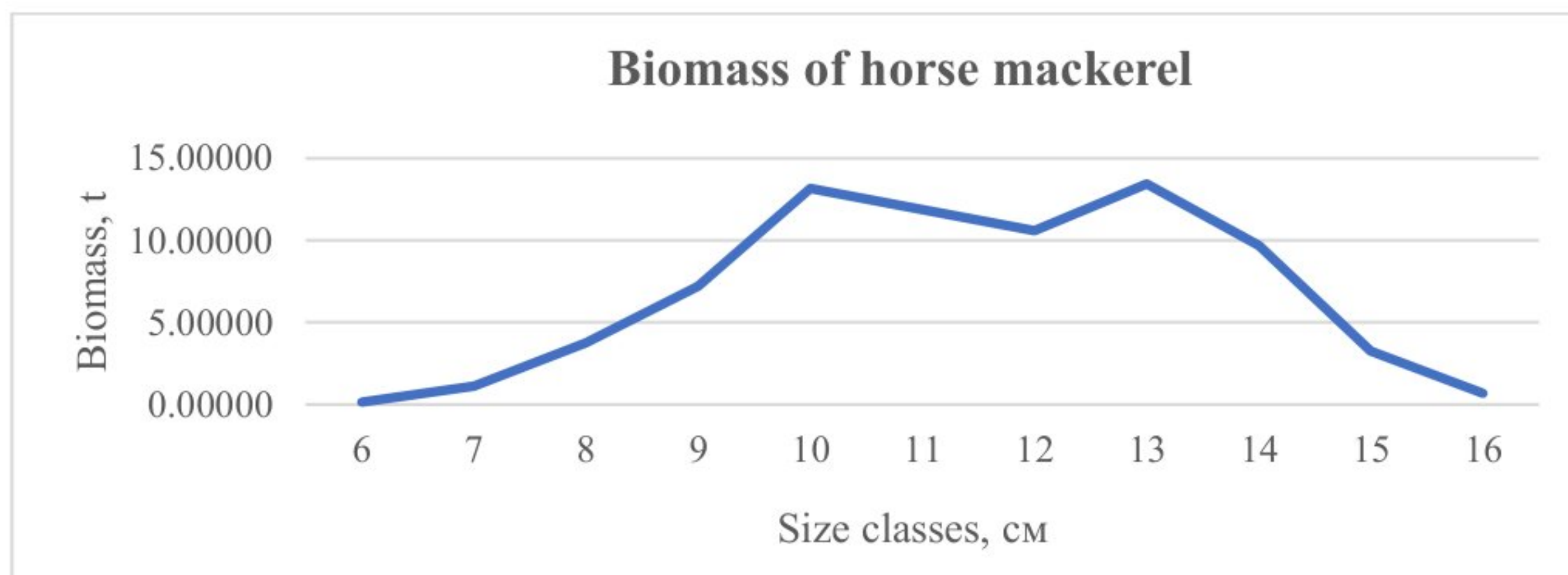


Figure 2.2.7.3. Biomass of horse mackerel by size classes in October–November 2025.

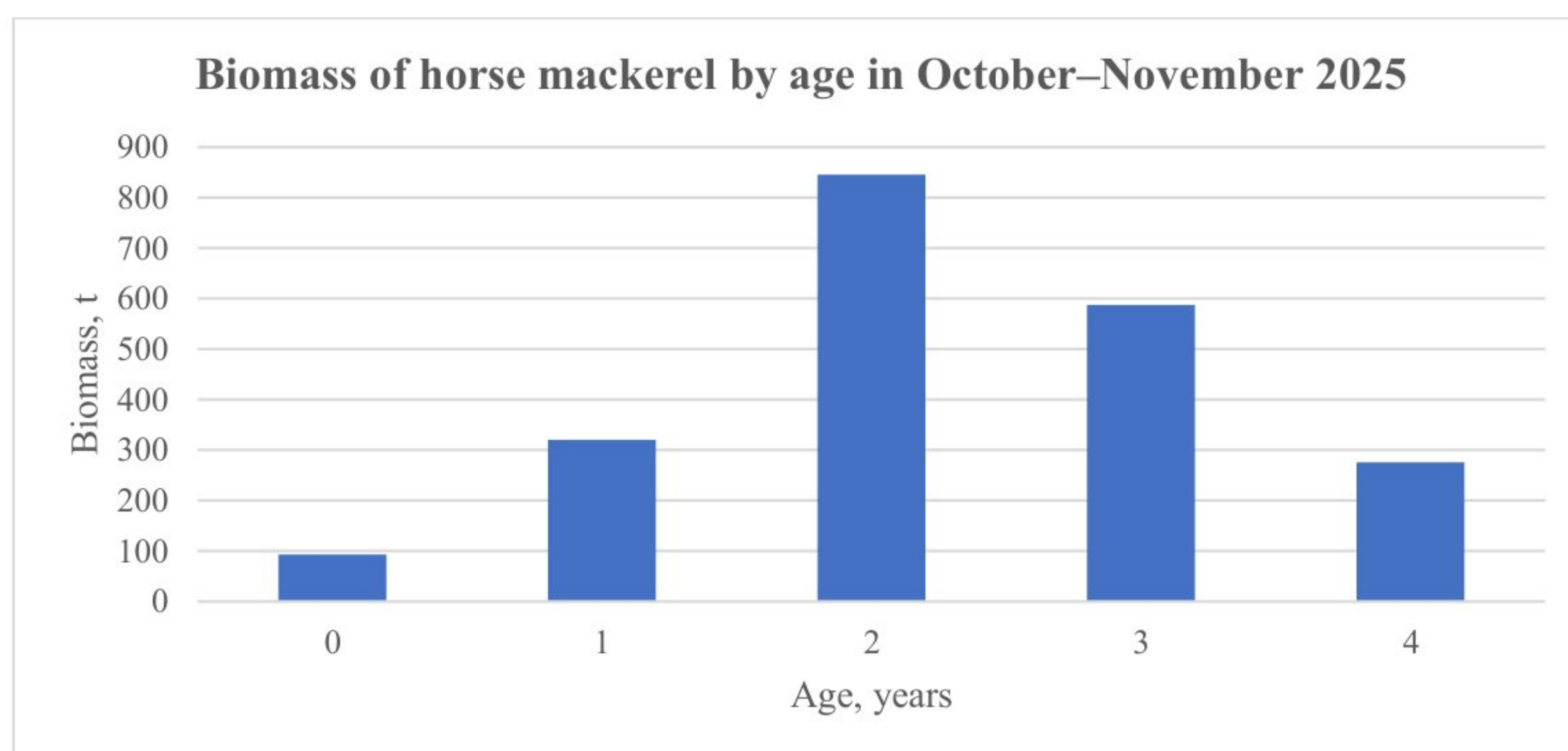
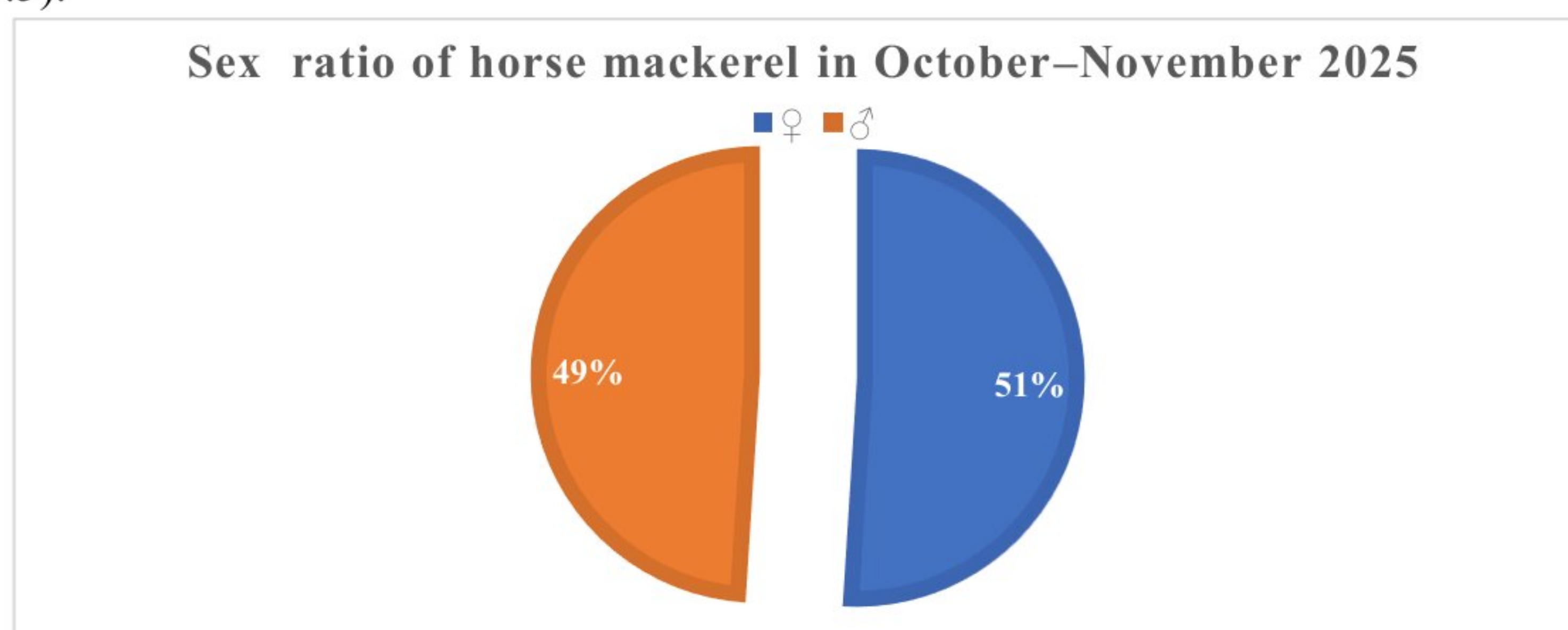


Figure 2.2.7.4. Biomass of horse mackerel by age groups in October–November 2025.

The sex ratio (250 individuals) of horse mackerel was 49% males ♂ and 51% females ♀ (Fig. 2.2.7.5).





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Figure 2.2.7.5. Sex ratio (females – ♀, males – ♂) of horse mackerel in October–November 2025.

The sexual maturity of the analyzed species by size classes is presented in Figure 2.2.7.6, and by age groups in Figure 2.2.7.7.

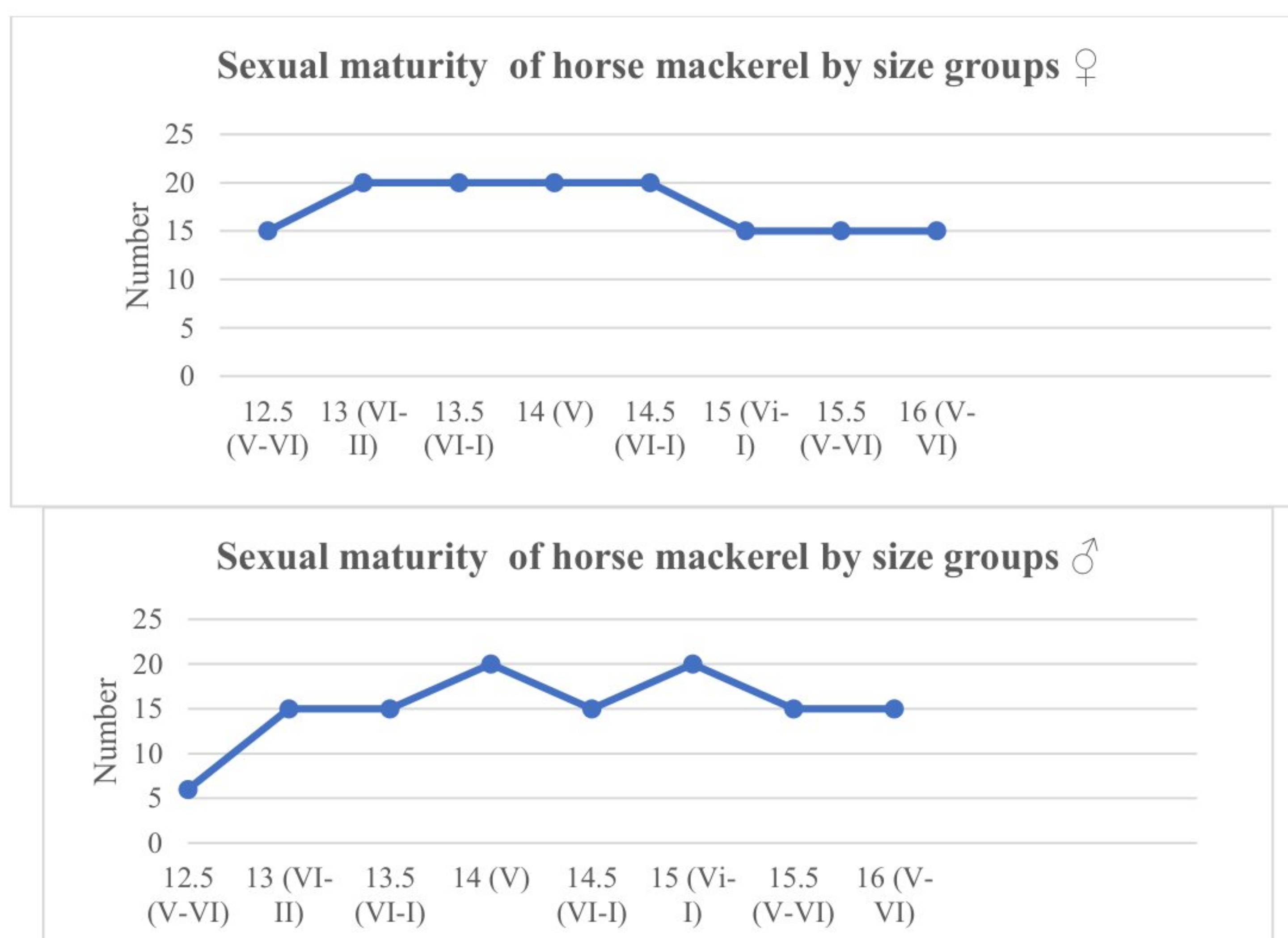


Figure 2.2.7.6. Sexual maturity of horse mackerel by size groups in October–November 2025.



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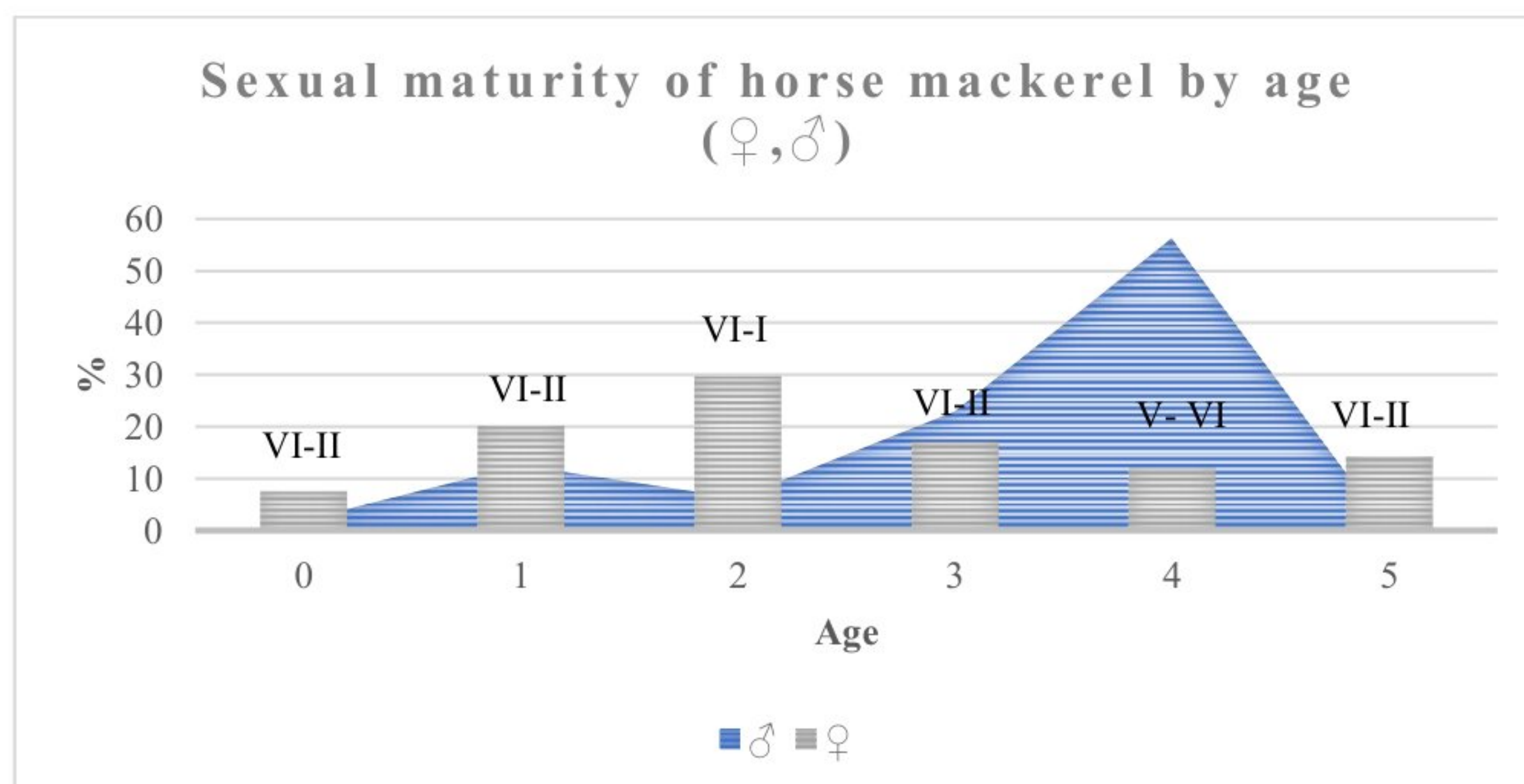


Figure 2.2.7.7. Sexual maturity of horse mackerel by age.

The gonadosomatic index (GSI, %) of horse mackerel based on 250 individuals measured, is indicative of a later stage of spawning. An R^2 value of 0.77 (Fig. 2.2.7.8) shows a strong correlation between gonad weight and the gonadosomatic index, which indicates mass spawning activity and active sexual maturity of the reproductive organs during the study period.

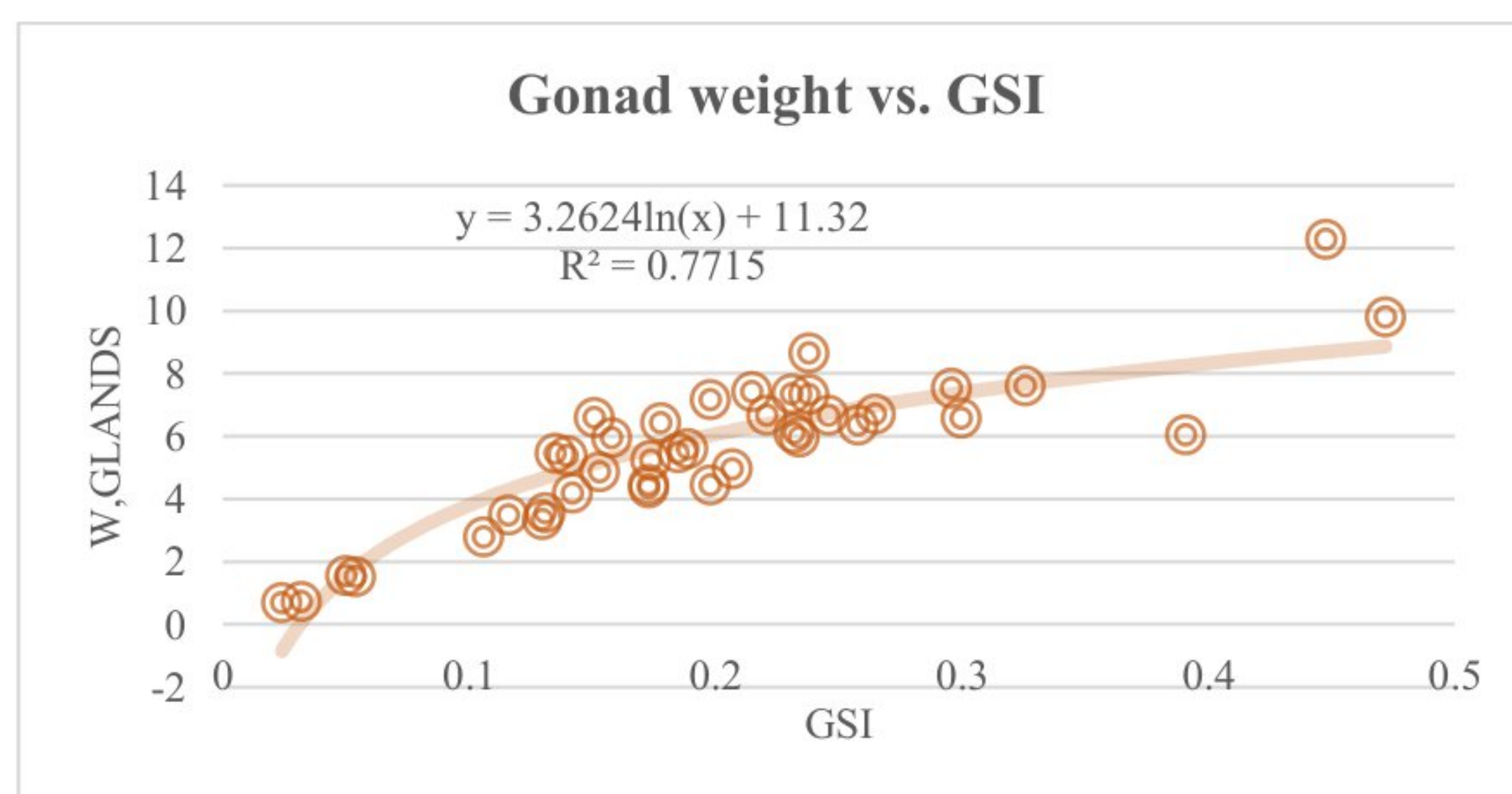


Figure 2.2.7.8. Gonadosomatic index of horse mackerel during the study period (GSI, % vs. Gonad weight).

2.2.8 Absolute and relative fecundity of horse mackerel

Absolute fecundity (measured on 250 ind) at length of 16 cm was the highest: 51040 cavier grains. In terms of relative fecundity, the highest was detected at 10 cm individuals: 1074. The



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mean values of absolute and relative fecundity of the whiting were as follows: 31255 and 978 (Table 2.2.8.1).

Table 2.2.8.1. Absolute and relative fecundity of horse mackerel in October–November 2025.

Size class	Mean weight (g)	Mean length (cm)	Absolute fecundity (number of cavier grains)	Relative fecundity	Numbers
10	7.77	9.71	8350±212	1074.65±111	20
10.5	8.99	10.44	8620±118	925.47±77	20
11	11.05	11.25	9910±242	896.83±48	20
11.5	16.74	11.62	11756±355	702.27±51	20
12	18.41	11.99	15220±405	826.72±66	20
12.5	23.05	12.44	28552±1205	1238.7±155	20
13	31.05	13.02	34215±1552	1102.77±168	20
13.5	40.88	13.44	41899±1774	1024.31±112	20
14	43.52	14	46050±1600	1058.13±125	20
14.5	45.99	14.44	46410±1717	1009.15±48	15
15	46.25	15.01	46700±2241	1009.73±61	10
15.5	51.02	15.55	47120±2555	923.55±23	10
16	55.36	16.15	51040±2100	921.98±31	10
Average			31255	978.08	250

2.3. Red mullet (*Mullus barbatus*)

2.3.1. Biomass of red mullet

The total surveyed area was 8010.24 km², and the total biomass of red mullet was 447.06 tonnes (Table 2.3.1.1). The species was recorded at 14 stations (out of a total of 36). The densest aggregations were observed southeast of Nesebar. A biomass peak was recorded in the 30–50 m depth range (435.23 t), but missing from catch in strata in 50–100 m stratum (0 t) (Fig. 2.3.1.1; Table 2.3.1.2).



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Table 2.3.1.1. Area-based method for stock assessment in October–November 2025 – average catch per unit area (CPUA), biomass (kg), A_x – area, and number of fields.

CPUA average	Strata (m)	Biomass (kg)	A_x Surface	Number of fields
5.728985	15–30	11.83116	2065.14	33
239.82	30–50	435.2301	1814.82	29
0	50–100	0	4130.28	66
		447.06	8010.24	128

**Biomass (tons) of Red Mullet
- Second Expedition'2025**

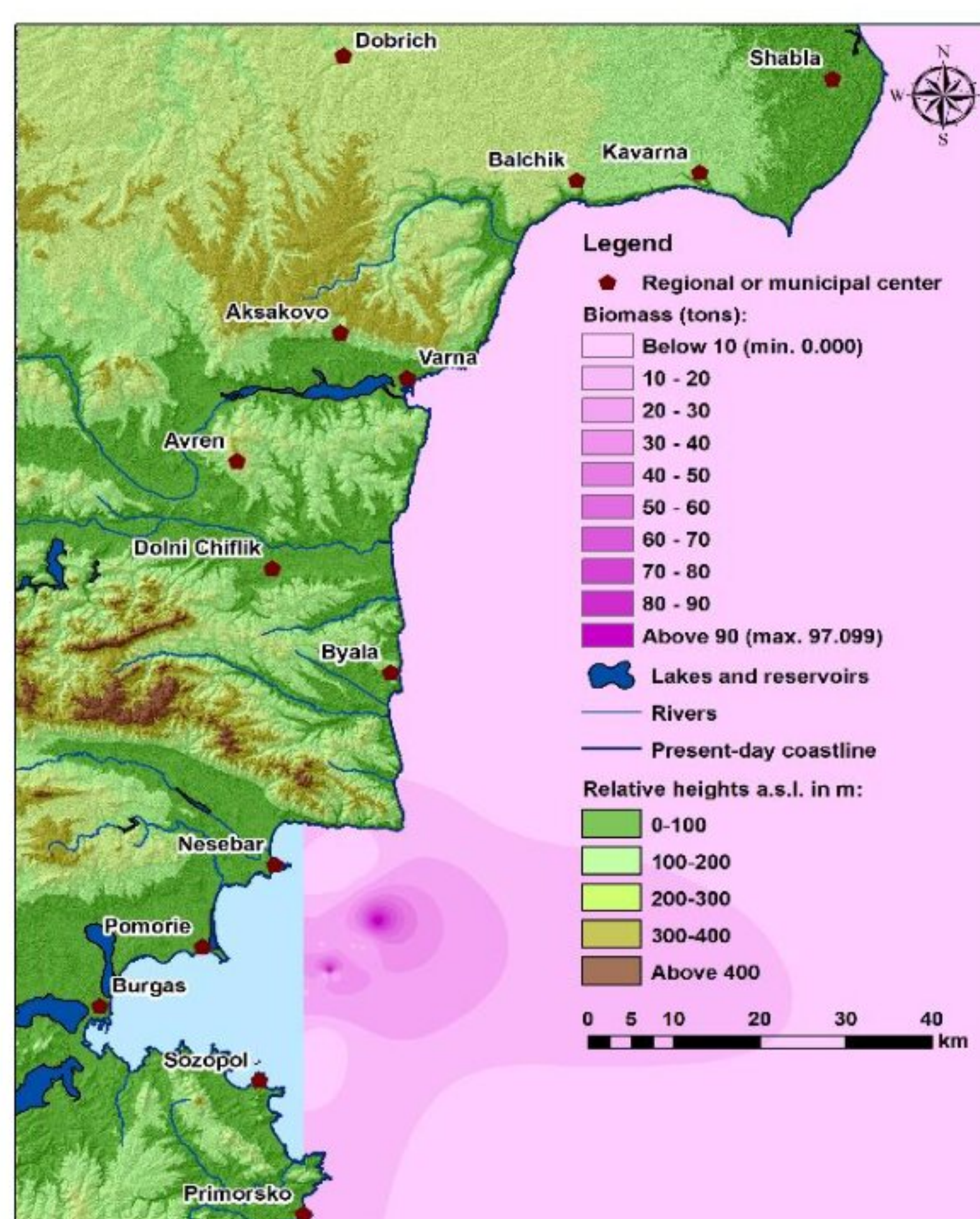


Figure 2.3.1.1. Biomass of red mullet in October–November 2025.

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Table 2.3.1.2. Descriptive statistics of the CPUA indices (t) of red mullet in October–November 2025.

	15-30m	30-50m	50-100m
Average	5.728985	239.8209	0
Standard error	4.790041	95.26552	0
Median	0	0.31032	0
Mode	0	0	0
Standard deviation	17.27074	446.8349	0
Variation	298.2784	199661.4	0
Excess	11.70291	6.002921	0
Asymmetry	3.384165	2.551421	0
Range	62.064	1551.6	0
Minimum	0	0	0
Maximum	62.064	1551.6	0
Amount	74.4768	5276.061	0
Number	13	22	0
Greatest Value (1)	62.064	1551.6	0
Smallest value (1)	0	0	0
	10.4366	198.1155	0
Confidence level (95.0%)			

2.3.2. Catch per unit area (CPUA kg.km⁻²)

The catch per unit area in the 15–30 m stratum was 80 kg.km⁻² (mean). In the 30–50 m – 1047 kg.km⁻² (average) and 50–100 m strata, the values was 0 kg.km⁻² (Fig. 2.3.2.1). From the analysis of the catch per unit area and the catch per unit area and unit effort (Fig. 2.3.2.1 and Fig. 2.3.2.2.) it is evident that the densest aggregations and numbers are found in a depth zone of 30–50 m (Byala and Kaliakra), followed by a zone of 15–30 m.



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**CPUA (kg/km²) of Red Mullet
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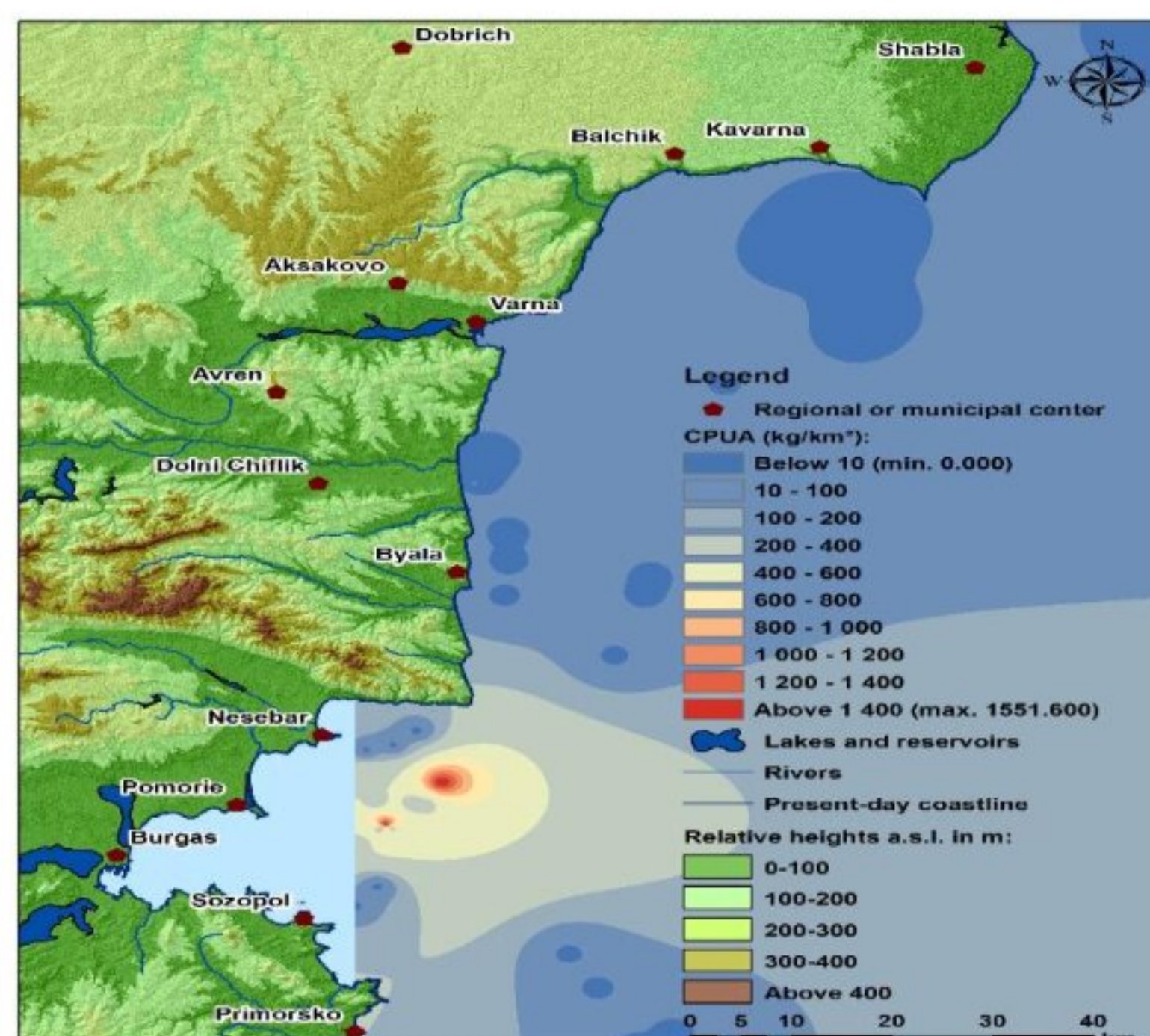


Figure 2.3.2.1. Catch per unit area (CPUA kg.km⁻²) of red mullet in October–November 2025.

