



BIOLOGICAL MONITORING OF LANDINGS OF COMMERCIALY IMPORTANT SPECIES

**Scientific report under contract N156/28/03/2025
covering the results for I-VI 2025**



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**BULGARIAN ACADEMY OF SCIENCES
INSTITUTE OF OCEANOLOGY VARNA**

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List of authors:

Associate Professor Maria Yankova, Ph.D.

Associate Professor Violin Raykov, Ph.D.

Main assistant Ivelina Zlateva Ph.D

Professor Petya Ivanova, Ph.D.

Associate Professor Nina Djembekova Ph.D

Technician Neli Valcheva

Technician Diana Hristova

logistics Jordan Yordanov

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In connection with the implementation of **Contract No. 156 of 28.03.2025**, sampling was done for inclusion in the biological monitoring from the northern and southern coasts. The data of this analysis are collected from the landings in the ports of the Bulgarian Black Sea coast of the Black Sea.

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During the first half of 2025, biological catch data were collected from a total of **16 fishing vessels** (Table 1).

Table 1. Fishing vessels and fish species from the biological monitoring survey in the first half of 2025.

№	Fishing vessel	External marking	Fishing gear - code	Fish species - code
1.	BAHARI	NS 769	OTM	WHG
2.	БУРЕБЕСТНИК	BS 032	OTM	MUT
3.	VENI	VN 2998	OTM	MUT
4.	VALNOBOR	BS 2330	OTM	HMM, HMM, WHT, ANE
5.	IVA - 1	VN 8194	LLD	DGS
6.	ISHTAR	NS 1182	OTM	SPR, MUT
7.	KALIAKRA	VN 8110	OTM	HMM
8.	MEDUZA 3	BS 288	OTM	HMM,HMM,
9.	R/K 28		OTM	SPR SPR
10.	R/K 37	BS 255	OTM	ANE
11.	R/K 40	R/K 40	OTM	SPR ANE
12.	RUSANO	VN 4445	LLD	DGS
13.	SVETI NIKOLA I	BS 175	OTM	SPR
14.	SVETA ANNA - 1	VN 8265	OTM	MUT
15.	VN 78112	VN 8112	LLS	DGS
16.	VN 7822	VN 7822	LLD	DGS
				5 samples of sprat (SPR) 5 samples of horse mackerel (HMM) 2 samples of whiting (WHG) 4 samples of red mullet (MUT) 3 samples of anchovy (ANE) 4 samples of shark (DGS) Σ 23 samples for I-VI 2025



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I. Biological monitoring of sprat (*Sprattus sprattus*) landings

I.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze sprat catches, as well as to form a database. The collection of biological samples of sprat catches in **I-VI 2025** includes the **following tasks**:

1. To collect and analyze the dynamics of length, weight and age distribution.
2. To determine the state of the sprat using the so-called state factor (Ricker, 1975).
3. Characteristics of the reproductive biology of sprat.
4. Collection of data on ports of landing, sampling vessels, number of samples collected, number of specimens tested, geographical catch data.

I.2 Sampling

The sampling was carried out by the actively operating fishing fleet in Bulgaria.

I.2.1 Geographic area coverage

The data from the current analysis is collected directly from the landings in the ports of the Bulgarian Black Sea coast. During the period **I-VI 2025** were collected **5 samples with 818 specimens**. Information on the size of the catches was also collected.

I.2.2 Sampling period

The biological data on sprat were collected from a total of **5 landings at the ports of Sozopol and Nessebar**. Information on the size of the catches was also collected. Ports and ships from which monitoring was carried out to collect biological data from landings are presented in **Table I.2.2.1**.

Table I.2.2.1 Ports and ships from which monitoring was carried out to collect biological data from sprat discharges.

N	SPR	Harbour	Fishing vessel	External marking	Catch	Number	Coordinates
1	31.3.2025	Sozopol	RK 28	BS221	1050 kg	93	42.504700 28.011300
2	31.3.2025	Nesebar	RK 40	BS258	1200 kg	268	42.6702690125 27.8198375702
3	3.4.2025	Nesebar	ISHTAR	NS 1182	2235 kg	114	42.6604614258

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							27.7332077026
4	28.5.2025	Nesebar	SVETI NIKOLA I	BS175	2620 kg	185	42.646200 27.727300
5	19.6.2025	Sozopol	RK 28	BS221	2640 kg	158	42.422300 27.691300
						818	

I.2.3 Statistical analysis of data

All samples were collected according to variation statistics from significant catches where possible. Samples were collected randomly. Samples are processed in laboratory conditions. Length is measured to the nearest 0.5 cm, and only the total length is taken into account. Weight is measured to the nearest gram (0.1 gram). Age determination was performed under an Olympus CX 31RTSF-6 microscope. Thus, the annual rings stand out as transparent zones, followed by darker zones (opaque) - zones of stagnation (stagnation) in growth. The Fulton index is estimated according to Ricker equation, (1975):

$$K = \frac{W}{L^3} * 100$$

"Length-age keys" are created for all samples. In this way, the average values of length, weight and condition factor are determined. The share (in %) of individuals from the respective age groups is determined.

Fecundity: All fish were measured to the nearest 1 mm in total length (TL) and weighed to the nearest 1 gram. The gonads of the fish are 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 (i.e, number of males ♂/ number of females ♀ (Simon *et al.*, 2012). Females were determined by macroscopic observation of a mature ovary (Laevastu, 1965a).

Batch fecundity rates can vary greatly during the short spawning season, being low at the beginning, peaking during the heaviest spawning and declining again towards the end. The fecundity rate of sprat was determined by the "hydrated oocyte method" (Hunter *et al* 1985). Oily hydrated females were used. After sampling their body cavity was opened and they ovary were 'preserved in a buffered formalin solution (Hunter *et al* 1985). The ovary free female weight and the ovary weight were determined. Three tissue samples of -50 mg were removed from different parts of the ovary and their exact weights were determined. Under a binocular microscope, the number of hydrated oocytes in each of the three subsamples was determined. Hydrated oocytes can be easily distinguished from all other types of oocytes due to their large size and translucent appearance and their wrinkled surface due to formalin preservation. Batch fecundity was estimated based on the average number of hydrated oocytes per unit weight of the three samples. The gonadosomatic index (GSI) was calculated as:

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

where, GW is gonad weight and SW is somatic weight (represents BW without GW).

The length – weight relationship is obtained by the following equation: $W_t = qL_t^n$
where: q – parameter, n – parameter of the relationship between length and weight.

I.3 Results

I.3.1 Landings statistics

The graph shows the landings of the sprat with OTM in kilograms for the first half of 2025. The month of January has the lowest value. During the first three months low weight values of landings are observed. During the second three months landings are significantly higher and in May the highest value for the half-year is recorded (**Fig. I.3.1.1**).

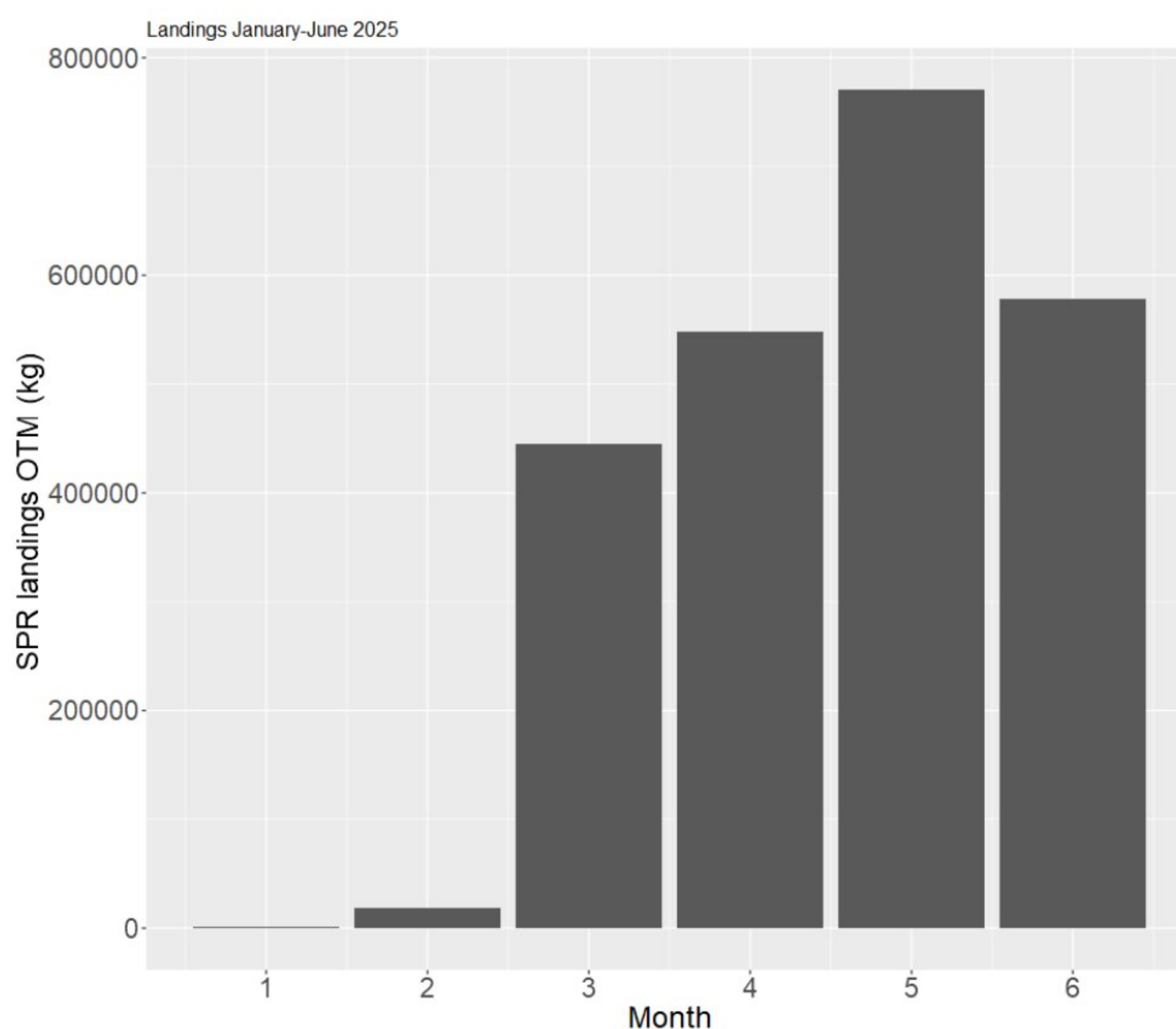


Figure I.3.1.1 Official statistics records for sprat landings.

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I.3.2 Length structure of landings

In the first quarter, an increase in the percentage of individuals from the size groups 6-6.5 cm was observed, representing over 18%. A sharp decrease in the presence was noted in the group of 10-10.5 and 11 cm, participating with less than 5%. In the second quarter, the classes with a length of 9 cm had the highest share in the landings and again the lowest percentage was observed in the oldest size classes 10-11 cm (**Fig.I.3.2.1**).

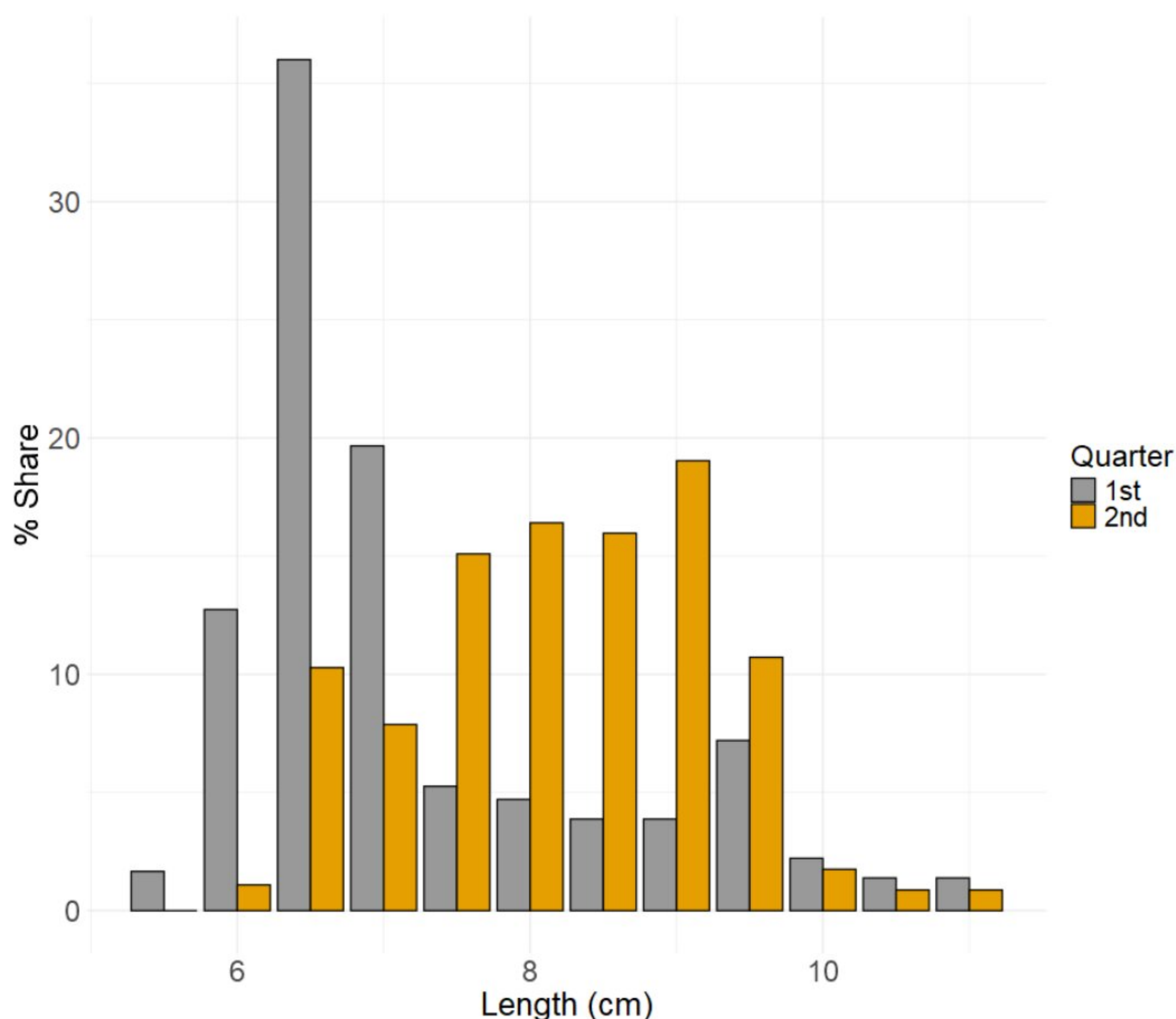


Fig I.3.2.1 Size structure and percentage share of length classes in the catch composition.



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I.3.3 Age structure of landings

During the first and second quarters, the highest percentage share is occupied by individuals in the age group 1-1+ and they significantly prevail over the others. The lowest share is in the age groups: 3-3+ and 4-4+ (**Fig.I.3.3.1**).

Experimental age determination - three specialists determined the age of the otoliths, and determiner 1 looked at all otoliths twice. Samples **n = 818 specimens** were used for age determination.

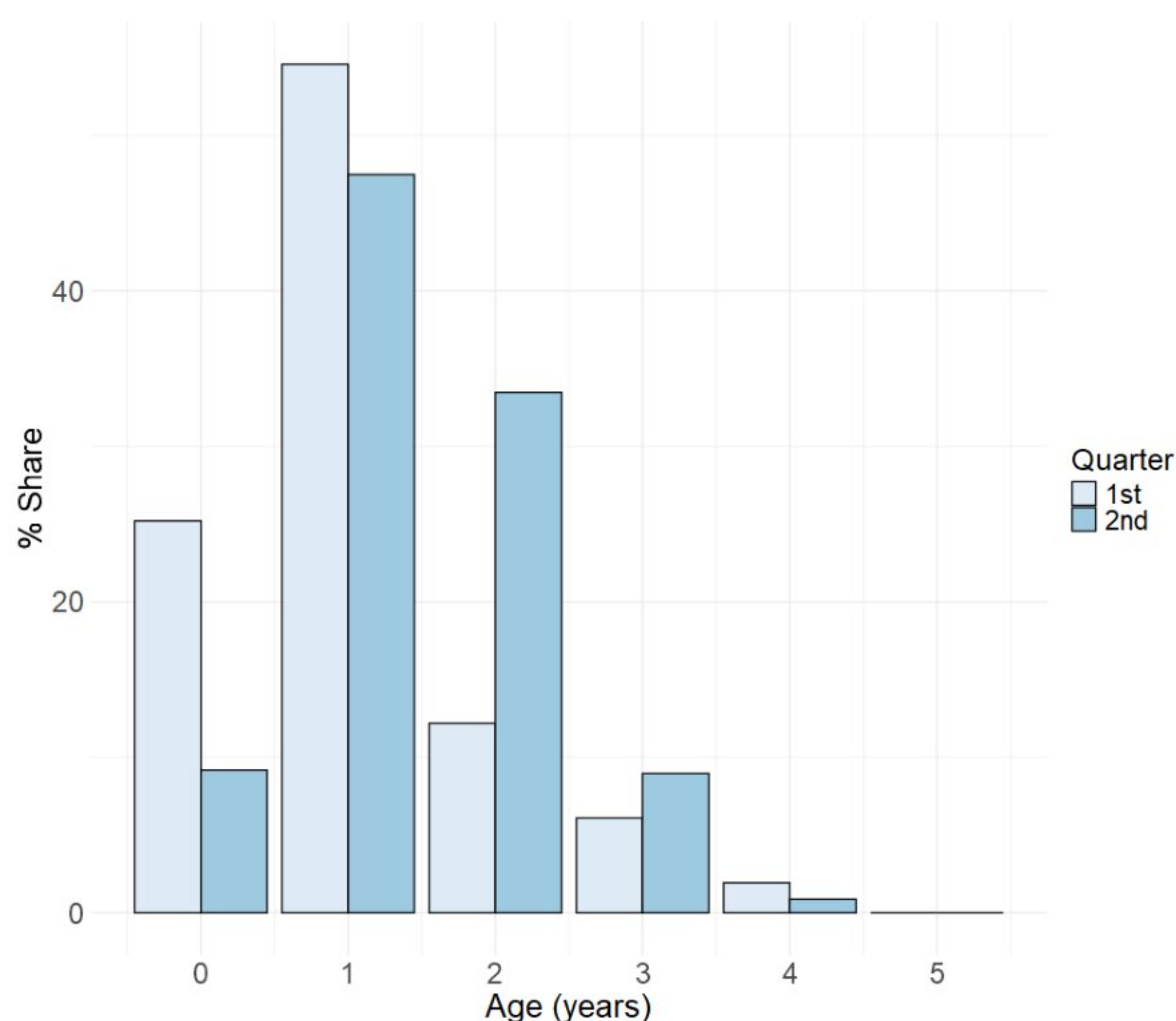


Fig. I.3.3.1 Percentage representation of sprat age groups in the catch composition in the first and second semesters of 2025.

Age structure of the sprat.

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The comparative analysis of the age structure of catches from commercial fishing was carried out mainly in the area in front of the town of Sozopol and the town of Nessebar. In these catches, 1-1+ years prevail, followed by 0+ years and 2-2+ in the first quarter, with 4-4+ being present with a small percentage. The replenishment (0+) was represented by 3.3%.

In the second quarter of the year, a dominant role of 1-1+ stands out, with 2-2+ years peaking at 33.47%. Four-years were the least represented with 0.87%.

Results of age slicing methods – analyzes were performed in the R programming environment (Program Language for Statistical Modeling and Analysis) using ELEFAN functions (ELEctronic LENgth Frequency Analysis).

ELEFAN is a size-frequency sampling analysis method that is used in fish stock research to estimate growth and other biological parameters of research species based on measured lengths of individuals of different age groups.

The samples are restructured for analysis purposes to follow the evolution of the cohorts over time (**Fig. I.3.3.2-3** - the first and second frequency diagram shows the size structure of the collected specimens in the respective months, and the second - the restructured data with a moving average MA = 5).



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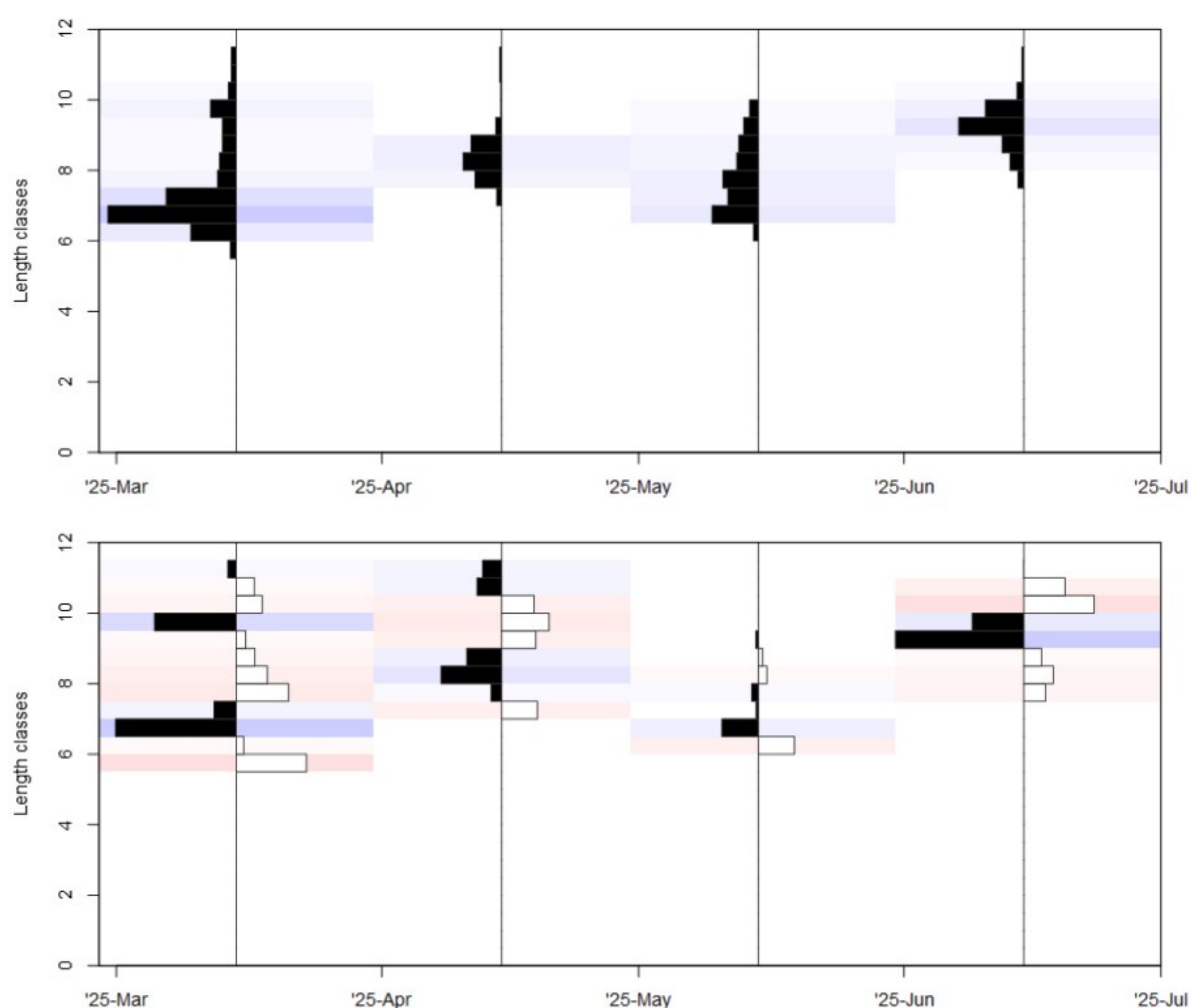


Fig.I.3.3.2 Size-frequency samples for the first half of the year visualized as (diagram above) number of individuals in a size class and (diagram below) the restructured data with moving average MA = 5 for the purposes of frequency analysis and determination of growth parameters.

I.1.3.3.1 Frequency analysis RSA – response surface analysis

Growth parameters determined by RSA with initial conditions: conditional interval of for the asymptotic length L_{∞} in the sample [11;13cm] and the parameter that determines the rate of growth to $L_{\infty} - K = \exp(seq(from \log(0.1), to \log(2)))$ at an upper limit for $L_{\infty} = 13.0$ cm with $\Delta_t = 0.05$.

The parameters in the von Bertalanffy model are calculated as follows:

$L_{\infty} = 12.65$ cm; $K = 0.41$ u $t_0 = -0.55$. According to the latter, the ages with their corresponding lengths were calculated (**Table I.1.3.3.3.1**).

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I.1.3.3.2 Frequency analysis ELEFAN with simulated annealing (ELEFAN SA)

The growth parameters determined under initial conditions: a conditional interval of for the asymptotic length $[L_{\infty}]_{\text{guess}}=11.75$ cm and a search for the value of L_{∞} in the interval $[L_{(\infty\text{guess})} \cdot 0.9 \div L_{(\infty\text{guess})} \cdot 1.2]$, and for K in the interval $[0 \div 1]$.

The parameters in the von Bertalanffy model were calculated as follows: $L_{\infty} = 12.72$ cm; $K = 0.38$ u $t_0 = -0.78$. The ages with their corresponding lengths were calculated using the latter (Table I.1.3.3.3.1).

I.1.3.3.3 Frequency analysis ELEFAN – Genetic algorithm (ELEFAN GA)

Growth parameters determined under initial conditions: conditional interval of for the asymptotic length $[L_{\infty}]_{\text{guess}}=11.75$ cm and search for value L_{∞} in the interval $[L_{(\infty\text{guess})} \cdot 0.9 \div L_{(\infty\text{guess})} \cdot 1.2]$, and for K in the interval $[0 \div 1]$.

The parameters in the von Bertalanffy model are calculated as follows: $L_{\infty} = 13.50$ cm; $K = 0.37$ u $t_0 = -0.59$. The latter were used to calculate the ages with their corresponding lengths (Table I.1.3.3.3.1).

Table I.1.3.3.3.1 Ages with their corresponding lengths for the studied species calculated using von Bertalanffy parameters, obtained with RSA, ELEFAN with simulated annealing, ELEFAN with genetic algorithm and compared with experimentally determined ages from otoliths **for the first semester.**

	ELEFAN RSA	ELEFAN SA	ELEFAN GA	Experimentally determined
age	La	La	La	L_{mean} (mid-point)
0	2.6	3.3	2.7	n/a
0.5	4.4	4.9	4.5	6
1	5.9	6.3	6.0	7.5
1.5	7.2	7.4	7.3	
2	8.2	8.3	8.4	9
2.5	9.0	9.1	9.2	
3	9.7	9.7	10.0	9.75

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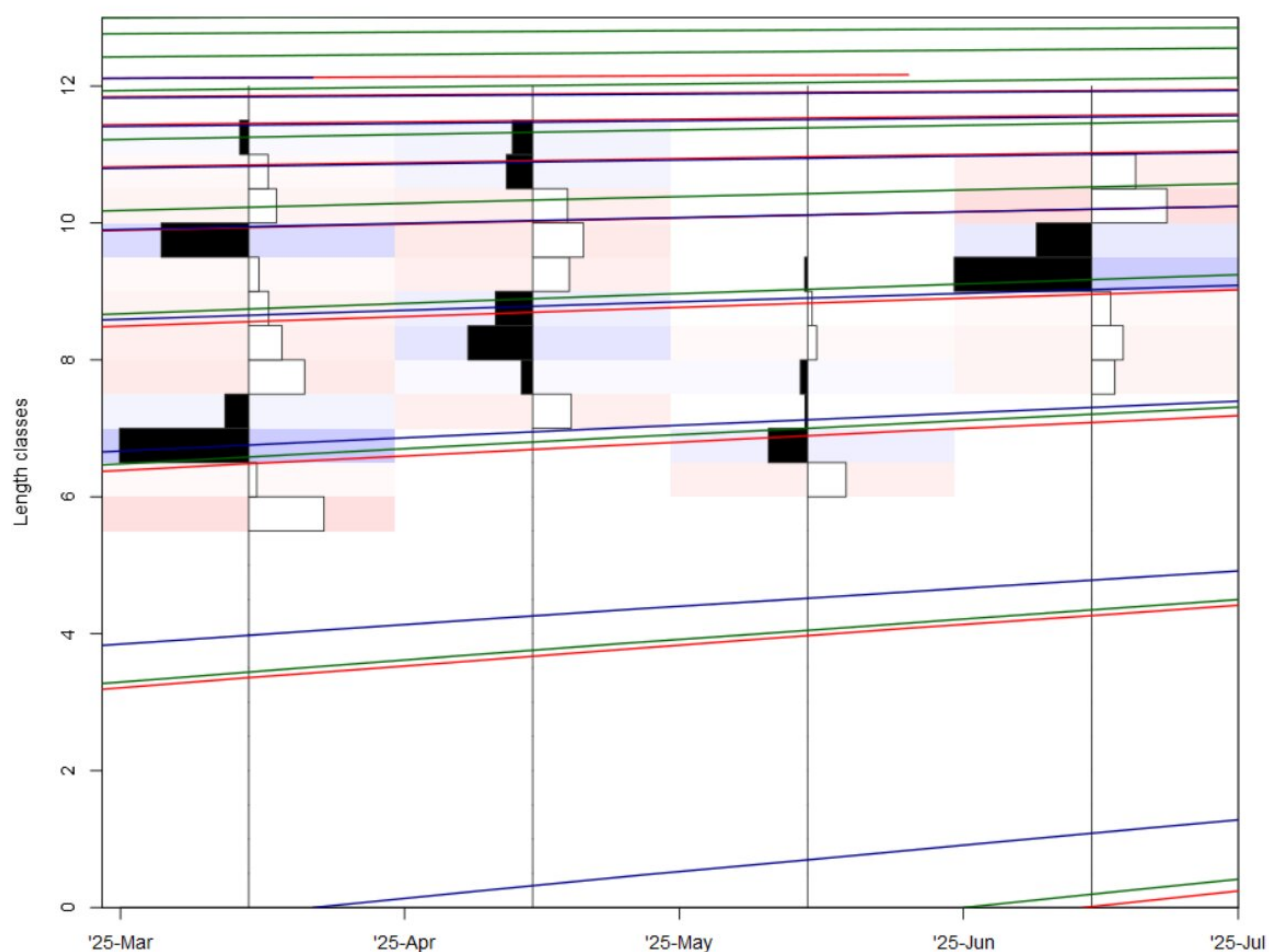


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3.5	10.2	10.2	10.6	
4	10.7	10.7	11.1	10.75
4.5	11.1	11.0	11.5	
5	11.4	11.3	11.8	n/a



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Fig. I.1.3.3.3.1 Growth curves (in red for growth parameters determined with ELEFAN RSA, in blue for ELEFAN SA, and in green for ELEFAN GA), visualized on the restructured data for the purpose of visualizing the tracking of cohorts over time **for the first semester of 2025**.

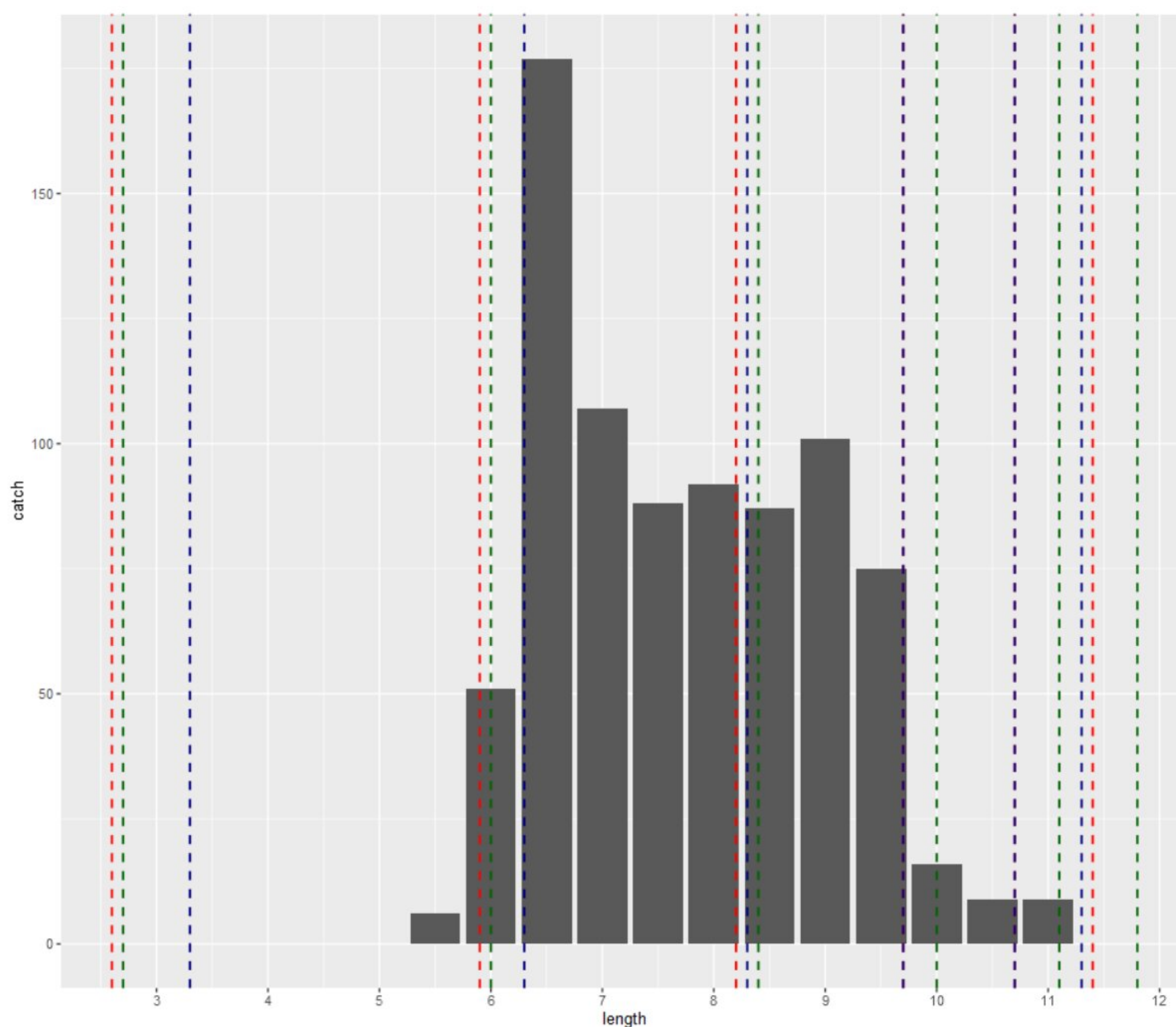


Fig. I.1.3.3.3.3 The ages represented with dashed lines, calculated based on the growth parameters determined by ELEFAN RSA, are overlaid on the cumulative sample of the composition of commercial catches of sprat, aiming to visualize the range of size classes represented in a specific age group (0-5 years) **for the first half of 2025**.

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The results from ELEFAN with the three applied methods are relatively consistent and applicable to the experimentally determined ages with small discrepancies for the age group 0-0+, the likely reason for this being limiting factors such as the sample size and the consideration of growth parameters for an age of less than a year. Another serious problem is selectivity, which leads to an incomplete representation of the size composition of the stock in the samples, which in turn affects the calculation of biological potentials.

Based on the analysis conducted, ELEFAN RSA gives results closest to those experimentally determined for the aging of individuals in the samples and, accordingly, the growth parameters of the stock *S. sprattus* for the first half of 2025 can be determined as follows: $L_{\infty} = 12.95 \text{ cm}$; $K = 0.39 \text{ u}$ $t_0 = -0.64$.

I.3.4 Condition factor

The graph (**Fig.I.3.4.1**) shows that during the first six months K is highest for the 8.0 cm size class. The other size groups also have good condition, which indicates food security and good physiological condition.

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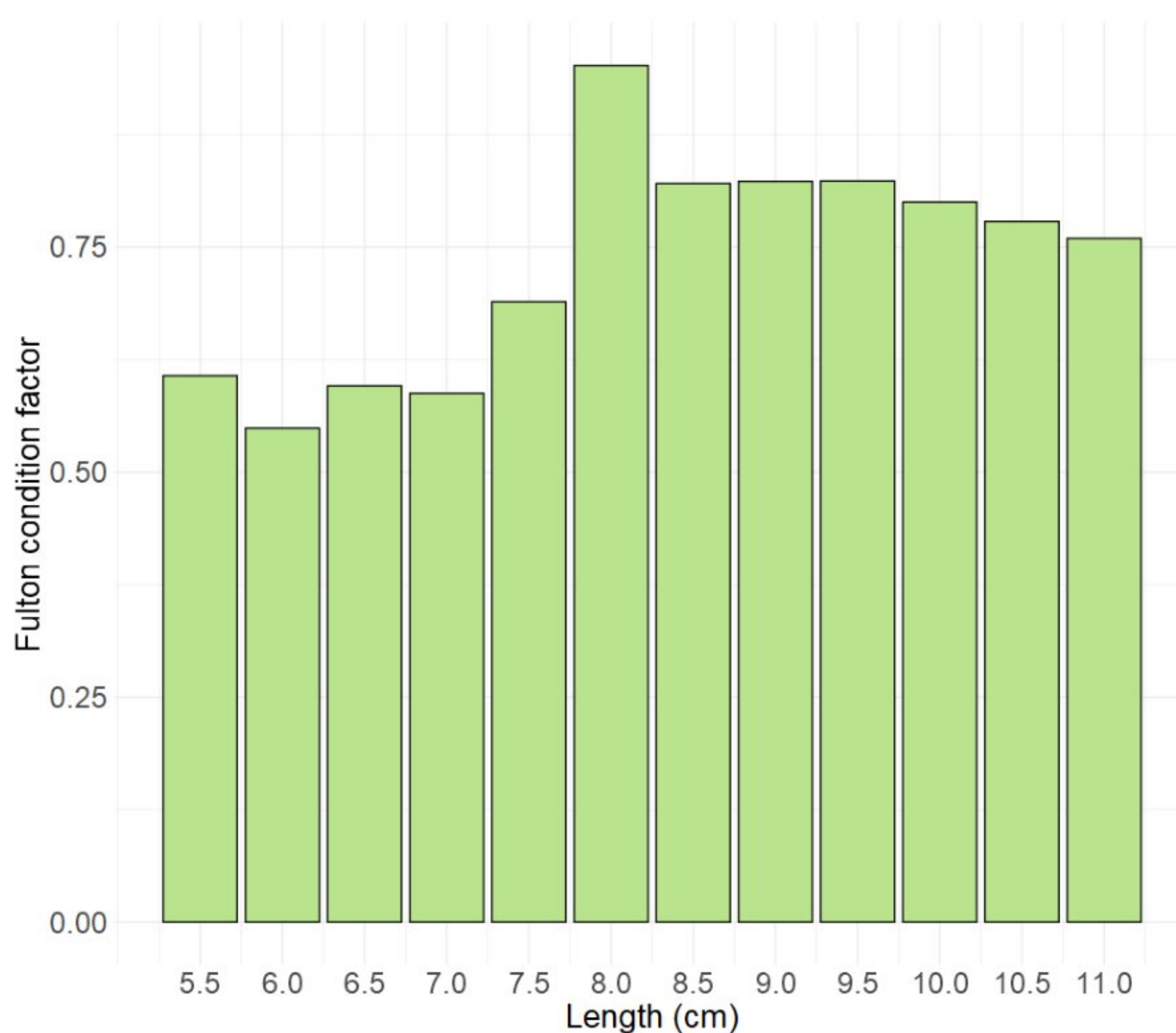


Fig. I.3.4.1 Fulton condition coefficient values of sprat by length classes for the first semester of 2025.

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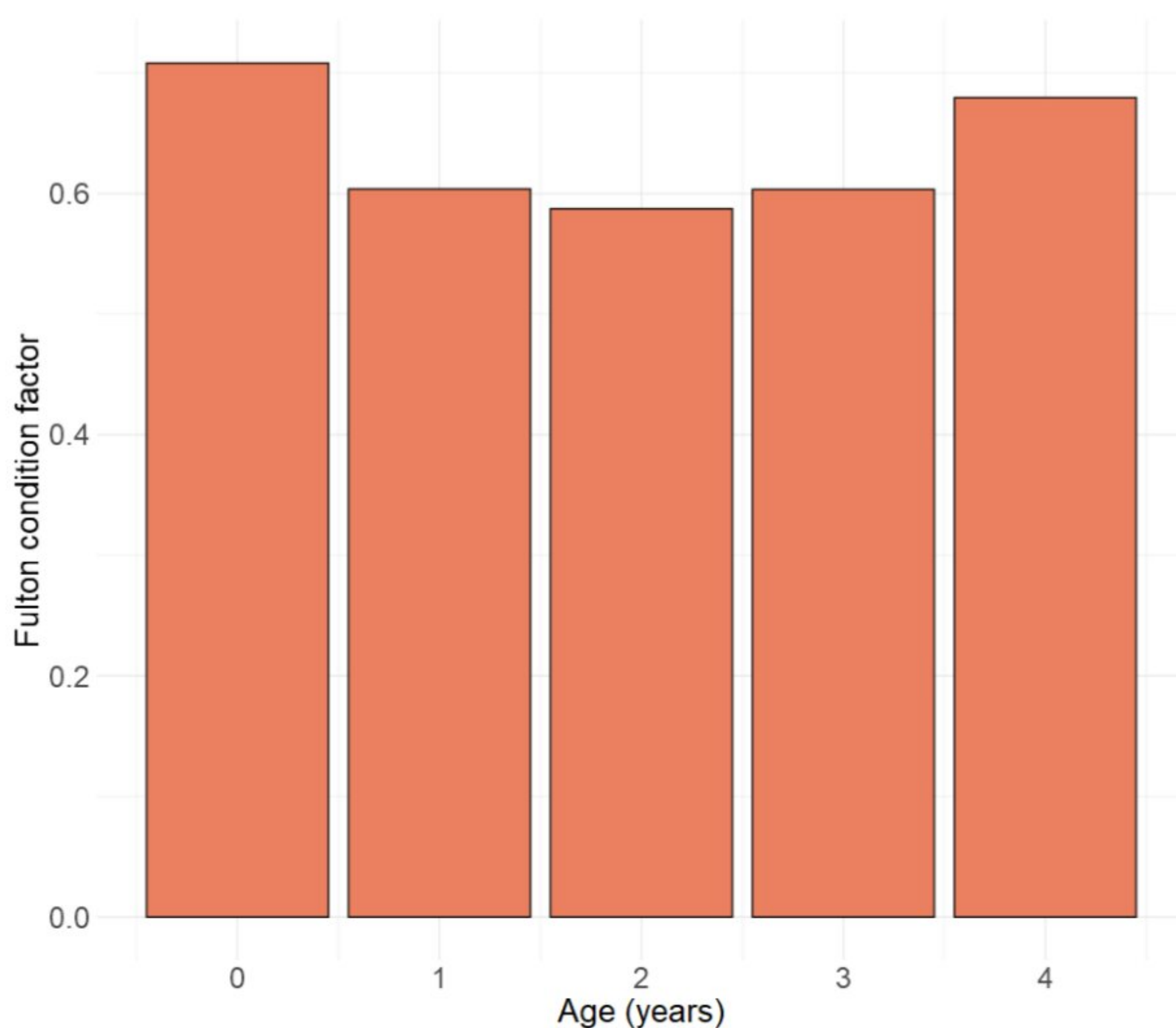


Fig. I.3.4.2 Fulton condition coefficient values of sprat by age groups classes for the first semester of 2025.

I.3.5 Weight structure of sprat

The weight of **818 specimens** was measured. A gradual increase in the average weight was observed in relation to the age groups. For the age group 0-0+ the lowest average weight was 1.52g (participating with 16.25% of the catch), and for the group 4-4+ the highest average weight was observed at 8.44g (participating with 1.34% of the catch). For the remaining age groups, the weights are as follows: 1-1+-2.54g (50.61% of the catch); 2-2+-4.28g (24.08%); 3-3+-5.59g (7.70%) (**Fig. I.3.5.1**).

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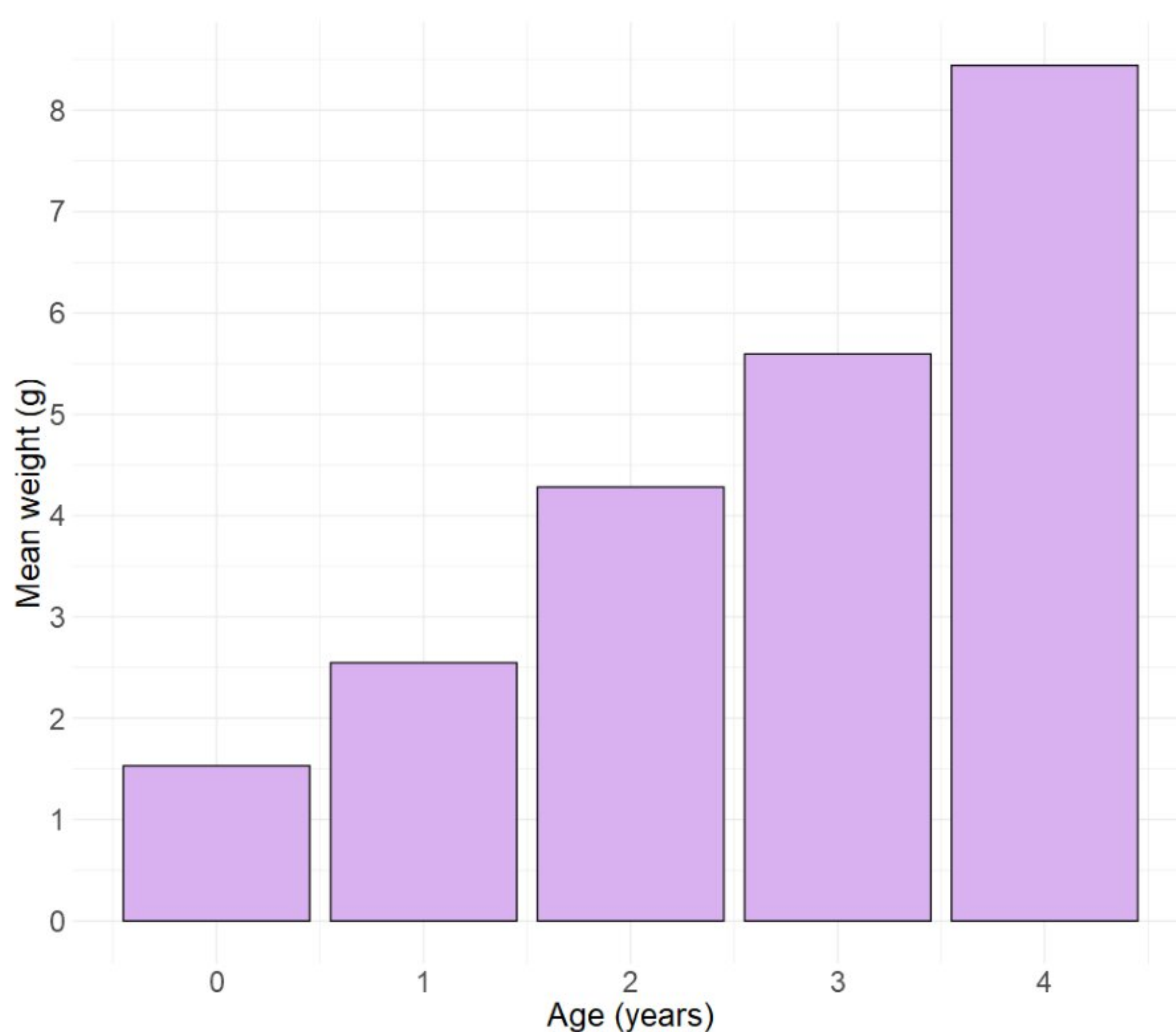


Fig.I.3.5.1 Average weights by age groups for the first semester of 2025.

The most numerous size classes 6.5-7cm participated in the catch with 21.64% and 13.08% and weighed 1.64g and 2.01g. For 11 cm the highest average weight of 10.11g was observed (participating with 1.10% of the catch) (**Fig. I. 3.5.2**).

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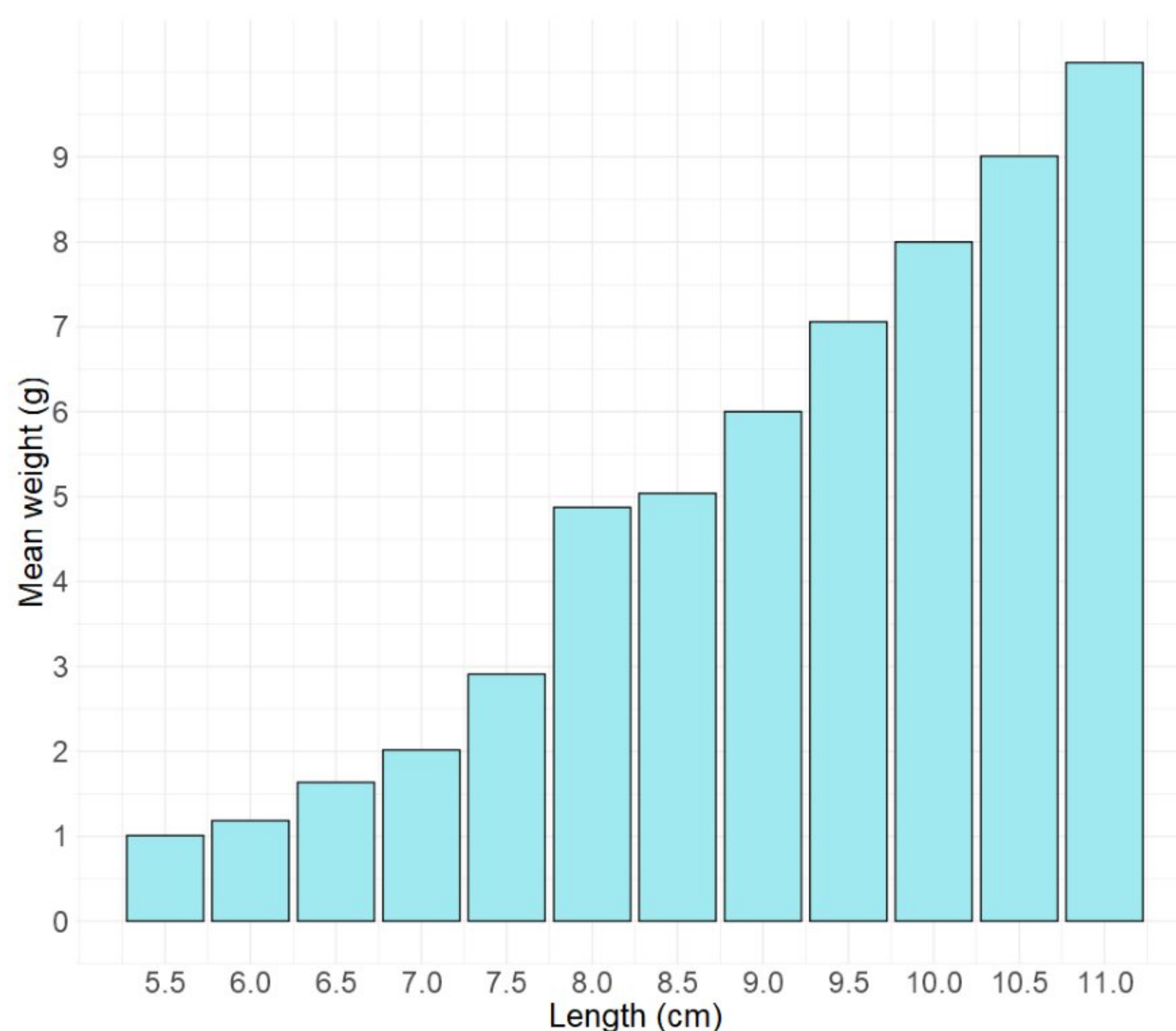


Fig. I. 3.5.2 Distribution of the average weight of the sprat by size groups for the first half of 2025.

I.3.6 Size structure of sprat by age group

The length of **818 specimens** was measured. A gradual increase in the average length was observed across age groups. The average length by age group was highest for the fourth age group (**Table I.3.6.1**).

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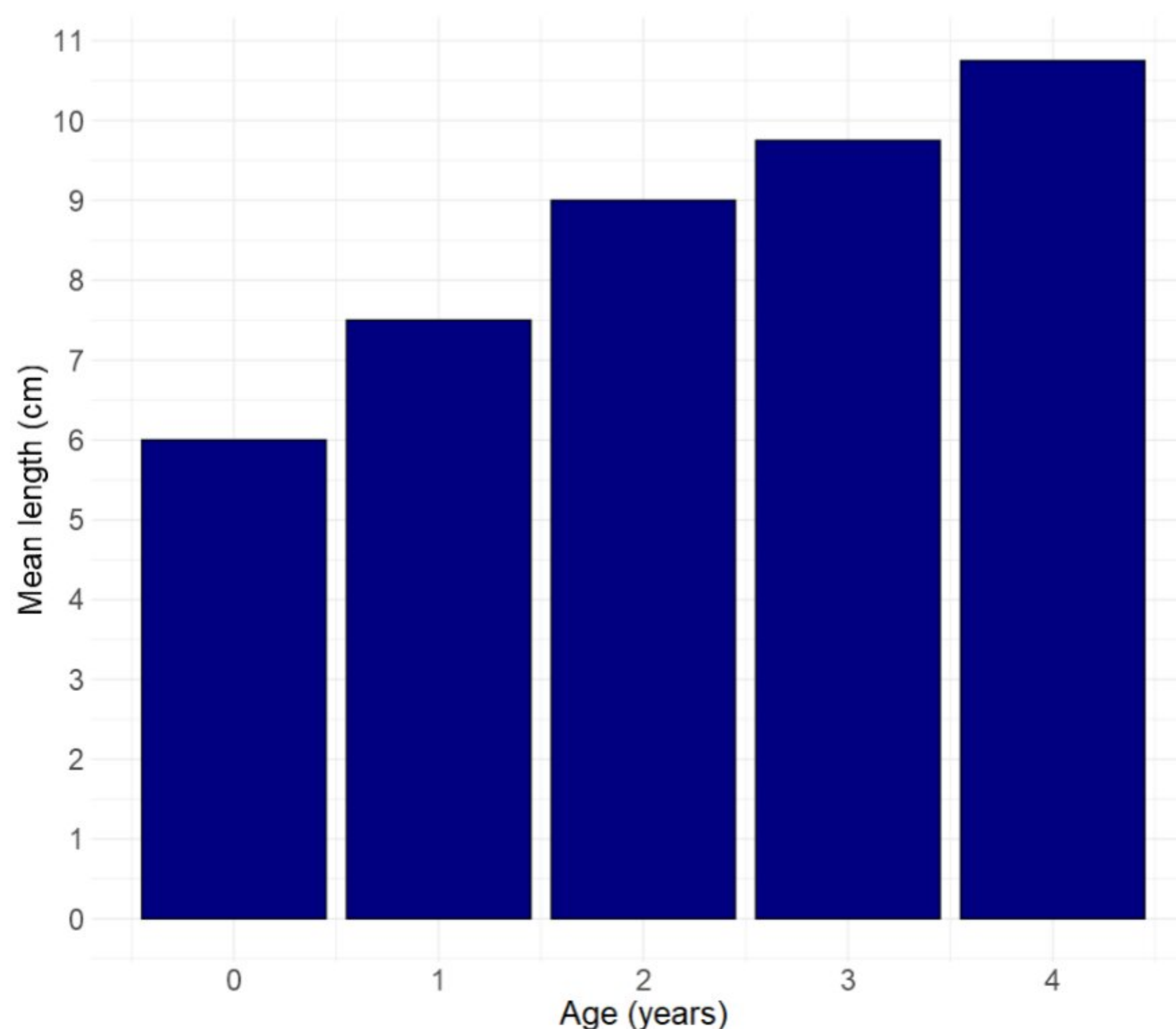


Figure I.3.6.1 Size structure of the sprat by age groups.