**CPUE (kg/km²) of Red Mullet
- Second Expedition'2025**

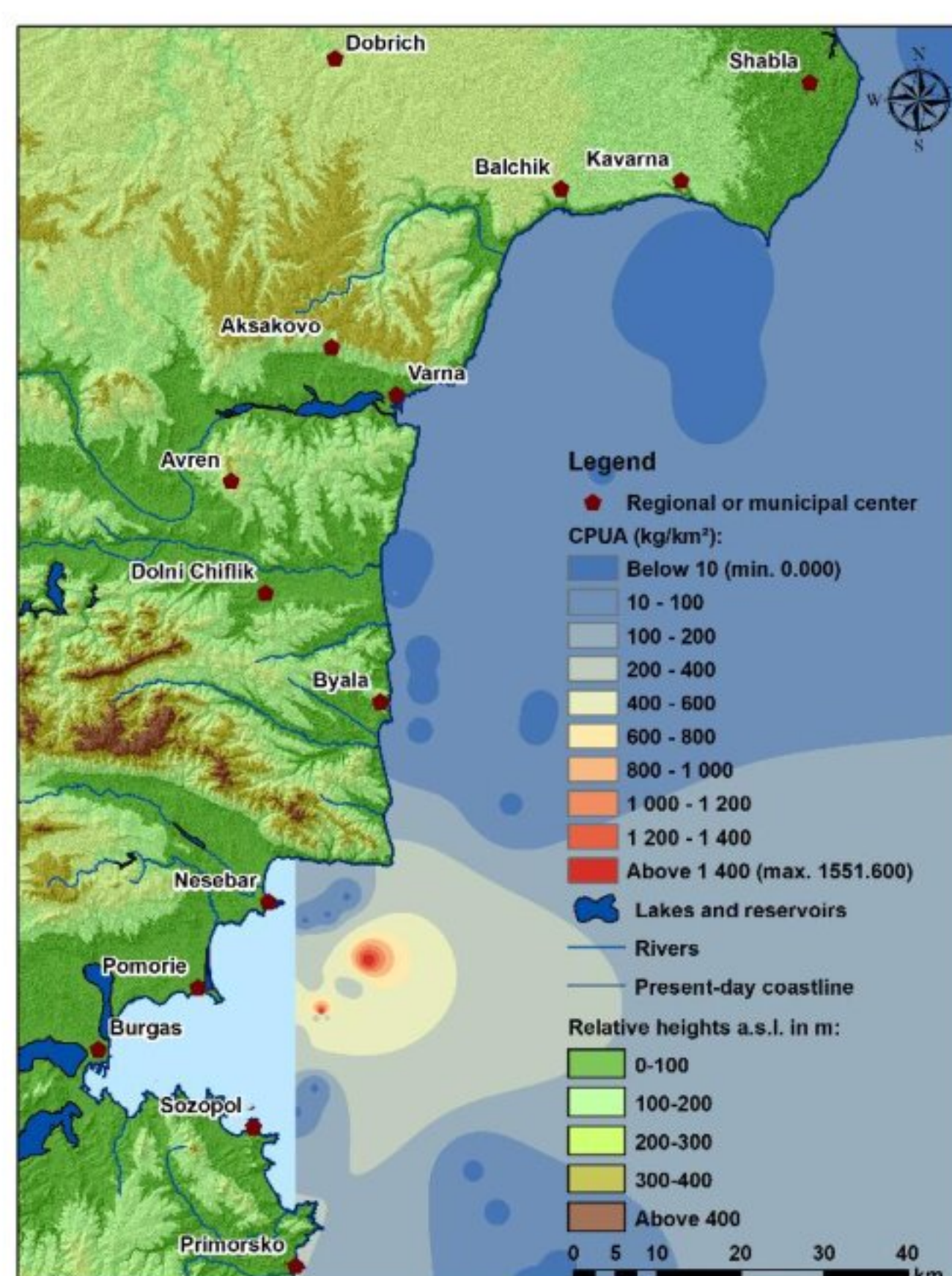


Figure 2.3.2.2. Catch per unit effort (CPUE kg.h⁻¹) of red mullet in October–November 2025.

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The length-weight (L–W) analysis of red mullet in October–November 2025 (Fig. 2.3.2.3) shows a very strong correlation between length and weight, with clearly expressed allometric growth ($R^2 = 0.99$) and a high determination coefficient ($n = 2.99$).

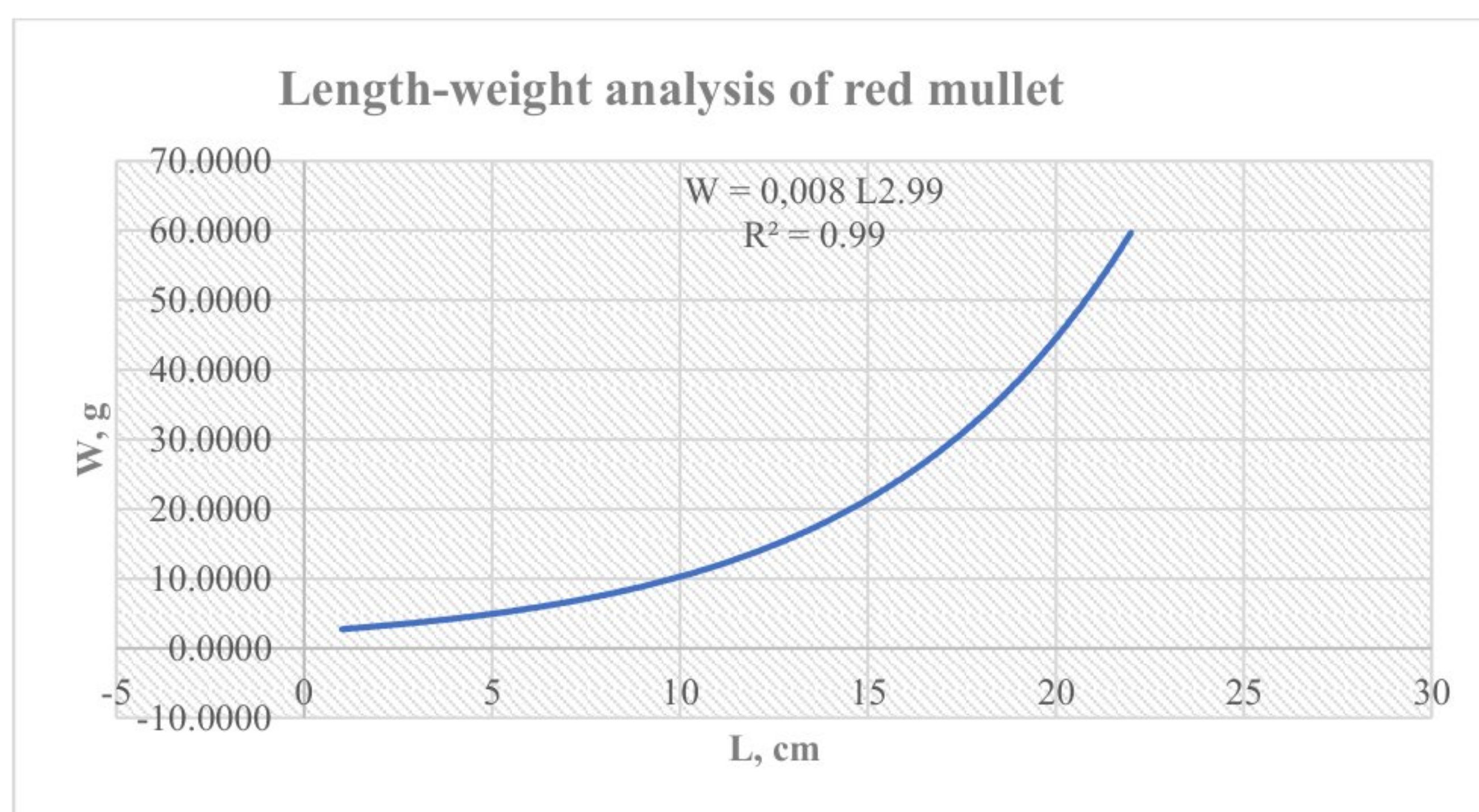


Figure 2.3.2.3. Length-weight analysis of red mullet (L-W) in October–November 2025.

The size structure of red mullet (1200 ind.) is presented in Figure 2.3.2.4. During the survey, the dominant size classes in the catch composition were 12 cm and 12.5 cm.

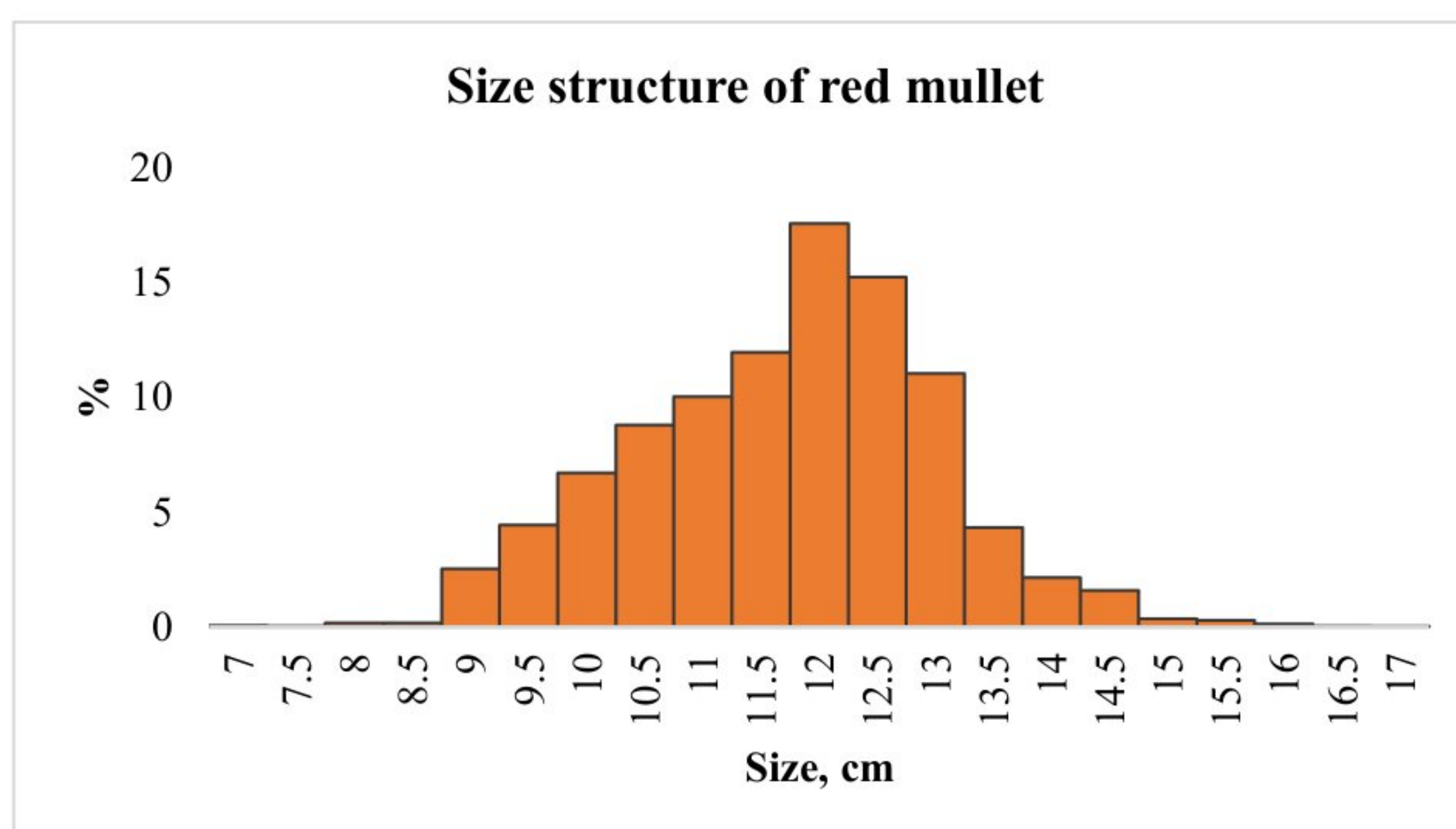


Figure 2.3.2.4. Size structure of red mullet in October–November 2025.

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Age group 2-2+ years was dominant, followed by 3-3+y⁻¹ and 1-1+y⁻¹ (500 ind). The remaining age groups had a negligible presence in the catches during October–November 2025 (Fig. 2.3.2.5).

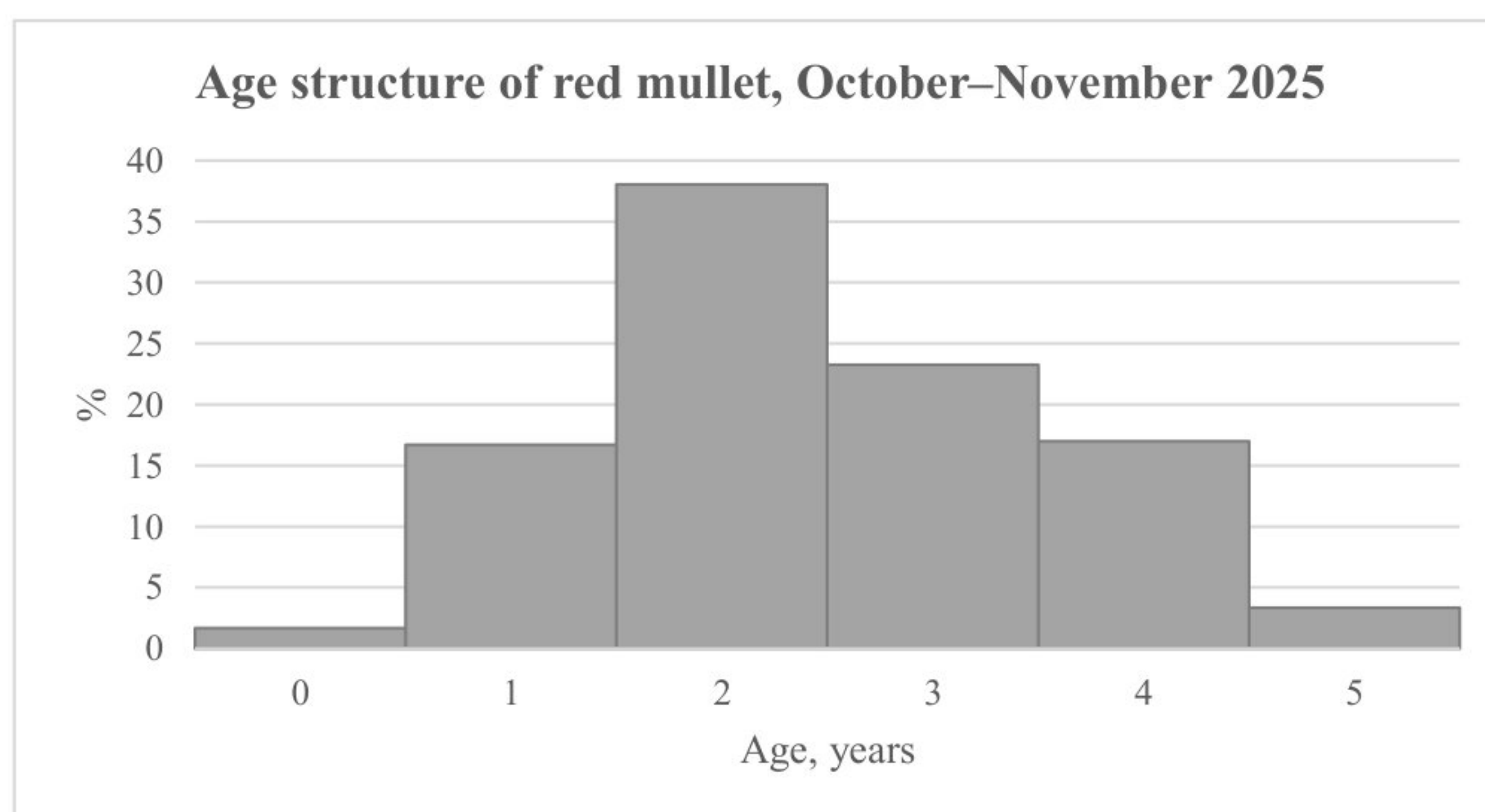


Figure 2.3.2.5. Age structure of red mullet, October–November 2025.

The growth parameters (1200 ind.) of red mullet, calculated using the von Bertalanffy model, indicate an asymptotic length of 18.41 cm and higher values of the coefficient that defines the rate of approaching the asymptote (Table 2.3.2.1).

Table 2.3.2.1. Von Bertalanffy growth model (VBGF) for red mullet.

Species	Asymptotic length	Growth rate	Growth parameter	Growth coefficient	Allometric coefficient
<i>M. barbatus</i>	$L_{\infty} = 18.4$	$K = 0.24$	$t_0 = -1.232$	$q = 0.009$	$n = 3.1194$

Somatic growth of red mullet by age did not show any deviations from the norm (Fig. 2.3.2.5).



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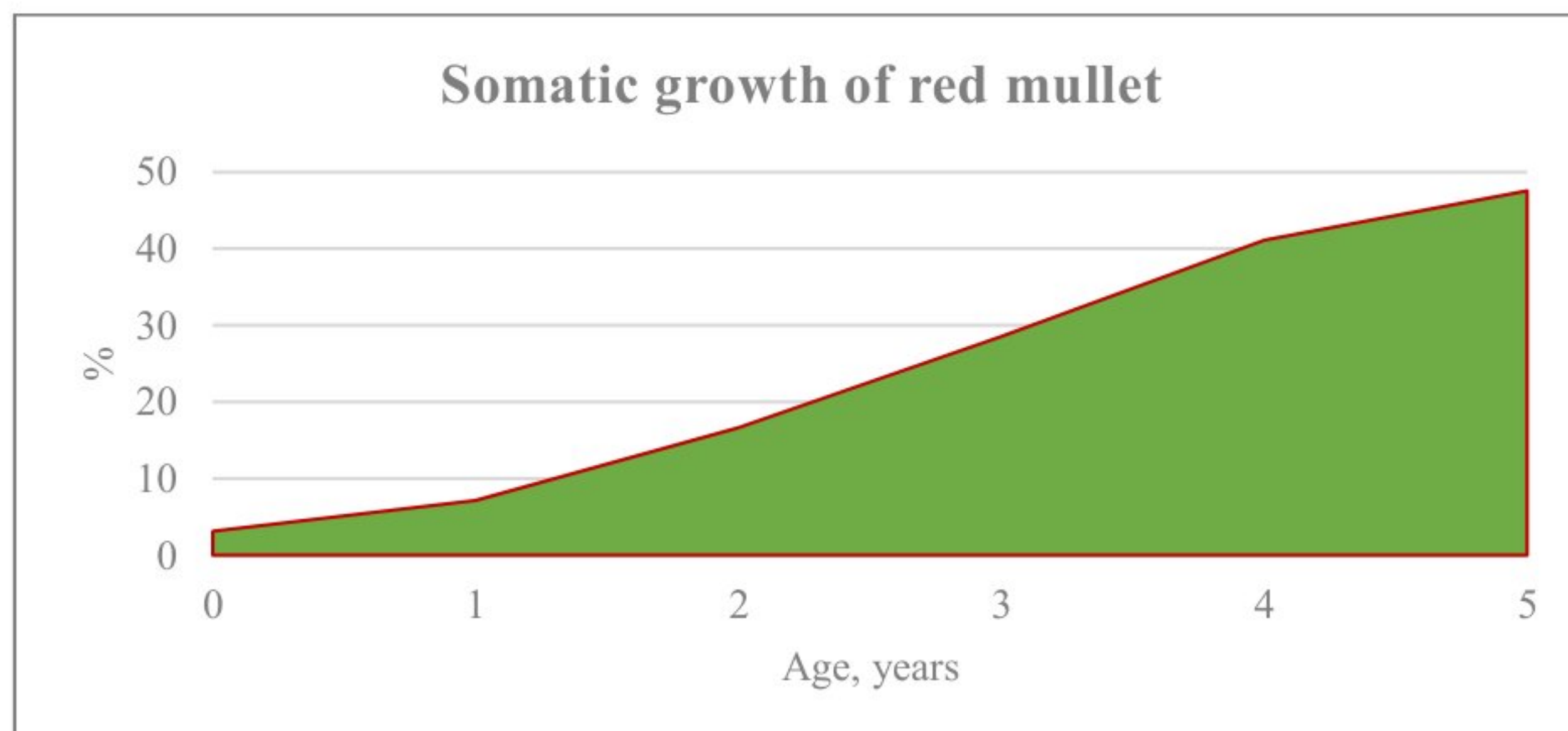


Figure 2.3.2.5. Somatic growth of red mullet by age.

2.3.3. Abundance and biomass by length and age classes

The 11 cm and 11.5 cm length classes dominated the red mullet catches, while larger length classes were represented by a smaller percentage (Fig. 2.3.3.1; Fig. 2.3.3.2).

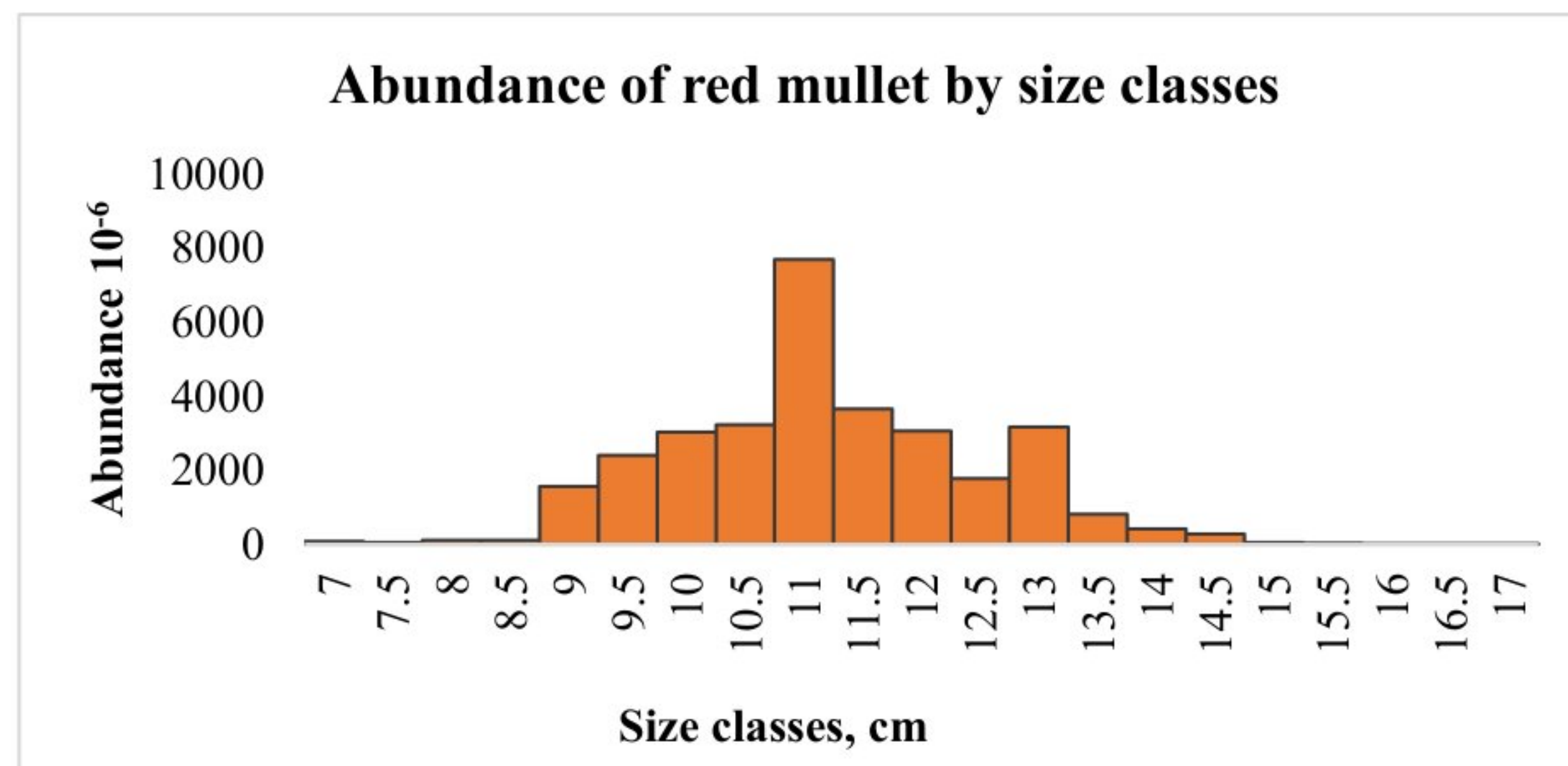


Figure 2.3.3.1. Abundance of red mullet by size classes.



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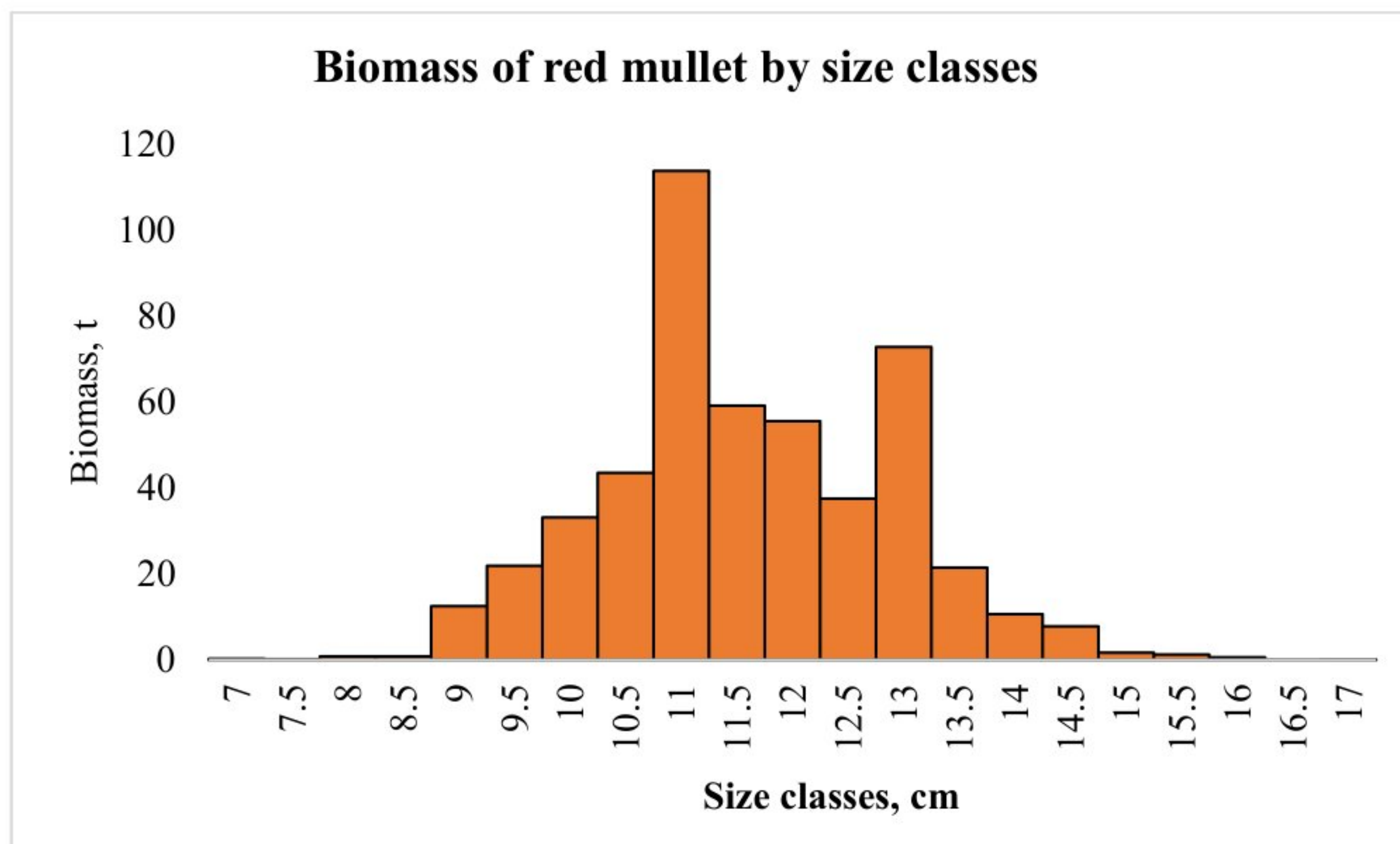


Figure 2.3.3.2. Biomass of red mullet by size classes.

The highest abundance was recorded in the 2-2+ year age group, followed by the 1-1+ year group. Older age groups are in subordinate presence (Fig. 2.3.3.3; Fig. 2.3.3.4).

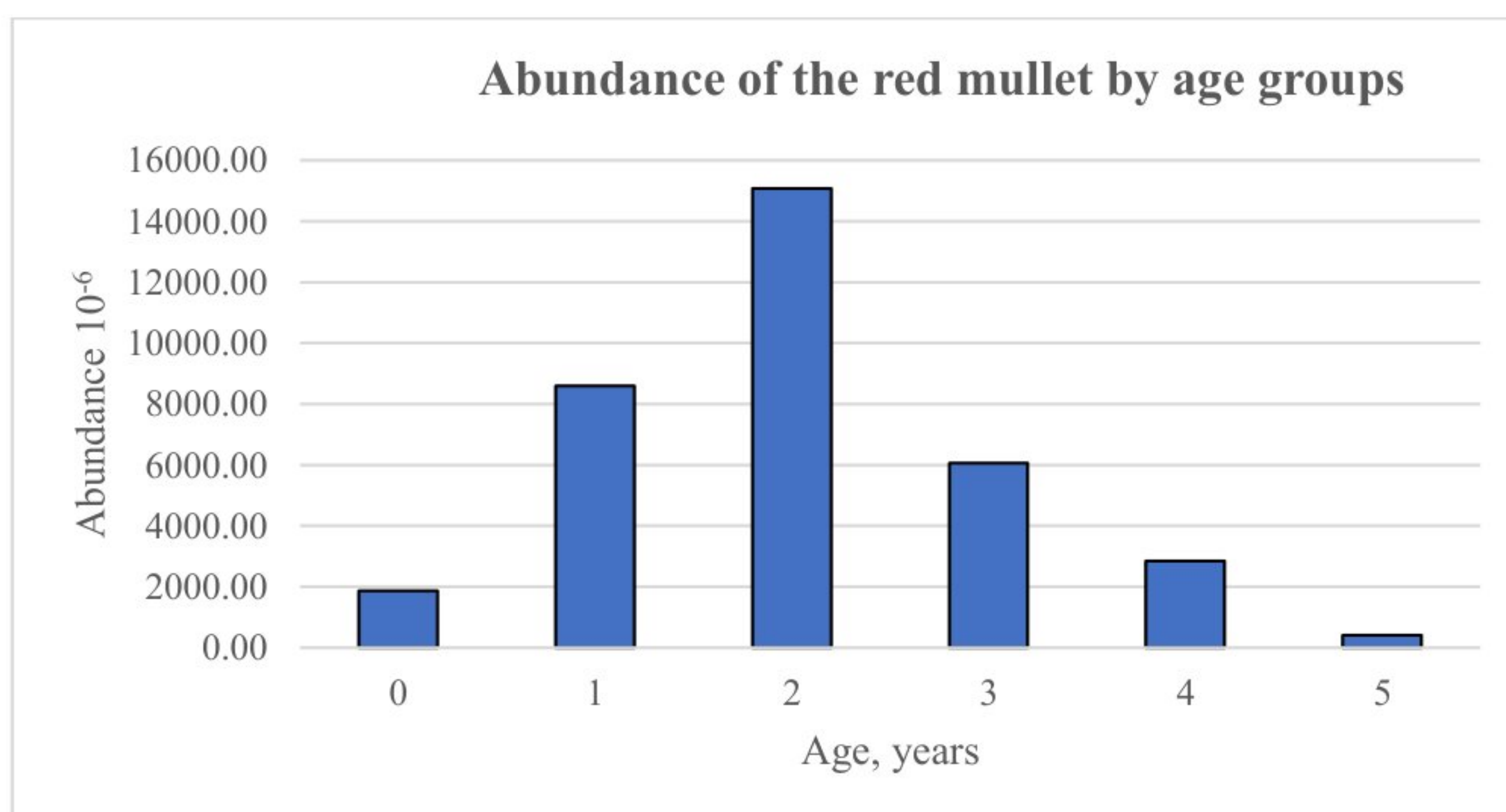


Figure 2.3.3.3. Abundance of the red mullet by age groups.



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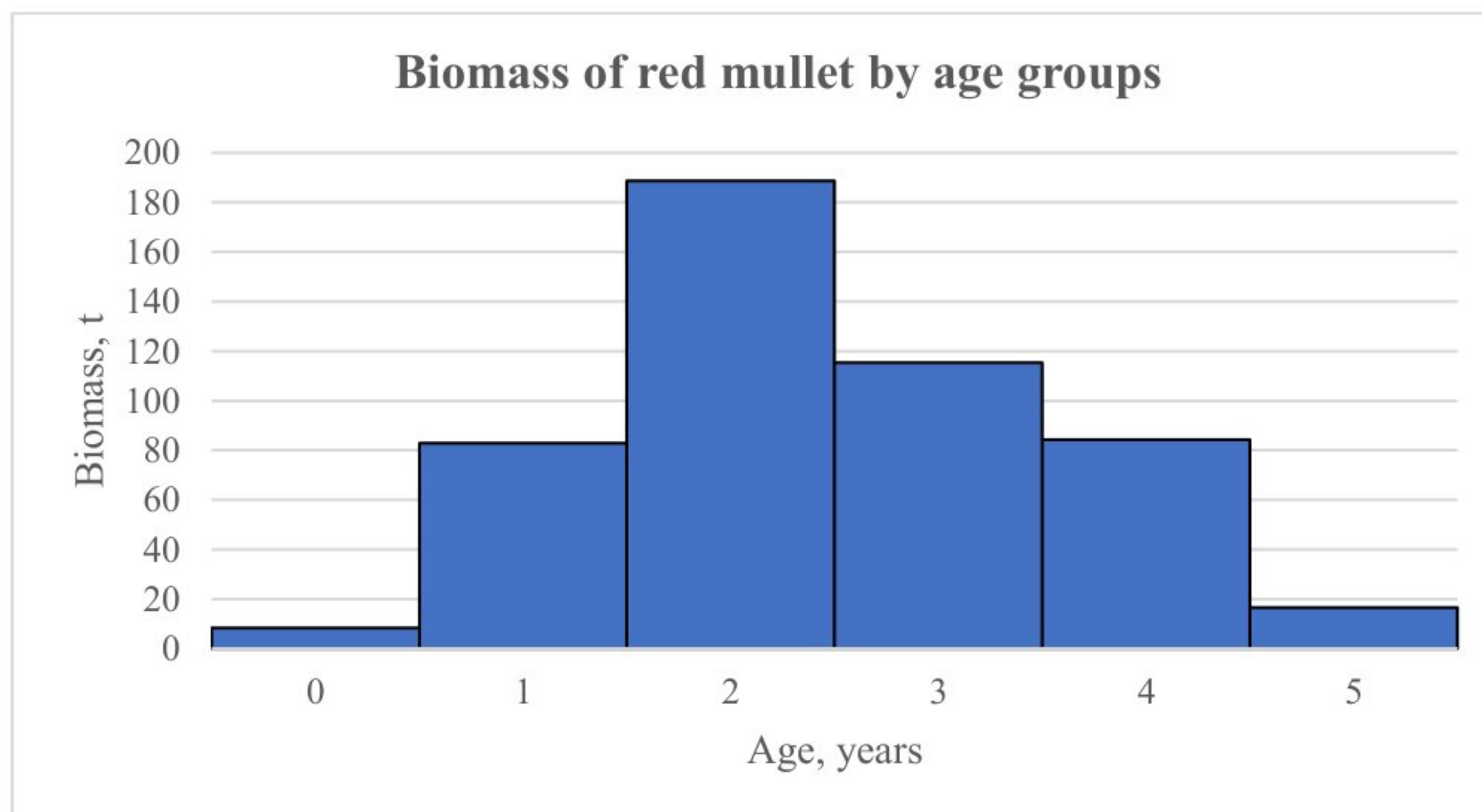


Figure 2.3.3.4. Biomass of red mullet by age groups.

2.3.4. Sex Ratio and Maturity

The percentage representation of females, males, and sexually immature individuals in red mullet was as follows: 47:45:8 (Fig. 2.3.4.1).

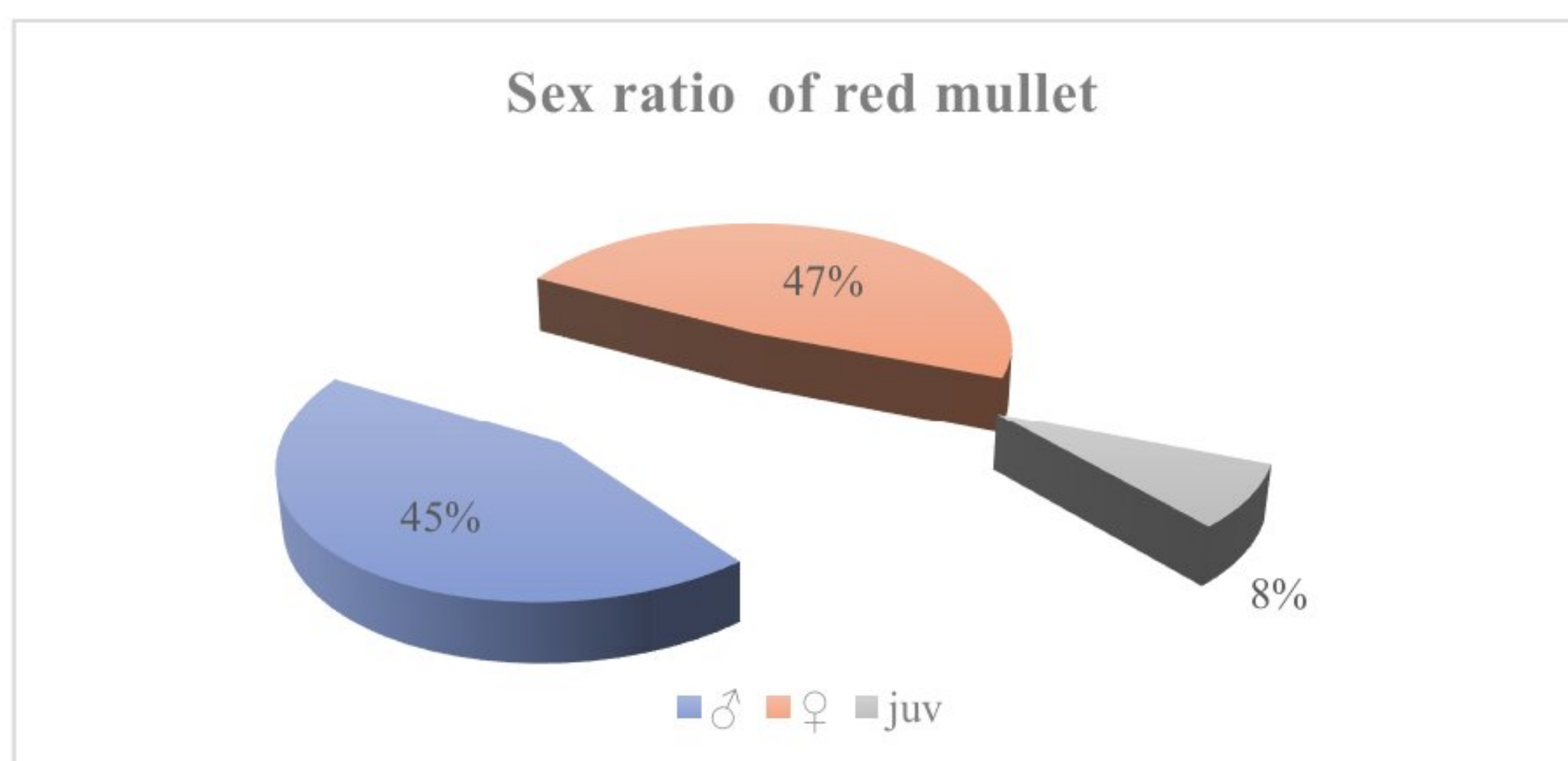


Figure 2.3.4.1. Sex ratio (females – ♀, males – ♂, and juveniles – juv) of red mullet in October–November 2025.

The sexual maturity of 250 individuals of the analyzed species by size classes is presented in Figure 2.3.4.2, and by age groups in Figure 2.3.4.3.



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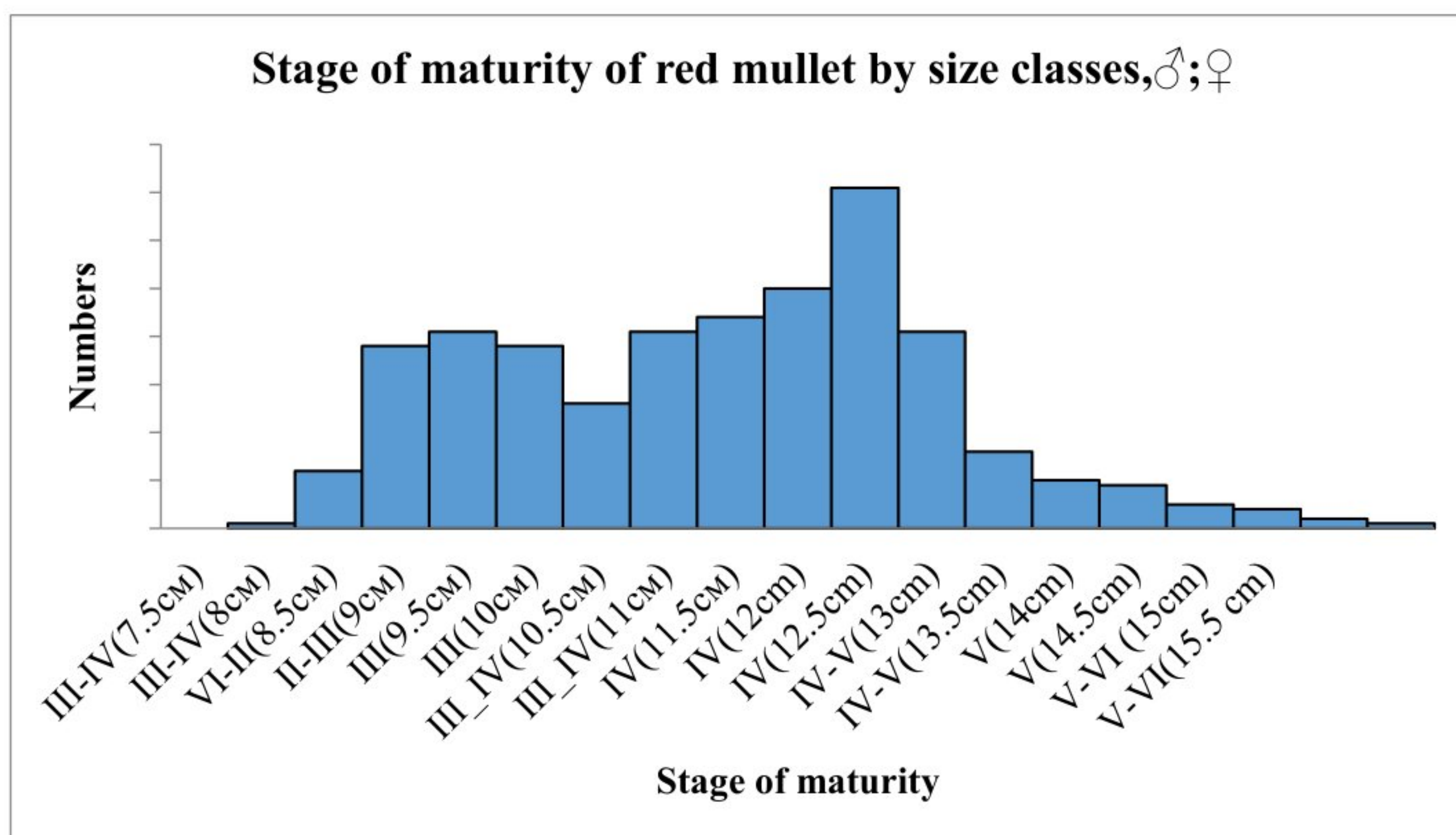


Figure 2.3.4.2. Sexual maturity of the studied species, analysed by size classes (females – ♀, males – ♂, and juveniles) of red mullet.

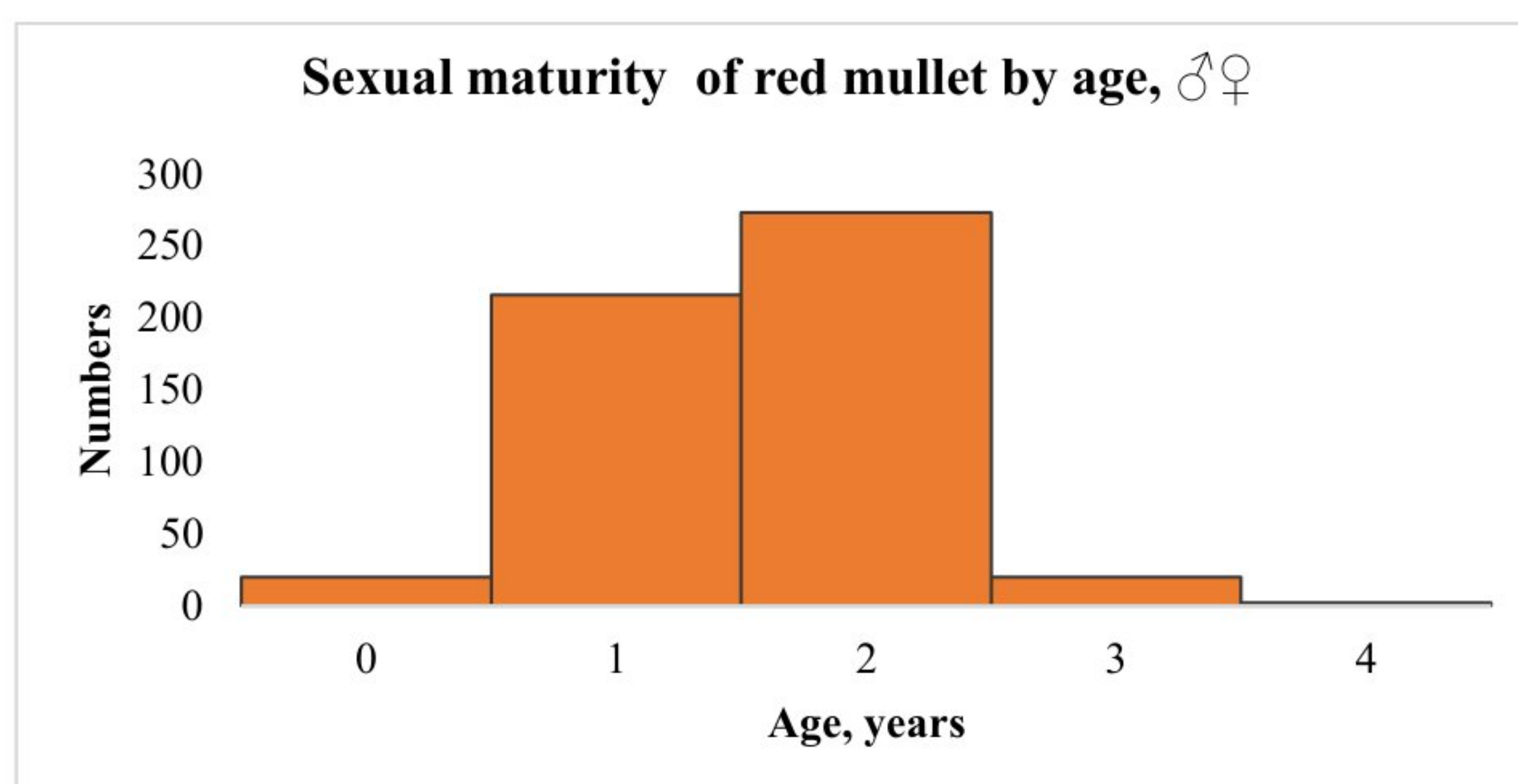


Figure 2.3.4.3. Sexual maturity (females – ♀, males – ♂, and juveniles) of the studied species, analysed by age groups.

2.3.5. Fecundity and Gonado-somatic index (GSI)

Red mullet (250 individuals) was in an active phase of gonadal development ($R^2 = 0.79$), likely related to the high sea water temperatures (Fig. 2.3.5.1).

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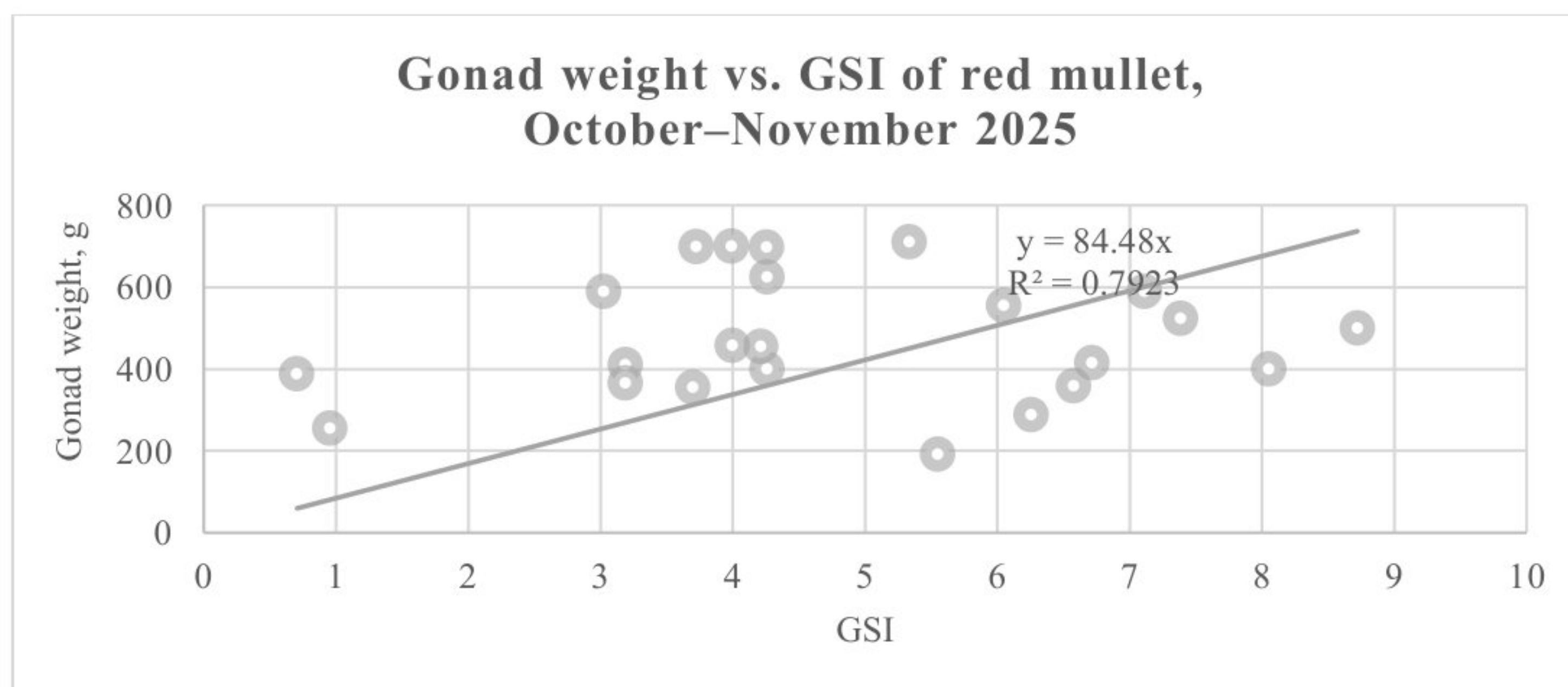


Figure 2.3.5.1. Sexual maturity (females – ♀, males – ♂ and juveniles – Juv) of red mullet by age groups.

2.3.6. Absolute and relative fecundity of red mullet

Absolute fecundity (measured on 250 individuals) at length of 16 cm was the highest: 11250 cavier grains. In terms of relative fecundity, the highest was detected at 9 cm TL individuals: 739.8. The mean values of absolute and relative fecundity of red mullet were as follows: 8738 and 429 (Table 2.3.6.1).

Table 2.3.6.1. Absolute and relative fecundity of red mullet, October–November 2025.

Size classes, cm	Mean weight, (g)	Mean lenght, (cm)	Absolute fecundity F, cavier grains	Relative fecundity	Numbers
9	8.11	9.12	6000±345	739.8274	10
9.5	9.25	9.5	7150±451	772.973	10
10	10.89	10.05	7350±501	674.9311	10
10.5	13.13	10.6	7550±586	575.019	20
11	14.88	11.02	7600±346	510.7527	20
11.5	16.25	11.52	7900±452	486.1538	20
12	17.99	12.39	8200±502	455.8088	20
12.5	21.59	12.67	8300±587	384.4372	20
13	22.87	13.11	8350±347	365.1071	20
13.5	26.26	13.44	9111±453	346.9535	20
14	27.2	14.22	9780±503	359.5588	20
14.5	28.44	14.36	10233±588	359.8101	10

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15	34.59	15.09	10300±348	297.7739	10
15.5	39.02	15.69	10750±454	275.4997	10
16	44.99	16.4	11250±504	250.0556	10
16.5	46.33	17.1	10665±589	230.1964	10
17	50.02	17.36	10325±349	205.677	10
Average			8737.765	428.855	250

2.4. Whiting (*Merlangius merlangus*)

2.4.1. Distribution

Whiting inhabits the bottom depths and its main food is the sprat. The studied species is a predator and represents an important component of the food chain of other larger predators such as turbot and dolphins. During the study, whiting was not strongly represented in the catch composition, which is most likely a result of the higher than usual temperatures during the study period.

2.4.2 Biomass of whiting by strata

The highest value of whiting biomass was observed in the 50–100 m stratum – 5810 t. In the 30–50 m depth layer the values were 2042 t and 256 t in the 15–30 m layer (Fig. 2.4.2.1.).



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Biomass (tons) of Whiting - Second Expedition'2025

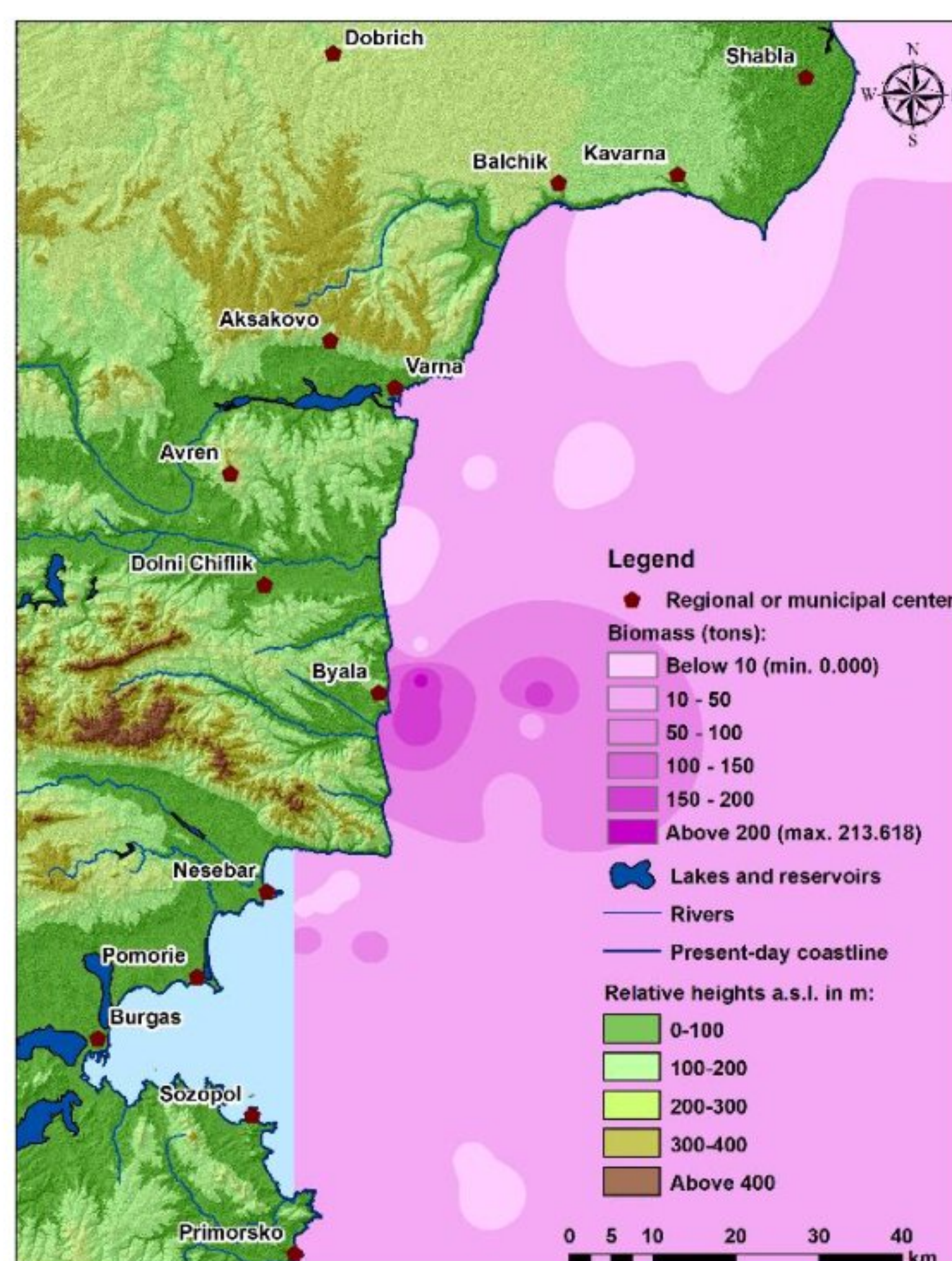


Figure 2.4.2.1. Distribution of whiting biomass by depth in October–November 2025. The total surveyed area was 8010.24 km², and the amount of total whiting biomass in the Bulgarian waters of the Black Sea in October–November 2025 amounted to 8109.2 tons (Table 2.4.2.1).

Table 2.4.2.1. Area method for stock survey in October–November 2025 – average values of catch per unit area (CPUA), Biomass (in kg), Ax – area and number of fields.

CPUA mean		Biomass (kg)	Area	Number of fields
124.128	15–30	256.3416996	2065.14	33
1125.427	30–50	2042.447804	1814.82	29
1406.784	50–100	5810.411857	4130.28	66
		8109.20136	8010.24	128

The descriptive statistics of the catch per unit area of whiting from October–November 2025 are presented in Table 2.4.2.2.

Table 2.4.2.2. Descriptive statistics of biomass indices by strata in October–November 2025.

Parameters	Descriptive statistics in stratum 15–30m	Descriptive statistics in stratum 30–50 m	Descriptive statistics in stratum 50–100 m
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Maximum	124.1280008	1125.427207	1406.784009
Minimum	38.38826538	362.5144408	462.6902564
Range	62.0640004	372.3840024	993.0240064
Size	62.0640004	310.320002	#N/A
Sum	132.9808521	1255.78686	1133.355037
Average	17683.90703	1577000.637	1284493.64
Median	2.64401856	-1.34377871	-1.253454236
Mode	1.979605911	0.833675877	0.804483196
Standart deviation	403.4160026	3096.99362	2792.880018
Varians	31.0320002	6.20640004	310.320002
Avg. range	434.4480028	3103.20002	3103.20002
Int.quartile	1489.53601	13505.12649	8440.704054
Deviation	12	12	6
Standard Error	434.4480028	3103.20002	3103.20002
Skewness	31.0320002	6.20640004	310.320002
Kurtosis	84.49200243	797.8889044	1189.383169
Coefficient of variation	124.1280008	1125.427207	1406.784009
Relative Standard Deviation	215.80%	190.33%	123.95%

2.4.3. Catch per unit area

Whiting was represented in the composition of the catches with the highest density of distribution of the species recorded in the Byala and Maslen Nos region (Fig. 2.4.3.1.). In the depth layer 15–30 m the species was registered at all 12 stations of this stratum. In the depth layer 30–50 m whiting was present at 13 stations. In the depth layer 50–100 m, the species is registered in 7 stations.

In the depth layer 30–50 m, the highest recorded value for CPUA was 3413 kg.km⁻², with an average value of CPUA – 1125.4 kg.km⁻². In the depth layer 15–30 m, 124 kg.km⁻² and 50–100 m – 1406.88 kg.km⁻² (Fig. 2.4.3.1.).



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CPUA (kg/km²) of Whiting - Second Expedition'2025

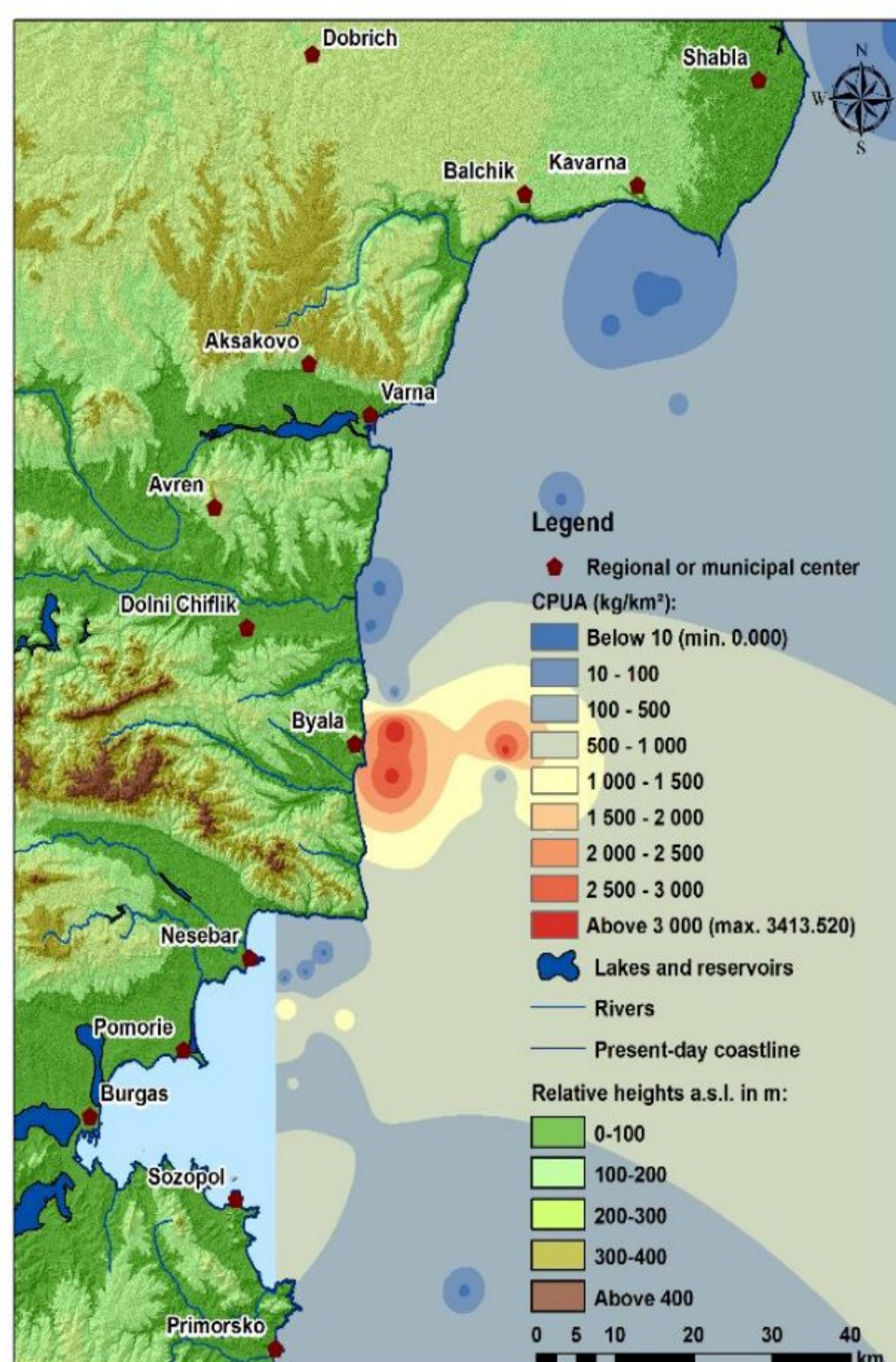


Figure 2.4.3.1. Catch per unit area (CPUA kg.km⁻²) and biomass of whiting in October–November 2025.