I.3.7 Length- weight relationship

To calculate the length-weight relationship, a linear model was used on the logarithmically transformed values for the average weights and lengths **for the first half of 2025**. The modeling results are presented in **Table I.3.7.1**.

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Table I.3.7.1 Results from modeling the length-weight relationship of sprat.

Call:				
lm(formula = logW ~ logL, data = weight_1)				
Residuals:				
Min	1Q	Median	3Q	Max
-0.12676	-0.08334	-0.01283	0.05065	0.28061
Coefficients:				
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-6.1225	0.3440	-17.80	0.000000006691 ***
logL	3.5709	0.1639	21.79	0.000000000929 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error: 0.1226 on 10 degrees of freedom				
Multiple R-squared: 0.9794, Adjusted R-squared: 0.9773				
F-statistic: 474.6 on 1 and 10 DF, p-value: 0.0000000009292				

The resulting model is statistically significant ($R^2 = 0.98$), the value of the scaling coefficient a in the length-weight relationship model $W_i = aL_i^b$ **e: $a = 0.0022$** and the allometry coefficient **$b = 3.57$** , which indicates negative/negative allometric growth of the species, or the increase in weight is disproportionate / less than the increase in length.

I.3.8 Sex ratio

The sex ratio is determined for **250 individuals**. Females ♀ predominate over males ♂ in I-VI 2025.



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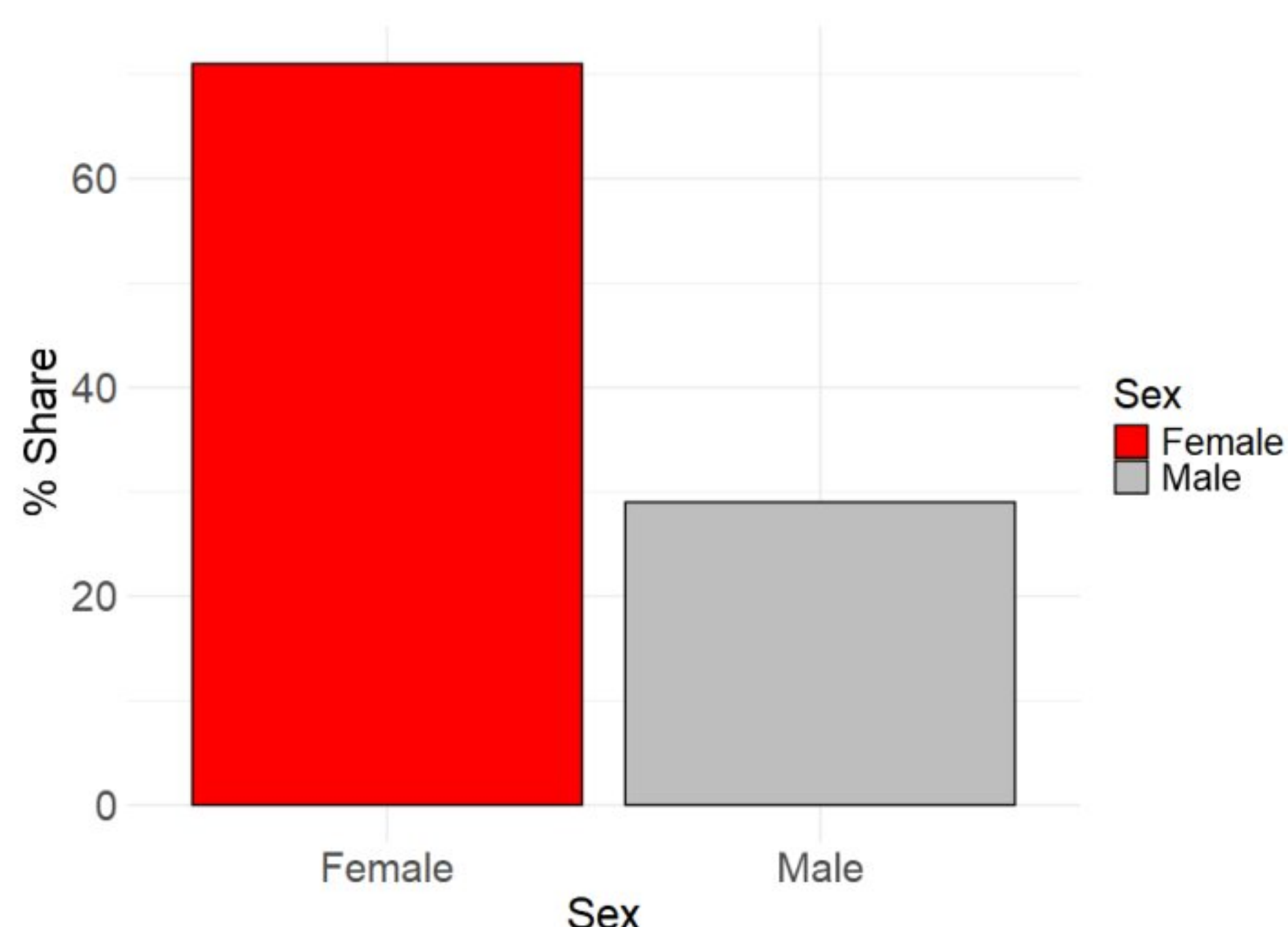


Fig.I.3.8.1 Percentage ratio between the sexes of the sprat for the first semester of 2025.

In size classes 6.0-6.5 cm, females and males are represented with higher percentages. In terms of age, one and three-year-olds are represented with the highest percentage for females and zero and three-year-olds for males (Figure I. 3.8.2).

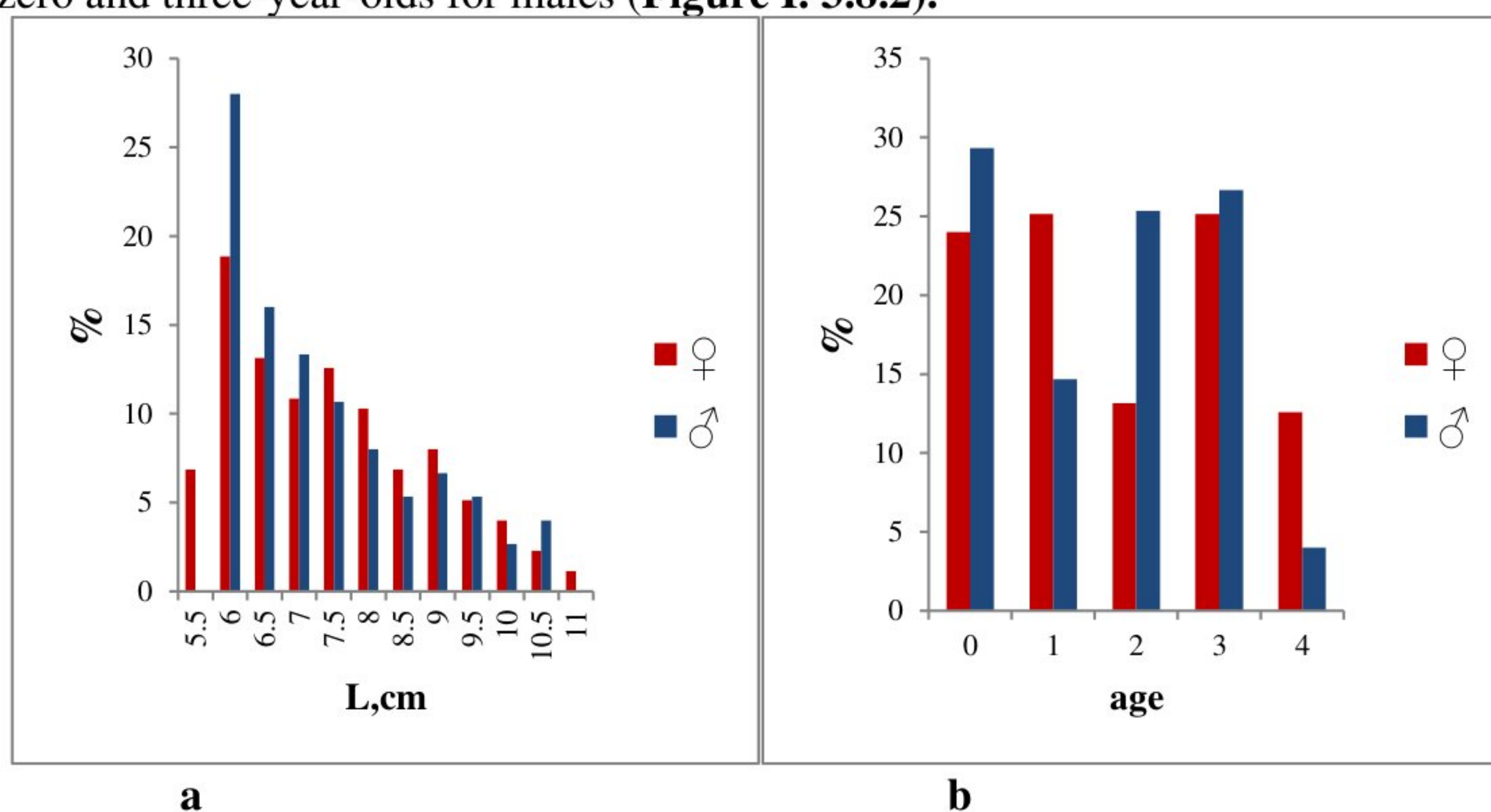


Fig. I. 3.8.2 Sex ratio (%) by size (a) and age(b).

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I.3.9 Fertility

Fecundity is determined on **250 specimens**. In the sprat there is a very strong correlation between the weight of the glands and the gonadosomatic index ($R^2 = 0.91$), which is an indication of mass reproduction processes and active maturity of the sexual products during the studied period (**Fig. I. 3.9.1**).

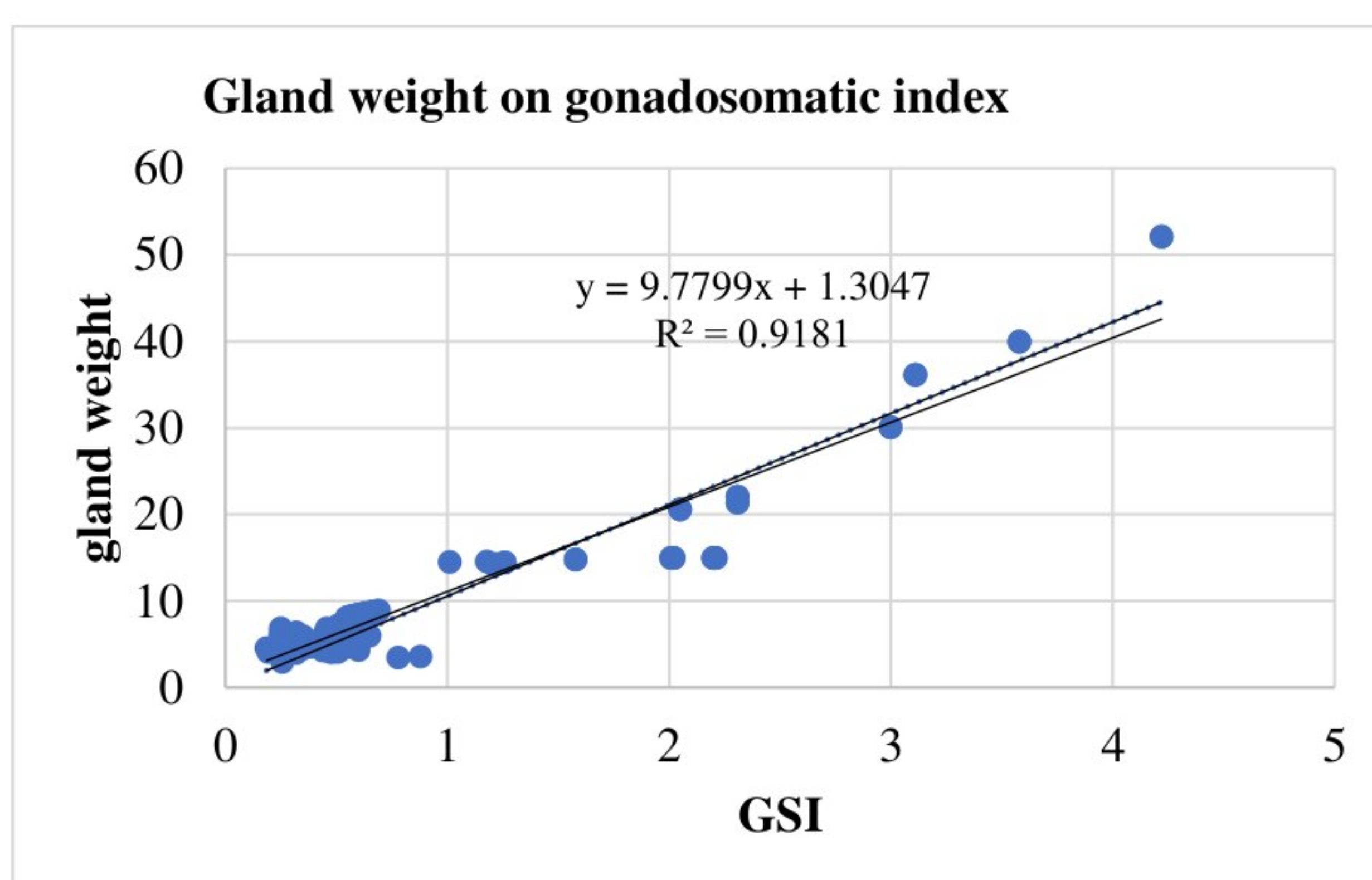


Figure I. 3.9.1 Dependence of gland weight on gonadosomatic index (GSI).

Table I.3.9.1 describes the absolute and relative fecundity of sprats with average lengths and weights. The average value of absolute fecundity was estimated at 35555.91 spawn grains. The average value of relative fertility is 7471.434.

Table I.3.9.1 Absolute and relative fecundity of the sprat.

Lengths class, cm	Mean weight,w,g)	Mean length (cm)	Absolute fecundity F, (cav.grains)	Relative fecundity	N♀
6	1.34	6.01	na		2
6.5	2.3	7.12	15999	6956.087	12

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7	2.51	7.59	26110	10402.39	26
7.5	2.94	8.26	26888	9145.578	28
8	3.71	8.61	33258	8964.42	29
8.5	4.445	8.63	36001	8099.213	40
9	5.08	9.22	36985	7280.512	39
9.5	5.38	9.4	41578	7728.253	38
10	5.91	10.25	42555	7200.508	23
10.5	7.12	10.58	42666	5992.416	7
11	8.05	11.22	44187	5489.068	4
11.5	9.11	11.68	44888	4927.333	2
			average	average	
			35555.91	7471.434	250

I.3.10 Sexual maturity

250 specimens were examined to determine sexual maturity. During the first six months, the senior age groups 3-3+, have a maturity level of VI-II for females and VI-I for males. At the age of 1-1+ years: stages IV-V for females and males; 0+ stages I-II and for 2-2+ years IV-V (**Fig. I.3.10.1**).

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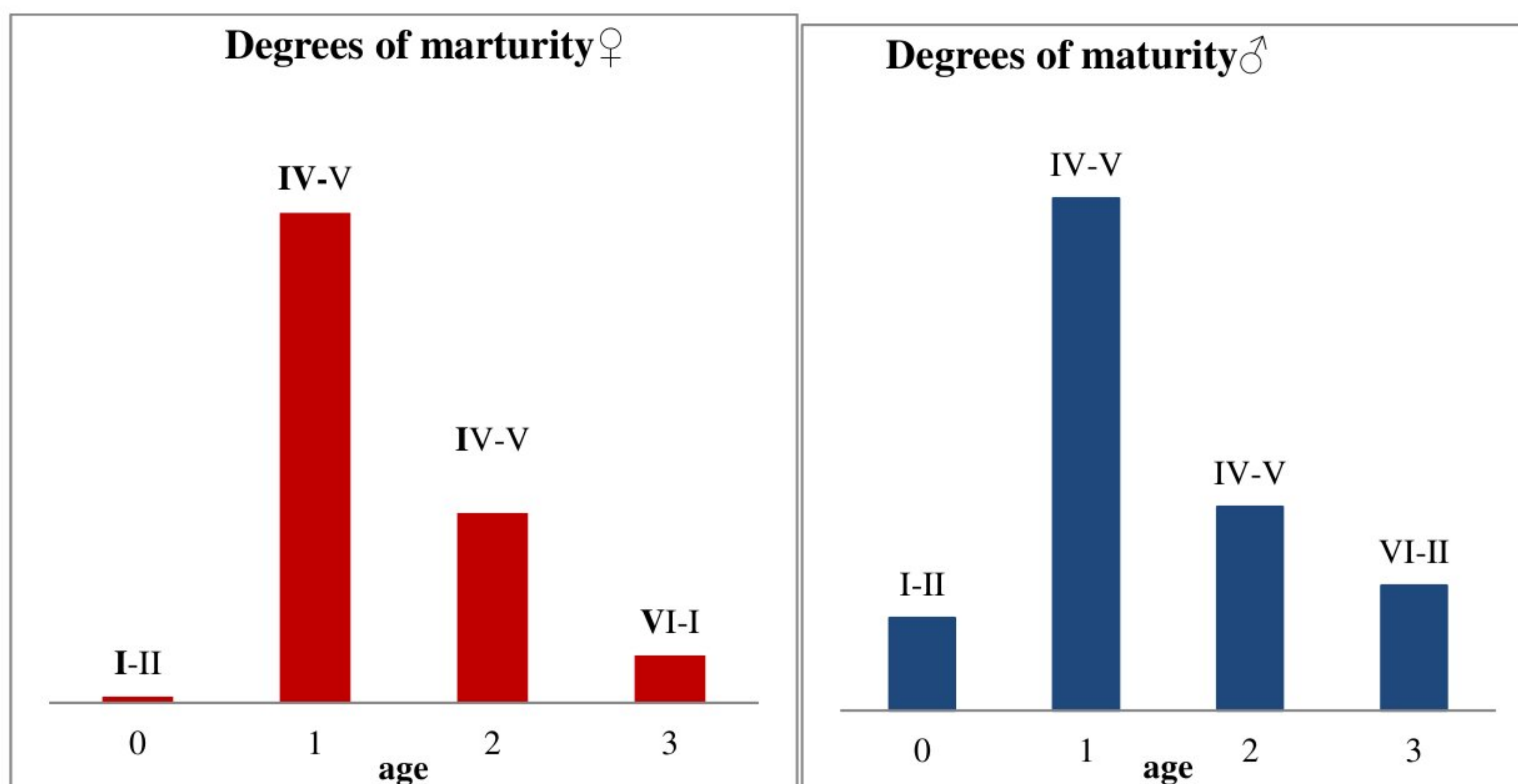


Figure I.3.10.1 Degrees of maturity by age of sprat.

In terms of sexual maturity in length, it varies from I, I-II, III-IV, IV-V and VI-II stage for the different size groups and by sex (**Fig. I. 3.10.2**).

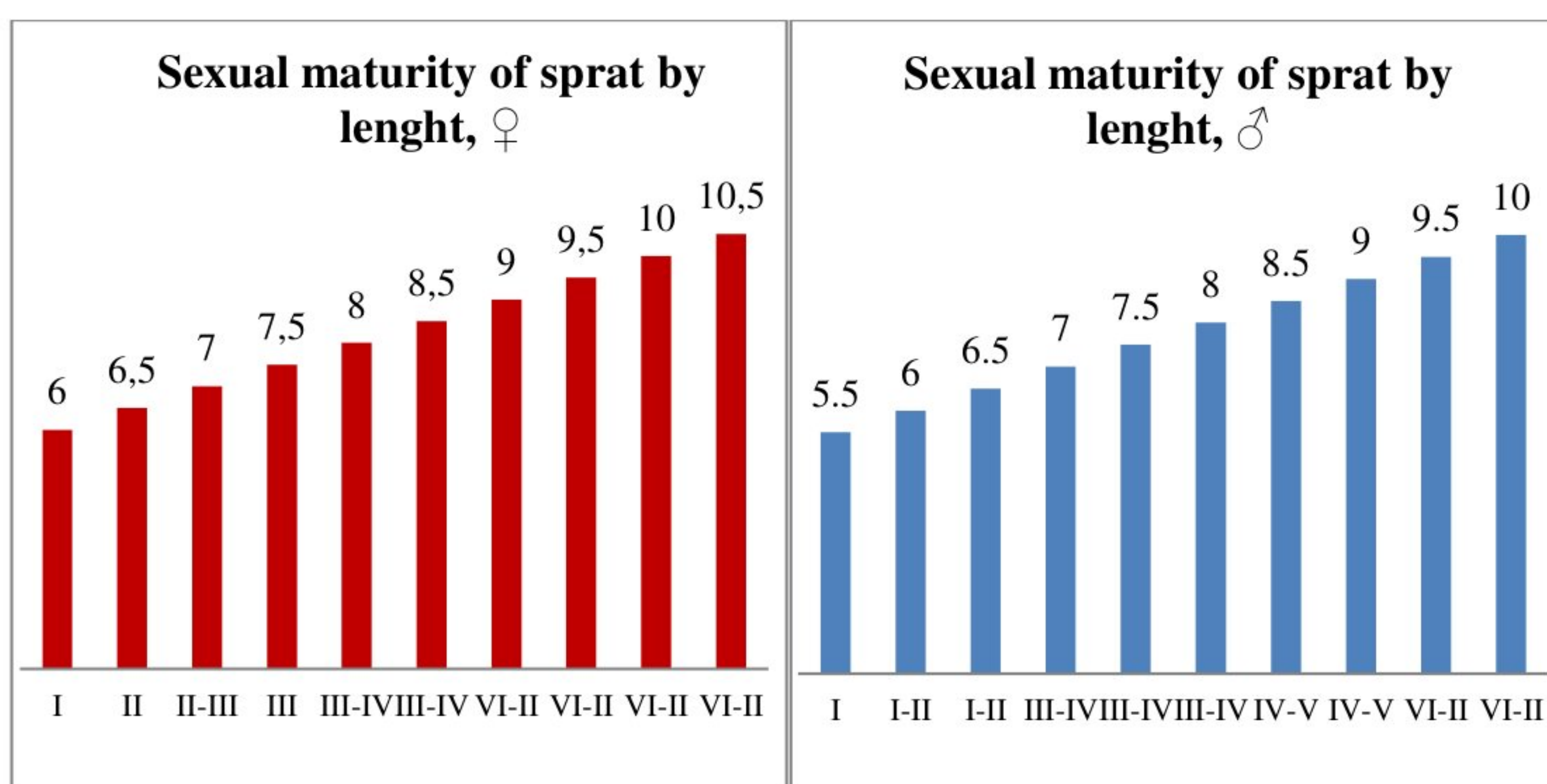


Fig.I.3.10.2 Degrees of maturity of the sprat by length (cm)- (♀), (♂).

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I.3.11 Catch numbers and biomass by age and length

Monthly OTM catches together with average weights were used to obtain the abundance and biomass of the species by quarter in the reported catches (**Table I.3.11.1-2**).

Table I.3.11.1 Catch at age with OTM matrix and biomass of the of sprat.

<i>Catch at age</i>		
<i>Age groups (yr)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
0-0+	78.4348	107896.1139
1-1+	133.1836	287902.4567
2-2+	11.6226	154045.1962
3-3+	4.9520	30978.0756
4-4+	1.0801	1896.8298
Σ	229.2730	582718.672
<i>Biomass</i>		
<i>Age groups (yr)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
0-0+	0.1172	174.2712
1-1+	0.2537	900.4014
2-2+	0.0567	634.8452
3-3+	0.0283	170.1219
4-4+	0.0090	16.5973
Σ	0.4648	1896.2370

Table I.3.11.2 Number of individuals in the catch by size class (for OTM) and biomass of the of the sprat.

<i>Catch in numbers</i>		
<i>Length classes (cm)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
5.5	7.6495	
6	45.1952	19572.2410
6,5	105.8453	115381.4990
7	45.7121	73550.6136
7,5	7.3128	110336.0172
8	4.7795	98291.3783
8,5	3.1095	63264.8570
9	2.8197	63344.4251
9,5	4.3423	31482.0842
10	1.2119	4149.8338

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10,5	0.6591	1702.2831
11	0.6361	1643.4396
Σ	229.2730	582718.672
Biomass		
Length classes (cm)	Ist quarter	IInd quarter
5.5	0.0077	
6	0.0592	20.7466
6,5	0.1674	195.0178
7	0.0914	149.3753
7,5	0.0245	286.3027
8	0.0219	311.1986
8,5	0.0180	302.9000
9	0.0180	360.9904
9,5	0.0335	203.3164
10	0.0103	33.1945
10,5	0.0064	16.5973
11	0.0064	16.5973
Σ	0.4648	1896.2370

I.3.12 Conclusions

The analysis of the biological parameters of the sprat makes it possible to draw the following **conclusions**:

1. The size structure of the sprat in the first quarter of 2025 showed an increase in the percentage of individuals from the 6-6.5 cm size groups, representing over 18%. A sharp decline in presence was noted by the 10-10.5 and 11 cm group, participating with less than 5%. For the second quarter of 2025, the 9 cm length classes had the highest share in landings and again the lowest percentage was observed in the oldest size classes 10-11 cm.
2. During the first and second quarter, the highest percentage share is occupied by individuals in the age group 1-1+ and they significantly prevail over the others. The lowest share is in the age groups: 3-3+ and 4-4+.
3. Based on the analysis conducted, ELEFAN RSA gives results closest to those experimentally determined during the aging of the individuals in the samples and, accordingly, the growth parameters of the *S. sprattus* stock for the first half of 2025 can be determined as follows: $L_{\infty}=12.95$ cm; $K = 0.39$ and $t_0=-0.64$.