2.4.4. Catch per unit effort

Catch per unit effort for the identified species is presented in Fig. 2.4.4.1, with the highest value of CPUE kg.h⁻¹ recorded in the area off the town of Byala and southwards toward Maslen Nos.



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CPUE (kg/h) of Whiting - Second Expedition'2025

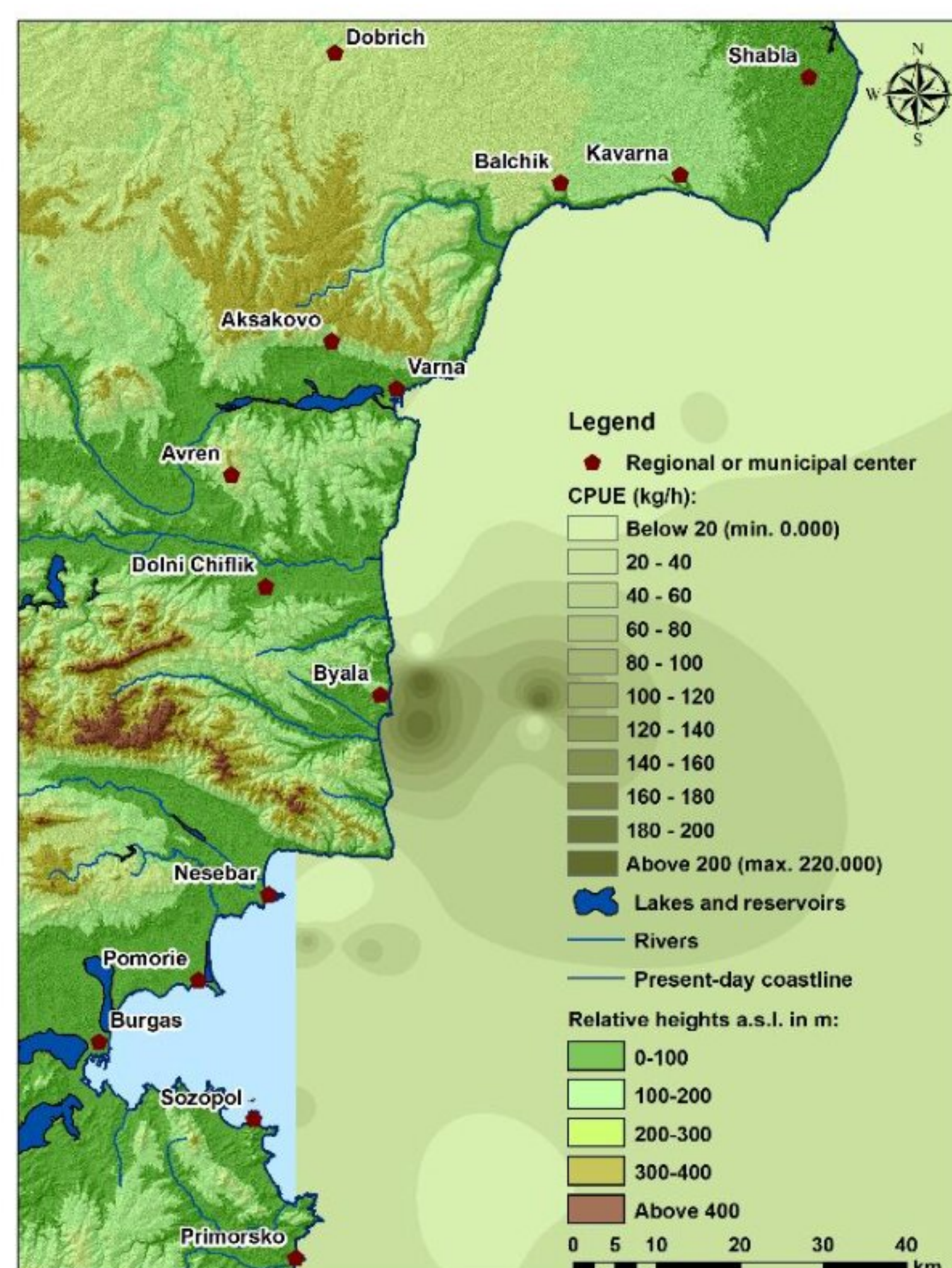


Figure 2.4.4.1. Catch per unit effort (CPUE $\text{kg}\cdot\text{h}^{-1}$) of whiting, October–November 2025.

2.4.5. Size structure

The size distribution of whiting (1200 individuals) showed a normal pattern, with peaks at 10.5 cm and 12.5cm (Fig. 2.4.5.1).



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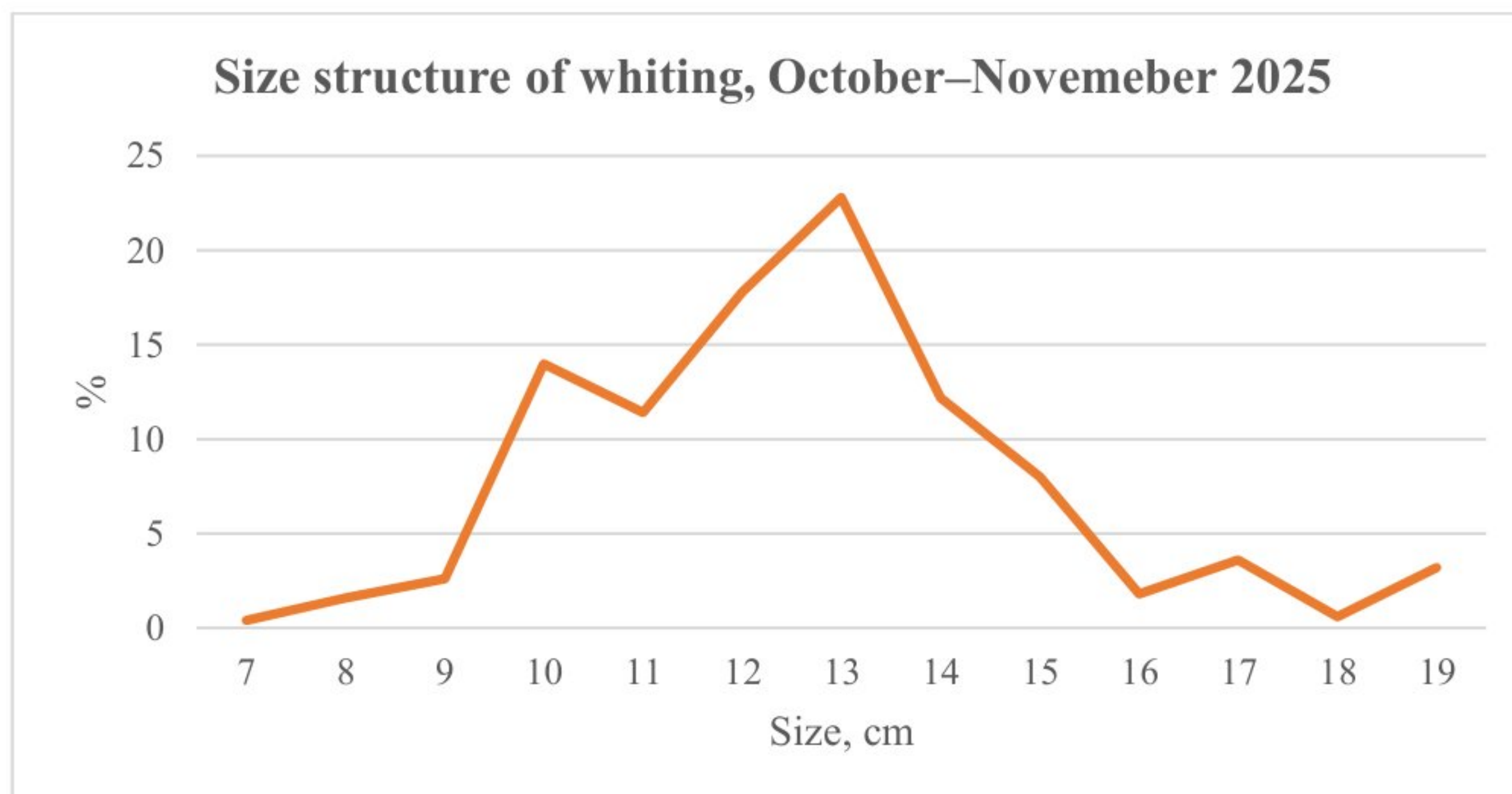


Figure 2.4.5.1. Size structure of whiting in October–November 2025.

The weights of the whiting specimens (1200 individuals) ranged from 3.18 to 26.91 g in the present study (Fig. 2.4.5.2).

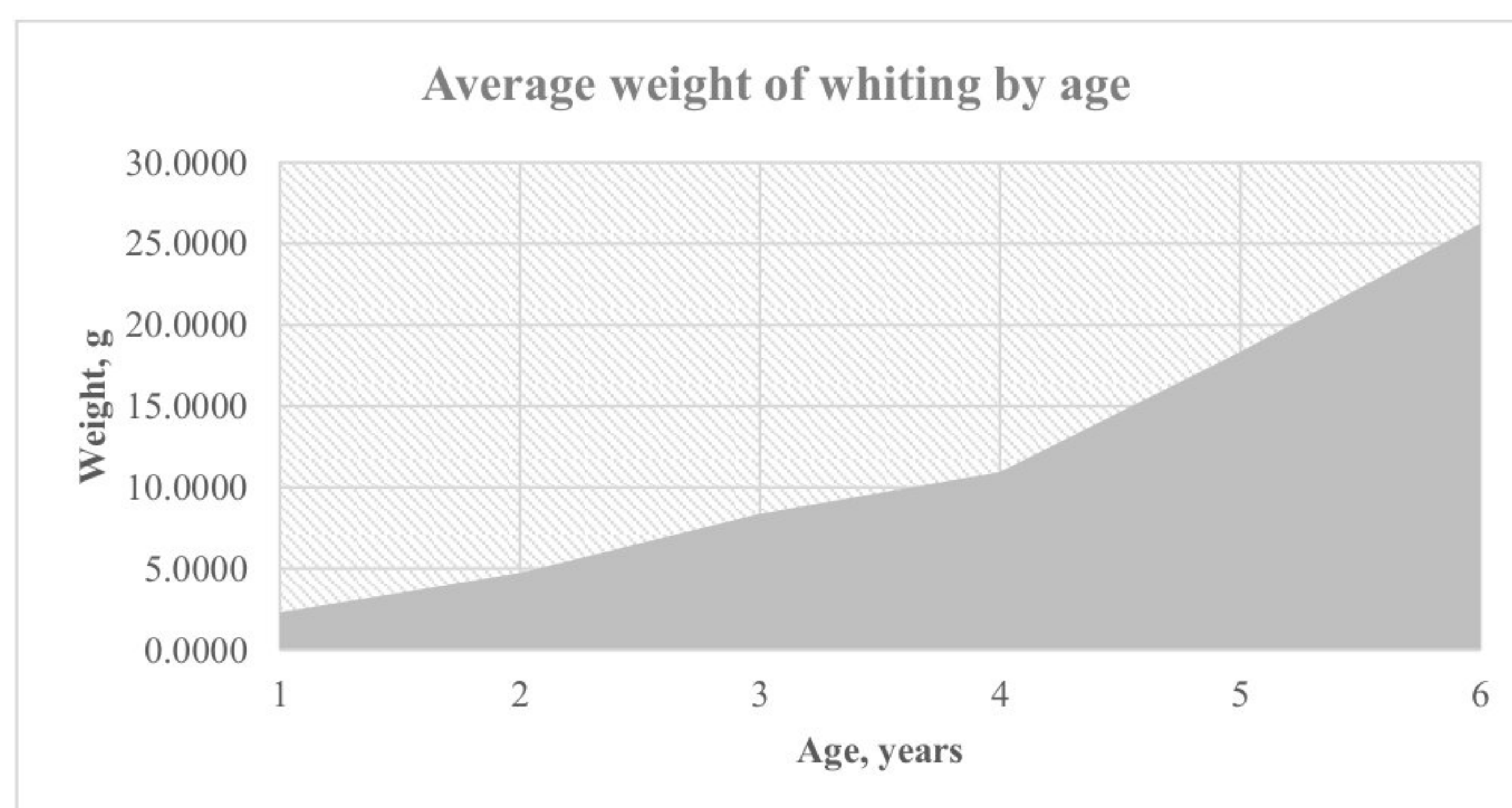


Figure 2.4.5.2. Average weight of whiting by age in October–November 2025.

In the catches from the autumn 2025 survey, individuals aged 3–3+ years (28%) and 2–2+ years (20%) were predominant based on the sampling of 1200 individuals (Fig. 2.4.5.3).



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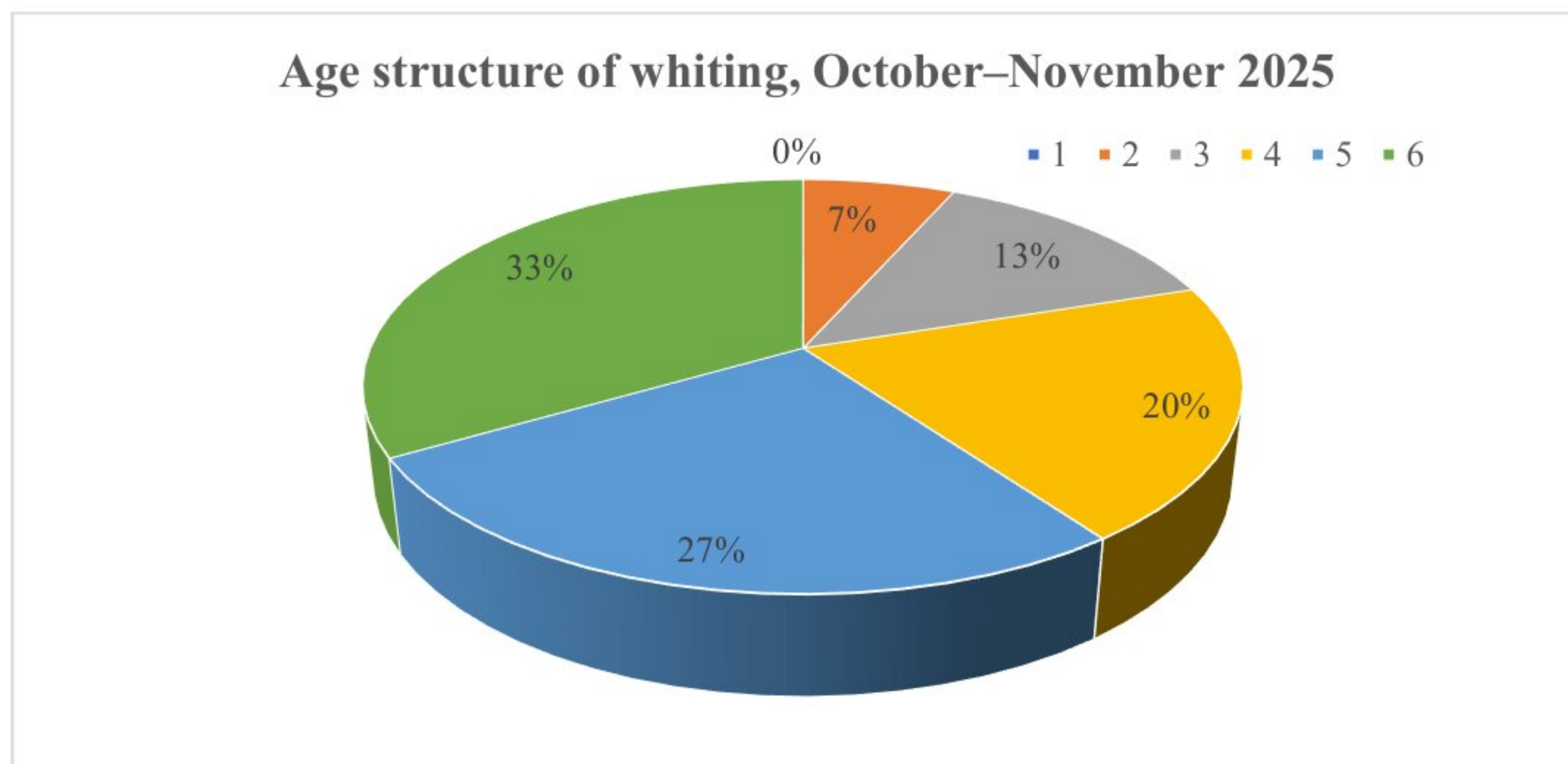


Figure 2.4.5.3. Age distribution of whiting in October–November 2025.

The length–weight relationship for the species showed a very high degree of reliability ($R^2 = 0.96$) (Fig. 2.4.5.4).

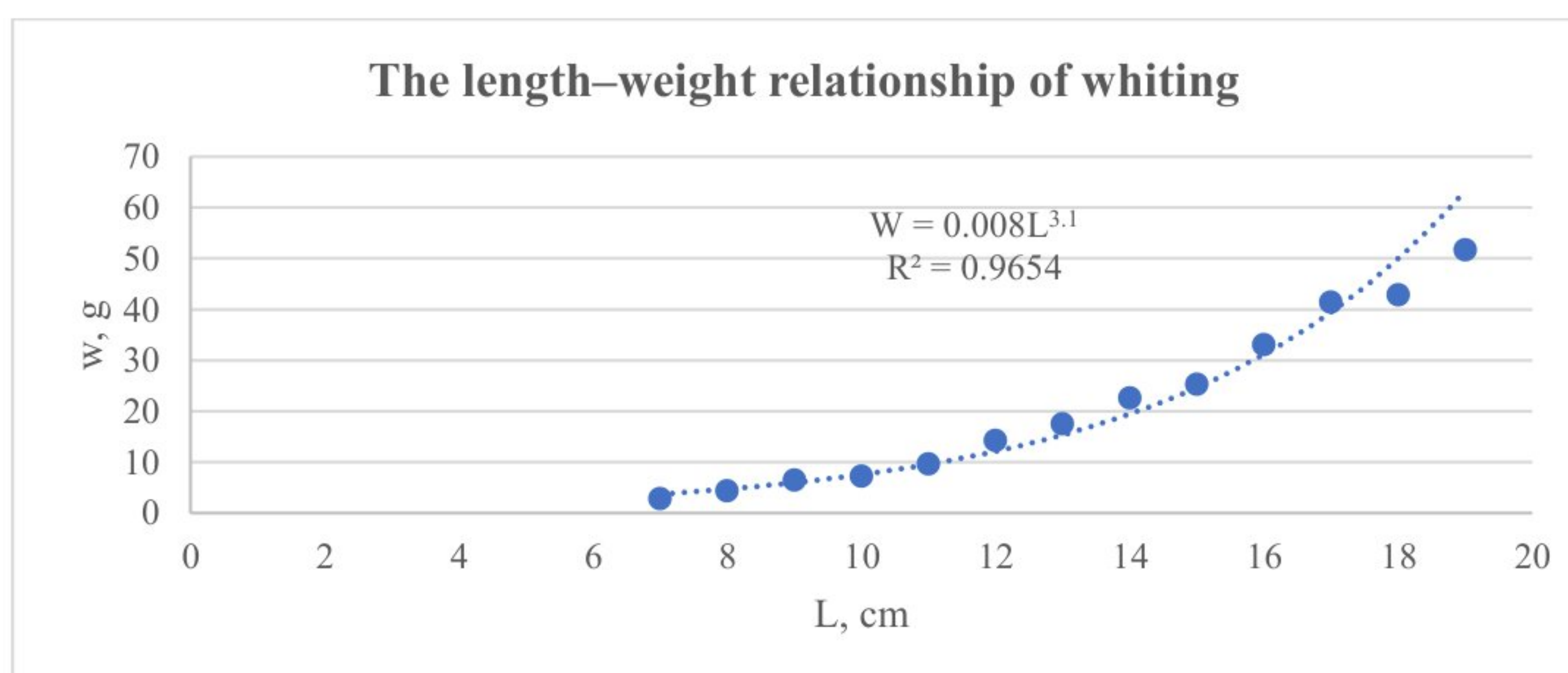


Figure 2.4.5.4. The length–weight relationship of whiting in October–November 2025.

To determine the growth parameters, the von Bertalanffy Growth Function (VBGF) was applied. The calculated growth parameters (1200 individuals) are presented in Table 2.4.5.1. The asymptotic length (L_∞) of whiting reached 27.6 cm, with a growth rate that can be classified as low ($k = 0.23$).

Изчислените растежни параметри (1200 екземпляра) са показани в Таблица 2.4.5.1. Асимптотичната дължина (L_∞) на меджида достигна 27.6 cm, като скоростта на растежа може да бъде определена като ниска ($k = 0.23$).

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Table 2.4.5.1. von Bertalanffy Growth Function of whiting.

Species	Asymptotic length	Growth rate	Growth parameter	Growth coefficient	Allometric coefficient
<i>M. merlangus</i>	$L_{\infty} = 27.6$	$K = 0.234$	$t_0 = -2.01$	$q = 0.008$	$n = 3.1$

In terms of sex ratio, females made up 50%, males 49%, and larvae 1% of the population (Fig. 2.4.5.5).

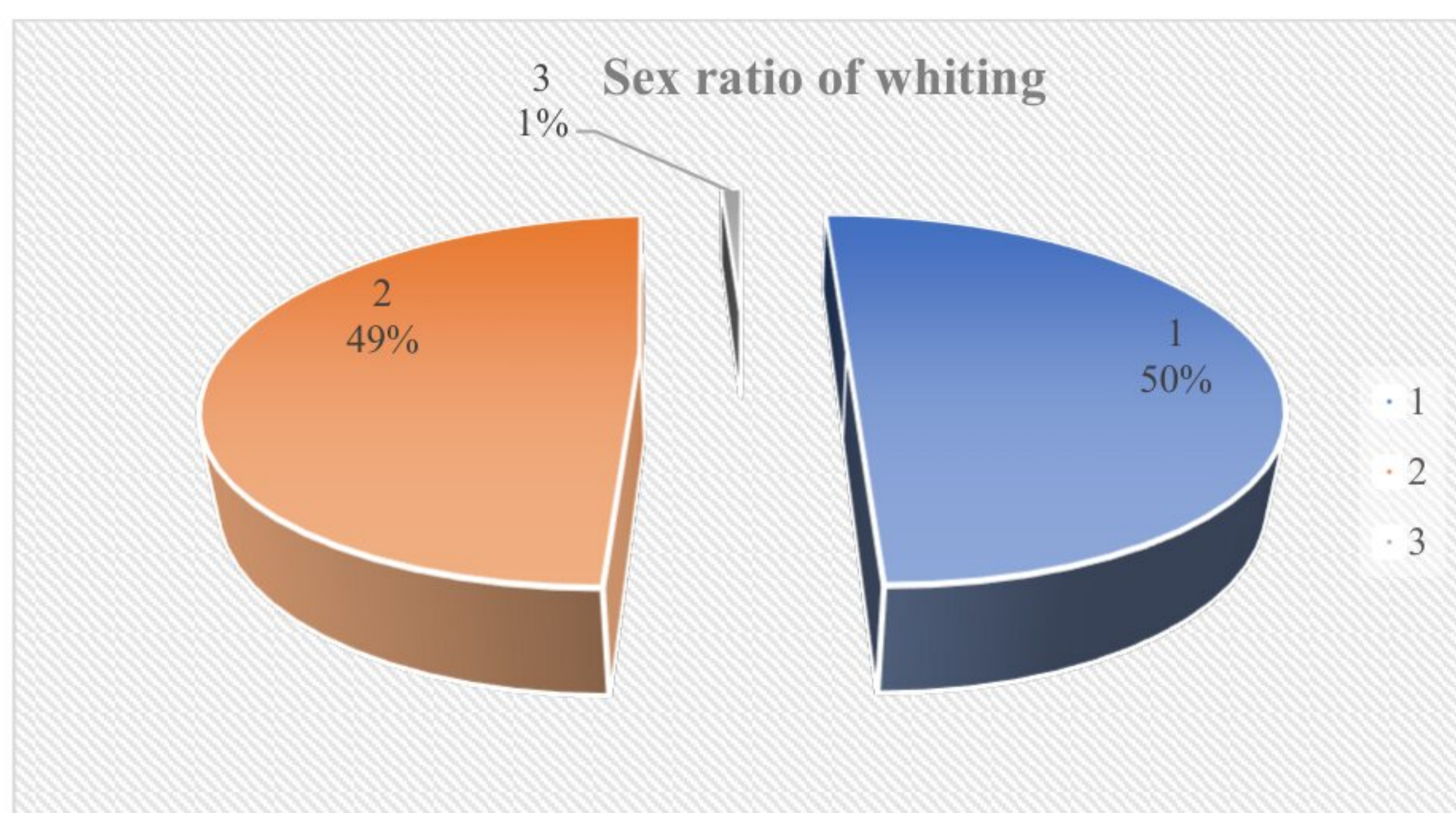


Figure 2.4.5.5. Sex ratio of whiting in October–November 2025.

2.4.6. Fecundity and gonadosomatic index (GSI)

The maturation of the gonads indicates the beginning of the species' active reproductive period. Due to the warmer weather, the spawning process is likely to intensify in the coming months, even at relatively lower sea water temperatures. The analysis of gonadal maturity in whiting based on 250 individuals showed that the gonads were in stages 2a to 3b, with no dominance of a particular size group exhibiting a specific degree of gonad development. No deviations from the norm were observed in gonadal maturation, which, in terms of stage and intensity, corresponds to the species' active reproductive period (Fig. 2.4.6.1.).



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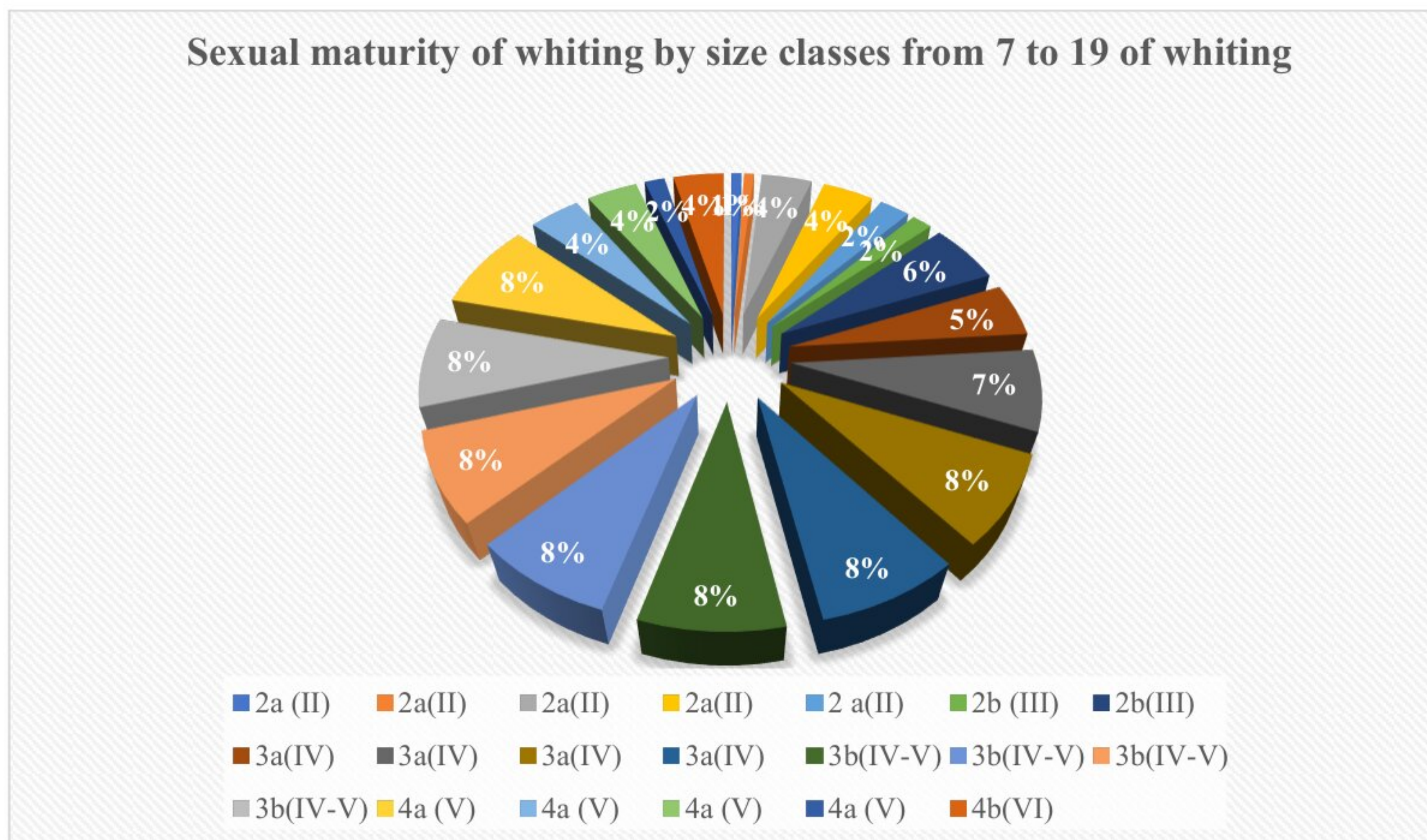


Figure 2.4.6.1. Sexual maturity of whiting analysed by size classes in October–November 2025.

Male and female individuals of whiting aged 3–3+ years had the highest presence in the catches, with a maturity stage of 3a (2.4.6.2).