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4. A gradual increase in the average weight is observed according to the age groups. For the age group 0-0+ the lowest average weight is 1.52g (participating with 16.25% of the catch), and for the group 4-4+ the highest average weight is observed at 8.44g.
5. There is a gradual increase in the average length across age groups. The average length by age group is highest for the fourth age group.
6. The resulting model is statistically significant ($R^2=0.98$), the value of the scaling coefficient a in the length-weight relationship model $W_i = aL_i^b$ is: $a=0.0022$, and the allometry coefficient $b=3.57$, which indicates positive / allometric growth of the species in the first half of the year, or the increase in weight is proportional to or greater than the increase in length.
7. Females ♀ predominate over males ♂ in the first half of 2025.
8. In the sprat *S. sprattus* there is a very strong correlation between the weight of the glands and the gonadosomatic index ($R^2 = 0.91$), which is an indication of mass reproduction processes and active maturity of the sexual products during the studied period.



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II. Biological monitoring of horse mackerel (*Trachurus mediterraneus*) landings

II.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze horse mackerel catches, as well as to form a database. The collection of biological samples of horse mackerel catches in **I-VI 2025** includes the following tasks:

1. *To collect and analyze the dynamics of length, weight and age distribution.*
2. *To determine the state of the of horse mackerel using the so-called state factor (Ricker, 1975).*
3. *Characteristics of the reproductive biology of horse mackerel.*
4. *Collection of data on ports of landing, sampling vessels, number of samples collected, number of specimens tested, geographical catch data.*

I.2 Sampling

The sampling was established from catches declared by the actively operating fishing fleet of the Republic of Bulgaria.

II.2.1 Geographic area coverage

Data of present analysis were collected from landing ports of Bulgarian Black Sea coast. **In I-VI 2025, 5 samples with 765 specimens** were collected and processed. Information on the size of the catches was also collected.

II.2.2 Sampling period

In I-VI 2025, the biological data on sprat were collected from a total of **5 landings at the ports of Sozopol and Kavarna**. Information on the size of the catches was also collected. Ports and ships from which monitoring was carried out to collect biological data from landings are presented in **Table II. 2.1.1**.



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Table II. 2.2.1 Ports and ships from which monitoring was carried out to collect biological data from horse mackerel discharges.

N	HMM	Sampling ports	RK	External marking	Catch,kg	N	Coordinate
1	27.1.2025	Sozopol	MEDUZA 3	BS288	630 kg	169	42.422600 27.691300
2	14.2.2025	Sozopol	MEDUZA 3	BS288	5340 kg	154	42.449600 27.638300
3	24.4.2025	Sozopol	Valnabor	BS2330	200 kg	163	42.3064 27.9862
4	5.5.2025	Sozopol	Valnabor	BS2330	500 kg	134	42.422600 27.691300
5	27.6.2025	Kavarna	KALIAKRA	VN 8110	32 kg	145	43.367000 28.379500
						765 бп.	

II.2.3 Statistical analysis of data

See section statistical analysis of sprat

II.3 Results

II.3.1 Landings statistics

The graph shows the landings of horse mackerel with OTM for the first half of 2025. The month of April has the lowest value. During the first three months, reduced catch weight values are observed with the exception of the month of February. In the month of February, the highest value of the half-year is observed. In the second three months, landings are not significantly higher (**Figure II. 3.1.1**).

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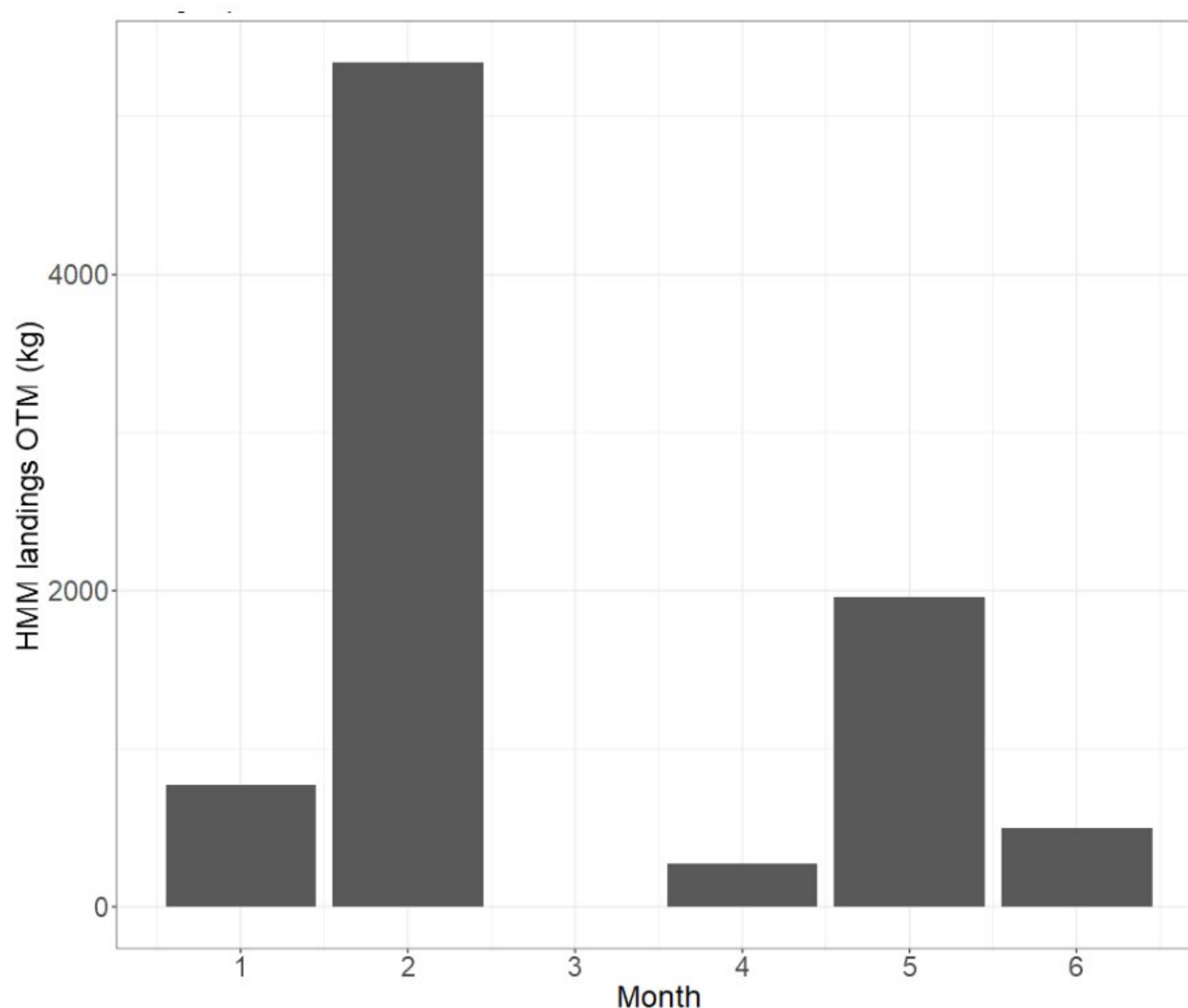


Figure II. 3.1.1 Landings statistics of horse mackerel.

II.3.2 Length structure of landings

For the first quarter, the 10 cm class has the highest share in landings. Classes in the 13.5-14 cm range have a relatively lower percentage share. For the second quarter, the lowest percentage is for the 14 cm size class, and the highest is for the 9.5 cm (**Fig. II.3.2.1**).



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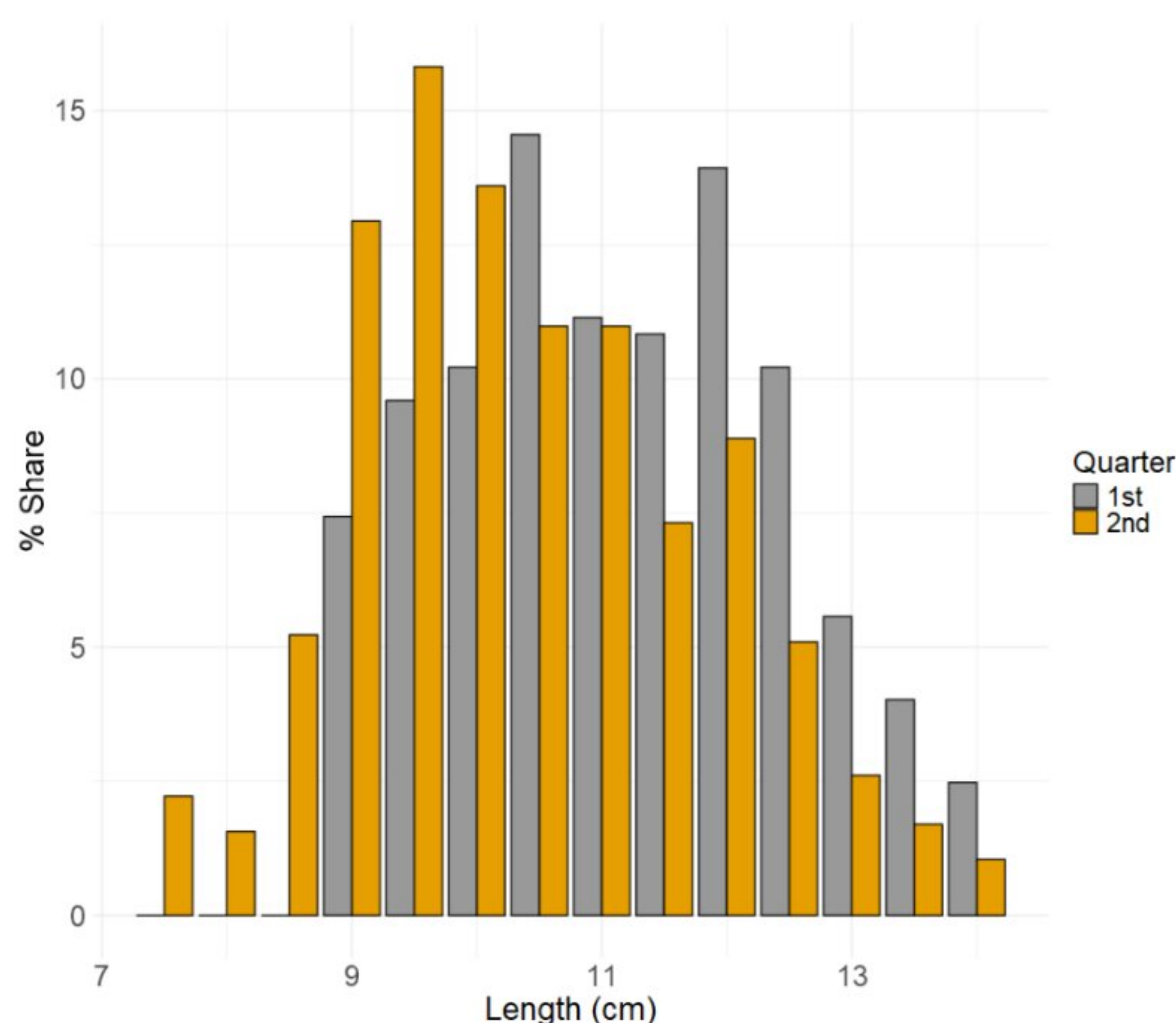


Figure II. 3.2.1 Percentage representation in the composition of catches in the first and second quarter of 2025.

II.3.3 Age structure of landings

The three readers determined the age of horse mackerel otoliths, and reader 1 read all otoliths twice. The age of **765 horse mackerel** was determined. In the first half of the year, the age distribution showed the presence of age groups from 0+ to 3-3+ years. In the first quarter, the highest percentage share was occupied by individuals in the age group 2-2+ followed by 3-3+. The lowest share was occupied by one-year-old fish. The second quarter showed that the two-year-old age groups had the highest percentage followed by 1-1+ and 3-3+ year-olds. Also in this quarter, the youngest ages (0+) were represented by the smallest percentage (**Fig. II.3.3.1**).



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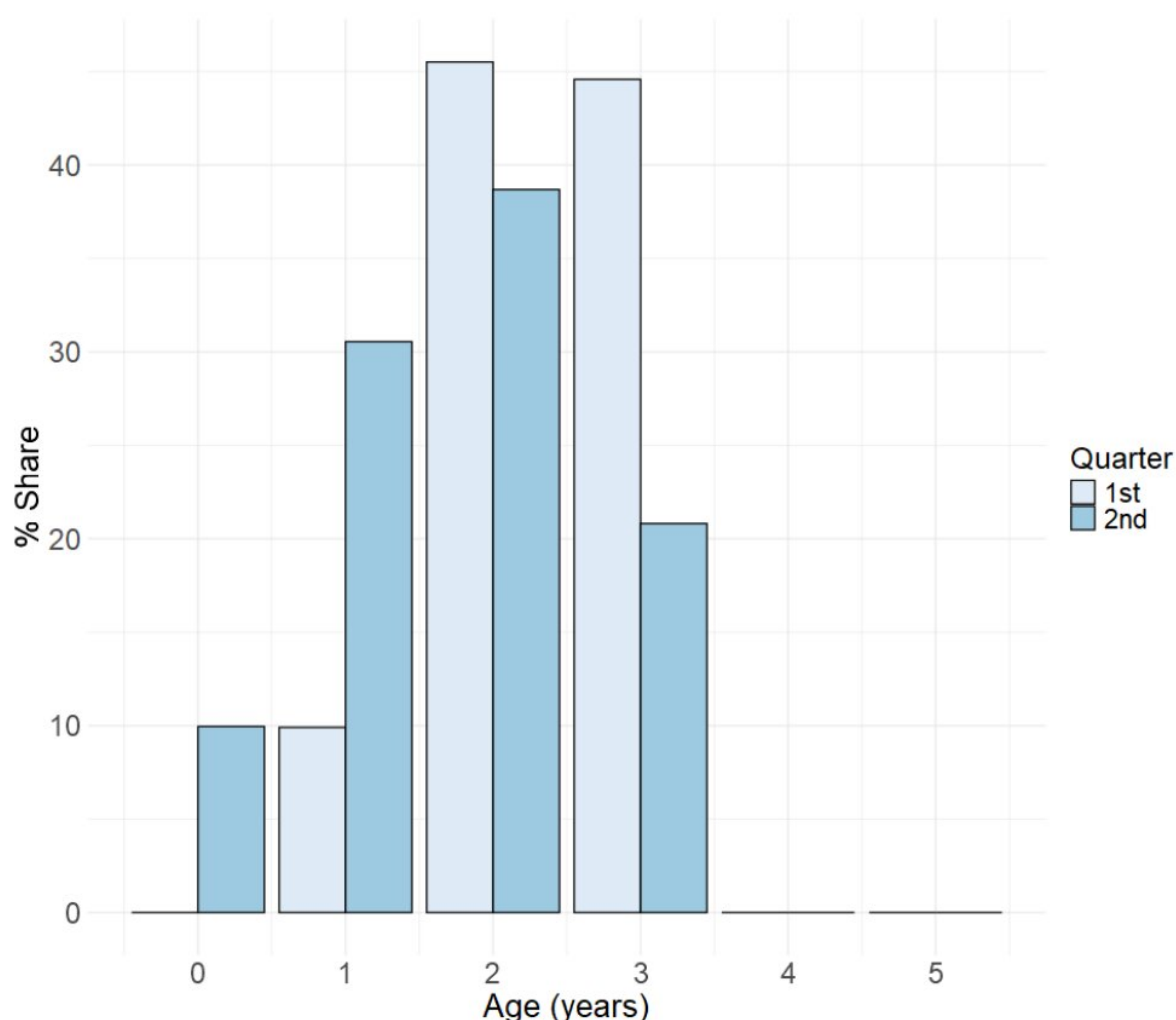


Figure II.3.3.1 Percentage representation of horse mackerel age groups in the catch composition in the first and second semesters of 2025.

The results from ELEFAN with the three applied methods are inconsistent and inapplicable to the experimentally determined ages, due to the small number of different classes represented in the sample. The obtained elongation parameters by all three methods are very close: $L_{\infty} \approx 15.10$ cm; $K \approx 0.34$ и $t_0 = -0.65$, but the growth model with these parameters does not approximate well-experimented data (the calculated average lengths per bundle are significantly lower than expected) and the determination of growth parameters should be repeated when more biological data with a more adequate representation of the size classes in the size-frequency sample are available.

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II.3.4 Condition factor

The graph shows that in the first half of the year K is highest for the size classes 12.5-13 cm. The lowest condition factor is for the size class 10-10.5 cm. For the remaining condition factors it is approximately similar, varying in a close range (**Fig. II.3.4.1**).

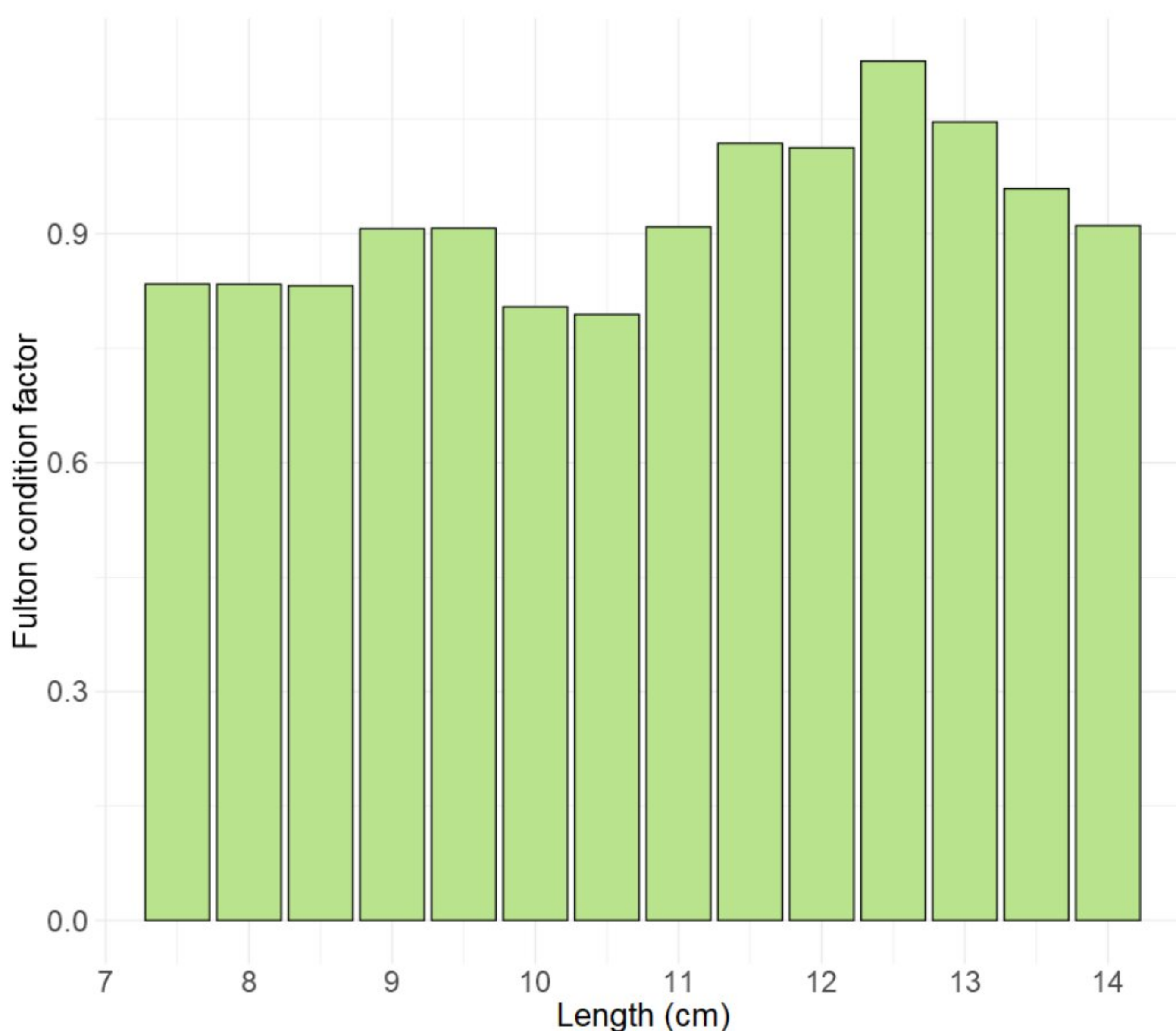


Fig.II.3.4.1 Condition factor of horse mackerel by size classes for the first half of 2025.

The Fulton condition factor by age group is relatively evenly distributed. The highest values are for one-year-old specimens (**Fig. II. 3.4.2**).



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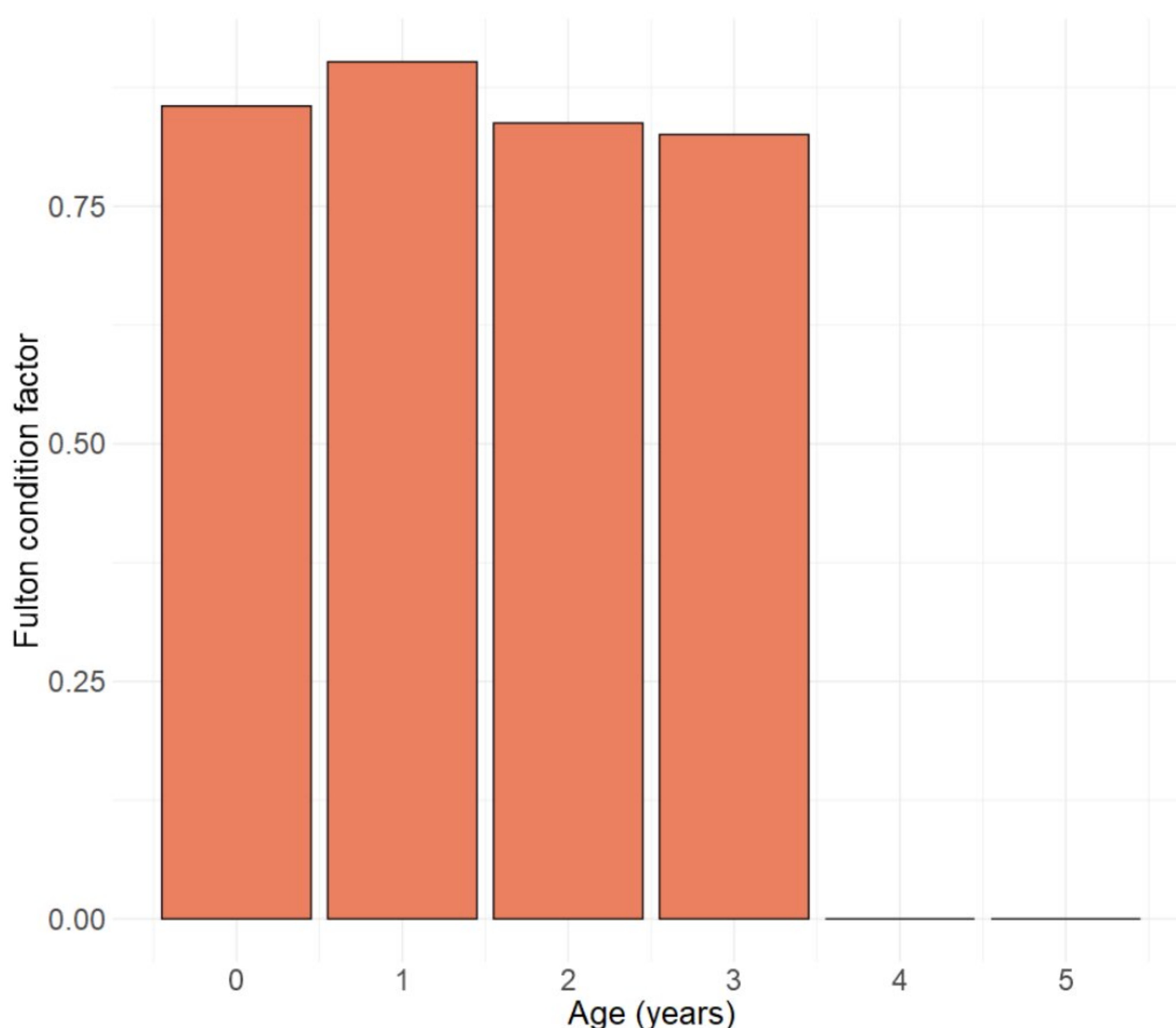


Fig. II.3.4.2 Fulton condition coefficient values of horse mackerel by age groups for the first half of 2025.

II.3.5 Weight structure of horse mackerel

The weight of **765 specimens** was measured. A gradual increase in the average weight is observed according to the age groups. The lowest average weight is observed for the age group 0-0+ (4.38g), and the highest average weight is observed for the group 3-3+ (15.17g) (**Fig. II. 3.5.1**).

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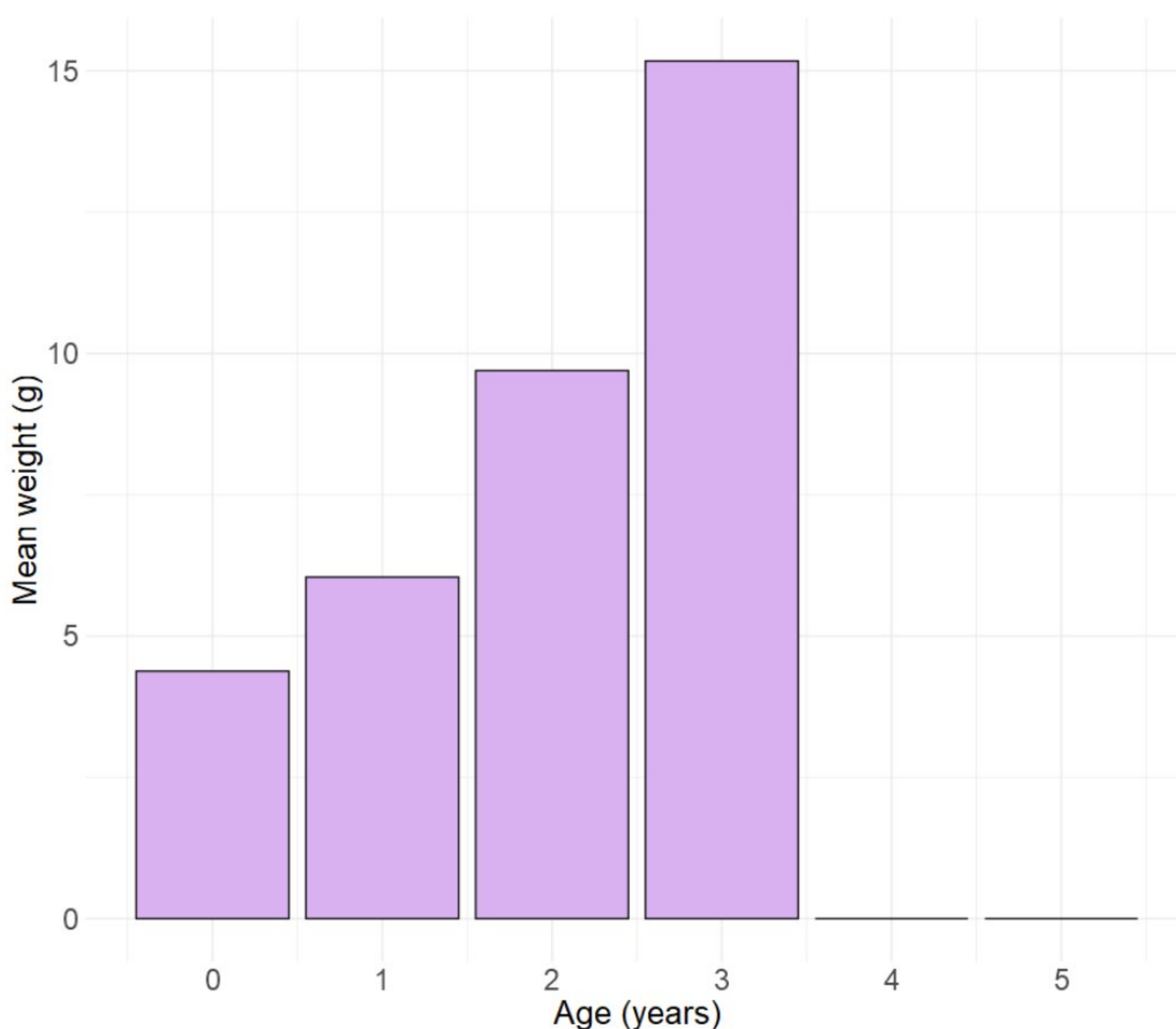


Fig. II. 3.5.1 Distribution of average weight of horse mackerel by age groups for the first half of 2025.