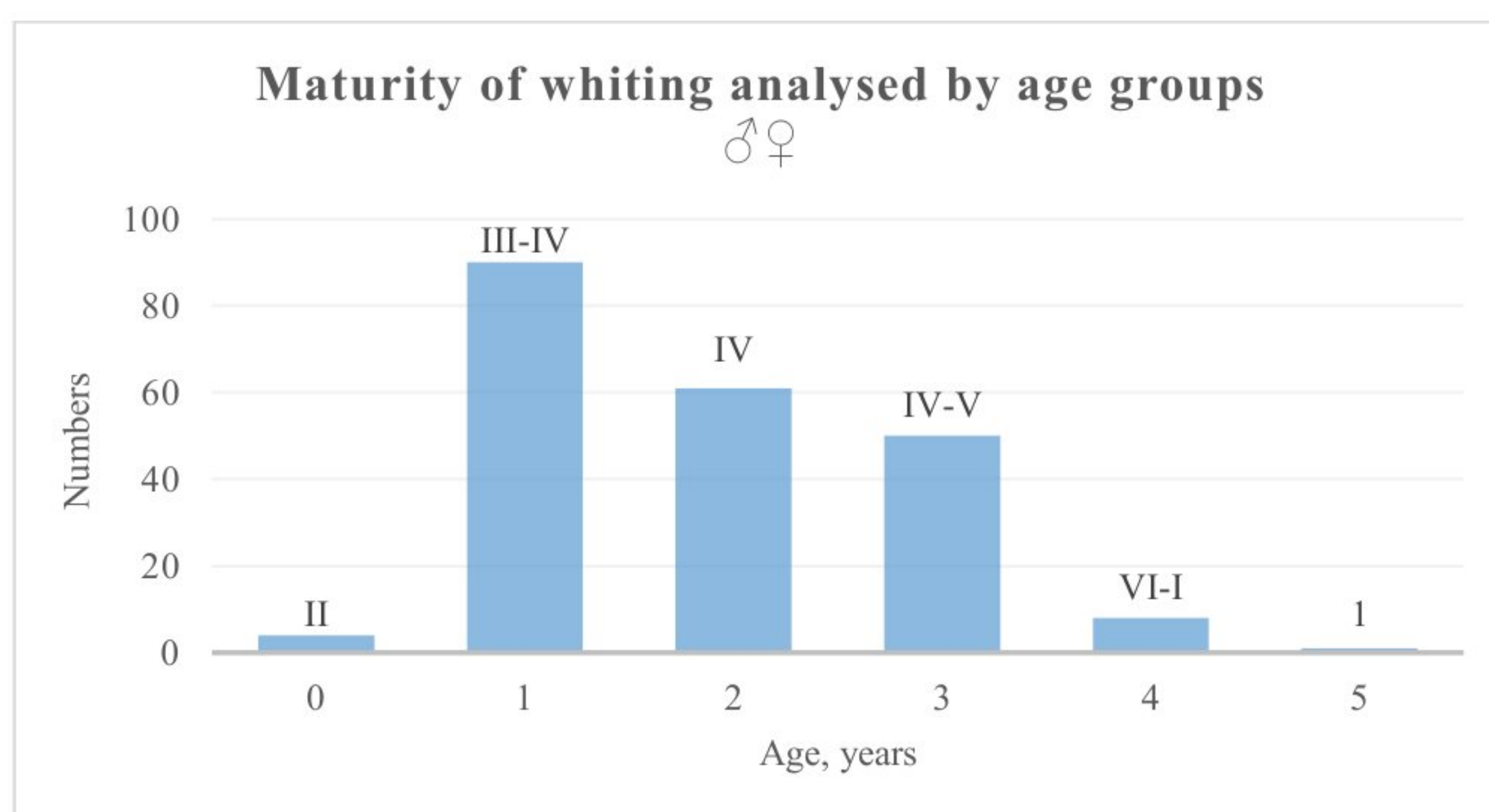


Figure 2.4.6.2. Maturity of whiting analysed by age groups.



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The weight of the gonads, compared to the gonadosomatic index, showed a high degree of reliability ($R^2 = 0.856$) (Fig. 2.4.6.3).

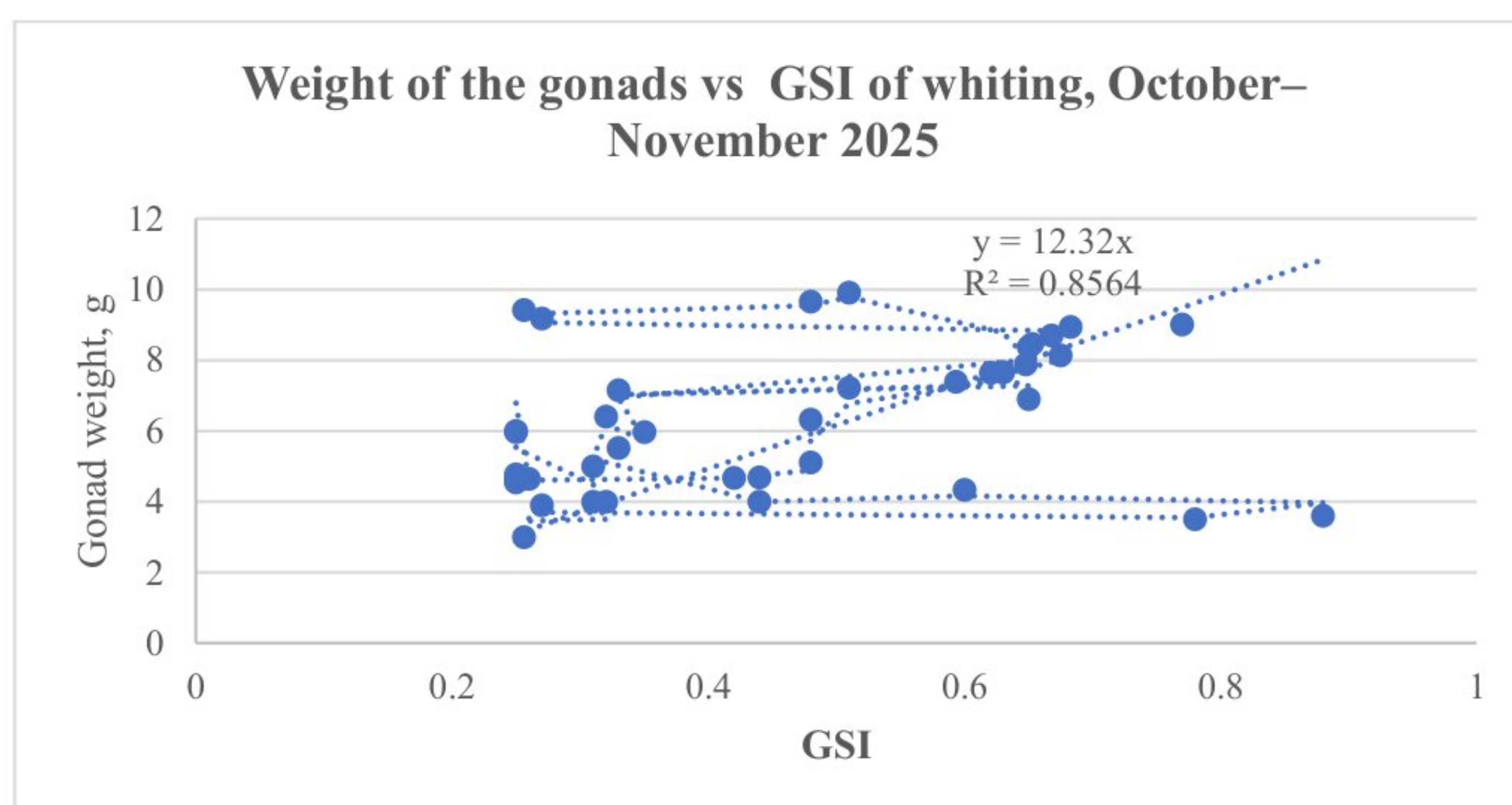


Figure 2.4.6.3. Gonad weight compared to the gonadosomatic index of whiting in autumn 2025.

2.4.7. Absolute and relative fecundity

Absolute fecundity (measured in 250 individuals) at a length of 17.5 cm was the highest, reaching 60322 caviar grains. In terms of relative fecundity, the highest value was detected in individuals with a total length (TL) of 14 cm, at 3247.66. The mean values of absolute and relative fecundity of the whiting were 40881.6 and 1480.86, respectively (Table 2.4.7.1).

Table 2.4.7.1. Absolute and relative fecundity of whiting, October–November 2025.

Size class, cm	Average weight, (g)	Average length, (cm)	Absolute fecundity (F, caviar grains)	Relative fecundity	Number
10	7.22	10.12	8300±242	1149.58±106	10
10.5	8.37	10.47	8522±112	1018.16±111	10
11	9.18	11.33	9835±212	1071.61±211	20
11.5	10.66	11.51	11706±146	1098.42±99	20
12	15.29	12.08	14800±112	967.95±77	20
12.5	14.6	12.48	28180±241	1930.14±112	20
13	15.63	13.15	36035±356	2305.02±89	20



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13.5	17.65	13.52	44250±388	2507.08±111	20
14	18	14.08	56744±412	3152.44±146	10
14.5	27.3	14.55	50112±455	1835.60±256	20
15	28.34	15.2	52418±652	1849.61±199	20
15.5	31.23	15.49	51115±705	1678.45±56	20
16	33.45	16.01	56425±1184	1528.1±63	10
16.5	36.58	16.5	46332±922	1542.5±58	10
17	49.1	17.22	46898±602	943.63±45	10
17.5	55.33	17.56	60322±512	847.61±99	7
18	62.58	18.14	61222±622	964.1±88	1
18.5	69.11	18.48	61100±500	885.9±76	1
19	71	18.95	60888±412	860.56±58	1
Average			40881.6	1480.86	250

2.5. Sprat (*Sprattus sprattus* L.)

2.5.1. Spatial distribution

In October–November 2025, the sprat was scattered in the nearshore area, mainly due to high water temperatures. The highest biomass values were recorded at depths of 30–50 m, reaching 4272.4 t. Sprat was recorded at 7 of the 36 studied stations.

2.5.2. Sprat biomass in different depth layers

In October–November 2025, the biomass of the sprat in the 15–30 m stratum was estimated at 0 tons, followed by the 30–50m stratum – 6870.7 tons and 50–100m – 25.7 tons (Fig. 2.5.2.1.).



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**Biomass (tons) of Sprat
- Second Expedition'2025**

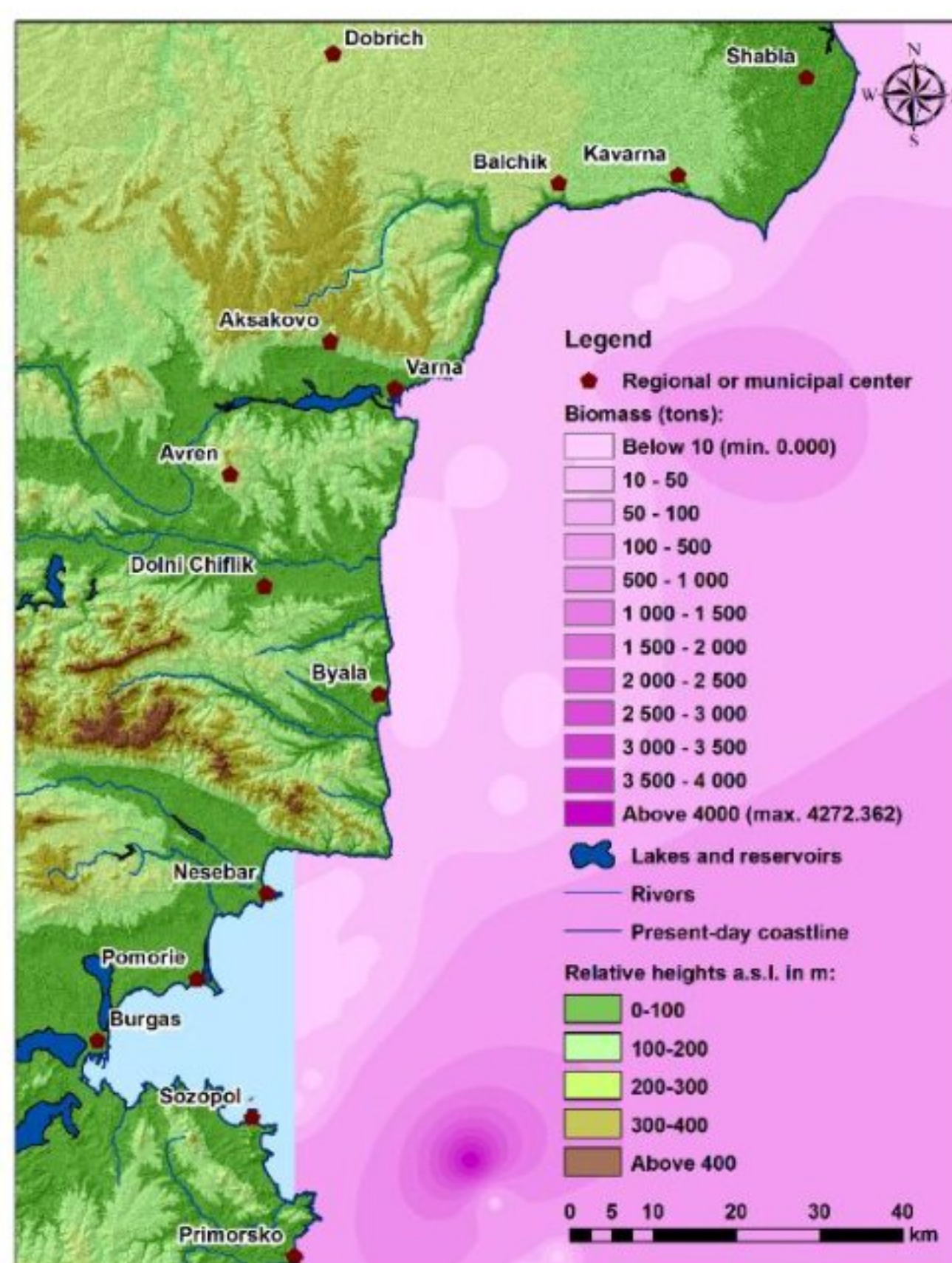


Figure 2.5.2.1. Distribution of the sprat biomass by depth layers (strata) in October–November 2025.

The biomass in the 30–50 m stratum had the highest value (in the Sozopol–Primorsko area), as the seawater temperature decreased compared to September 2025, and a clear migration of aggregations toward the coastal areas was observed (Tables 2.5.2.1 and 2.5.2.2). The total surveyed area was 8010.24 km², and the estimated total biomass of the sprat stock was 6896.4 t. Compared to September 2025, the instantaneous biomass of sprat along the Bulgarian Black Sea coast decreased by 93% in October–November. This indicates the high dynamics of sprat schools and the influence of external factors, such as hydrometeorological conditions and predation, on the distribution of small pelagic fish.

Table 2.5.2.1. Area method for surveying the sprat stock in October–November 2025 – average values of catch per unit area (CPUA), biomass (in kg), Ax – area and number of fields.

CPUA avg	Strata	Biomass (kg)	Ax area	Number of fields
0	15-30	0	2065.14	33
3785.9	30-50	6870.727	1814.82	29
6.21	50-100	25.64904	4130.28	66
		6896.376	8010.24	128

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Table 2.5.2.2. Descriptive statistics of biomass indices by strata in October–November 2025.

Parameters	Descriptive statistics in 15–30 m stratum	Descriptive statistics in 30–50 m stratum	Descriptive statistics in 50–100 m stratum
Maximum	0	3785.904	1.24128
Minimum	0	3098.013	1.24128
Range	0	0	0
Size	0	0	0
Sum	0	14530.97	2.775586
Average	0	2.11E+08	7.70388
Median	0	21.11565	5
Mode	0	4.561801	2.236068
Standard error	0	68270.4	6.2064
Variance	0	0	0
Mid-range	0	68270.4	6.2064
Int.quartile	0	83289.89	1
Deviation	0	22	5
Skewness	0	68270.4	6.2064
Kurtosis	0	0	0
C.of variation	0	6442.671	3.446346
Rel.St.Dev.	0	348	155
Maximum	0	248	412

2.5.3. Catch per unit area

The catch per unit area (CPUA, $\text{kg} \cdot \text{km}^{-2}$) was relatively high in the 50–100 m stratum, with the formation of aggregations atypical for sprat. The densest schools were recorded off Primorsko and southeast of Sozopol (30–50 m), while in the other surveyed areas the species was more dispersed in terms of spatial distribution (Fig. 2.5.3.1)



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CPUA (kg/km²) of Sprat - Second Expedition'2025

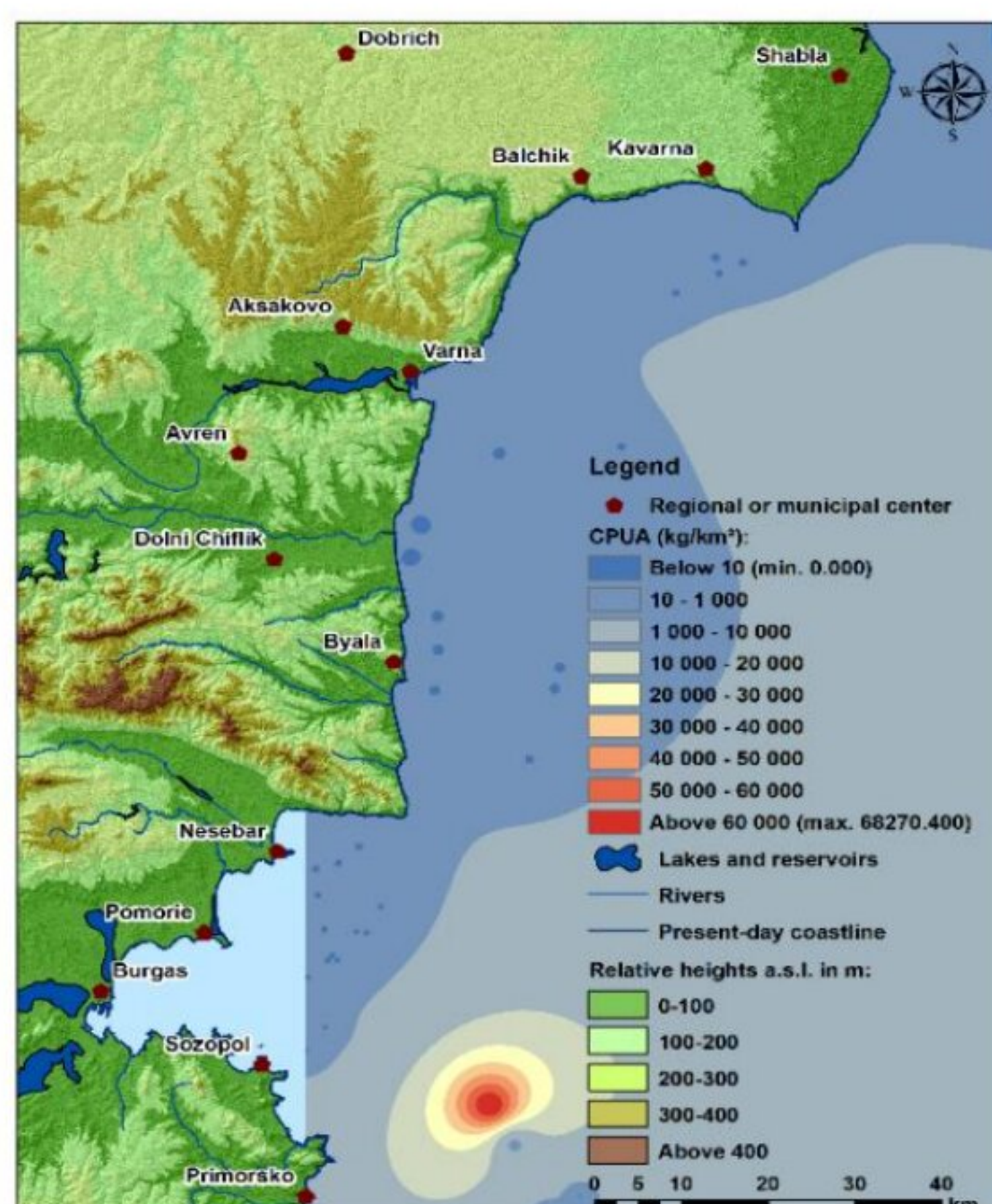


Figure 2.5.3.1. Catch per unit area (CPUA kg·km⁻²) of the sprat by depth layers - spatial distribution, October–November 2025.

2.5.4. Catch per unit effort

The catch per unit effort (CPUE) for the identified species is spatially represented with GIS (Fig. 2.5.4.1.).



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**CPUE (kg/h) of Sprat
- Second Expedition'2025**

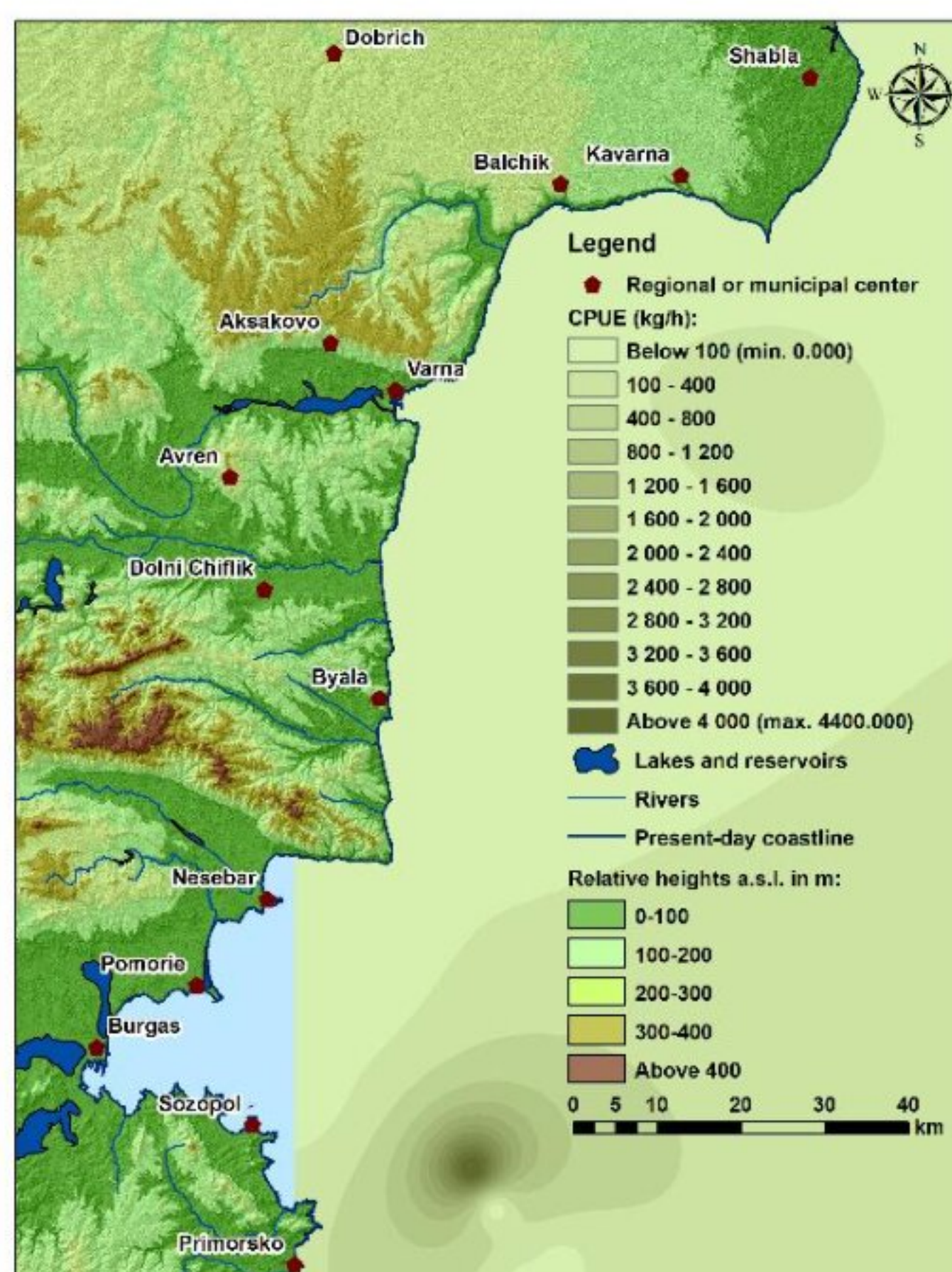


Figure 2.5.4.1. Catch per unit effort by depth layers for the sprat in October–November 2025.

The length structure of the sprat stock is presented in Fig. 2.5.4.2. During the survey in October–November 2025, the smallest identified length class was 6 cm and the largest was 12 cm, with the dominant length classes in the catch being 7 cm and 10 cm. The other length classes were less represented in the catch composition.

The age distribution of sprat during the study period is shown in Fig. 2.5.4.3. A predominance of age groups 2–2+ years was observed, followed by 3–3+ years. Juvenile individuals and the older age groups (4–4+ years) had minimal representation.



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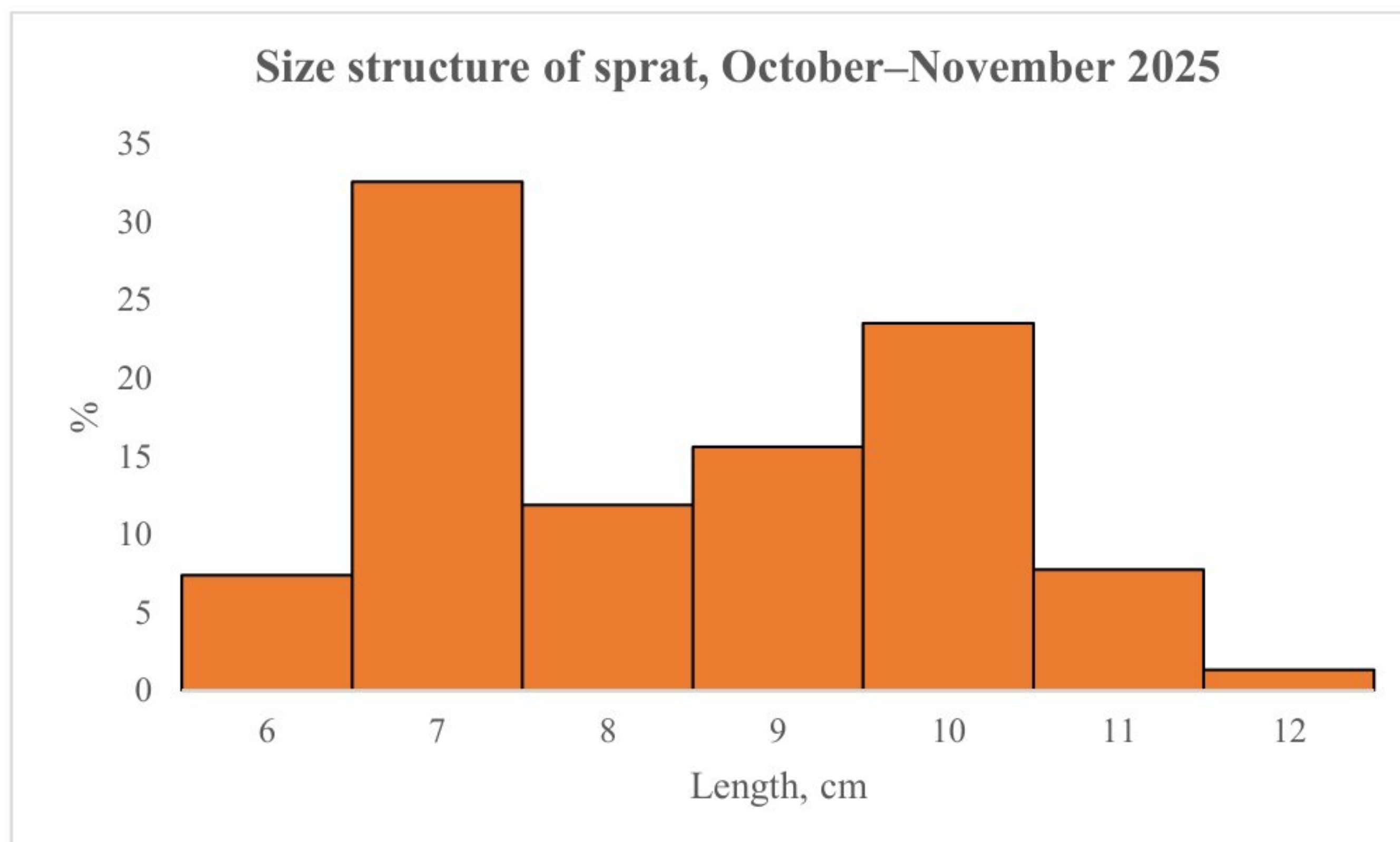


Figure 2.5.4.2. Size structure of sprat, October–November 2025.

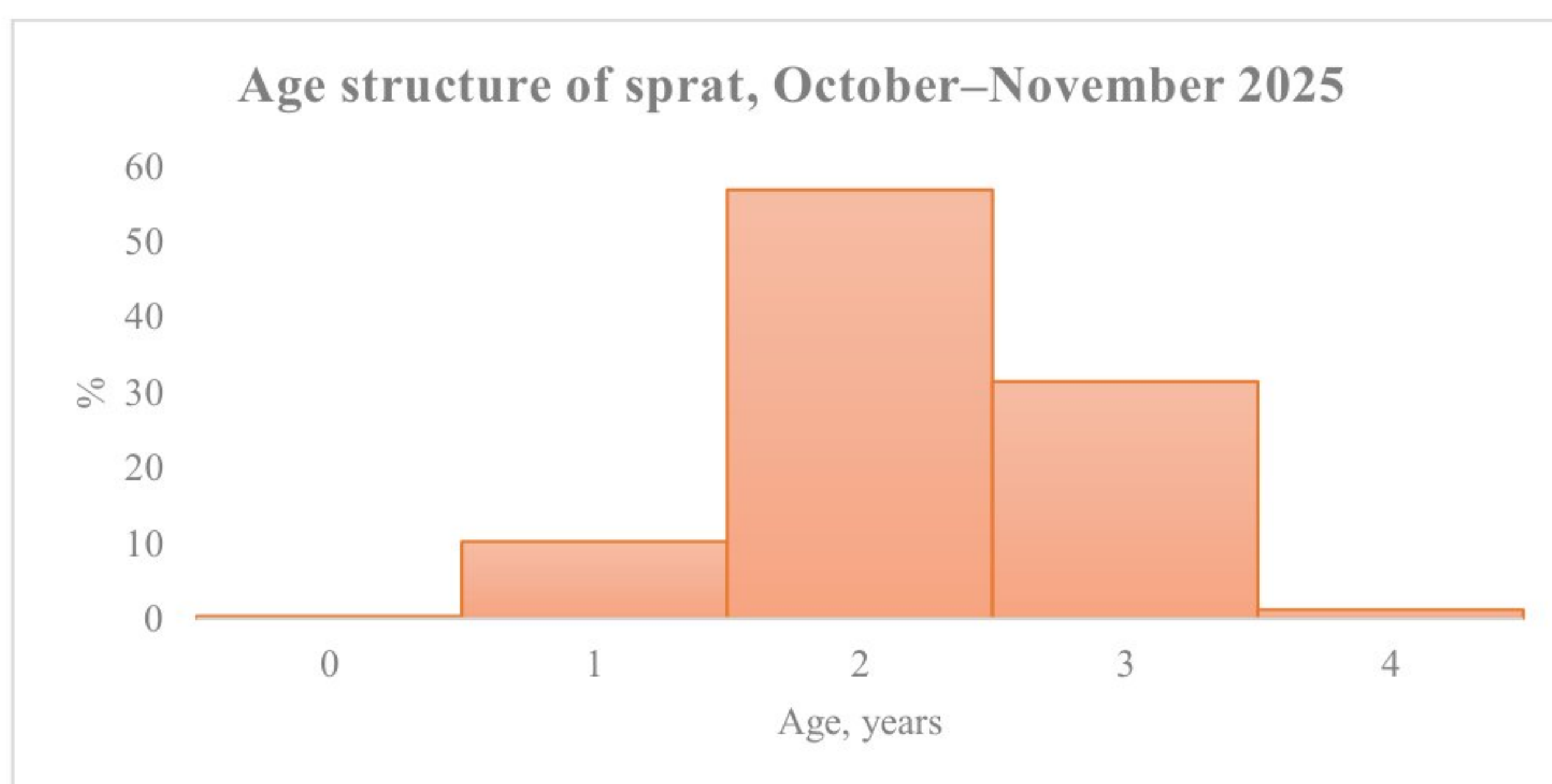


Figure 2.5.4.3. Age structure of sprat, October–November 2025.

Sprat exhibited exponential growth during October–November 2025, and the increase in age and weight showed no deviations from the norm (Fig. 2.5.4.4).