Distribution of the average weight of horse mackerel by size groups showed that the lowest average weight was measured in the smallest size class -7.5cm (3.52g), and the largest size class 14cm had the highest average weight - (24.99g) (**Fig. II. 3.5.2**).

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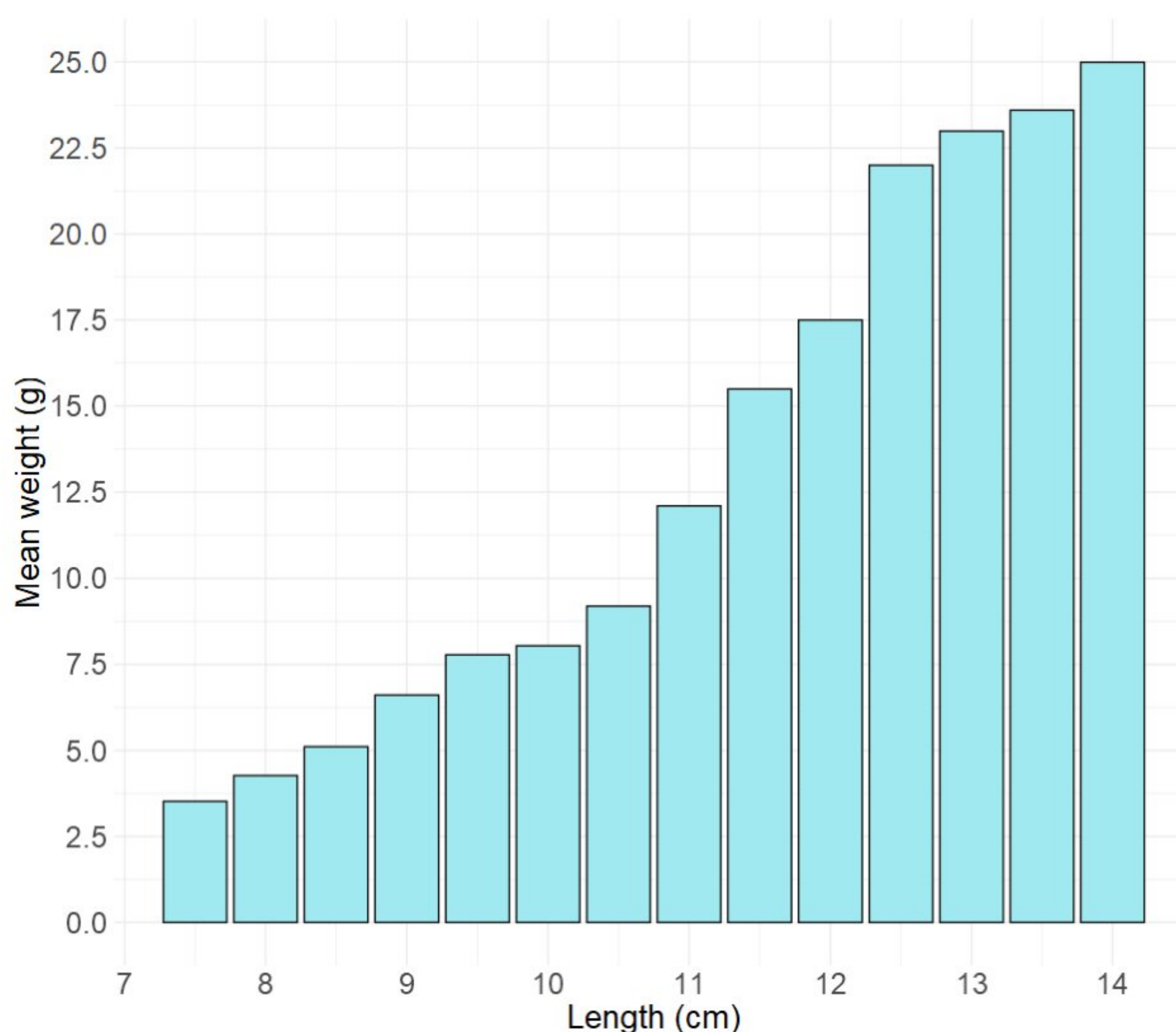


Fig. II. 3.5.2 Distribution of average weight of horse mackerel by size groups for the first half of 2025.

II.3.6 Size structure of horse mackerel by age group

The fish length was measured on **765 specimens**. A gradual increase in the average length values is observed across age groups for the first six months. The lowest average length values are in the 0-0+ age group, and the highest are in the 3-3+ year group (**Fig. III.3.6.1**).



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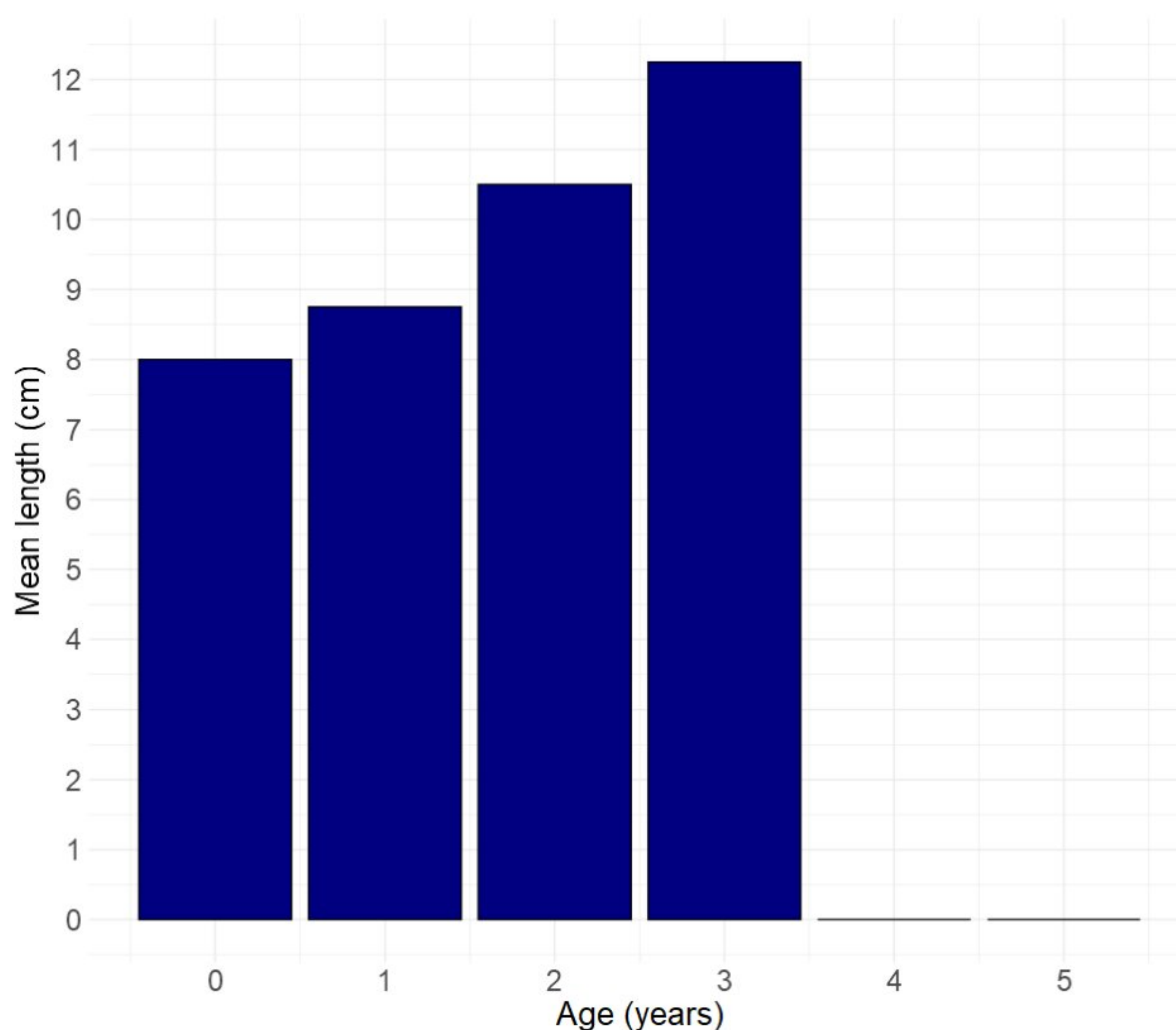


Figure III.3.6.1 Size structure of horse mackerel by age groups.

II.3.7 Length- weight relationship

To calculate the length-weight relationship, a linear model was used on the logarithmically transformed values for the average weights and lengths **for the first half of 2025**. The modeling results are presented in **Table II.3.7.1**.

Table II.3.7.1 Results of modeling the length-weight relationship.

Call:					
lm(formula = logW ~ logL, data = weight_1)					
Residuals:					
Min	1Q	Median	3Q	Max	

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	-0.14095	-0.03651	0.01561	0.05256	0.14670
Coefficients:					
	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	-5.5273	0.2740	-20.17	0.00000000001263	***
logL	3.3541	0.1159	28.94	0.00000000000018	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 0.08339 on 12 degrees of freedom					
Multiple R-squared: 0.9859, Adjusted R-squared: 0.9847					
F-statistic: 837.7 on 1 and 12 DF, p-value: 0.000000000001801					

The resulting model is statistically significant, the value of the scaling coefficient a in the length-weight relationship model $W_i = aL_i^b$ e : $a = 0.004$, and the allometry coefficient $b = 3.35$, which indicates positive allometric growth of the species in the first half of the year, or the increase in weight is proportional and greater than the increase in length.

II.3.8 Sex structure

The sex ratio in the first six months was determined on **140 specimens**. Females♀ predominate over males ♂ (**Fig. II. 3.8.1**).

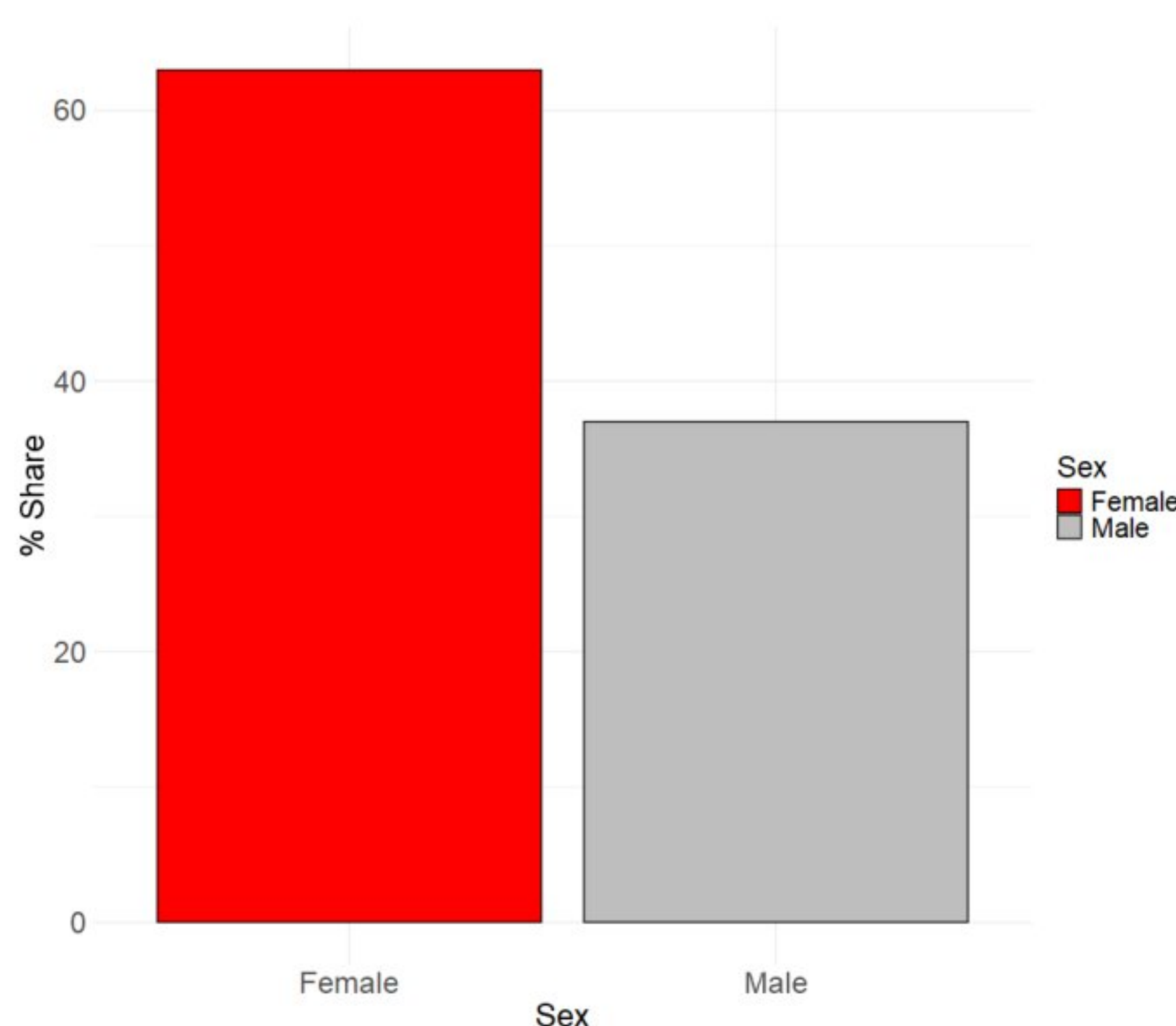


Figure II. 3.8.1 Sex ratio of horse mackerel.

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In size classes 9.0-9.5 and 10 cm, females and males are represented with higher percentages. In terms of age, one and two-year-olds are represented with the highest percentage of females and males (**Figure II 3.8.2**).

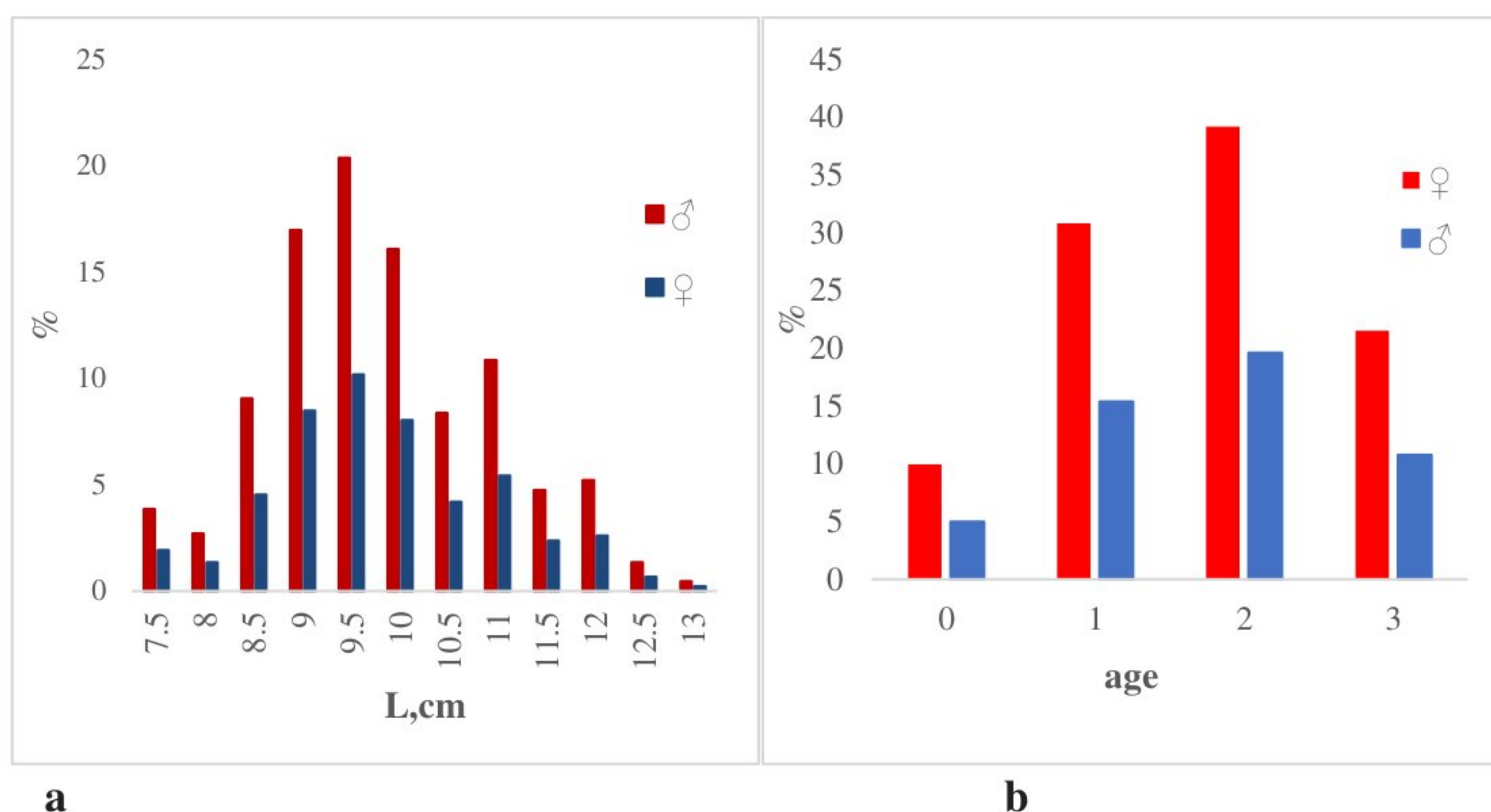


Figure II.3.8.2 Sex ratio (%) by size (a) and age (b) of horse mackerel.

II.3.9 Fertility

The fertility of **140 specimens** was determined. The dependence on individual gland weights and the gonadosomatic index of the horse mackerel showed a weaker dependence ($R^2=0.6582$) during the first six months (**Figure II. 3.9.1**).



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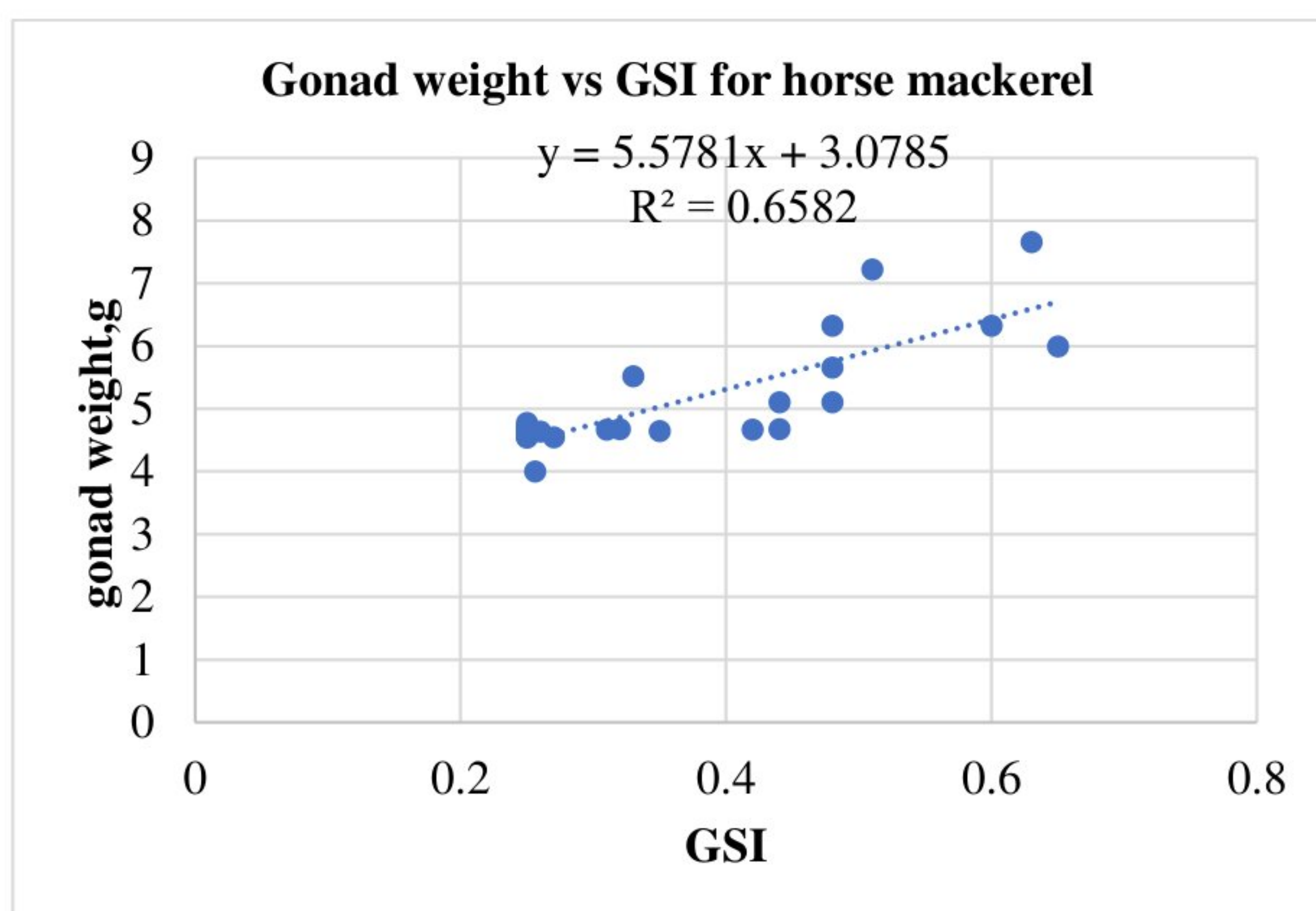


Figure II.3.9.1 Dependence of gland weight on gonadosomatic index (GSI).

Absolute fecundity is with an average weighted fecundity of 6078.65 eggs for the first semester. Absolute fecundity increases with increasing length, mass and age. The average weighted relative fecundity is 2826.073 for the first semester (**Table II. 3.9.1**).

Table II.3.9.1 Absolute and relative fertility.

Size class	Average body weight (W, g)	Average lenght(cm)	Absolute fertility F, caviar grains)	Relative fertility	N
					♀
12,5	16.99	12.41	4888.33	2877.180695	20
13	17.23	13.01	6003.25	3484.184562	20
13,5	19.2	13.33	6222.5	3240.885417	20
14	21.05	14	6500	3087.885986	20
14,5	23.66	14.31	6589.47	2785.067625	15
15	25.14	15.18	6999	2784.009547	15
15,5	31.22	15.51	7245.888	2320.912236	15
16	36.55	15.98	7414	2028.454172	15

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			средно	средно	$\Sigma 140$
			6078.65	2826.07253	

II.3.10 Sexual maturity

Sexual maturity was determined on **140 specimens**. The examined specimens showed a degree of flowing gonads (VI- II for 4 and 5 year olds and V- VI for three year olds, while zero one and two year olds were with I, V and VI-II degree of sexual maturity, respectively) (**Fig. II. 3.10.1**).

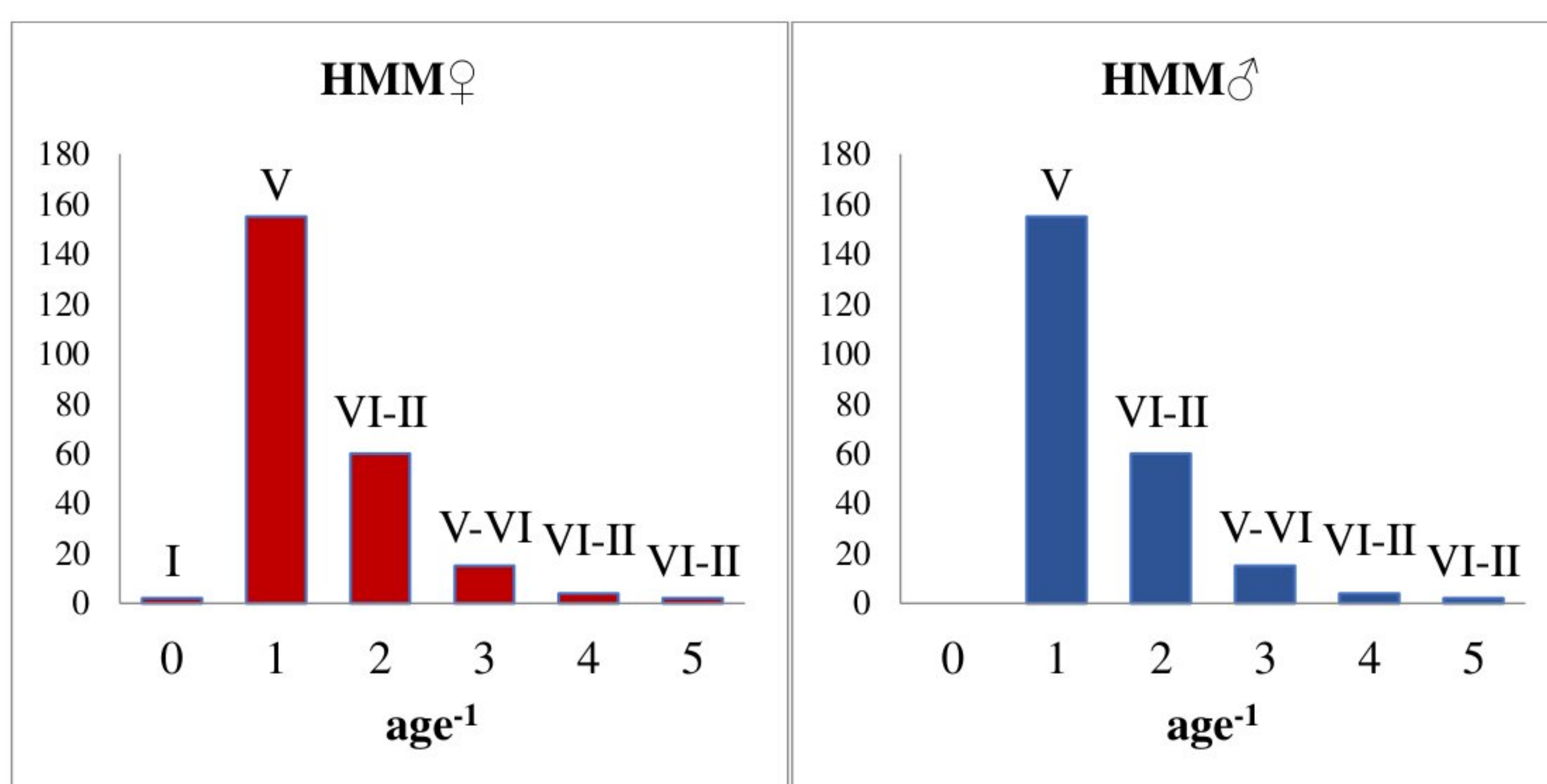


Figure II.3.10.1 Sexual maturity by age of horse mackerel - female ♀ and male ♂.