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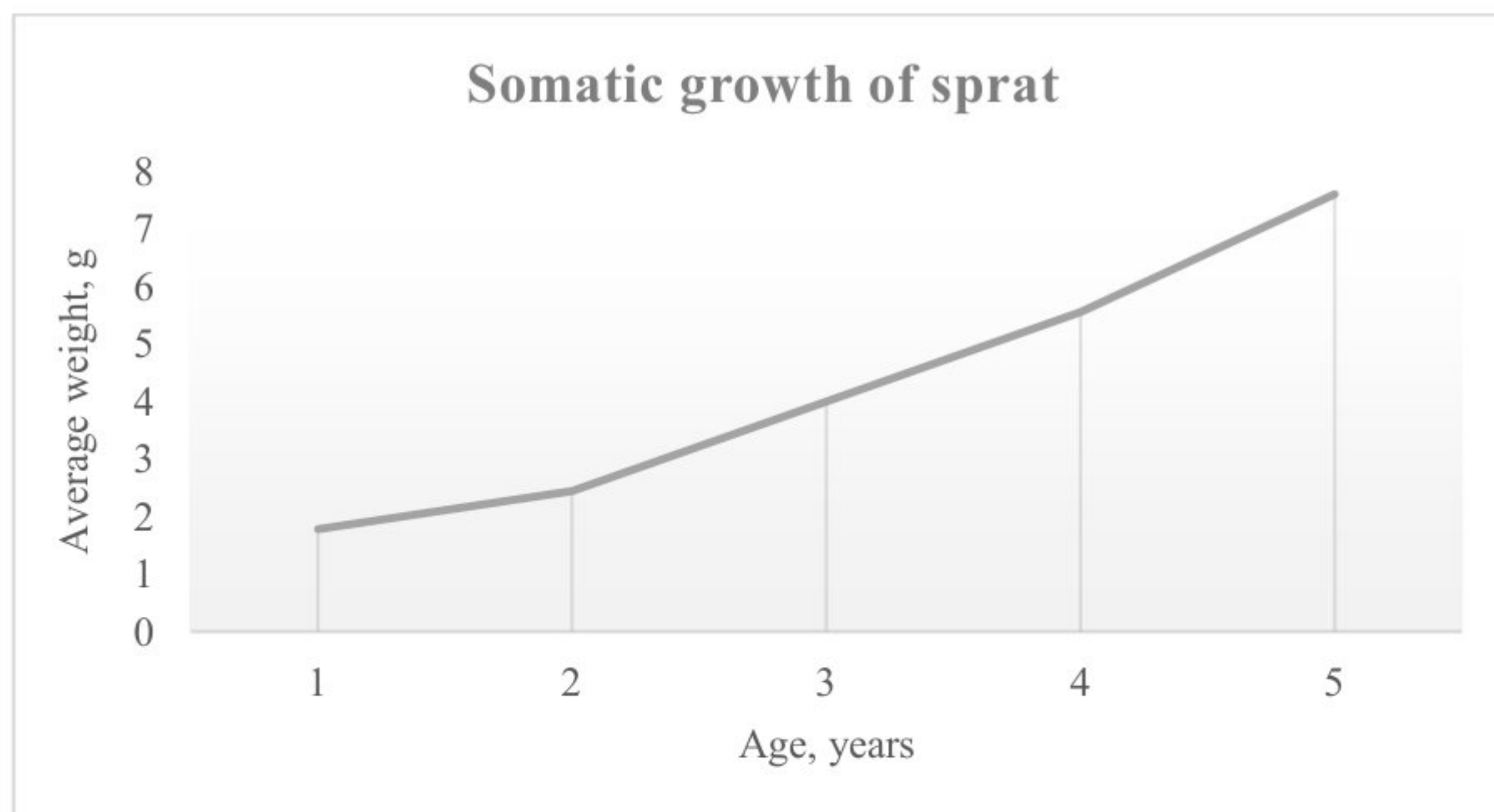


Figure 2.5.4.4. Somatic growth of sprat.

2.5.5. Sex ratio

The sex ratio (49:49:2) indicated an equal representation of males and females, with juveniles accounting for 2% of the catches (Fig. 2.5.5.1).

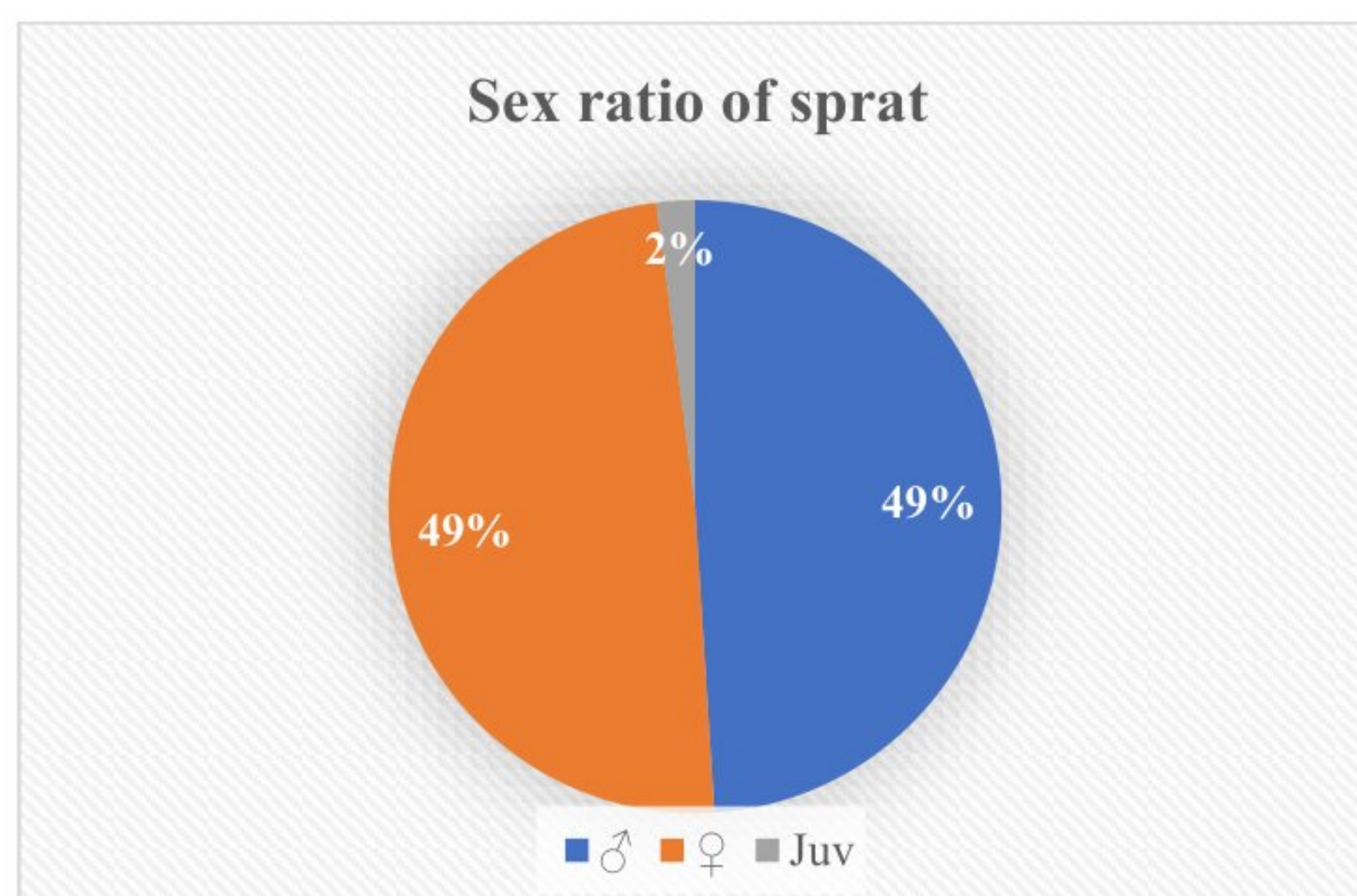


Figure 2.5.5.1. Sex ratio (♀,♂ and juveniles) of the sprat October–November 2025.

The size at sexual maturity of the sprat showed values similar to those reported in previous studies, with maturity stages ranging from stage 2a to 4a. A predominance was observed for stages 3a, 3b, and 4a (12–14%) (Fig. 2.5.5.2).



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Sexual maturity of sprat, October–November 2025

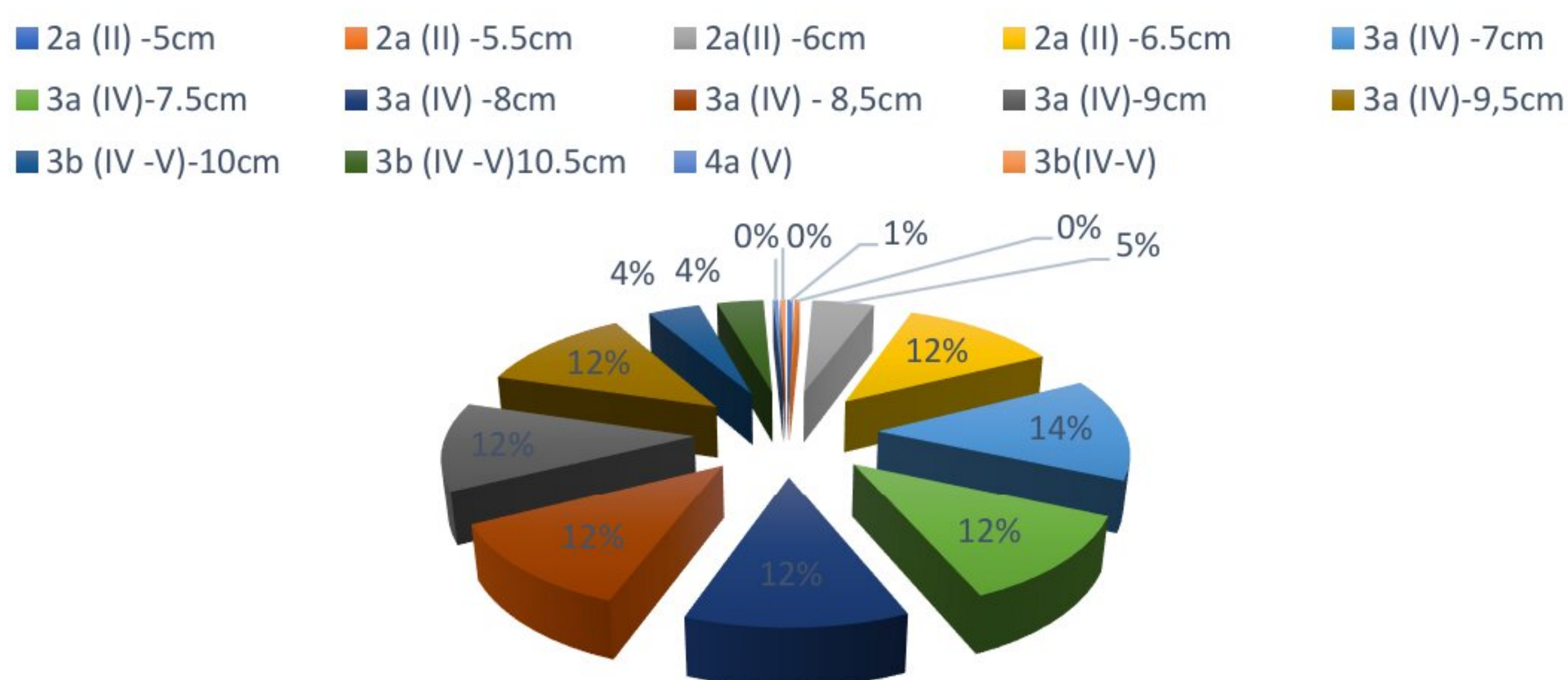
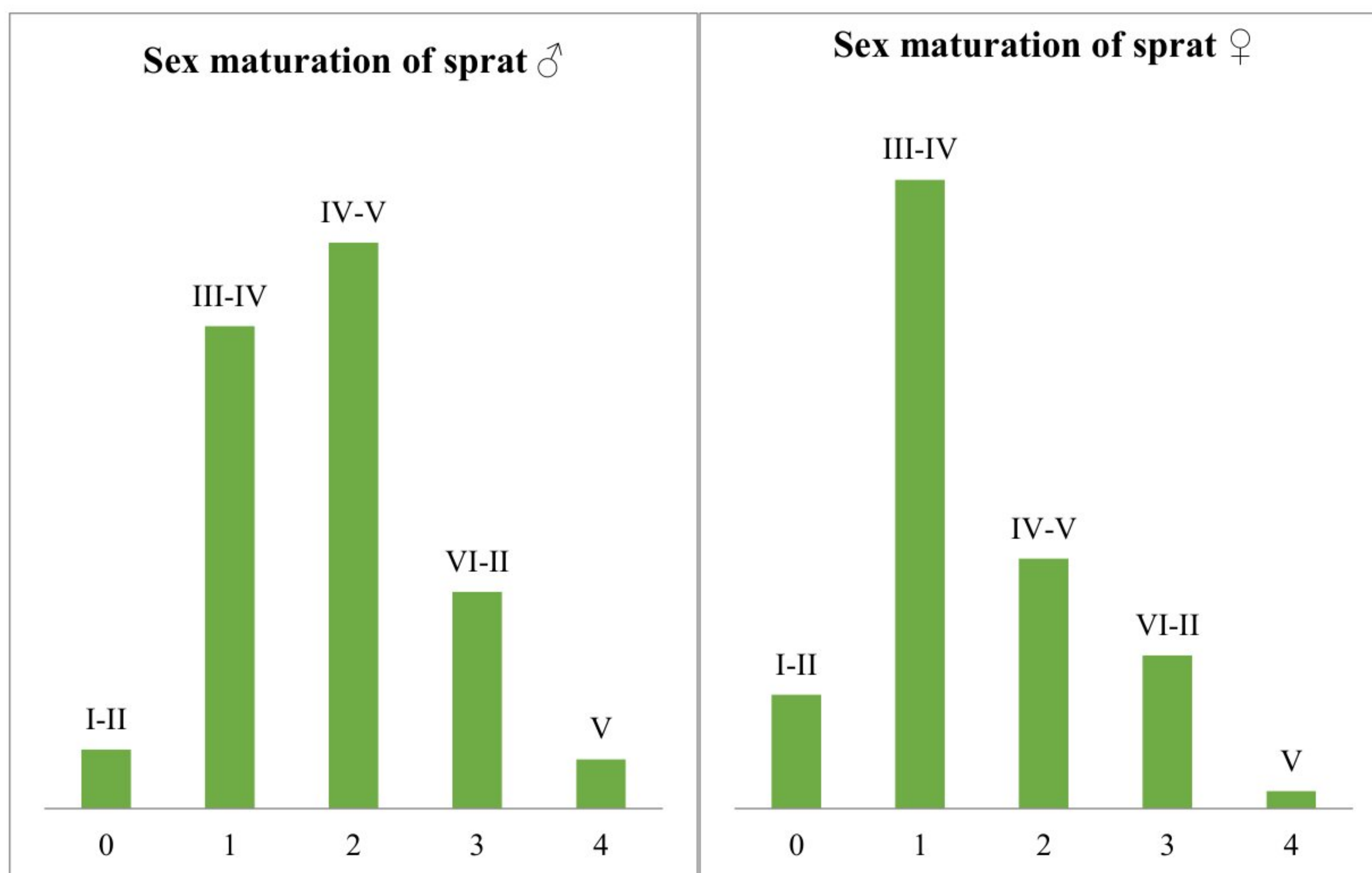


Figure 2.5.5.2. Sexual maturity of sprat analyzed by size classes, October–November 2025.

Sexually mature individuals at maturity stages III–IV (1–1+ years) in both males and females had the highest proportion, followed by individuals at stages IV–V (2–2+ years). In the 3–3+ year age group, the gonads were in a resting phase (VI–II) (Fig. 2.5.5.3).



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Figure 2.5.5.3. Sexual maturity of the sprat (males and females), analyzed by age groups.

The absolute fecundity of the sprat showed a mean value of 35544 eggs, while the relative fecundity was 7352 eggs (Table 2.5.5.1).

Table 2.5.5.1. Absolute and relative fertility of the sprat.

Size class (cm)	Average weight (g)	Average length, (cm)	Absolute fertility F, caviar grains	Relative fertility	Numbers ♀
6	1.36	6.02	na	na	2
6.5	2.33	7.12	15200	6523.605	2
7	2.52	7.59	22585	8962.302	25
7.5	3.01	8.33	27010	8973.422	28
8	3.8	8.64	35222	9268.947	40
8.5	4.39	8.63	36599	8336.902	40
9	5.18	9.22	39005	7529.923	40
9.5	5.42	9.42	42005	7750	40
10	5.91	10.11	42563	7201.861	20
10.5	7.12	10.64	43010	6040.73	10
11	8.05	11.31	44587	5538.758	2
11.5	9.1	11.59	43200	4747.253	1
Average			35544.18	7352.155	250

2.6. Picked dogfish (*Squalus acanthias*)

The picked dogfish species was represented, with 8 individuals caught by chance. The growth parameters of the individuals are presented in Table 2.6.1.

Table 2.6.1. Picked dogfish (*Squalus acanthias*), catch in October–November 2025.

Sex	Total length, cm	Weight, kg
male	118	6.02
male	121.5	6.3
female	118	6.02
male	117.5	6.15
male	120	6.11



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female	118	6.055
female	116	6.05
female	122	6.2

2.7. Planktivorous fish species feeding

2.7.1. Length-weight relationships (LWR), index of stomach fullness (ISF)

The analysis of the stomach content of planktivorous fish conducted in October and November 2025 revealed significant differences in size and feeding between the two studied species. Sprat (*Sprattus sprattus*) had smaller average sizes, with a length of 8.62 ± 0.79 cm and weight of 3.72 ± 1.03 g (Table 2.7.1.1). The coefficient of variation (CV) for these parameters was relatively low (9.14% for length and 27.70% for weight), indicating a comparatively homogeneous sample. The examined horse mackerel (*Trachurus mediterraneus*) individuals had a mean length of 10.68 ± 1.32 cm and a mean weight of 10.45 ± 3.45 g (Table 2.7.1.2). The variability in size (CV for length: 12.39%, CV for weight: 32.98%) was higher than that in sprat, particularly for weight, which likely reflects a wider age range within the sample.

Table 2.7.1.1. Statistical data for length (L, cm), weight (W, g), and ISF (% of BW) of plankton-eating fish: sprat (1) and horse mackerel (2) as determined by stomach content analysis in X-XI.2025.

1. Sprat

	L, cm	W, g	ISF, % BW
Average value	8.62	3.72	1.11
Standard error	0.10	0.13	0.06
Median	8.50	3.50	1.08
Mode	8.50	3.30	#N/A
Standard deviation	0.79	1.03	0.52
Sample Variance	0.62	1.06	0.27
Kurtosis	0.73	0.34	1.14
Skewness	-0.38	0.30	0.57
Range	4.20	5.00	2.65
Minimum	6.20	1.40	0.06

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Maximum	10.40	6.40	2.71
Confidence interval (95.0%)	0.19	0.25	0.13
Coefficient of variation	9.14	27.70	46.61

2. Horse mackerel

	L, cm	W, g	ISF, % BW
Average value	10.68	10.45	0.19
Standard error	0.15	0.39	0.02
Median	10.90	10.65	0.14
Mode	11.00	10.70	#N/A
Standard deviation	1.32	3.45	0.20
Sample Variance	1.75	11.88	0.04
Kurtosis	1.72	1.22	7.13
Skewness	-1.07	-0.27	2.21
Range	6.60	18.70	1.19
Minimum	6.90	2.50	0.00
Maximum	13.50	21.20	1.20
Confidence interval (95.0%)	0.29	0.77	0.05
Coefficient of variation	12.39	32.98	105.06

The relationship between the body weight (W, g) and length (L, cm) of the examined specimens was described by the following regression equations:

(1) Sprat: $W (g) = 0.0054 * L (cm)^{3.2041}$ ($R^2 = 0.91$, $p < 0.001$, Figure 2.7.1.1)

(2) Horse mackerel: $W (g) = 0.0058 * L (cm)^{3.1411}$ ($R^2 = 0.93$, $p < 0.001$, Figure 2.7.1.1)

Growth of both species was positive allometric, as indicated by the allometric coefficient $b > 3$.



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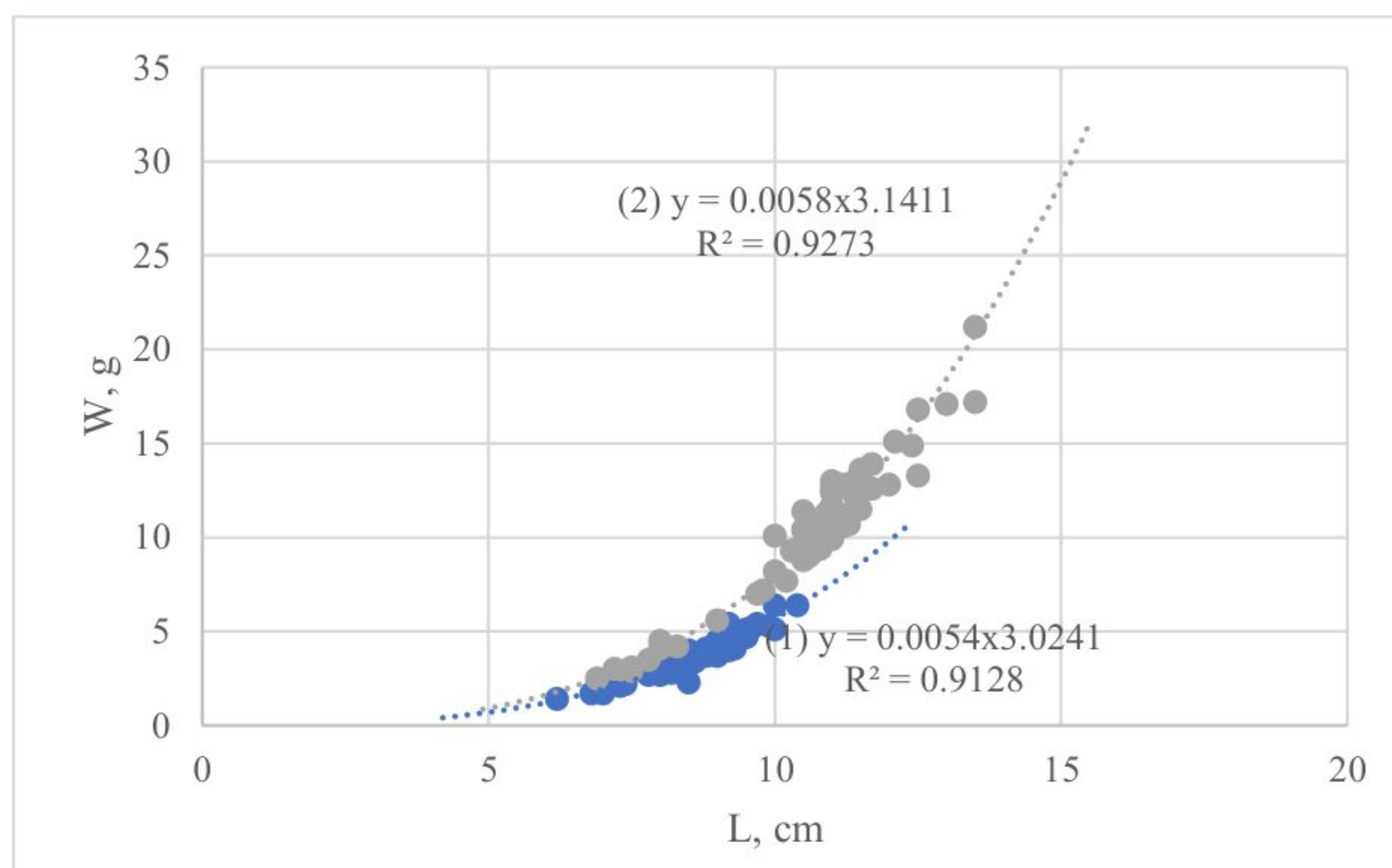


Figure 2.7.1.1. Linear weight relationships for the studied specimens of sprat (1) and horse mackerel (2) during X-XI.2025.

The mean index of stomach fullness (ISF) for sprat was $1.113\% \text{ BW} \pm 0.515 \text{ SD}$, and for horse mackerel, it was $0.194\% \text{ BW} \pm 0.203 \text{ SD}$ (Table 2.7.1.1, Fig. 2.7.1.2). In sprat, the distribution of the index was relatively symmetrical: 75% of individuals had an $\text{ISF} < 1.377\% \text{ BW}$, and the median (1.076%) was close to the mean, indicating a moderate variability. The highest recorded ISF value was 2.713% , associated with *Paracalanus parvus* consumption, whereas the minimum was 0.064% . For horse mackerel, the median (0.142%) was considerably lower than the mean (0.194%), and the coefficient of variation was high (105%), indicating a highly skewed distribution. This indicates that most individuals had nearly empty stomachs ($Q_1: 0.052\%$; minimum: 0.002%), whereas a few well-fed individuals (maximum: 1.196% ; due to active localized consumption of *Calanus euxinus*) caused a spike in the mean value. Thus, the observed horse mackerel patterns reflect significant heterogeneity in feeding, which is likely associated with seasonal changes in activity.



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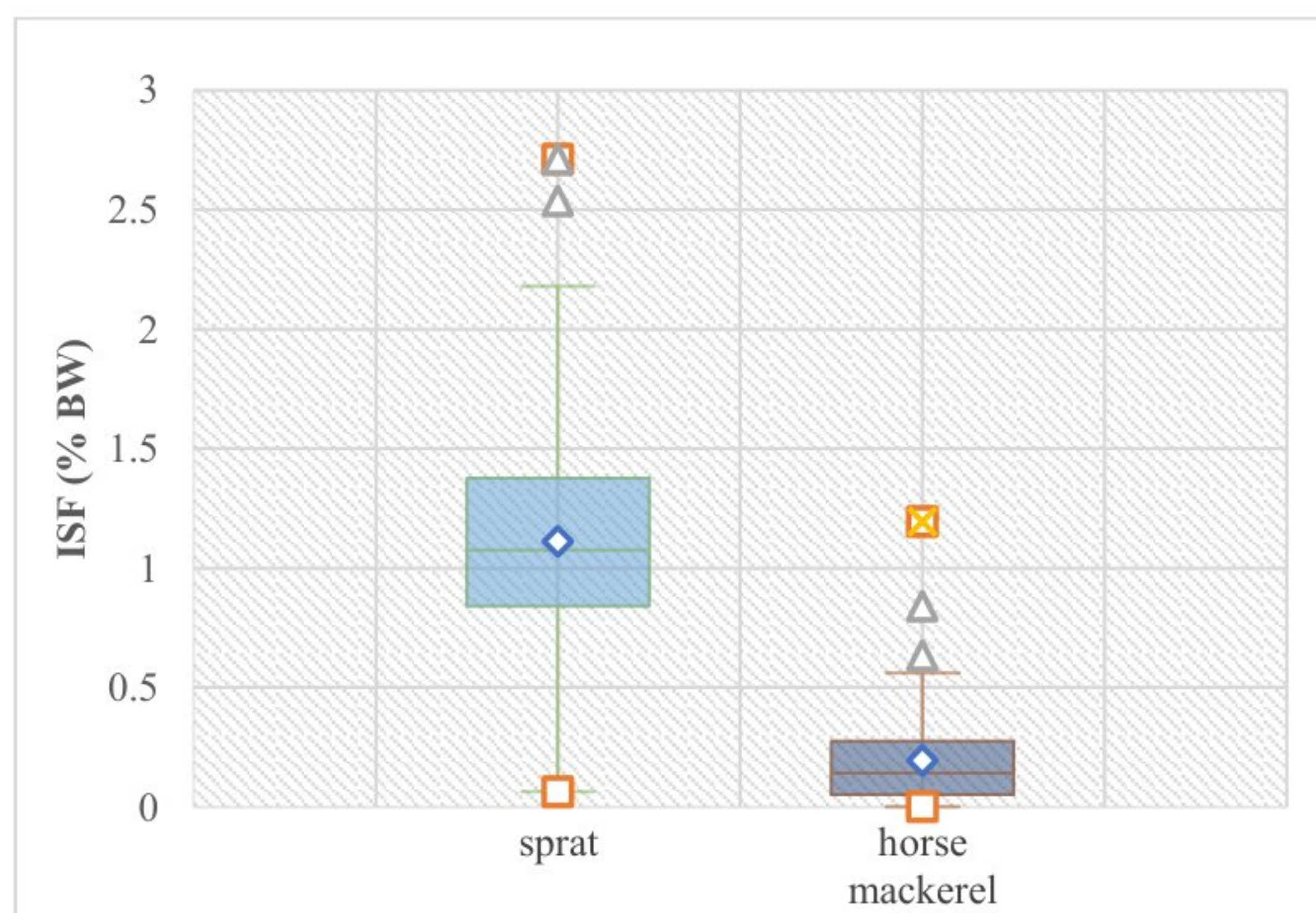


Figure 2.7.1.2. Box plot: ISF values (% BW) by species in the X-XI.2025 (median, range of values: 25-75%; minimum and maximum values are indicated).

The analysis of the spatial distribution of the mean ISF (% BW) revealed more intensive sprat feeding (1.098-1.629 % BW) in the central and southern parts of the Bulgarian Black Sea coast (Fig. 5.3.1). In the northern part, the ISF was considerably lower (0.956 %), which may reflect differences in food availability or specific migratory patterns. In horse mackerel, ISF was extremely low along the entire coast (0.032-0.360 % BW), with the highest values recorded at southern stations (0.360 %), while the stomachs in the north were nearly empty (0.032–0.183 %) (Fig. 2.7.1.3.). This supports the conclusion that during October–November 2025, horse mackerel were likely in a phase of reduced feeding, whereas sprat exhibited active and regionally heterogeneous feeding, primarily oriented towards the central and southern waters.



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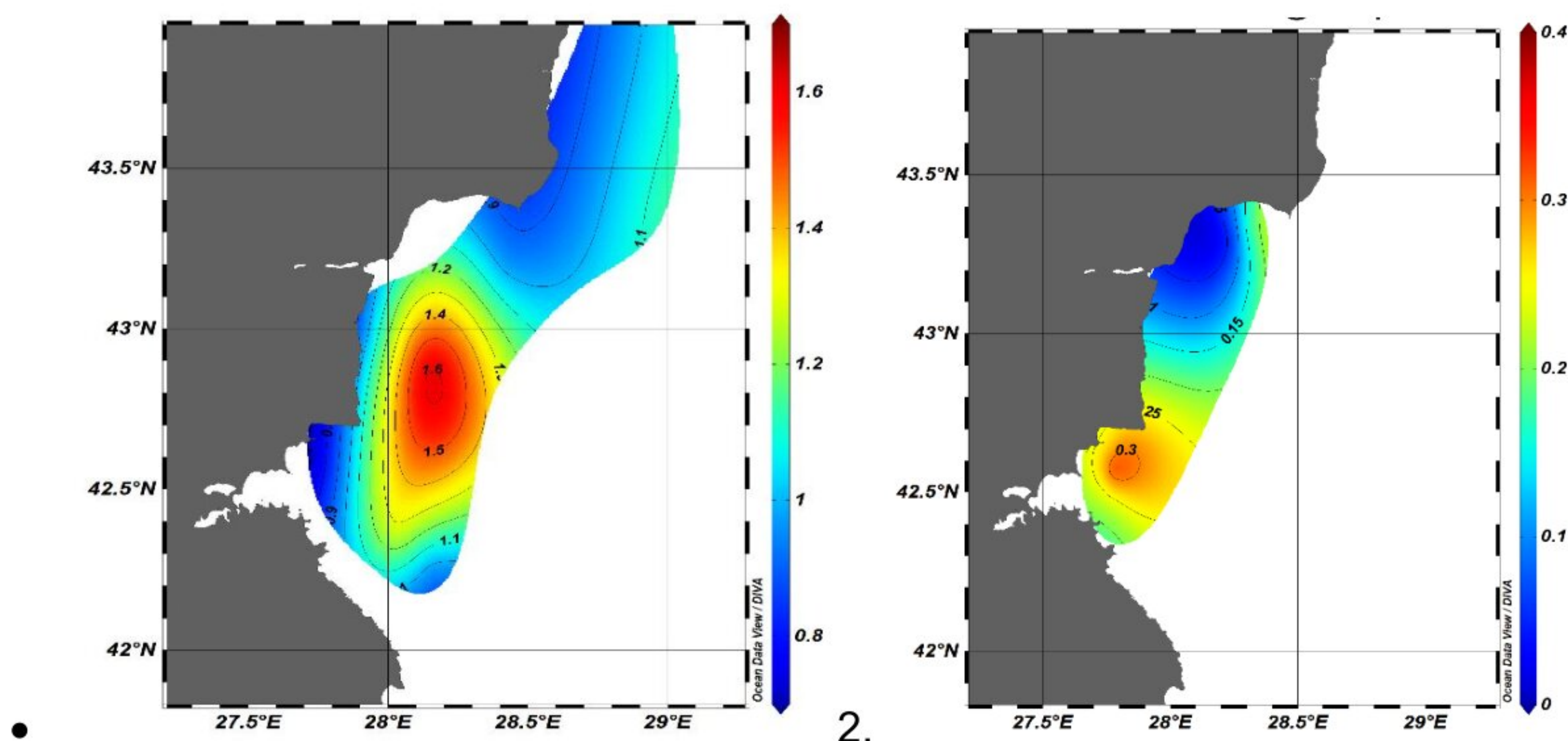


Figure 2.7.1.3. Spatial distribution of ISF (% BW) of sprat (1) and horse mackerel (2) in X-XI.2025.