In terms of sexual maturity in length, it varies from VI-I, IV-V, V-VI, IV-VI, and V degree for the different size groups and by sex (**Fig. II. 3.10.2**).



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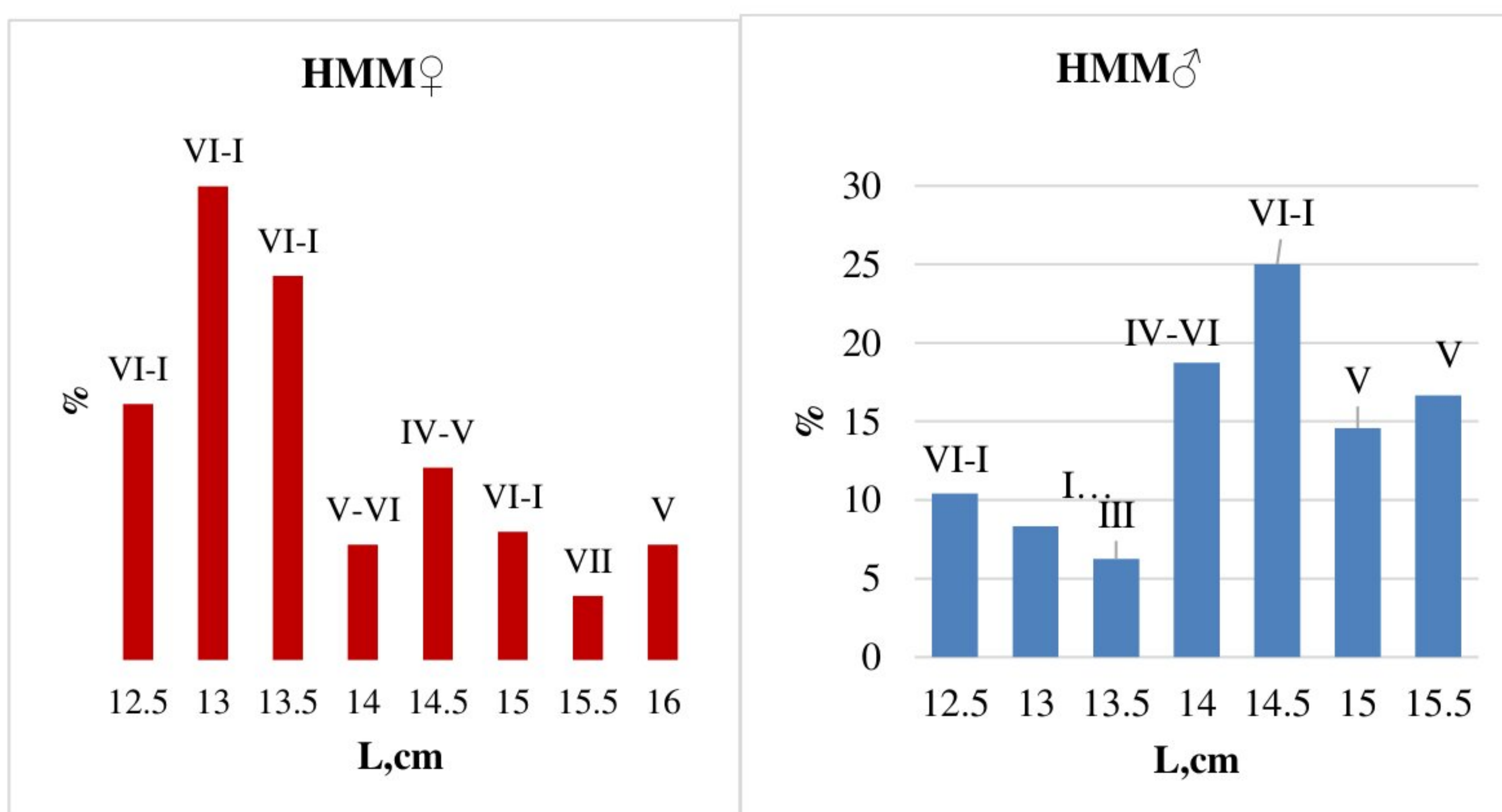


Figure II. 3.10.2 Sexual maturity by length(cm) of horse mackerel - female ♀ and male ♂.

II.3.11 Catch numbers and biomass by age and length

Monthly OTM catches together with average weights were used to obtain the abundance and biomass of the species by quarter in the reported catches (**Table II.3.11.1-2**).

Table II.3.11.1 Catch at age with OTM, matrix and biomass of horse mackerel.

<i>Catch at age</i>		
<i>Age groups (yr)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
<i>0-0+</i>		62.0000
<i>1-1+</i>	91.3549	141.4132
<i>2-2+</i>	276.54	128.5153
<i>3-3+</i>	190.019	44.8425
Σ	557.914	376.771
<i>Biomass</i>		
<i>Age groups (yr)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
<i>0-0+</i>		0.27157
<i>1-1+</i>	0.60523	0.83321
<i>2-2+</i>	2.78026	1.0554
<i>3-3+</i>	2.72352	0.56782
Σ	6.109	2.728

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Table II.3.11.2 Number of individuals in the catch by size class (for OTM) and biomass of the horse mackerel.

<i>Catch-at-length</i>			
<i>Length (cm)</i>	<i>groups</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
7,5			29.8177
8			17.3484
8,5			48.3221
9		75.6533	84.5359
9,5		83.759	82.9067
10		76.2789	44.1715
10,5		94.4554	22.5394
11		56.3302	25.2066
11,5		47.4304	9.81653
12		54.2347	9.228
12,5		34.6804	2.22591
13		17.6597	0.65225
13,5		11.1274	
14		6.30444	
Σ		557.914	376.771
<i>Biomass</i>			
<i>Length (cm)</i>	<i>groups</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
7,5			0.1049
8			0.0741
8,5			0.2469
9		0.45392	0.4629
9,5		0.58631	0.5555
10		0.62414	0.4382
10,5		0.88893	0.2284
11		0.68088	0.2963
11,5		0.66197	0.1296
12		0.8511	0.1420
12,5		0.62414	0.0370
13		0.34044	0.0123
13,5		0.24587	
14		0.15131	
Σ		6.109	2.7280

II.3.12 Conclusions

The analysis of the biological parameters of the horse mackerel makes it possible to draw the following **conclusions**:

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1. For the first quarter, the 10 cm class has the highest share in landings. Classes in the 13.5-14 cm range have a relatively lower percentage share. For the second quarter, the lowest percentage is for the 14 cm size class, and the highest is for the 9.5 cm.
2. In the first quarter, the highest percentage share was occupied by individuals in the age group 2-2+ followed by 3-3+. The lowest share was for one-year-old fish. The second quarter showed that the age groups of two-year-olds had the highest percentage followed by 1-1+ and 3-3+ year-olds.
3. The results from ELEFAN with the three applied methods are inconsistent and inapplicable to the experimentally determined ages, due to the small number of different classes represented in the sample. The obtained elongation parameters by all three methods are very close: $L_{\infty} \approx 15.10$ cm; $K \approx 0.34$ and $t_0 = -0.65$, but the growth model with these parameters does not approximate the experimentally collected data well and the determination of the growth parameters should be repeated when more biological data with a more adequate representation of the size classes in the size-frequency sample are available.
4. A gradual increase in the average weight is observed across age groups. The 0-0+ age group has the lowest average weight, while the 3-3+ group has the highest average weight.
5. A gradual increase in the values of the average length is observed in relation to the age groups for the first six months. The lowest values for the average length are in the age group 0-0+, and the highest are in the group 3-3+ years.
6. The resulting model is statistically significant, the value of the scaling coefficient a in the length-weight relationship model $W_i = aL_i^b$ is: $a = 0.004$, and the allometry coefficient $b = 3.35$, which indicates a positive allometric growth of the species.
7. The average lengths of females ♀ are higher in all age groups.
8. Absolute fecundity is with an average weighted fecundity of 6078.65 eggs for the first semester. Absolute fecundity increases with increasing length, mass and age. The average weighted relative fecundity is 2826.073 for the first semester.
- 9.

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III. Biological monitoring of whiting (*Merlangius merlangus*) landings

III.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze whiting catches, as well as to form a database. The collection of biological samples of whiting catches in **I-VI 2025** includes the following tasks:

1. To collect and analyze the dynamics of length, weight and age distribution.
2. To determine the state of the of whiting using the so-called state factor (Ricker, 1975).
3. Characteristics of the reproductive biology of whiting.
4. Collection of data on ports of landing, sampling vessels, number of samples collected, number of specimens tested, geographical catch data.

III. 2 Sampling

The sampling was carried out by the actively operating fishing fleet in Bulgaria.

III. 2.1 Geographic area coverage

Data of present analysis were collected from Bulgarian Black Sea coast. In **I-VI 2025**, **2 samples with 249 specimens** were collected and processed. Information on the size of the catches was also collected.

III. 2.2 Sampling period

In **I-VI 2025**, the biological data for the species were collected from a total of **2 landings at the ports of Nesebar and Sozopol**. Information on the size of the catch was also collected. Ports and ships from which monitoring was carried out to collect biological data from landings are presented in **Table III.2.2.1**.

Table III.2.2.1 Ports and ships from which monitoring was carried out to collect biological data of whiting landings.

N	WHG	Sampling ports	RK	External marking	Catch/kg	N	Coordinates
1	31.3.2025	Nesebar	BAHARI	NS 769	40 kg	116	42.656100 27.731000
2	23.5.2025	Sozopol	VALNOBOR	VS 2330	80 kg	133	42.3398 27.9051
						249	



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III. 2.3 Statistical analysis of data

See section statistical analysis of sprat.

III.3 Results

III.3.1 Landings statistics

Catches in the first six months are dominated by March. This is followed by a decline in April and May, and during these months catches are very low, with whiting catches increasing in June (**Figure III.3.1.1**).

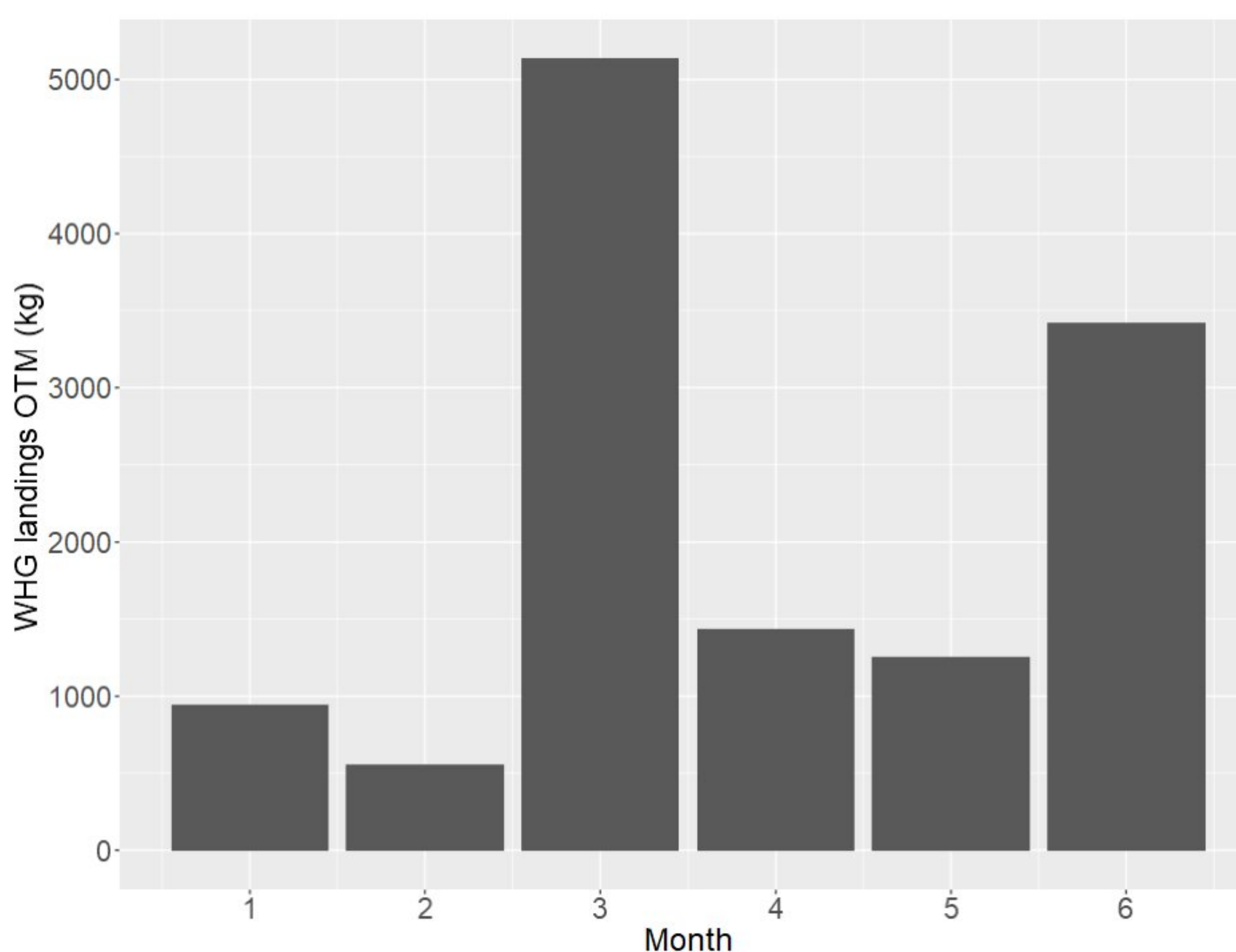


Figure III.3.1.1 Landings statistics of whiting.

III.3.2 Length structure of landings

For the first quarter, the classes in the range of 7.5-8.5 cm have the lowest share in landings - under 3%. The class with a length of 10 cm occupies the highest percentage share in landings.

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For the second quarter, the lowest percentage is the size class 8-8.5 and 15.5-16 cm, and the highest percentage is the classes in the range of 12.5 -13 cm. The remaining classes fall in the range between 5% and 15%. (**Fig. III.3.2.1**).

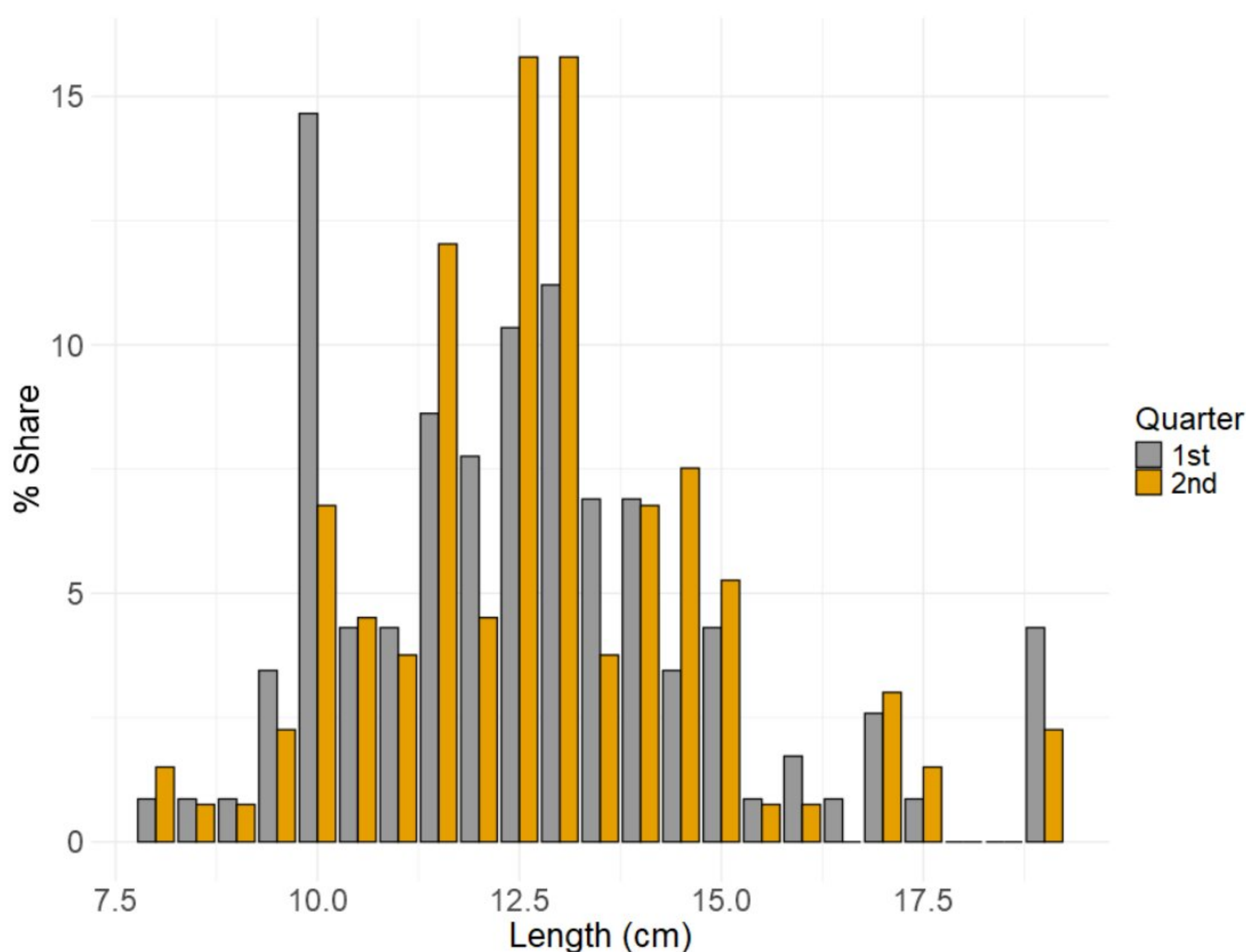


Figure III.3.2.1 Whiting length frequency from landings.

III.3.3 Age structure of landings

Three ichthyologists determined the age of the whiting, with one of the ichthyologists examining the otoliths twice. Age was determined on **249 specimens**. In the first quarter, the highest percentage share - 40% is occupied by individuals in the age group 3-3+, followed by 2-2+. The lowest share is in the age groups: 0-0+ and 5-5+. The second quarter shows that the

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age groups of 2-2+ and 3-3+ have an equal share and significantly prevail over the others. The age groups 0-0+ and 5-5+ are under 5%. The 4-4+ year olds participate with an equal percentage in the catches in both quarters (**Fig. III.3.3.1**).

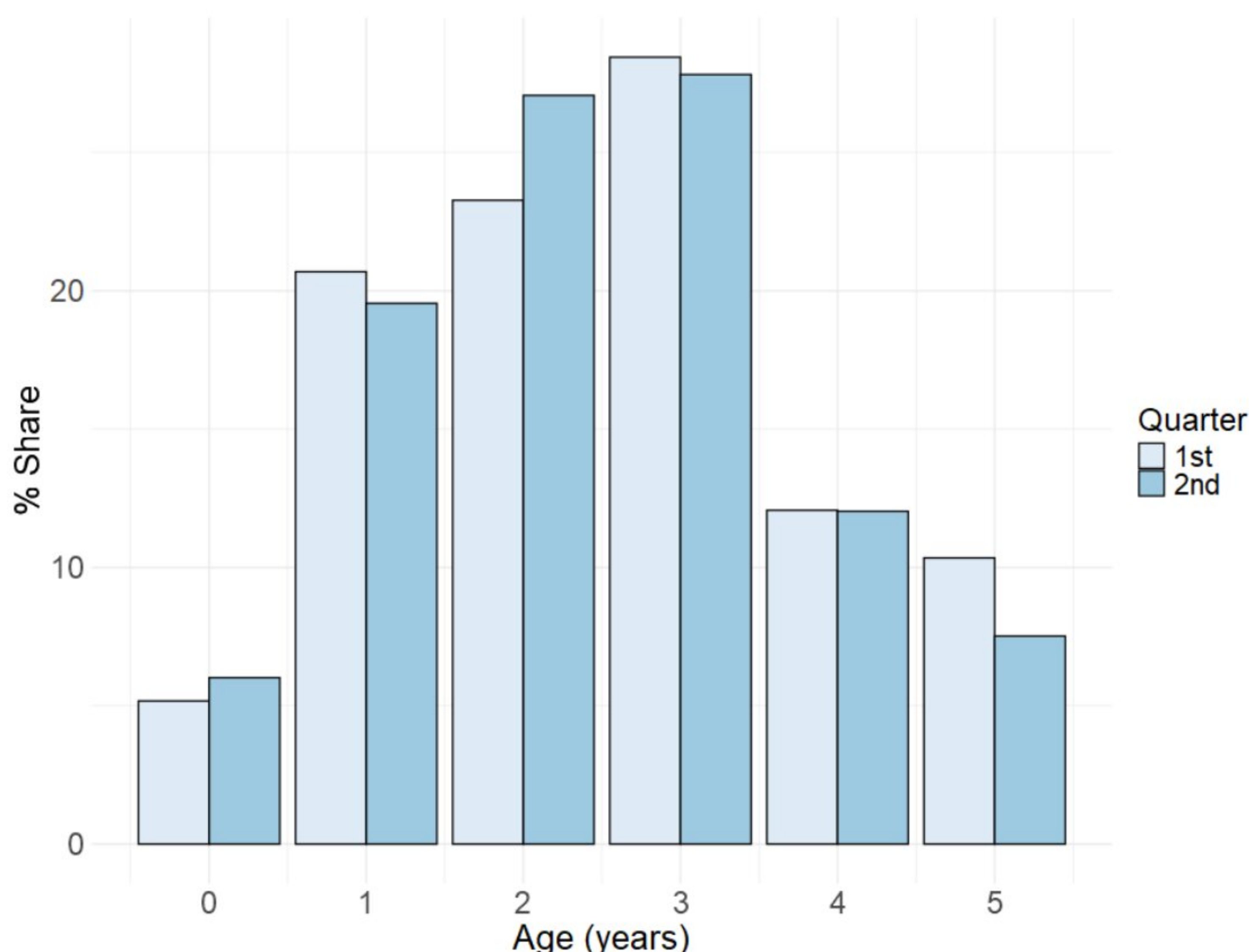


Figure III.3.3.1 Percentage representation of whiting age groups in the catch composition in the first and second semesters of 2025.

During the first semester results of analytical age slicing methods – similar to the analysis of the age structure of the sprat, the analyzes were made in the R programming environment (Program Language for Statistical Modeling and Analysis) using the ELEFAN functions (ELectronic LENgth Frequency Analysis). and the growth and other biological parameters of the studied species were evaluated based on the measured lengths of individuals of different age groups. The samples are restructured for the purposes of the analysis in order to track the evolution of the cohorts over time (**Fig. III.3.3.2** - the first frequency diagram shows the size structure of the collected specimens in the corresponding months, and the second - the restructured data with a moving average MA = 7).

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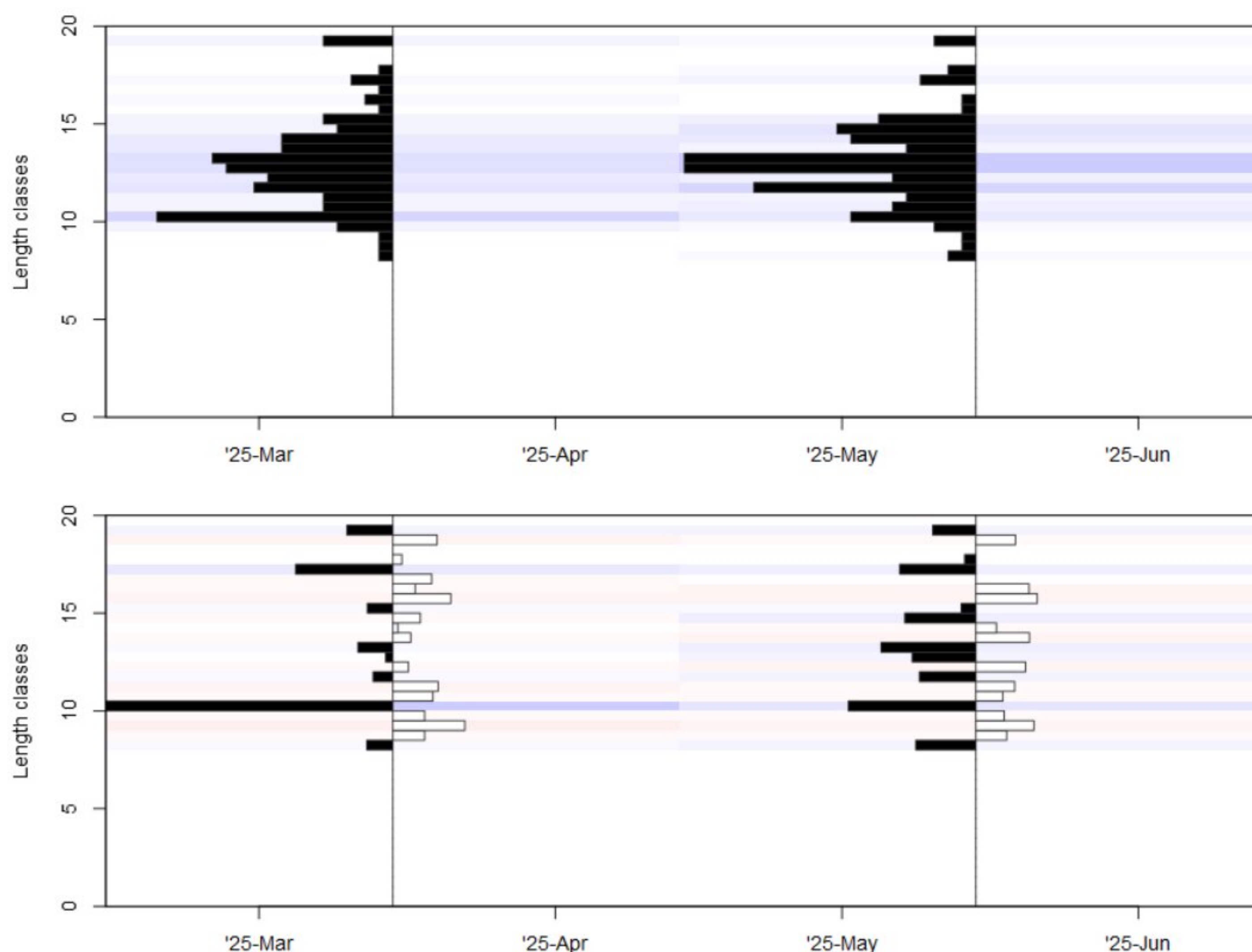


Fig. III.3.3.2 Size-frequency samples visualized as (diagram above) number of individuals in a size class and (diagram below) restructured data with a moving average MA = 7 for the purposes of frequency analysis and determination of growth parameters.