2.7.2. Prey number (PN), species composition of food and relative importance index (IRI) of zooplankton

The number of prey items (PN) in the stomach content was considerably higher in sprat, with a mean of 285 ind/stomach (median: 170; maximum: 1493 ind/stomach), than in horse mackerel, which had a mean PN of 41.3 ind/stomach (maximum: 559 ind/stomach) (Fig. 2.7.2.1).

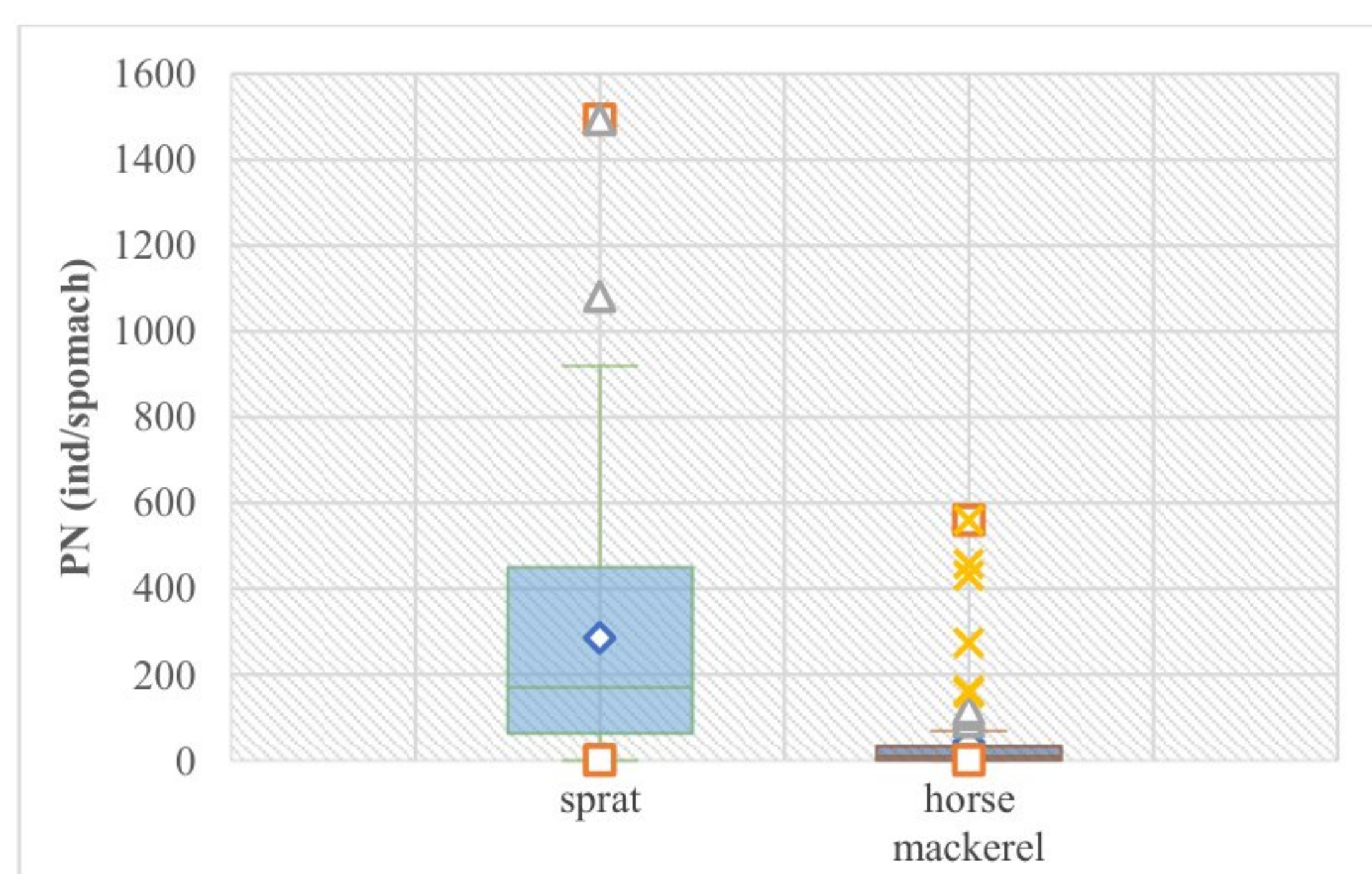


Figure 2.7.2.1. Box plot: Prey number (PN, ind/stomach) in the stomach contents of the surveyed specimens by species during X-XI.2025 (median, range of values: 25–75%; minimum and maximum values are indicated).



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The distribution of prey number in sprat was strongly skewed, with a wide range and high variability ($SD = 298.1$), where 75 % of individuals had fewer than 450 prey per stomach. In horse mackerel, variability was lower ($SD = 97.7$), but the distribution was still highly uneven: most individuals had few prey items ($Q_1: 1.0$ ind/stomach), whereas a few individuals had very high PN values (up to 559 ind/stomach), causing a spike in the mean (Fig. 2.7.2.1.).

Accordingly, 27 species/groups were identified in zooplankton samples from the marine environment, of which 14 species/groups were found in the diet of sprat and horse mackerel. The sprat diet includes a wide range of zooplankton groups: Copepoda - *Calanus euxinus*, *Paracalanus parvus*, *Pseudocalanus elongatus*, *Acartia clausi*, *Oithona davisae*, *Oithona similis*; Cladocera - *Penilia avirostris*; meroplankton - *Lamellibranchia veliger*, *Cirripedia larvae*, *Decapoda larvae*; the class Appendicularia is represented by *Oicopleura dioica*; phylum Annelida by Polychaete larvae; phylum Chaetognatha by *Parasagitta setosa*.

The diet of horse mackerel consists of the following main groups and species: Copepoda - *Calanus euxinus*, *Paracalanus parvus*, *Pseudocalanus elongatus*, *Acartia clausi*, *Oithona davisae*; Cladocera - *Penilia avirostris*; meroplankton - *Lamellibranchia veligers*, *Gastropoda veligers*, *Cirripedia larvae*, *Decapoda larvae*; Annelida are represented by Polychaete larvae; and Appendicularia are represented by the species *Oicopleura dioica*. *Upogebia* spp. were also found in the horse mackerel diet.

The indices of the relative importance of the main food components in the pelagic fish species diet, their percentage contributions by abundance and biomass, and their frequency of occurrence are presented in Table 5.3.

Table 2.7.2.1. The diet composition of pelagic fish species (X-XI.2025).

1. Sprat

Food composition	N (% of the total abundance)	M (% of total biomass)	FO - Frequency of Occurrence	IRI - Relative Importance Index
<i>Calanus euxinus</i>	18.15	53.35	76.73	5486.61
<i>Paracalanus parvus</i>	37.24	12.85	68.98	3455.38
<i>Pseudocalanus elongatus</i>	13.26	9.84	80.00	1847.81
<i>Acartia clausi</i>	3.21	4.02	53.10	383.65
<i>Decapoda larvae</i>	0.79	4.84	54.64	307.93
others	27.4	15.1		
	100.00	100.00		

2. Horse mackerel

Food composition	N (% of the total abundance)	M (% of total biomass)	FO - Frequency of Occurrence	IRI - Relative Importance Index
<i>Pseudocalanus elongatus</i>	18.93	19.18	32.86	1252.30

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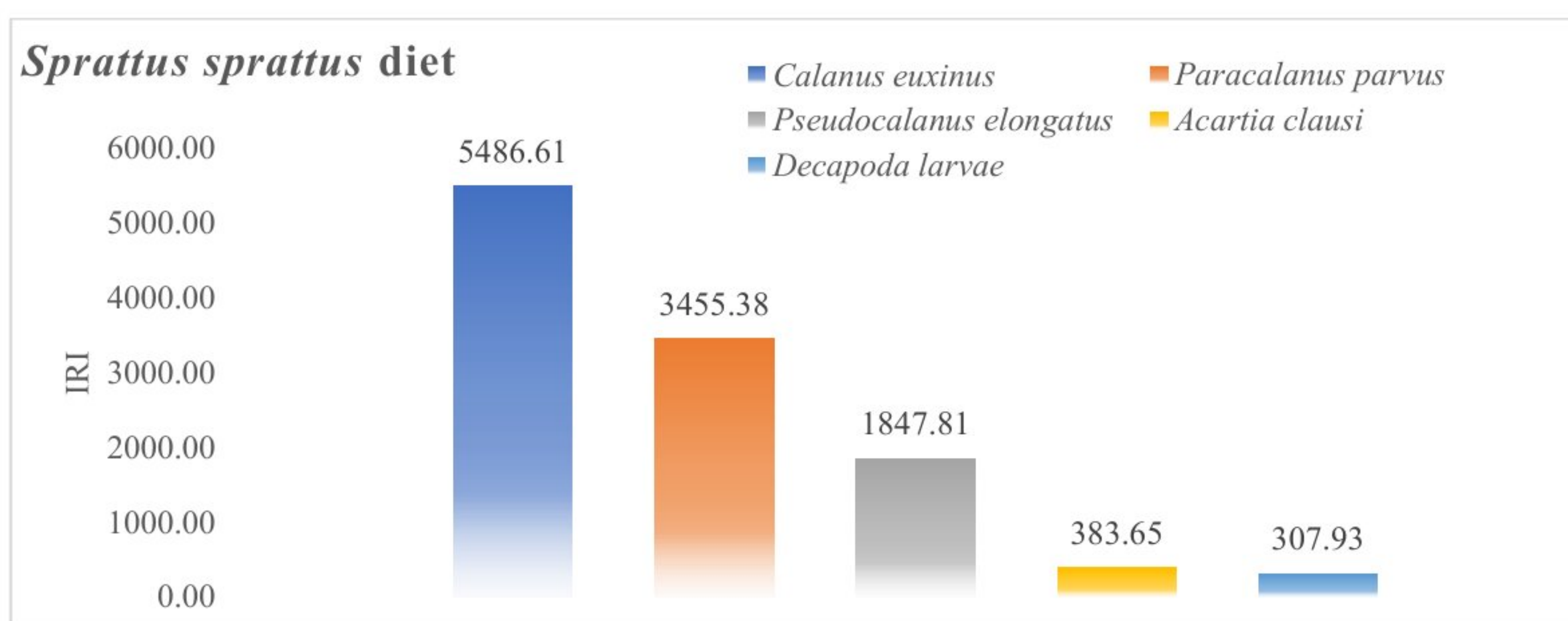


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<i>Lamellibranchia veliger</i>	19.31	4.08	52.50	1228.13
<i>Paracalanus parvus</i>	18.96	8.54	38.33	1054.14
<i>Calanus euxinus</i>	6.25	25.83	26.00	833.99
<i>Cirripedia cypris</i>	14.27	6.02	40.00	811.85
<i>Cirripedia nauplii</i>	3.86	3.96	62.00	484.75
<i>others</i>	18.4	32.4		
	100.00	100.00		

The analysis of sprat stomach contents, measured using the Index of relative importance (IRI), shows that this species feeds primarily on zooplankton organisms, with its main prey consisting of several key taxa (Table 2.7.2.1, Fig. 2.7.2.2). The most significant dietary component for sprat was *Calanus euxinus* (IRI = 5486.61), followed by *Paracalanus parvus* (IRI = 3455.38). The third place was occupied by *Pseudocalanus elongatus* (IRI = 1847.81), while lower values were recorded for *Acartia clausi* (383.65) and decapod larvae (307.93).

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2.

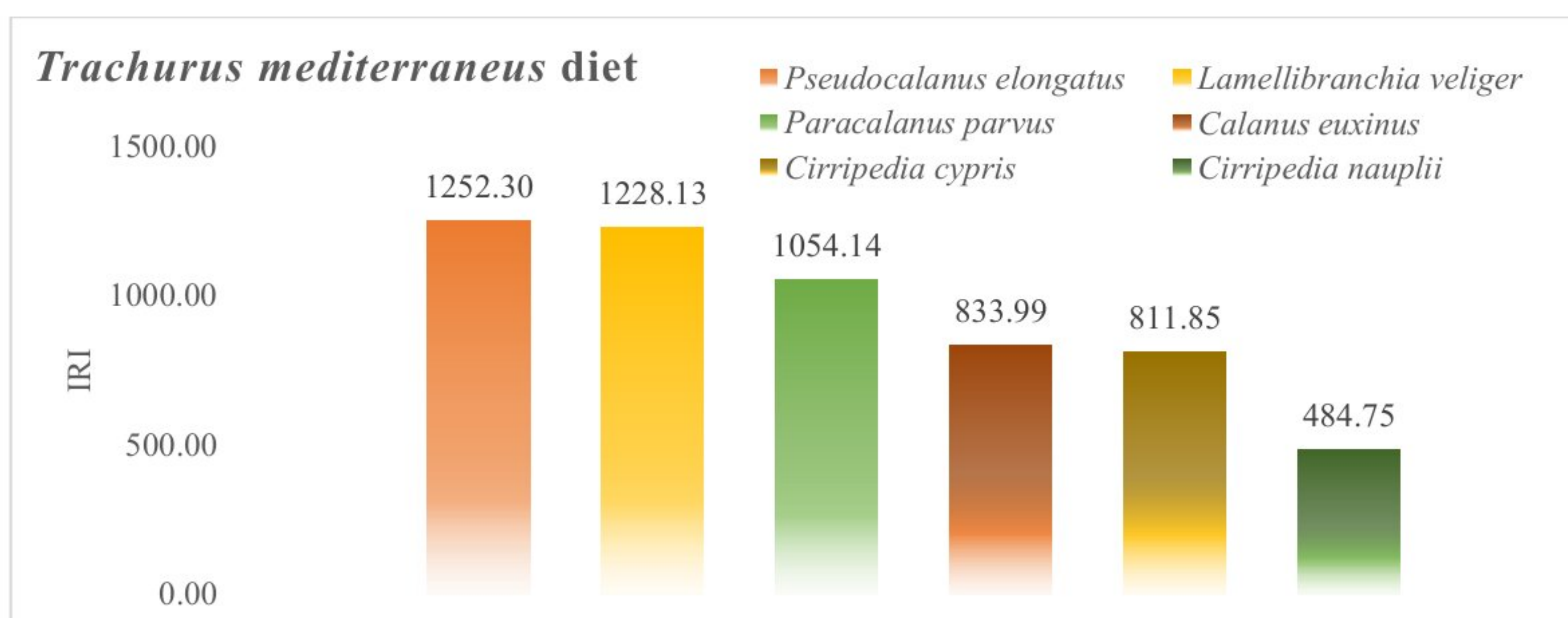


Figure 2.7.2.2. Average relative importance index (IRI) of the main species in the diets of sprat (1) and horse mackerel (2) in X-XI.2025.

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According to the Index of relative importance (IRI), the most important food components in the horse mackerel diet were *Pseudocalanus elongatus* (IRI = 1252.30) and veliger larvae of bivalve molluscs (IRI = 1228.13), which dominated with nearly equal values (Table 2.7.2.1, Fig. 2.7.2.2). The third most abundant component species was *Paracalanus parvus* (IRI = 1054.14), followed by lower values for *Calanus euxinus* (IRI = 833.99), cirripede cyprid larvae (Cirripedia cypris, IRI = 811.85), and cirripede nauplii (IRI = 484.75).

2.7.3. Species composition and quantities of zooplankton in the marine environment

During the study period, zooplankton biodiversity comprised 27 species and groups of organisms (Table 2.7.3.1).

Table 2.7.3.1. The diet composition of pelagic fish species (X-XI.2025).

	X-XI. 2025
1	<i>Noctiluca scintillans</i>
2	<i>Hydrozoa</i> spp.
3	<i>Aurelia autria</i>
4	<i>Beroe ovata</i>
5	<i>Pleurobrachia pileus</i>
6	<i>Calanus euxinus</i>
7	<i>Pseudocalanus elongatus</i>
8	<i>Paracalanus parvus</i>
9	<i>Oithona similis</i>
10	<i>Oithona davisae</i>
11	<i>Acartia clausi</i>
12	<i>Acartia tonsa</i>
13	<i>Centropages ponticus</i>
14	<i>Harpacticoida</i> spp.
15	<i>Pleopis polyphemoides</i>
16	<i>Penilia avirostris</i>
17	<i>Polychaeta</i> larvae
18	<i>Lamellibranchia veliger</i>
19	<i>Gastropoda veliger</i>
20	<i>Cirripedia</i> larvae
21	<i>Decapoda</i> larvae
22	<i>Phoronis</i> larvae
23	<i>Bryozoa</i> larvae
24	<i>Ascidia</i> larvae
25	<i>Parasagitta setosa</i>
26	<i>Oicopleura dioica</i>
27	<i>Pisces ova</i>



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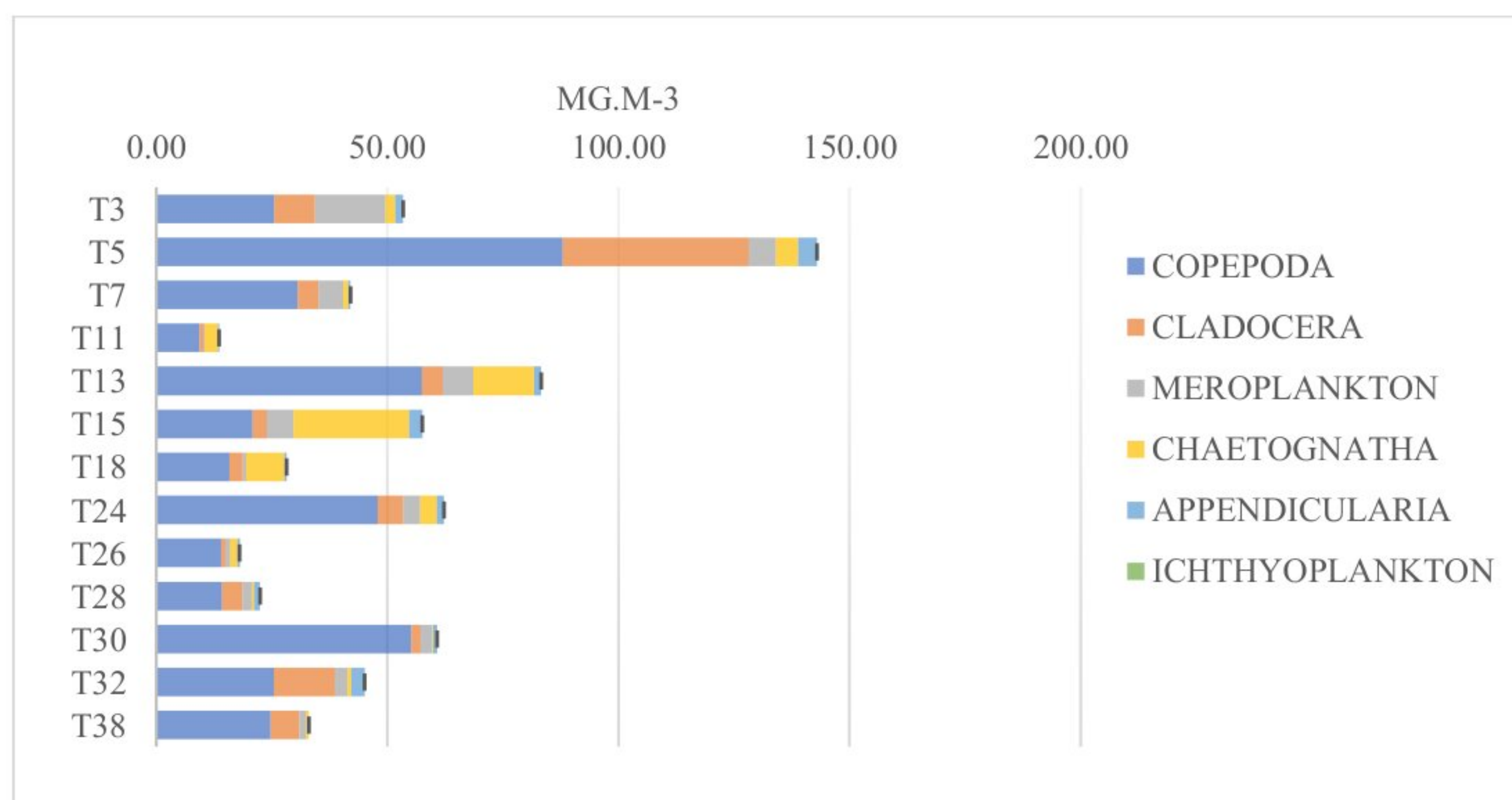
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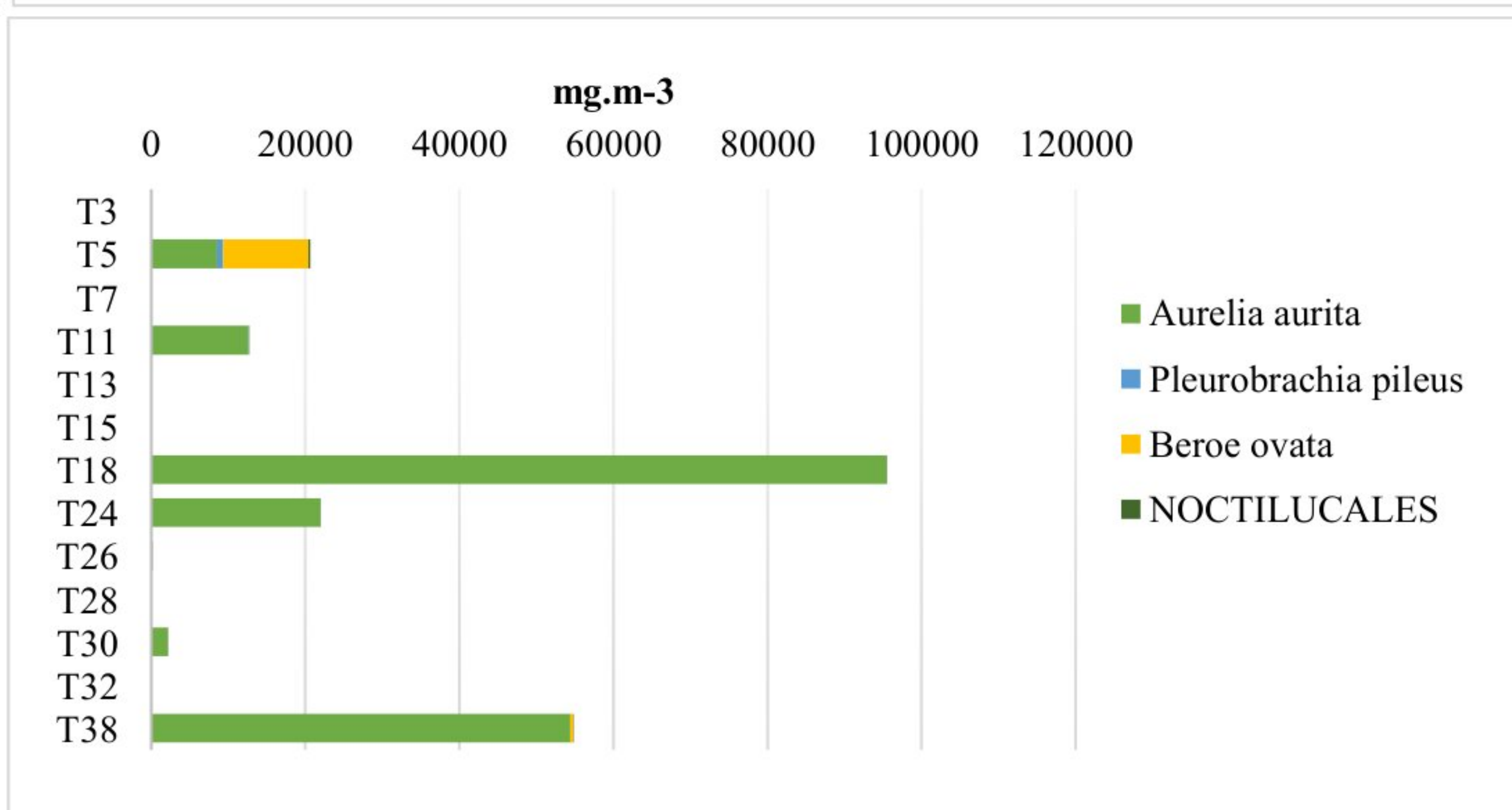
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The groups Copepoda (66%) and Cladocera (13%) played a dominant role in the formation of mesozooplankton biomass (Fig. 2.7.3.1, Table 2.7.3.2), whereas gelatinous zooplankton was represented by *Aurelia aurita*, *Pleurobrachia pileus*, and *Beroe ovata*, as well as Protozoa (Noctilucales), with *Aurelia aurita* being predominant, accounting for 94% of the biomass (Fig. 2.7.3.1).

In terms of abundance, the dominant groups were Copepoda (70%), meroplankton (9%), and Protozoa (8%) (Fig. 2.7.3.1).



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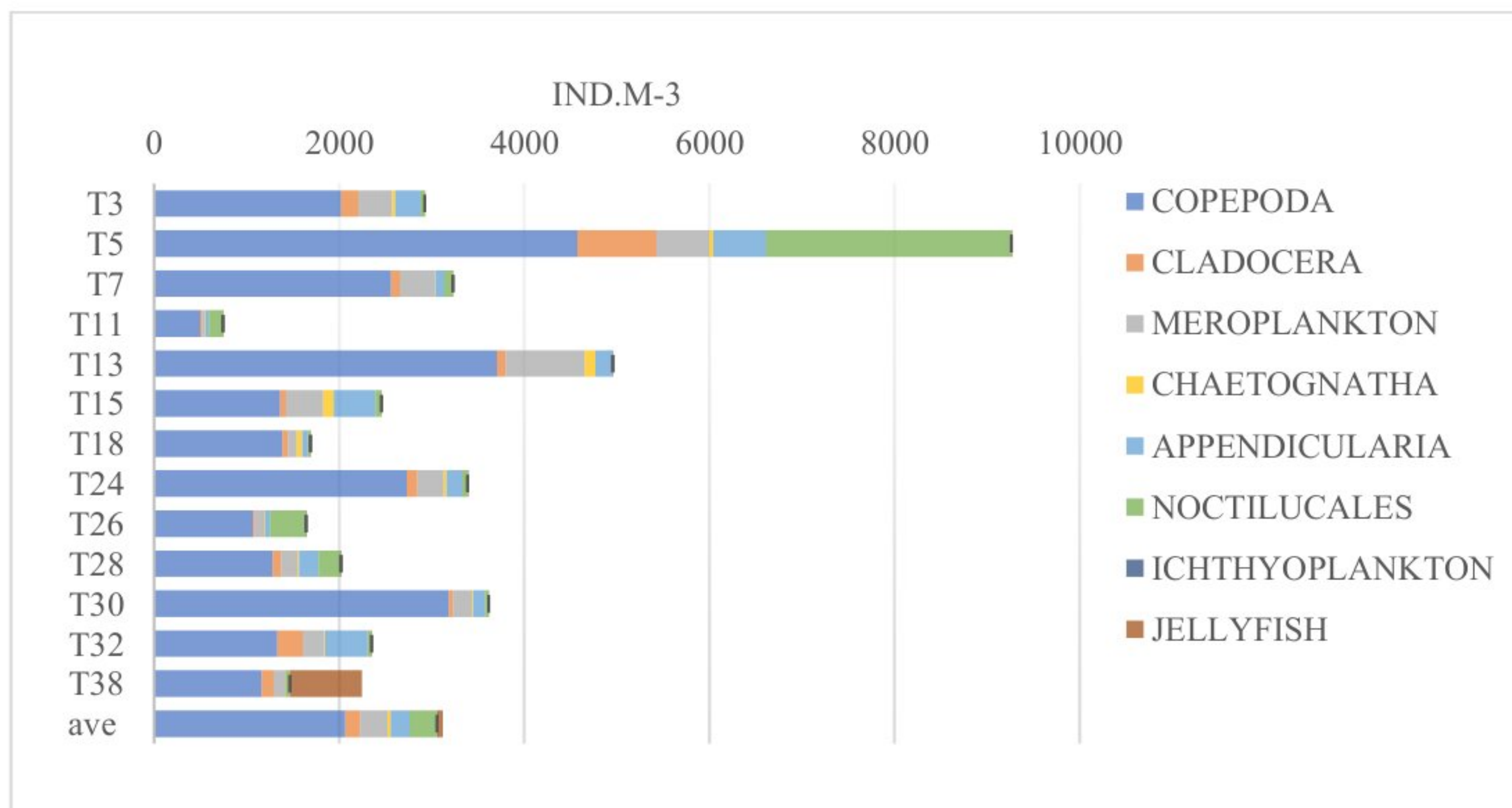
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3.

Figure 2.7.3.1. Distribution of mesozooplankton biomass (1, mg.m^{-3}), gelatinous zooplankton (2, mg.m^{-3}), and abundance of major zooplankton groups (3, ind.m^{-3}) by station in X-XI.2025.

Table 2.7.3.2. Percentages (% , relative to biomass mg.m^{-3}) of the major zooplankton groups by station in the X-XI.2025.

station	Cope-poda	Clado-cera	Mero-plankton	Chaeto-gnatha	Appen-dicularia	Ichthyo-plankton
T3	47.75	16.44	28.64	3.84	3.33	0.00
T5	61.54	28.11	4.16	3.36	2.83	0.00
T7	72.76	10.85	12.58	2.50	1.31	0.00
T11	68.59	6.00	2.08	21.38	1.95	0.00
T13	68.97	5.48	7.83	15.94	1.78	0.00
T15	36.13	5.42	10.03	43.42	5.00	0.00
T18	56.12	10.21	2.70	29.31	1.66	0.00
T24	76.99	8.79	5.92	5.80	2.32	0.17
T26	77.85	5.06	6.01	8.64	2.29	0.15
T28	63.42	19.45	9.15	2.00	5.98	0.00
T30	90.74	3.32	4.12	0.35	1.48	0.00
T32	56.41	29.29	6.19	1.82	6.29	0.00
T38	75.02	18.75	4.54	1.69	0.00	0.00
Average	65.56	12.86	8.00	10.77	2.79	0.02



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Table 2.7.3.3 presents the summarised statistical data on the total zooplankton biomass and its main constituent groups: mesozooplankton, gelatinous zooplankton, and protozoans. The total zooplankton biomass reached $16.03 \text{ g} \cdot \text{m}^{-3} \pm 7.95 \text{ (SE)}$ and was primarily composed of gelatinous species, which accounted for $15.96 \text{ g} \cdot \text{m}^{-3} \pm 7.95 \text{ (SE)}$. The fodder zooplankton biomass was typical for the season, amounting to $50.98 \text{ mg} \cdot \text{m}^{-3}$.

Table 2.7.3.3. Summary data on the total biomass ($\text{mg} \cdot \text{m}^{-3}$) of zooplankton and major groups in X-XI.2025.

	<i>Meso - zooplankton</i>	<i>Gelatinous zooplankton</i>	<i>Protozoa</i>	<i>Total zoo-plankton biomass</i>
Mean	50.98	15960.16	23.76	16034.90
Standard error	9.48	7952.47	15.88	7951.38
Median	45.07	64.76	4.56	113.92
Standard deviation	34.20	28673.05	57.25	28669.11
Kurtosis	3.82	4.78	12.26	4.77
Skewness	1.69	2.21	3.47	2.21
Minimum	13.59	0.02	0.00	41.86
Maximum	142.96	95450.86	212.16	95481.46
Confidence interval (95.0%)	20.66	17326.95	34.60	17324.57

During the study, mesozooplankton biomass increased to $142.96 \text{ mg} \cdot \text{m}^{-3}$ off the central and northern parts of the coast (Fig. 2.7.3.2.). In the same zones, the maximum protozoan biomass was recorded at approximately $212 \text{ mg} \cdot \text{m}^{-3}$ (Fig. 2.7.3.2.), while the main aggregation of gelatinous zooplankton, with a peak biomass of $95 \text{ g} \cdot \text{m}^{-3}$, was observed in an extensive area off the central and southern coasts (Fig. 2.7.3.2.).