III.1.3.3.1 Frequency analysis RSA – response surface analysis

Growth parameters determined by RSA with initial conditions: conditional interval of for the asymptotic length L_{∞} in the sample [17;23 cm] (based on a literature review of the characteristics and biological potentials of the species for the Black Sea) and the parameter that determines the growth rate to L_{∞} - $K = \exp(seq(from \log(0.1), to \log(1))$ with an upper limit for $L_{\infty} = 22$ cm. The parameters in the von Bertalanffy model are calculated as follows: **$L_{\infty}=20.50$ cm; $K = 0.18$ and $t_0=-0.63$** . The ages with their corresponding lengths were calculated from the latter, as the calculated values do not correspond to the characteristics of the species and the experimentally determined ages, probably due to an

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incorrectly identified coefficient of the growth rate to the asymptotic length, and for this reason they were not taken into account in the analysis of the growth parameters.

III.1.3.3.2 Frequency analysis ELEFAN with simulated annealing (ELEFAN SA)

The growth parameters determined under initial conditions: a conditional interval for the asymptotic length $[L_{\infty}]_{\text{guess}}=19.75$ cm and a search for the value of L_{∞} in the interval $[L_{(\infty\text{guess})}*0.8 \div L_{(\infty\text{guess})}*1.2]$, and for K in the interval $[0 \div 1]$. The parameters in the von Bertalanffy model were calculated as follows: **$L_{\infty}=23.63$ cm; $K = 0.127$ and $t_0=-0.127$.**

The ages with their corresponding lengths were calculated from the latter, as the calculated values do not correspond to the characteristics of the species and the experimentally determined ages and for this reason were not taken into account in the analysis of the growth parameters.

III.1.3.3.3 Frequency analysis ELEFAN – Genetic algorithm (ELEFAN GA)

The growth parameters determined under initial conditions: a conditional interval of for the asymptotic length $[L_{\infty}]_{\text{guess}}=19.75$ cm and a search for the value of L_{∞} in the interval $[L_{(\infty\text{guess})}*0.8 \div L_{(\infty\text{guess})}*1.2]$, and for K in the interval $[0 \div 1]$. The parameters in the von Bertalanffy model were calculated as follows: **$L_{\infty}=22.15$ cm; $K = 0.224$ and $t_0=-0.497$.** The ages with their corresponding lengths were calculated using the latter (**Table III.1.3.3.3.1, Figure III.1.3.3.3.2**). The results show that the experimental data do not match well with the analytical data, but the analytical data better represent the expected size composition by age, therefore, in this case, the growth parameters calculated by ELEFAN GA are considered valid and will be updated after the end of the year, when more information about the species will be available.



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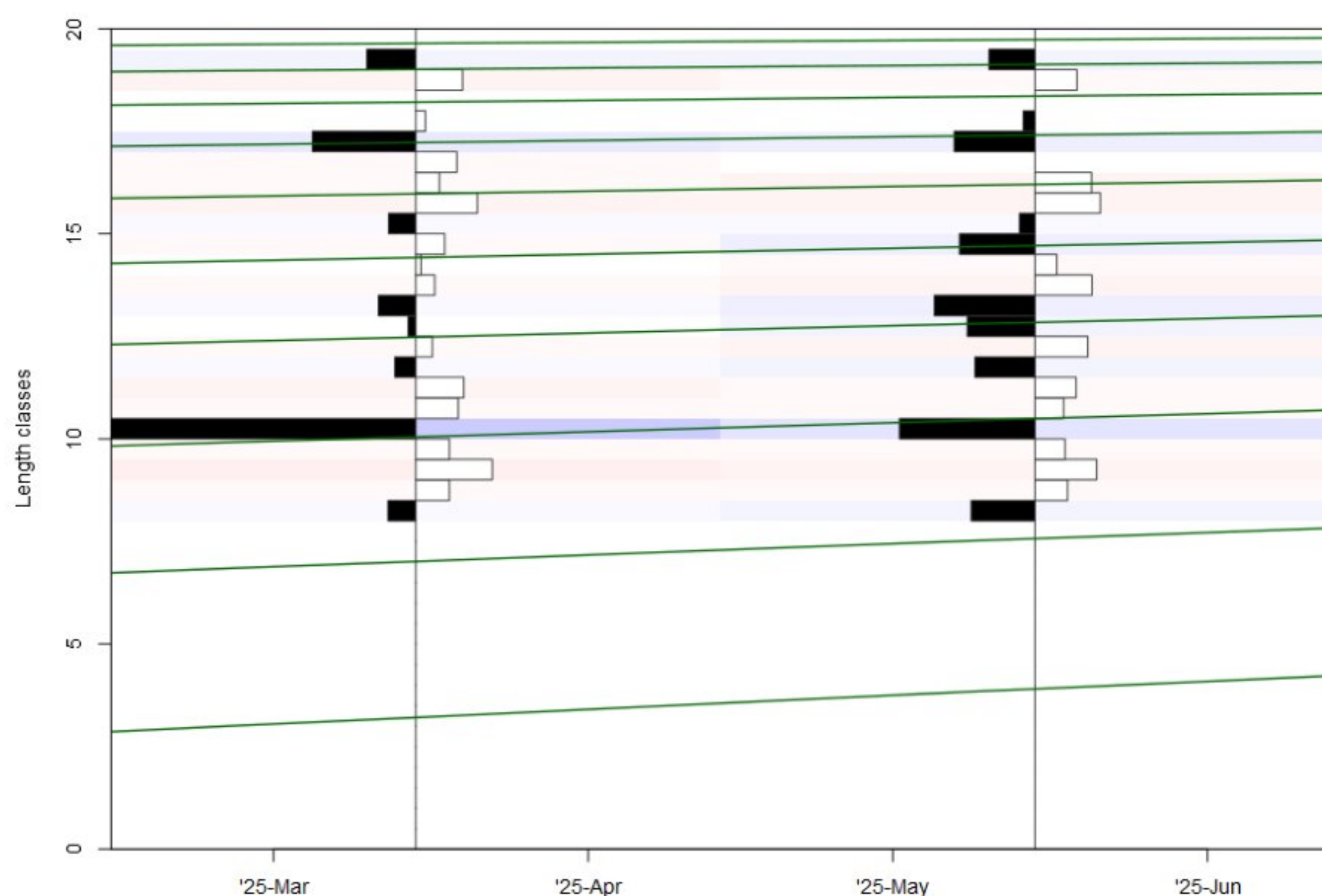


Figure III.1.3.3.3.1 Growth curves (in blue according to ELEFAN SA, and in green according to ELEFAN GA), visualized on the restructured data for the purpose of visualizing the tracking of cohorts over time.

Table III.1.3.3.3.1 Ages with their corresponding lengths for the studied species calculated using von Bertalanffy parameters, obtained with RSA, ELEFAN with simulated annealing, ELEFAN with genetic algorithm and compared with experimentally determined ages from otoliths.

	ELEFAN GA	Experimentally determined
age	La	L _{mean}
0	2.3	9
0.5	4.4	
1	6.3	11.25
1.5	8	
2	9.5	11.25
2.5	10.8	
3	12	12.5
3.5	13	
4	14.1	14.25
4.5	14.9	
5	15.7	17.2

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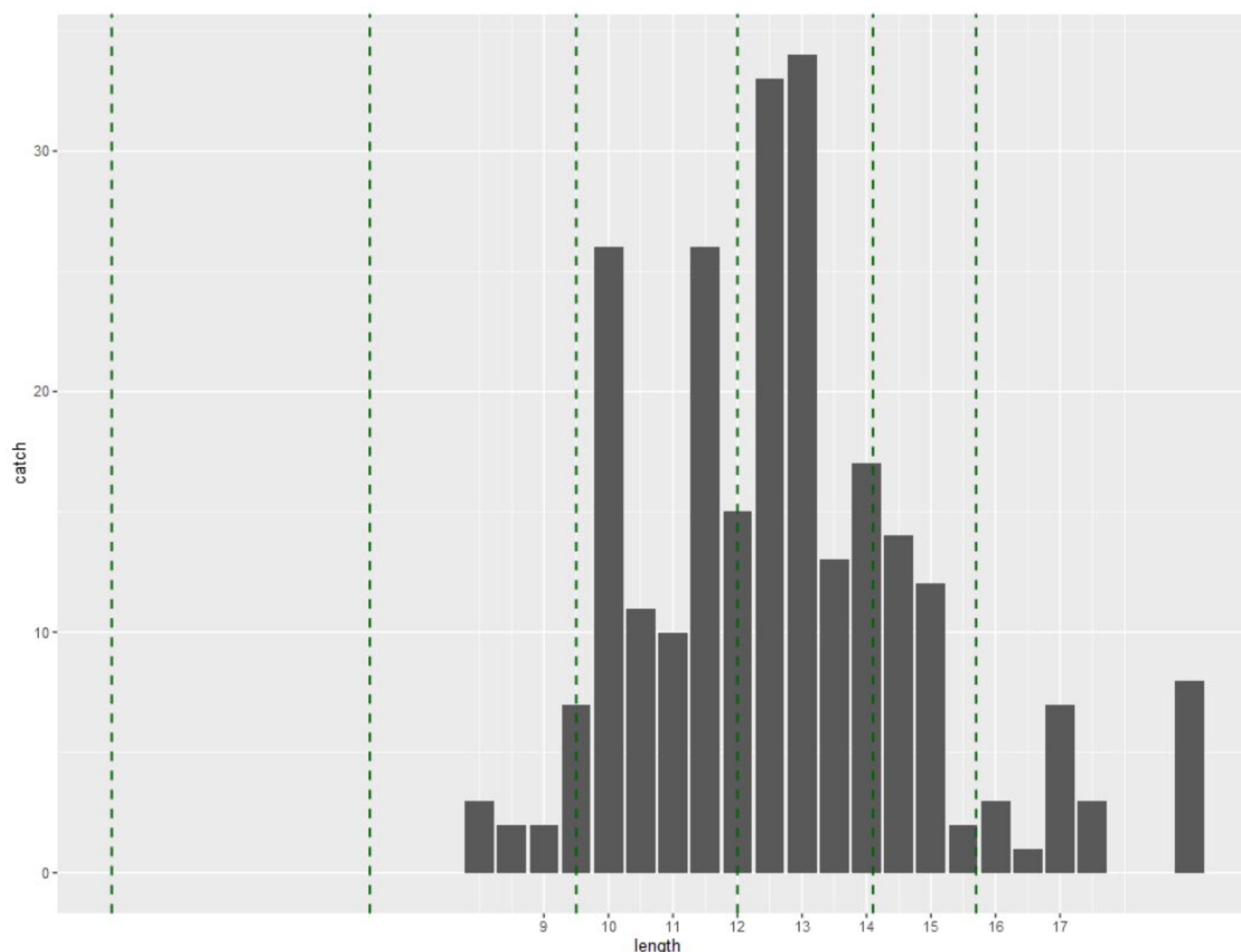


Figure III. 1.3.3.3.2 Growth curves determined with ELEFAN RSA, visualized on the restructured data for the purpose of visualizing the tracking of cohorts over time.

III.3.4 Condition factor

The best condition is reported in the size class 14.5 cm ($K = 0.87$). During the first half of the year, the condition factor did not show significant fluctuations (**Fig. III.3.4.1**).

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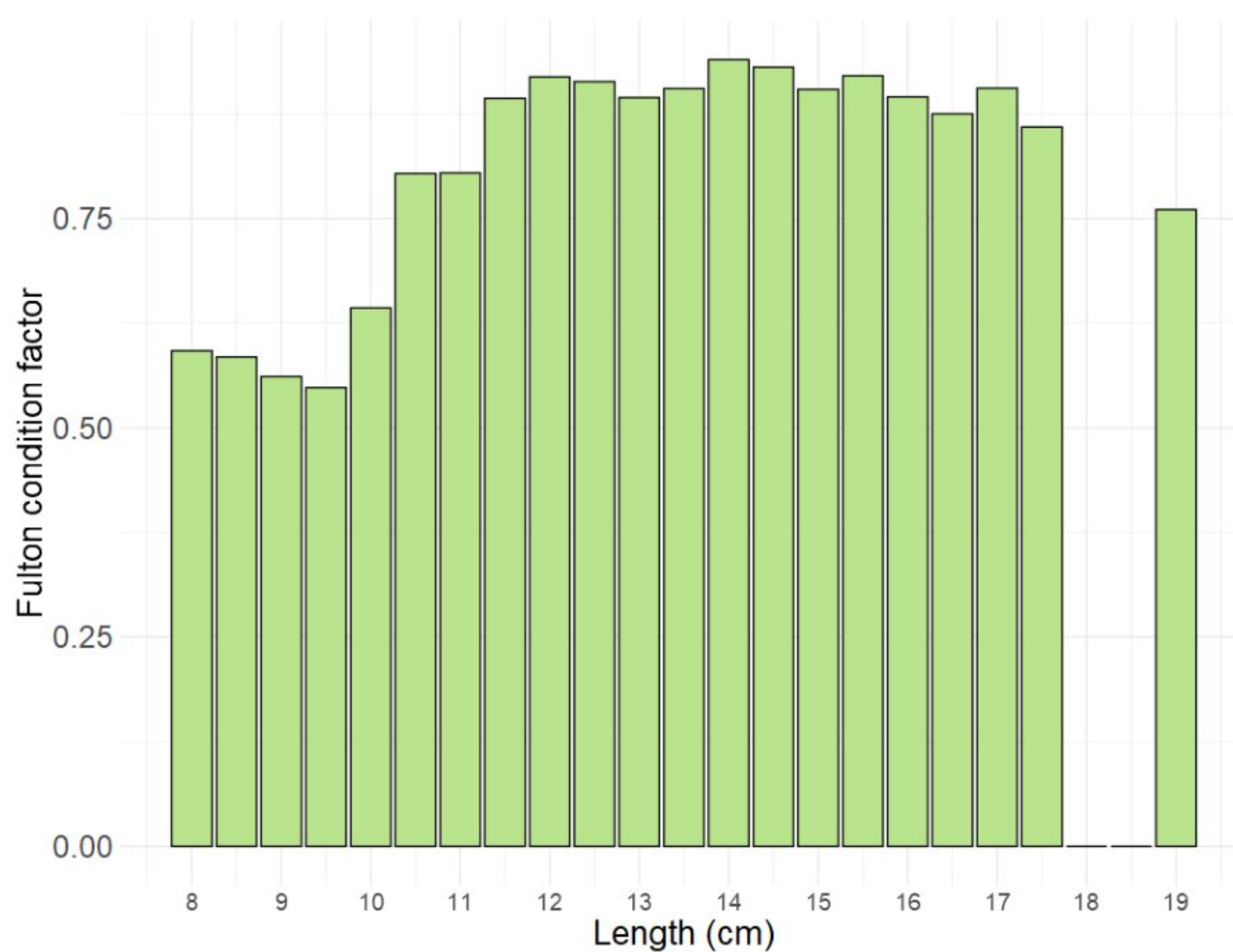


Figure III.3.4.1 Condition factor by size classes of whiting for the first six months of 2025.

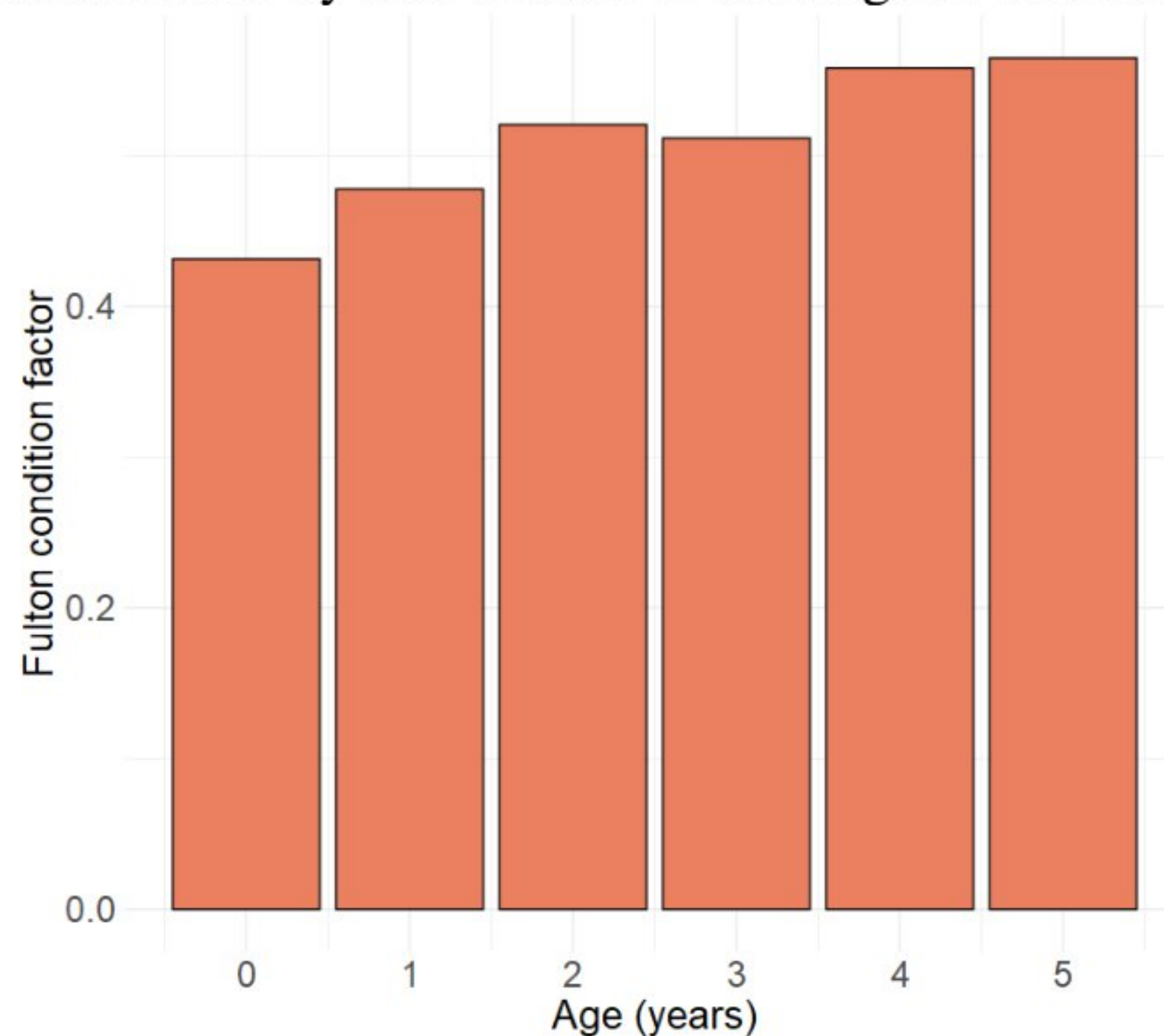


Figure III.3.4.2 Condition factor by age group of whiting.

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III.3.5 Weight structure of whiting

The weight of **249 individuals** was measured. The graph shows the distribution of the average weight by age group for two quarters. A gradual increase in the average weight is observed in relation to the age groups. The lowest average weight is observed for the age group 0-0+, and the highest average weight is observed for the group 5-5+. The average weights by age are 0+ (4.75 g), 1-1+ (10.28g), 2-2+ (12.0g), 3-3+ (17.98g), 4-4+ (22.27g), 5+ (43.68g).

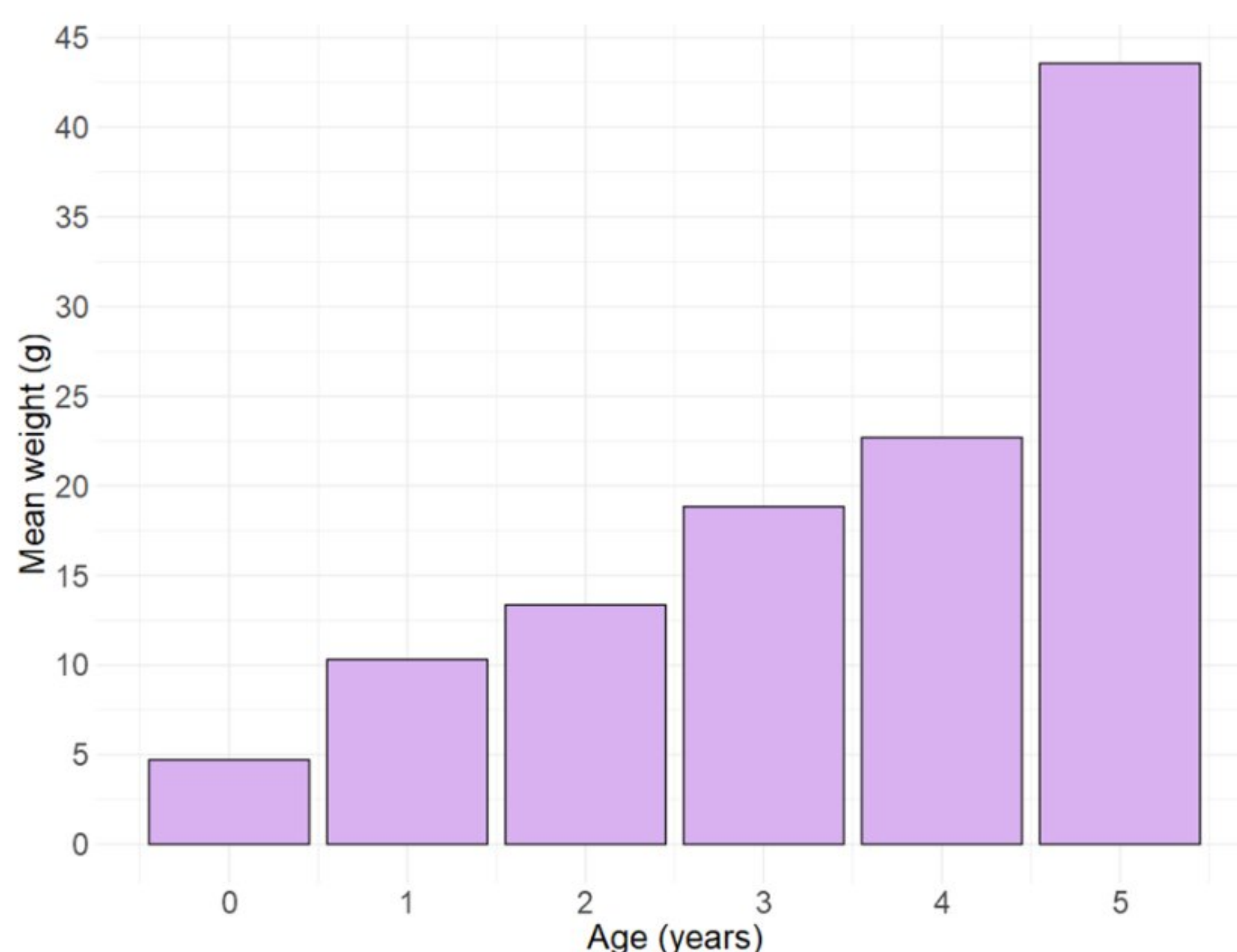


Fig. III. 3.5.1 Weight by age group.

A gradual increase in the average weight values is observed for both size classes. The lowest value for the average weight is for the 8 (3.03g) cm size class, and the highest is for the 19 cm (52.16g) size class (**Fig. III. 3.5.2**).



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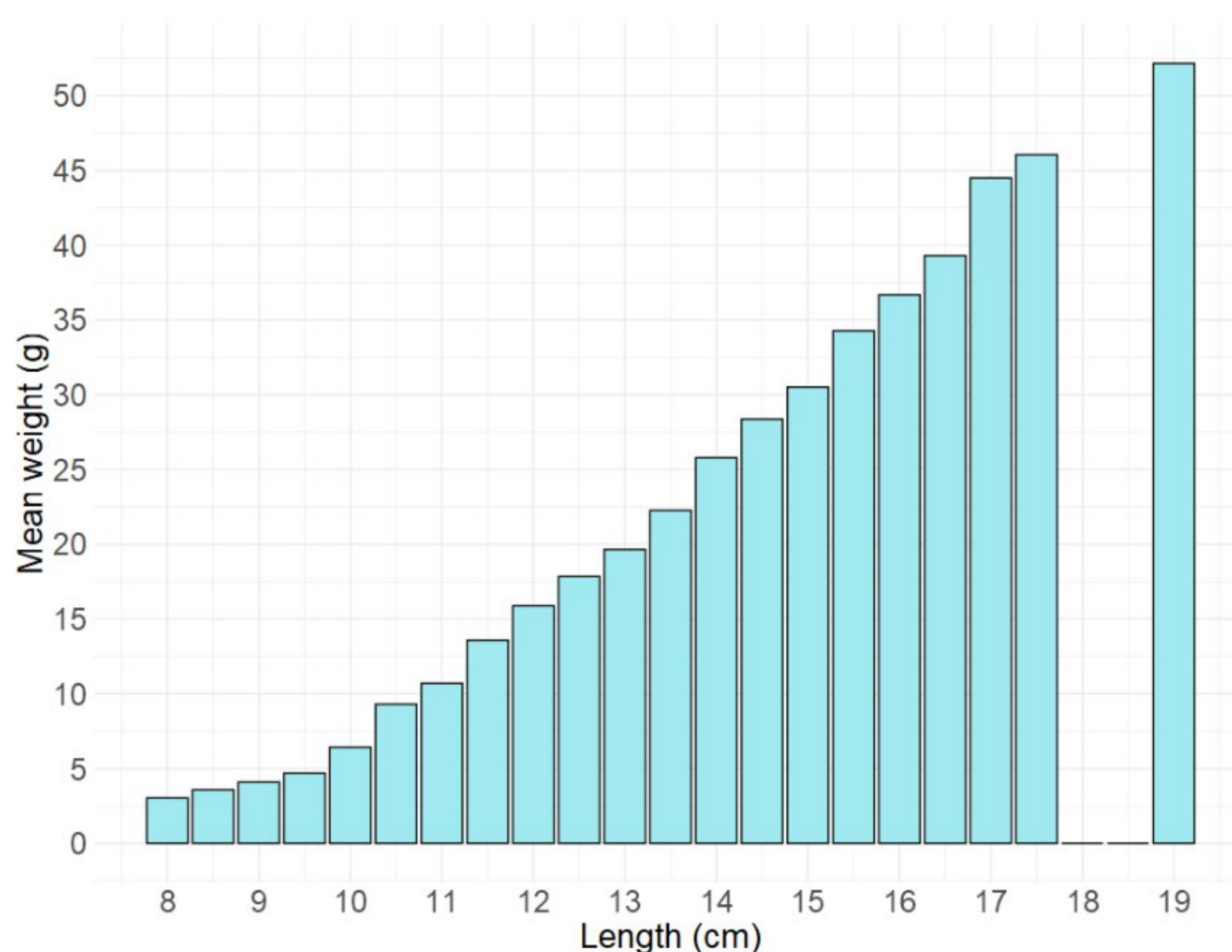


Fig. III. 3.5.2 Weight by size classes for the first semester of 2025.