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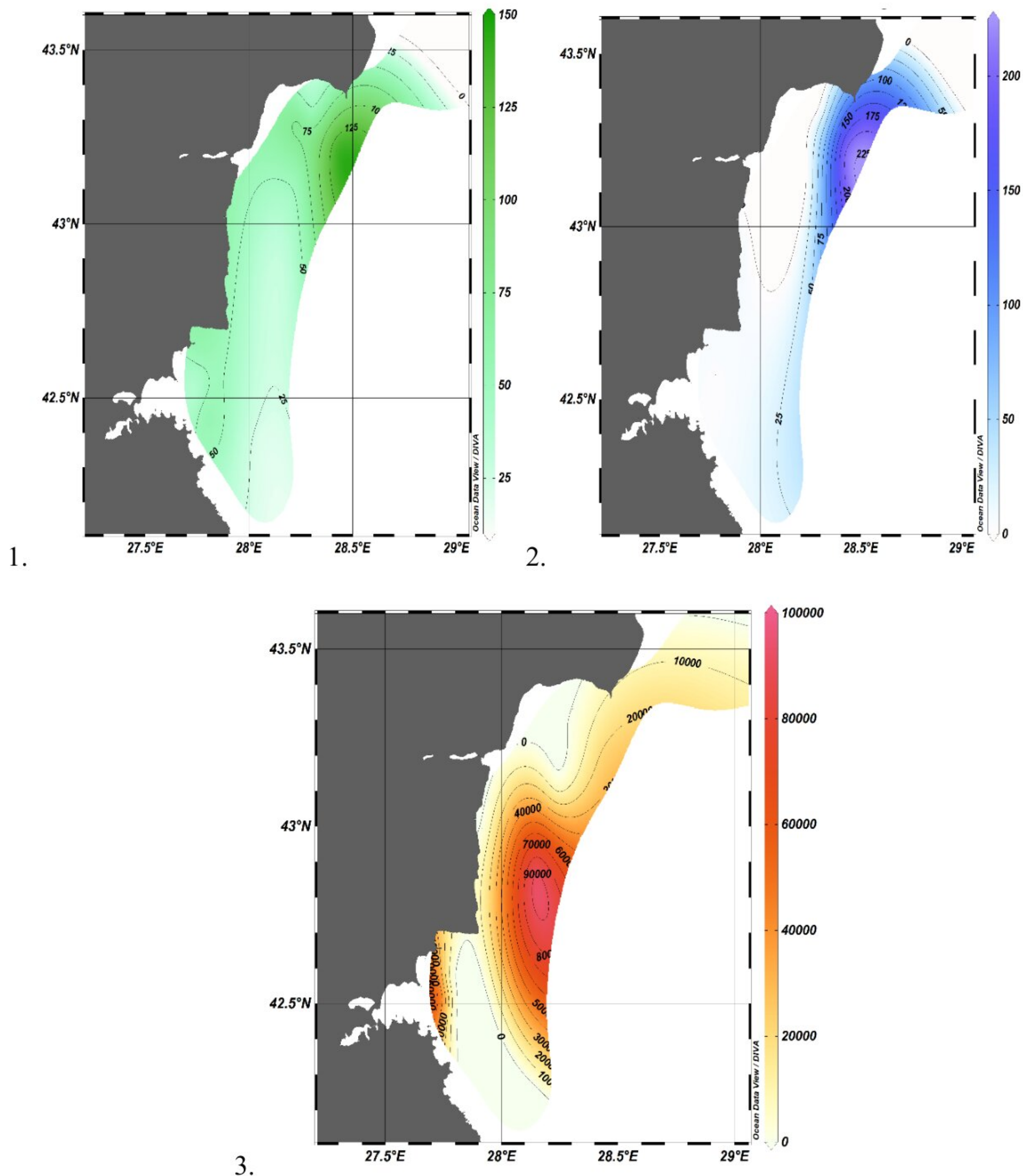


Figure 2.7.3.2. Spatial distribution of biomass (mg.m^{-3}) of mesozooplankton (1), protozoa (2), and gelatinous zooplankton (3) in X-XI.2025.



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3. Conclusions

➤ The total number of species identified during the survey was 28, including 19 fish species, 3 crustaceans, 2 mollusks, and 3 macrozooplankton species. The most frequently occurring species in the trawl catches (presence/absence) were: *Sprattus sprattus* (9.5%), *Merlangius merlangus* (19.22%), *Mullus barbatus* (20.05%), and *Trachurus mediterraneus* (44.21%), which was observed sporadically in the catches. Other species such as *Alosa immaculata*, *Neogobius melanostomus*, *Gobius niger*, *Mesogobius batrachocephalus*, *Zosterisessor ophiocephalus*, *Raja clavata*, *Dasyatis pastinaca*, *Pegusa lascaris*, *Aphia minuta*, *Uranoscopus scaber*, *Trachinus draco*, *Scophthalmus maximus*, *Squalus acanthias*, *Chelidonichthys lucerna*, *Acipenser gueldenstaedtii*, and *Acipenser stellatus* had negligible presence in the catches.

HORSE MACKEREL

➤ The total surveyed area was 8010.24 km², and the estimated total biomass of horse mackerel was 5629 t.

➤ The densest aggregations were observed off Balchik and Kavarna. Biomass in the 15–30 m stratum was the highest (4200 t), followed by 784 t (30–50 m) and 1.24 t (50–100 m).

➤ The highest CPUA values were recorded in the 15–30 m depth layer (1241 kg·km⁻²), with a mean of 512 kg·km⁻². In the 30–50 m layer, values ranged from 124 to 869 kg·km⁻², while in the 50–100 m layer they were very low (3.41 kg·km⁻²).

➤ The length–weight relationship for horse mackerel is described by the model $W = 0.009 \cdot L^{2.77}$. The allometric growth coefficient is >3 , and the fitted nonlinear model shows a high coefficient of determination ($R^2 = 0.97$).

➤ The length distribution of horse mackerel samples is bimodal (Gaussian), with two peaks, as the most frequent lengths range between 10 and 13.5 cm. A peak was observed at the 10 cm size class (1500 individuals).

➤ The dominant age group during the study period was 2–2+ years (31.5%), followed by 1–1+ years (9.8%). Recruitment accounted for 4.6%. The age structure ranged from 0 to 5+ years, with a notable contribution of the 3–3+ year group (19.66%).

➤ Growth parameters (based on 1500 individuals), estimated using the von Bertalanffy model, indicate an asymptotic length of 25.42 cm and relatively high values of the growth coefficient.

➤ During October–November 2025, the 10.0 cm length class had the highest percentage contribution to the catches.

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- Analysis of the age structure in the catches showed that age groups 3–3+ and 4–4+ years had high abundance indices and dominated the catches (Fig. 2.2.7.2). Recorded age groups ranged from 0 to 4+ years.
- Biomass, similarly to abundance, showed a predominance of the 10 mm size group, followed by the 13.5 mm size group. During October–November 2025, age groups 1–1+ years had a significantly higher contribution to the catches compared to the other age groups.
- Female and male individuals ($n = 250$) were represented as follows: 49% males and 51% females.
- The gonadosomatic index (GSI, %) based on 250 individuals indicates a later stage of spawning ($R^2 = 0.77$). A strong relationship between gonad weight and GSI suggests active reproductive processes and advanced gonadal maturity during the study period.
- Absolute fecundity (measured in 250 individuals) was highest at a length of 16 cm, reaching 51040 eggs. In terms of relative fecundity, the highest value was recorded in individuals of 10 cm length (1,074 eggs). The mean values of absolute and relative fecundity were 31255 and 978, respectively.

RED MULLET

- The catch per unit area (CPUA) in the 15–30 m stratum averaged $80 \text{ kg} \cdot \text{km}^{-2}$. In the 30–50 m and 50–100 m strata, the values were $1047 \text{ kg} \cdot \text{km}^{-2}$ (mean) and $0 \text{ kg} \cdot \text{km}^{-2}$, respectively.
- Analysis of CPUA and catch per unit effort (CPUE) showed that the highest densities and abundances were recorded in the 30–50 m depth zone (off Byala and Cape Kaliakra), followed by the 15–30 m zone.
- Length–weight (L–W) analysis of *Mullus barbatus* during October–November 2025 showed a very strong relationship between length and weight, with pronounced allometric growth ($R^2 = 0.99$) and a high growth coefficient ($b = 2.99$).
- The dominant length classes in the catch were 11 and 13.0 cm.
- Age groups 2–2+ years predominated, followed by 3–3+ years and 1–1+ years (based on 500 individuals). Other age groups had lower representation in the catches during October–November 2025.
- Growth parameters (based on 1,200 individuals), estimated using the von Bertalanffy model, indicated an asymptotic length (L_∞) of 18.41 cm and relatively high growth coefficients.
- Somatic growth by age showed no deviations from expected patterns.
- Length classes 11.0 and 13.0 cm dominated the catches, while larger size classes were less represented. During October–November 2025, the 11 cm class had the highest proportion, followed by the 13 cm class.

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- The abundance of the 2–2+ year group was the highest, followed by the 1–1+ year group. Older age groups were less represented.
- Females, males, and immature individuals were represented as follows: 47%, 45%, and 8%, respectively.
- Red mullet (250 individuals) were in an active phase of gonadal maturation ($R^2 = 0.80$), likely associated with higher seawater temperatures.
- Absolute fecundity (measured in 250 individuals) was highest at a length of 16 cm, reaching 11250 eggs. The highest relative fecundity was recorded in individuals of 9 cm length (739.8 eggs). Mean values of absolute and relative fecundity were 8738 and 429, respectively.

WHITING

- *Merlangius merlangus* inhabits near-bottom depth layers, and its primary prey is sprat. It is a predatory species and an important component of the food web, serving as prey for larger predators such as *Scophthalmus maximus* and dolphins. During the survey, whiting was not strongly represented in the catch composition, likely due to higher-than-usual seawater temperatures.
- The highest biomass of whiting was recorded in the 50–100 m stratum (5,810 t), followed by 2042 t in the 30–50 m layer and 256 t in the 15–30 m layer.
- The total surveyed area was 8010.24 km², and the estimated total biomass of whiting in Bulgarian Black Sea waters during October–November 2025 was 8109.2 t.
- Whiting showed the highest distribution density in the catches in the area off Byala and Cape Maslen Nos. In the 15–30 m depth layer, the species was recorded at all 12 stations; in the 30–50 m layer at 13 stations; and in the 50–100 m layer at 7 stations.
- In the 30–50 m depth layer, the highest C_{PUA} value recorded was 3413 kg·km⁻², with a mean of 1125.4 kg·km⁻². In the 15–30 m layer, C_{PUA} was 124 kg·km⁻², and in the 50–100 m layer, 1406.88 kg·km⁻².
- The highest C_{PUE} (kg·h⁻¹) values were recorded off Byala and southward toward Cape Maslen Nos.
- Length distribution (1200 individuals) was normal, with peaks at 10.5 and 12.5 cm.
- Individual weights ranged from 3.18 to 26.91 g.
- In the autumn 2025 survey, dominant age groups were 3–3+ years (28%) and 2–2+ years (20%), based on 1200 individuals.
- The length–weight relationship showed a high degree of fit ($R^2 = 0.96$).
- Growth parameters estimated using the von Bertalanffy growth function (VBGF) indicated an asymptotic length (L_{∞}) of 27.5 cm and a relatively low growth coefficient ($k = 0.23$).

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- Females comprised 50%, males 49%, and larvae 1% of the sampled individuals.
- Gonadal development indicates the onset of active reproduction. Due to warmer conditions, spawning activity is likely to intensify in the coming months as seawater temperatures decrease. Analysis of sexual maturity (250 individuals) showed gonads in stages 2a to 3b, with no clear dominance of a specific size group. No deviations from normal maturation patterns were observed.
- Male and female individuals aged 3–3+ years had the highest presence in the catches, predominantly at maturity stage 3a.
- The relationship between gonad weight and the gonadosomatic index (GSI) showed a high level of reliability ($R^2 = 0.86$).
- Absolute fecundity (measured in 250 individuals) was highest at a length of 17.5 cm, reaching 60322 eggs. The highest relative fecundity was observed in individuals of 14 cm length (3247.66 eggs). Mean values of absolute and relative fecundity were 36252 and 1596.02, respectively.

SPRAT

- During October–November 2025, sprat showed a scattered distribution in the nearshore zone, mainly due to high water temperatures. The highest biomass values were recorded at greater depths (30–50 m), reaching 4272.4 t. Sprat was recorded at 7 of the 36 surveyed stations.
- During October–November 2025, sprat biomass in the 15–30 m stratum was estimated at 0 t, followed by 6870.7 t in the 30–50 m stratum and 25.7 t in the 50–100 m stratum.
- The biomass in the 30–50 m stratum had the highest value (Sozopol–Primorsko area). As seawater temperature decreased compared to September 2025, a clear migration of aggregations toward coastal areas was observed. The total surveyed area was 8010.24 km², and the estimated total biomass of the sprat stock was 6896.4 t. Compared to September 2025, the instantaneous biomass of sprat along the Bulgarian Black Sea coast decreased by 93% during October–November. This indicates the high dynamics of sprat schools and the influence of external factors, such as hydrometeorological conditions and predation, on the distribution of small pelagic fish.
- The catch per unit area (CPUA, kg·km⁻²) was relatively high in the 50–100 m stratum, with the formation of aggregations atypical for sprat. The densest schools were recorded off Primorsko and southeast of Sozopol (30–50 m), while in other surveyed areas the species was spatially dispersed.
- Catch per unit effort (CPUE) for the identified species is presented spatially using GIS.



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➤ Length structure. During the survey (October–November 2025), the smallest identified length class was 6 cm and the largest 12 cm. The dominant length classes in the catch were 7, 9, and 10 cm, while other classes were less represented.

➤ Absolute fecundity showed a mean value of 35544 eggs, while relative fecundity was 7352 eggs.

PICKED DOGFISH

➤ The species *Squalus acanthias* was represented by incidental catches, with a total of 8 individuals (4 males and 4 females).

ANCHOVY

➤ During the October–November 2025 survey, only 7 individuals of *Engraulis encrasicolus* were caught at a single station out of 36. Biological and spatial–quantitative analyses could not be performed for the study period due to insufficient sample size.

Feeding – sprat and horse mackerel. Zooplankton in the environment.

➤ In October and November 2025, 27 species/groups were identified in zooplankton samples from the marine environment, of which 14 species/groups were present **in the diet** of both sprat and horse mackerel.

➤ **The main food items** for sprat were *Calanus euxinus* (IRI = 5486.61), followed by *Paracalanus parvus* (IRI = 3455.38) and *Pseudocalanus elongatus* (IRI = 1847.81). This characterizes sprat as a planktivorous filter feeder that primarily consumes copepod zooplankton. Horse mackerel also fed predominantly on zooplankton, with the most important prey items being *Pseudocalanus elongatus* (IRI = 1252.30), veliger larvae of bivalve mollusks (IRI = 1228.13), and *Paracalanus parvus* (IRI = 1054.14), indicating a planktivorous feeding strategy during October–November 2025. Although this species often shifts to active predation at larger sizes, such behavior was not observed during the study period. Differences in the abundance and composition of dietary items suggest that, despite partial overlap, the two species occupy distinct trophic niches: sprat prefer larger zooplankton, whereas horse mackerel consume smaller and larval forms.

➤ Data on the **index of stomach fullness (ISF)** in sprat and horse mackerel confirmed significant differences in feeding behavior between the two species. In sprat, the mean ISF was 1.113% of body weight (SD = 0.515), with a median of 1.076%, indicating relatively stable and widespread feeding within the population. The distribution of ISF showed moderate variability

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and was close to symmetrical, with 75% of individuals having an ISF $< 1.38\%$. However, in horse mackerel, the mean ISF is lower ($0.194\% \pm 0.203$ SD), with a median of 0.142% and a coefficient of variation exceeding 100%, indicating a highly skewed distribution. Most of the analyzed specimens had nearly empty stomachs ($Q_1 = 0.052\%$ BW; minimum = 0.002% BW), whereas improved feeding was observed in only a few individuals. Thus, the observed pattern reflects high heterogeneity in horse mackerel feeding, likely associated with reduced activity and/or a seasonal phase of low feeding in October - November 2025. These results, combined with spatial distribution data, confirm distinct trophic niches and feeding strategies between the two species, despite partial overlap in their dietary range and spatial occurrence.

➤ Analysis of the **number of prey items (PN)** in the stomach contents confirmed the differences in feeding activity between sprat and horse mackerel. In sprat, the mean number of prey was considerably higher ($285 \text{ ind/stomach} \pm 298.1$ SD), with 75% of individuals having fewer than 450 ind/stomach. Despite a strongly skewed distribution and wide range (up to 1493 ind/stomach), these data indicate widespread and relatively consistent feeding across the population. In horse mackerel, the mean PN was much lower (41.3 ± 97.7 ind/stomach, with a median of 10 ind/stomach), reflecting highly uneven feeding: most individuals had very few prey items in stomachs ($Q_1 = 1.0$ ind/stomach), while a few well-fed individuals (maximum: 559 ind/stomach) caused a spike in the mean value. These results again point to different feeding strategies: sprat exhibits stable and widespread filter-feeding activity, whereas horse mackerel shows episodic and selective feeding, likely associated with localized zooplankton aggregations.

➤ The **mean zooplankton biomass** was $16.03 \text{ g}\cdot\text{m}^{-3} \pm 7.95$ (SE), with gelatinous zooplankton being the dominant component (mean $15.96 \text{ g}\cdot\text{m}^{-3} \pm 7.95$ SE) and reaching local maxima of $\sim 95 \text{ g}\cdot\text{m}^{-3}$ off the central and southern coasts, indicating “bloom” events. The biomass of the fodder mesozooplankton was $50.98 \text{ mg}\cdot\text{m}^{-3}$, with the highest values ($\sim 142.96 \text{ mg}\cdot\text{m}^{-3}$) observed off the northern coast. Protozoa contributed a low mean biomass ($23.76 \text{ mg}\cdot\text{m}^{-3}$) but formed localized concentrations of up to $\sim 212.16 \text{ mg}\cdot\text{m}^{-3}$ off the northern and central coasts.

4. Measures for sustainable exploitation

1. Sprat:

$$\text{MSY} = B \cdot 0.5 = 6896.376 \cdot 0.5 = 3448.188 \text{ t}; \text{C}_{\text{msy}} = 2/3 \text{ MSY} = 2298.79 \text{ t}$$

Recommended catch levels in the western part of the Black Sea should not exceed 2298.79 t.

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2. Whiting:

$$MSY = B \cdot 0.5 = 2068.407 \cdot 0.5 = 1034.2; C_{msy} = \frac{2}{3} MSY = 689.5 \text{ t}$$

Recommended catch levels in the western part of the Black Sea should not exceed 689.5 t.

3. Red mullet:

$$MSY = B \cdot 0.5 = 447.06 \cdot 0.5 = 223.5; C_{msy} = \frac{2}{3} MSY = 149.02 \text{ t}$$

Recommended catch levels in the western part of the Black Sea should not exceed 149.02 t.

4. Horse mackerel:

$$MSY = B \cdot 0.5 = 5629 \cdot 0.5 = 2815; C_{msy} = \frac{2}{3} MSY = 1876 \text{ t}$$

Recommended catch levels in the western part of the Black Sea should not exceed 1876 t.



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ANNEX

Catch per unit effort (CPUE, $\text{kg} \cdot \text{h}^{-1}$), catch per unit area (CPUA, $\text{kg} \cdot \text{km}^{-2}$), and biomass (t) of the species from the October–November 2025 survey

A) whiting

стратум	начални координати	крайни координати	CPUE kg/h	CPUA kg/km^2	Biomass
15-30m	43.139535	28.038789 43.111946 28.025208	8	124.128	7.76793
15-30m	43.337701	28.388665 43.325230 28.202990	0	0	0
15-30m	43.325806	28.350185 43.331488 28.241957	0	0	0
15-30m	43.318006	28.354043 43.313231 28.392400	0	0	0
15-30m	43.308455	28.292927 43.292064 28.423581	0	0	0
15-30m	43.048990	27.927895 43.029864 28.362635	0	0	0
15-30m	43.024321	27.913585 42.995157 28.306160	0	0	0
15-30m	43.047696	27.925002 43.032705 28.765383	0	0	0
15-30m	43.011109	27.910010 42.993065 28.775455	0	0	0
15-30m	42.665860	27.833580 42.665242 28.928961	0	0	0
15-30m	42.660831	27.772767 42.640104 28.919681	0	0	0
15-30m	42.616297	27.804966 42.646605 28.309677	0	0	0
15-30m	42.907143	27.948108 42.926538 28.236452	0	0	0
30-50m	43.073545	28.179449 43.091484 27.914491	8	124.128	7.76793
30-50m	43.098259	28.211478 43.117791 27.915801	0	0	0
30-50m	43.161396	28.373468 43.183039 27.948545	28	434.448	27.18776
30-50m	43.188234	28.395617 43.209250 27.940227	4	62.064	3.883965
30-50m	43.024321	27.913585 42.995157 28.147134	0	0	0
30-50m	42.888691	27.948545 42.888691 28.089211	220	3413.52	213.6181
30-50m	42.861985	27.942716 42.842486 28.125817	200	3103.2	194.1983
30-50m	42.839789	28.119971 42.866506 27.914085	200	3103.2	194.1983
30-50m	42.733101	28.074665 42.762733 27.912727	40	620.64	38.83965
30-50m	42.815992	28.112346 42.842788 27.797553	20	310.32	19.41983
30-50m	42.332337	28.012977 42.368645 27.758281	8	124.128	7.76793
30-50m	42.456191	27.756395 42.433721 28.126536	44	682.704	42.72362
30-50m	42.433597	27.783598 42.459233 28.152567	40	620.64	38.83965
30-50m	42.514355	27.787837 42.535653 28.025653	40	620.64	38.83965
30-50m	42.544826	27.783901 42.571059 27.991012	40	620.64	38.83965
30-50m	42.584169	27.775522 42.610050 27.763764	88	1365.408	85.44723
30-50m	42.622021	27.863606 42.596737 27.790294	80	1241.28	77.6793
30-50m	42.560735	27.794585 42.542022 27.784807	20	310.32	19.41983
30-50m	42.590709	27.828328 42.568596 27.776703	20	310.32	19.41983
30-50m	42.538457	27.760130 42.516875 27.795119	20	310.32	19.41983
30-50m	42.516093	27.802194 42.535689 27.805984	20	310.32	19.41983
30-50m	42.546780	27.842685 42.566914 27.841667	20	310.32	19.41983
50-100m	43.607520	28.769174 43.592482 27.763332	0	0	0
50-100m	43.585432	28.768099 43.572231 27.806872	0	0	0
50-100m	42.230525	28.091367 42.243749 27.742845	20	310.32	19.41983
50-100m	42.248022	28.137175 42.263770 27.824576	24	372.384	23.30379
50-100m	42.295778	28.046968 42.323468 27.864138	0	0	0

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B) sprat

стратум	начални координати	крайни координати	CPUEkg/h	CPUAg/kg	Biomass
15-30m	43.139535	28.038789	43.111946	28.025208	8 124.128 7.76793
15-30m	43.337701	28.388665	43.325230	28.202990	0 0 0
15-30m	43.325806	28.350185	43.331488	28.241957	0 0 0
15-30m	43.318006	28.354043	43.313231	28.392400	0 0 0
15-30m	43.308455	28.292927	43.292064	28.423581	0 0 0
15-30m	43.048990	27.927895	43.029864	28.362635	0 0 0
15-30m	43.024321	27.913585	42.995157	28.306160	0 0 0
15-30m	43.047696	27.925002	43.032705	28.765383	0 0 0
15-30m	43.011109	27.910010	42.993065	28.775455	0 0 0
15-30m	42.665860	27.833580	42.665242	28.928961	0 0 0
15-30m	42.660831	27.772767	42.640104	28.919681	0 0 0
15-30m	42.616297	27.804966	42.646605	28.309677	0 0 0
15-30m	42.907143	27.948108	42.926538	28.236452	0 0 0
30-50m	43.073545	28.179449	43.091484	27.914491	8 124.128 7.76793
30-50m	43.098259	28.211478	43.117791	27.915801	0 0 0
30-50m	43.161396	28.373468	43.183039	27.948545	28 434.448 27.18776
30-50m	43.188234	28.395617	43.209250	27.940227	4 62.064 3.883965
30-50m	43.024321	27.913585	42.995157	28.147134	0 0 0
30-50m	42.888691	27.948545	42.888691	28.089211	220 3413.52 213.6181
30-50m	42.861985	27.942716	42.842486	28.125817	200 3103.2 194.1983
30-50m	42.839789	28.119971	42.866506	27.914085	200 3103.2 194.1983
30-50m	42.733101	28.074665	42.762733	27.912727	40 620.64 38.83965
30-50m	42.815992	28.112346	42.842788	27.797553	20 310.32 19.41983
30-50m	42.332337	28.012977	42.368645	27.758281	8 124.128 7.76793
30-50m	42.456191	27.756395	42.433721	28.126536	44 682.704 42.72362
30-50m	42.433597	27.783598	42.459233	28.152567	40 620.64 38.83965
30-50m	42.514355	27.787837	42.535653	28.025653	40 620.64 38.83965
30-50m	42.544826	27.783901	42.571059	27.991012	40 620.64 38.83965
30-50m	42.584169	27.775522	42.610050	27.763764	88 1365.408 85.44723
30-50m	42.622021	27.863606	42.596737	27.790294	80 1241.28 77.6793
30-50m	42.560735	27.794585	42.542022	27.784807	20 310.32 19.41983
30-50m	42.590709	27.828328	42.568596	27.776703	20 310.32 19.41983
30-50m	42.538457	27.760130	42.516875	27.795119	20 310.32 19.41983
30-50m	42.516093	27.802194	42.535689	27.805984	20 310.32 19.41983
30-50m	42.546780	27.842685	42.566914	27.841667	20 310.32 19.41983
50-100m	43.607520	28.769174	43.592482	27.763332	0 0 0
50-100m	43.585432	28.768099	43.572231	27.806872	0 0 0
50-100m	42.230525	28.091367	42.243749	27.742845	20 310.32 19.41983
50-100m	42.248022	28.137175	42.263770	27.824576	24 372.384 23.30379
50-100m	42.295778	28.046968	42.323468	27.864138	0 0 0

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C) horse mackerel

стратум	начални координати	крайни координати	CPUEkg/h	CPUAg/kg	Biomass
15-30m	43.139535	28.038789	43.111946	28.025208	40 620.64 38.83965
15-30m	43.337701	28.388665	43.325230	28.202990	240 3723.84 233.0379
15-30m	43.325806	28.350185	43.331488	28.241957	280 4344.48 271.8776
15-30m	43.318006	28.354043	43.313231	28.392400	340 5275.44 330.137
15-30m	43.308455	28.292927	43.292064	28.423581	340 5275.44 330.137
15-30m	43.048990	27.927895	43.029864	28.362635	4 62.064 3.883965
15-30m	43.024321	27.913585	42.995157	28.306160	8 124.128 7.76793
15-30m	43.047696	27.925002	43.032705	28.765383	100 1551.6 97.09913
15-30m	43.011109	27.910010	42.993065	28.775455	120 1861.92 116.519
15-30m	42.665860	27.833580	42.665242	28.928961	32 496.512 31.07172
15-30m	42.660831	27.772767	42.640104	28.919681	32 496.512 31.07172
15-30m	42.616297	27.804966	42.646605	28.309677	48 744.768 46.60758
15-30m	42.907143	27.948108	42.926538	28.236452	120 1861.92 116.519
30-50m	43.073545	28.179449	43.091484	27.914491	48 744.768 46.60758
30-50m	43.098259	28.211478	43.117791	27.915801	0 0 0
30-50m	43.161396	28.373468	43.183039	27.948545	0 0 0
30-50m	43.188234	28.395617	43.209250	27.940227	240 3723.84 233.0379
30-50m	43.024321	27.913585	42.995157	28.147134	4 62.064 3.883965
30-50m	42.888691	27.948545	42.888691	28.089211	0 0 0
30-50m	42.861985	27.942716	42.842486	28.125817	0 0 0
30-50m	42.839789	28.119971	42.866506	27.914085	0 0 0
30-50m	42.733101	28.074665	42.762733	27.912727	0 0 0
30-50m	42.815992	28.112346	42.842788	27.797553	0 0 0
30-50m	42.332337	28.012977	42.368645	27.758281	0.4 6.2064 0.388397
30-50m	42.456191	27.756395	42.433721	28.126536	16 248.256 15.53586
30-50m	42.433597	27.783598	42.459233	28.152567	16 248.256 15.53586
30-50m	42.514355	27.787837	42.535653	28.025653	20 310.32 19.41983
30-50m	42.544826	27.783901	42.571059	27.991012	44 682.704 42.72362
30-50m	42.584169	27.775522	42.610050	27.763764	40 620.64 38.83965
30-50m	42.622021	27.863606	42.596737	27.790294	80 1241.28 77.6793
30-50m	42.560735	27.794585	42.542022	27.784807	80 1241.28 77.6793
30-50m	42.590709	27.828328	42.568596	27.776703	40 620.64 38.83965
30-50m	42.538457	27.760130	42.516875	27.795119	44 682.704 42.72362
30-50m	42.516093	27.802194	42.535689	27.805984	200 3103.2 194.1983
30-50m	42.546780	27.842685	42.566914	27.841667	240 3723.84 233.0379
50-100m	43.607520	28.769174	43.592482	27.763332	0 0 0
50-100m	43.585432	28.768099	43.572231	27.806872	0 0 0
50-100m	42.230525	28.091367	42.243749	27.742845	0 0 0
50-100m	42.248022	28.137175	42.263770	27.824576	0 0 0
50-100m	42.295778	28.046968	42.323468	27.864138	0.4 6.2064 0.388397

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d) red mullet

начални координати крайни координати				CPUEkg/h	CPUAkg/kr	Biomass
43.139535	28.038789	43.111946	28.025208	4	62.064	3.883965
43.337701	28.388665	43.325230	28.202990	0	0	0
43.325806	28.350185	43.331488	28.241957	0	0	0
43.318006	28.354043	43.313231	28.392400	0	0	0
43.308455	28.292927	43.292064	28.423581	0	0	0
43.048990	27.927895	43.029864	28.362635	0	0	0
43.024321	27.913585	42.995157	28.306160	0	0	0
43.047696	27.925002	43.032705	28.765383	0	0	0
43.011109	27.910010	42.993065	28.775455	0.8	12.4128	0.776793
42.665860	27.833580	42.665242	28.928961	0	0	0
42.660831	27.772767	42.640104	28.919681	0	0	0
42.616297	27.804966	42.646605	28.309677	0	0	0
42.907143	27.948108	42.926538	28.236452	0	0	0
43.073545	28.179449	43.091484	27.914491	4	62.064	3.883965
43.098259	28.211478	43.117791	27.915801	0	0	0
43.161396	28.373468	43.183039	27.948545	0	0	0
43.188234	28.395617	43.209250	27.940227	0.04	0.62064	0.03884
43.024321	27.913585	42.995157	28.147134	0	0	0
42.888691	27.948545	42.888691	28.089211	0	0	0
42.861985	27.942716	42.842486	28.125817	0	0	0
42.839789	28.119971	42.866506	27.914085	0	0	0
42.733101	28.074665	42.762733	27.912727	0	0	0
42.815992	28.112346	42.842788	27.797553	0	0	0
42.332337	28.012977	42.368645	27.758281	0	0	0
42.456191	27.756395	42.433721	28.126536	0	0	0
42.433597	27.783598	42.459233	28.152567	0	0	0
42.514355	27.787837	42.535653	28.025653	16	248.256	15.53586
42.544826	27.783901	42.571059	27.991012	20	310.32	19.41983
42.584169	27.775522	42.610050	27.763764	20	310.32	19.41983
42.622021	27.863606	42.596737	27.790294	100	1551.6	97.09913
42.560735	27.794585	42.542022	27.784807	100	1551.6	97.09913
42.590709	27.828328	42.568596	27.776703	20	310.32	19.41983
42.538457	27.760130	42.516875	27.795119	20	310.32	19.41983
42.516093	27.802194	42.535689	27.805984	20	310.32	19.41983
42.546780	27.842685	42.566914	27.841667	20	310.32	19.41983
43.607520	28.769174	43.592482	27.763332	0	0	0
43.585432	28.768099	43.572231	27.806872	0	0	0
42.230525	28.091367	42.243749	27.742845	0	0	0
42.248022	28.137175	42.263770	27.824576	0	0	0
42.295778	28.046968	42.323468	27.864138	0	0	0

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