III.3.6 Size structure of whiting by age group

The length of the fish was measured on **249 individuals**. No major fluctuations were recorded in the period under consideration in 2025 in terms of average lengths by age. The lowest value for average length is in the age group 0-0+, and the highest is in the group 5-5+ years (**Fig. III.3.6.1**)

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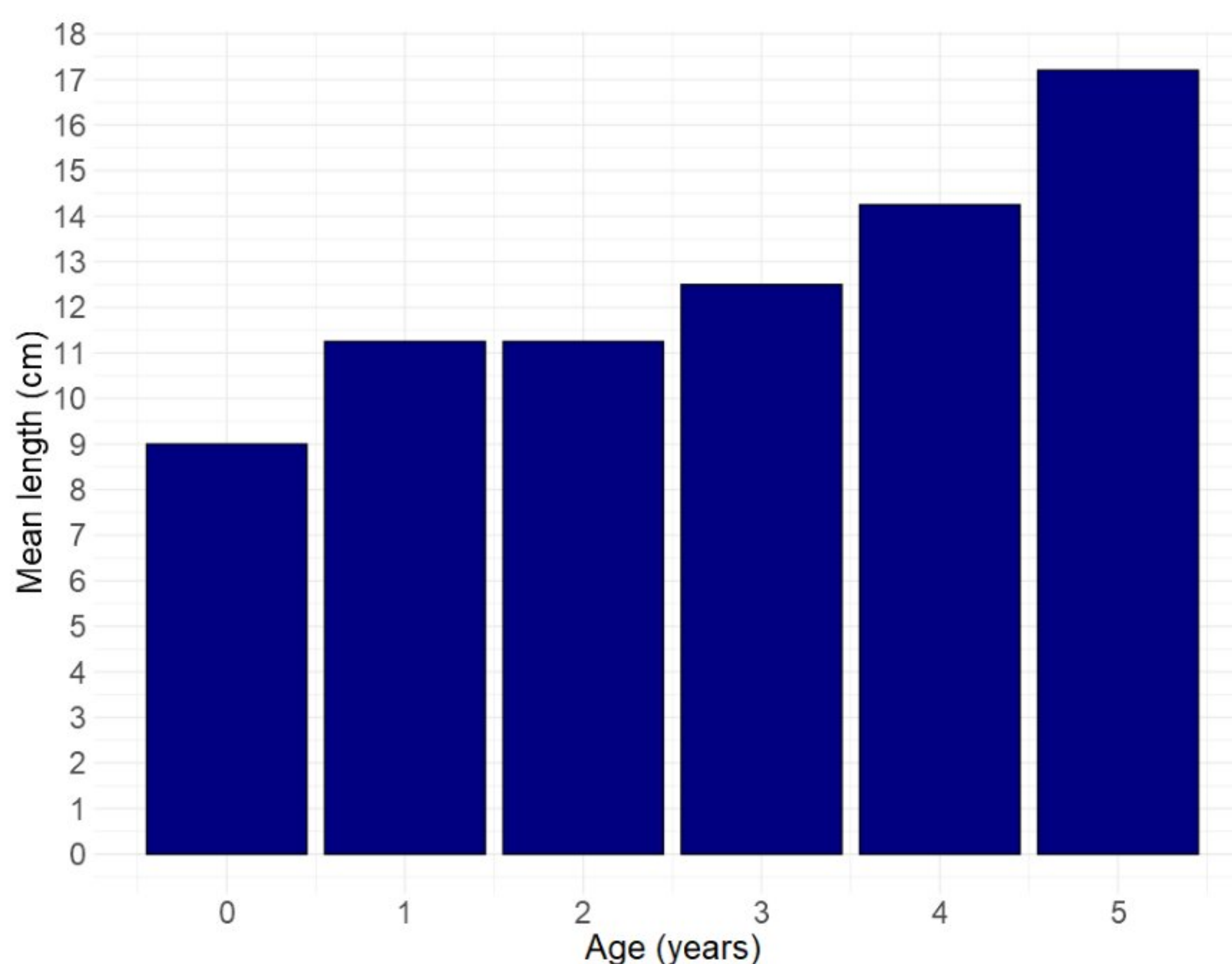


Figure III.3.6.1 Mean size of the whiting by age groups.

III.3.7 Length- weight relationship

The resulting model (**Table III.3.7.1**) is statistically significant, the value of the scaling coefficient a in the length-weight relationship model $W_i = aL_i^b$ is: $a = 0.00195$, and of the allometry coefficient $b=3.55$, which indicates a positive allometric growth of the species in the first half of the year, or the increase in weight is proportional to or greater than the increase in length.

Table III.3.7.1 Results of modeling the length L-weight W relationship for the first half of the year.

Call:					
lm(formula = logW ~ logL, data = weight_1)					
Residuals:					
Min	1Q	Median	3Q	Max	
-0.27516	-0.08584	0.02903	0.09792	0.16977	
Coefficients:					
Estimate	Std. Error	t value	Pr(> t)		
(Intercept)	-6.2404	0.2911	-21.44	0.000000000000000899	***

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logL	3.5558	0.1141	31.16	< 0.0000000000000002	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 0.1289 on 19 degrees of freedom					
Multiple R-squared: 0.9808, Adjusted R-squared: 0.9798					
F-statistic: 970.9 on 1 and 19 DF, p-value: < 0.00000000000000022					

III.3.8 Sex structure

The sex ratio was determined on **100 specimens**. Females ♀ predominated over males ♂ in the first half of 2025 (**Figure III 3.8.1**).

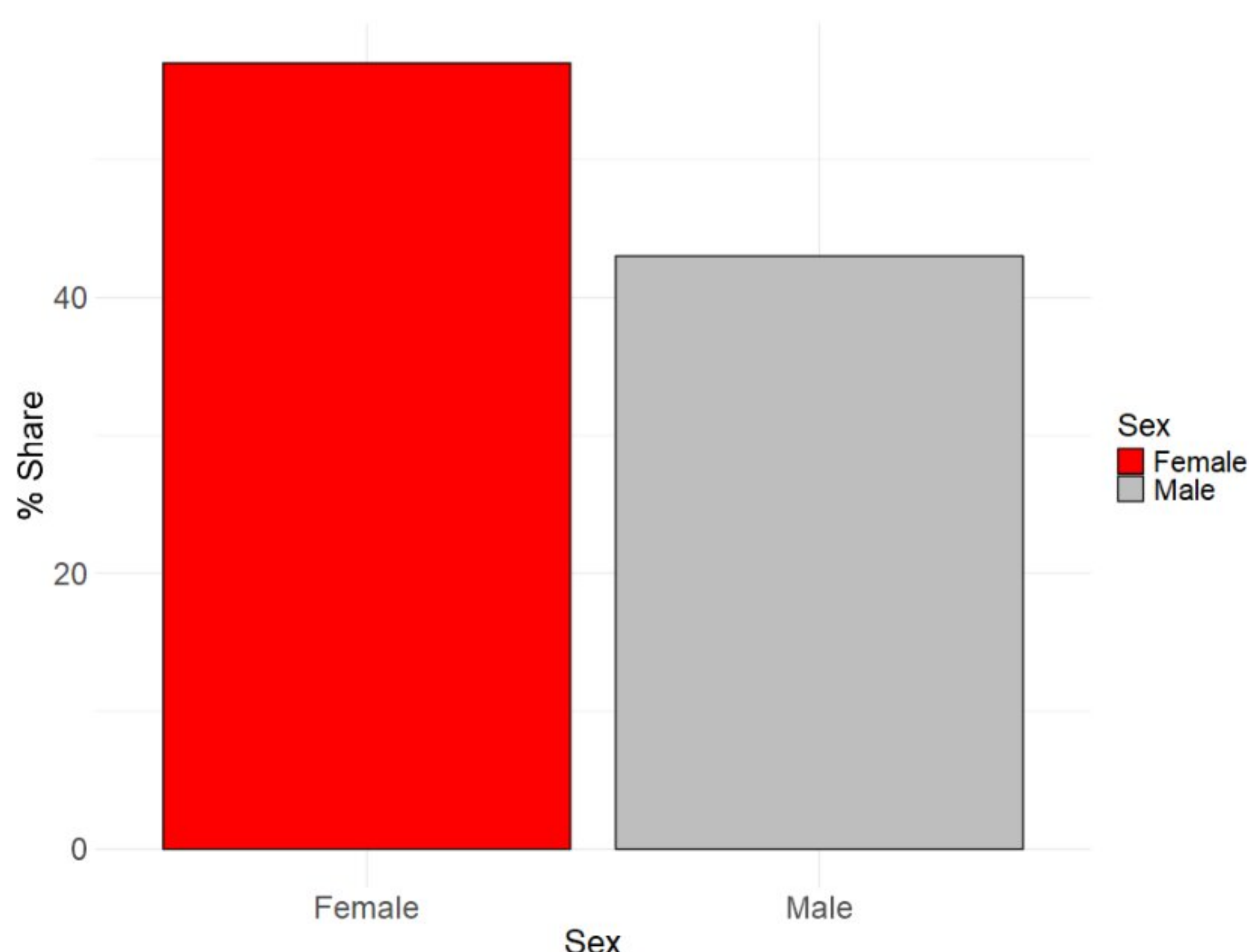


Figure III. 3.8.1 Sex ratio of whiting for the first semester of 2025.



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In size classes 11.0-11.5 cm for females and 12.5-13.0 for males are represented with higher percentage values. In terms of age, one-year-olds are represented with the highest percentage for females and zero-year-olds for males (**Figure III 3.8.2**).

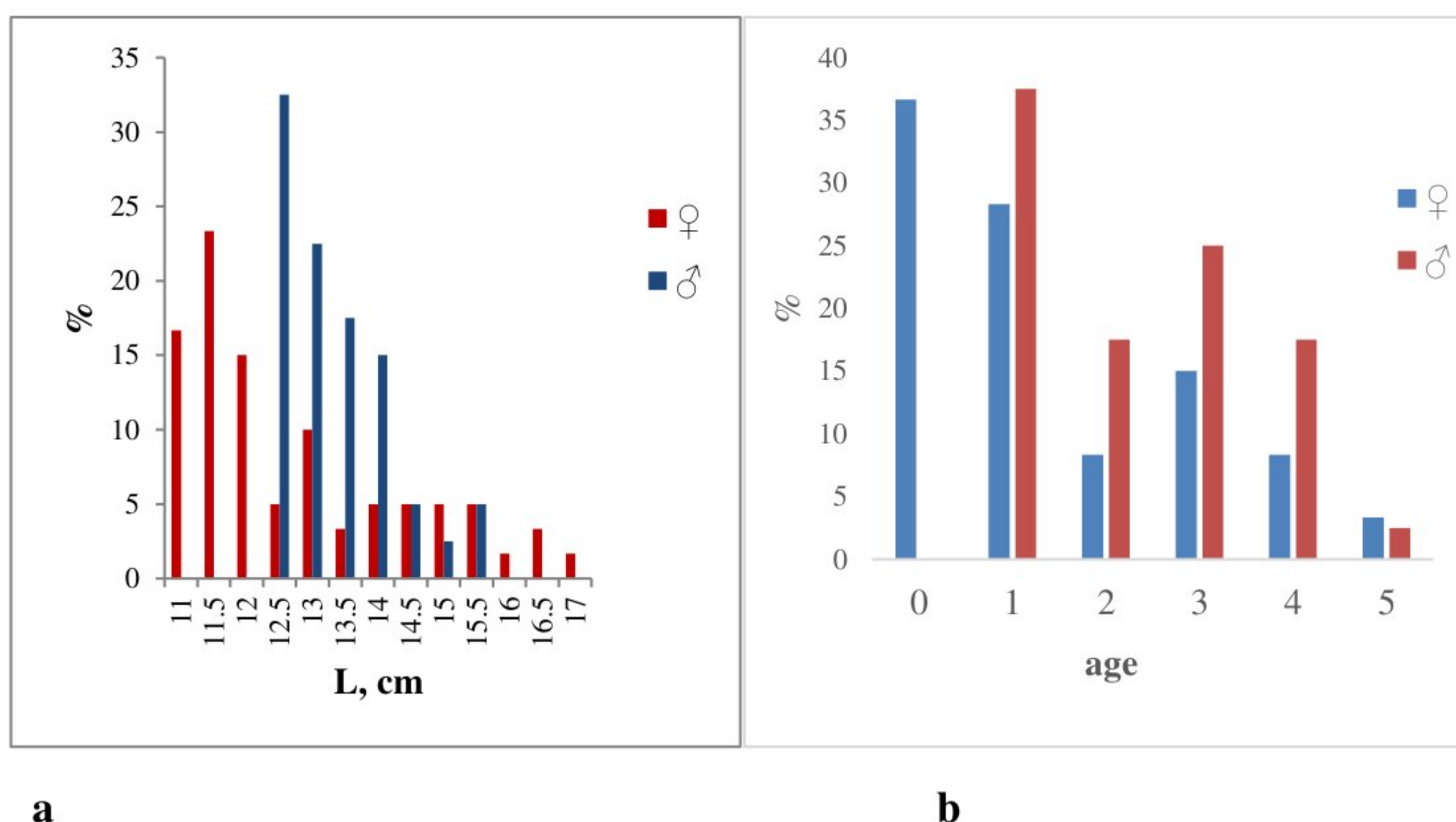


Figure III. 3.8.2 Sex ratio (%) by size (**a**) and age (**b**) of whiting.

III.3.9 Fertility

Fertility was determined on **100 specimens**. The gonad-somatic index is strongly dependent on the weight of the gonads ($R^2=0.8567$ in the first six months, which is associated with the high rate of maturation of females in late spring and the reproductive process of whiting (**Figure III 3.9.1**).



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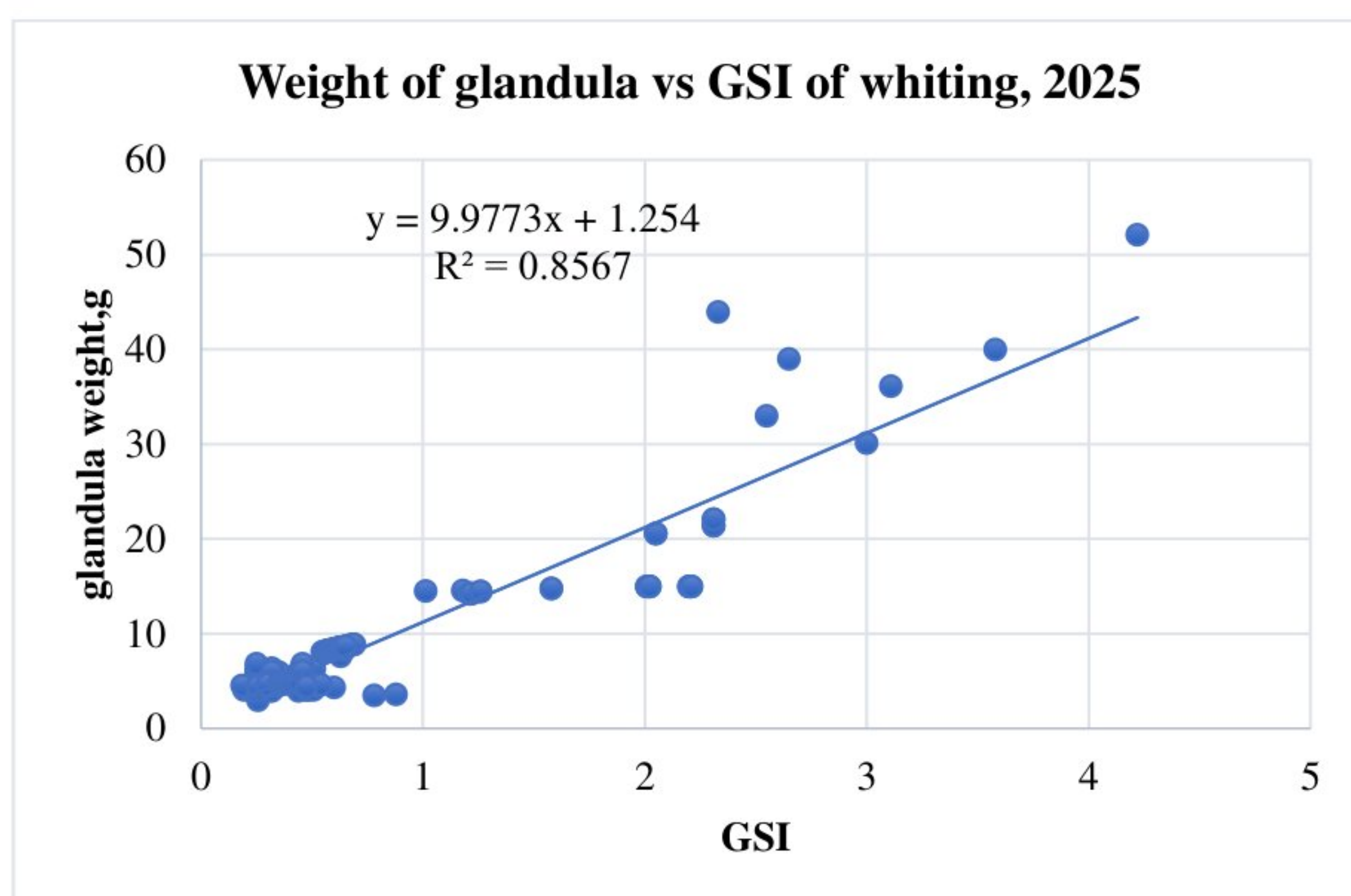


Figure III.3.9.1 Relationship between GSI and whiting glandule weight.

Absolute fertility increases with increasing length, and mass. The average weighted relative fertility is 1139.233 for the first semester and absolute fertility is 28289 caviar grains (**Table III 3.9.1**).

Table III.3.9.1 Absolute and relative fertility.

Size class	W average, g	Average length(cm)	Absolute fertility F, caviar grains)	Relative fertility	N♀
10	7.77	9.69	9005	1158.945	10
10.5	9.15	10.48	10258	1121.093	10
11	11.24	11.11	11022	980.605	10
11.5	15.56	11.63	12111	778.3419	10
12	18.02	11.99	14321	794.7281	10
12.5	21.33	12.48	36369	1705.063	10
13	28.96	13.11	40002	1381.285	10
13.5	36.89	13.6	43852	1188.723	10
14	42.55	14.05	51777	1216.851	10
14.5	45.99	14.55	52811	1148.315	5
15	46.44	15.09	49005	1055.233	5
			средно 28289	средно 1139.233	100

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III.3.10 Sexual maturity

Sexual maturity was determined on **50 specimens**. Active maturation of the reproductive products was observed, with the degree of maturity varying with increasing age groups and sex from I for zero-year-olds to IV for four- and five-year-old females and V for five-year-old male fish (**Fig.III.3.10.1**).

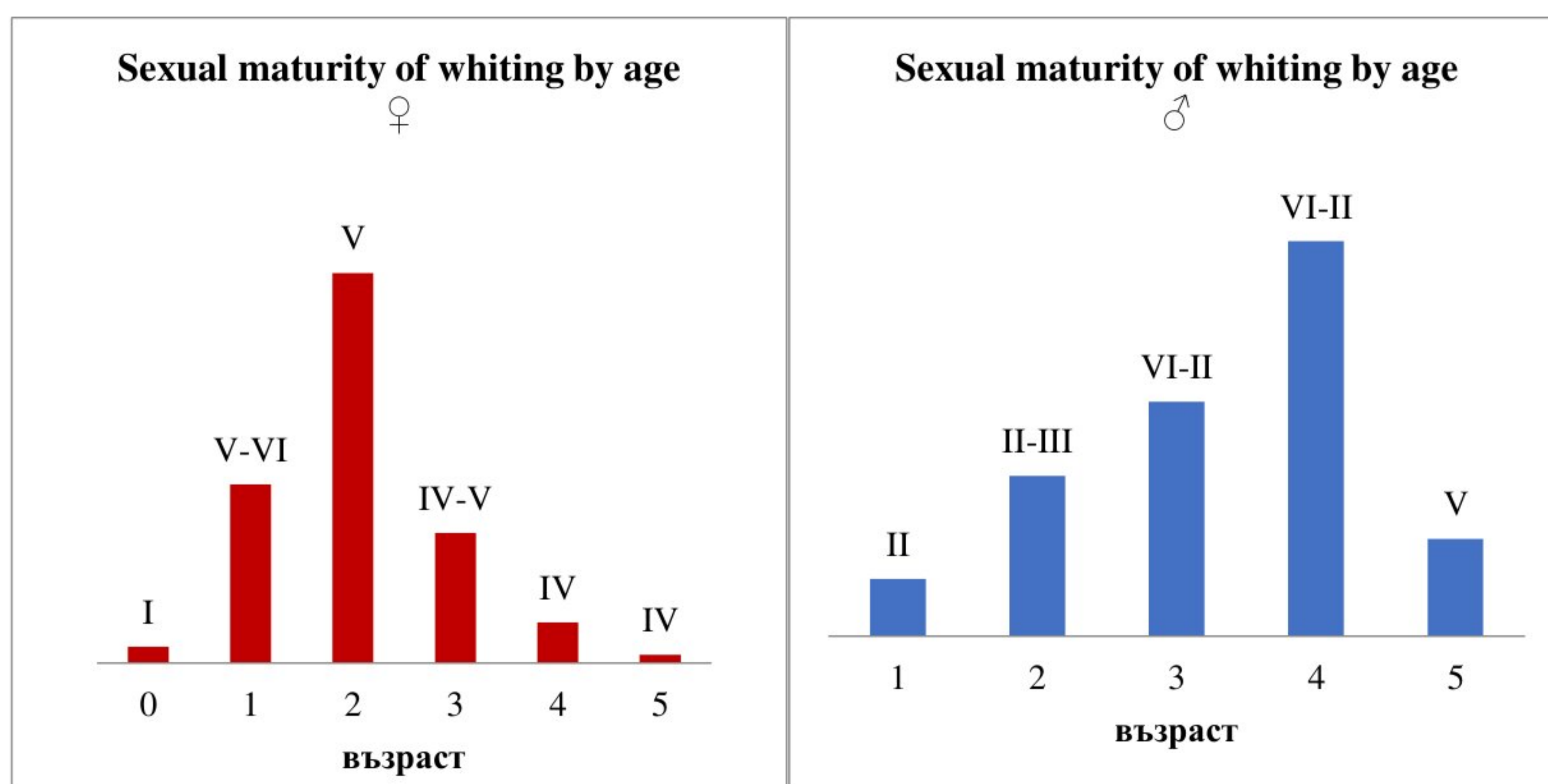


Figure III.3.10.1 Sexual maturity by age of whiting - female ♀ and male ♂.

In terms of sexual maturity in length, a mass IV-VI degree is observed in female ♀ and male ♂ fish (**Fig. III.3.10.2**).

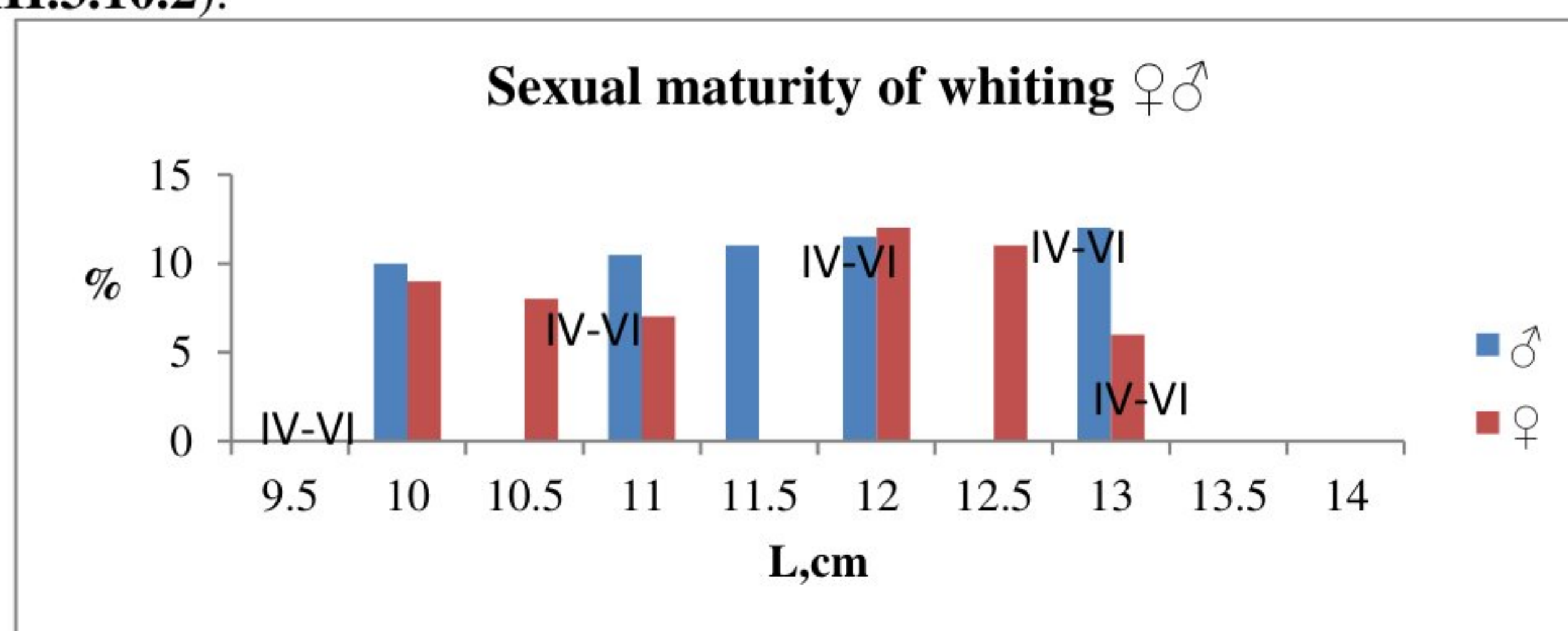


Figure III.3.10.2 Sexual maturity along the length (cm) of whiting - female ♀ and male ♂.

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III.3.11 Catch numbers and biomass by age and length

Monthly OTM catches (in kilograms) together with average weights were used to obtain the abundance and biomass of the species by quarter in the reported catches (**Table III.3.11.1-2**).

Table III.3.11.1 Catch at age matrix and biomass (kg) of whiting with OTM.

<i>Catch at age</i>		
<i>Age groups</i>	<i>Ith quarter</i>	<i>IInd quarter</i>
0-0+	71.0859	78.0709
1-1+	134.239	115.926
2-2+	151.437	123.844
3-3+	109.538	90.219
4-4+	36.2307	32.3841
5-5+	15.7116	10.5432
Σ	518.242	450.987
<i>Biomass</i>		
<i>Age groups</i>	<i>Ith quarter</i>	<i>IInd quarter</i>
0-0+	0.34334	0.36752
1-1+	1.37338	1.19444
2-2+	1.54505	1.65383
3-3+	1.8884	1.69977
4-4+	0.80114	0.73504
5-5+	0.68669	0.4594
Σ	6.638	6.11

Table III.3.11.2 Number of individuals in the catch by size class (for OTM) and biomass of the of the whiting.

<i>Catch in numbers</i>		
<i>Length group (cm)</i>	<i>Ith quarter</i>	<i>IInd quarter</i>
8	18.4000	28.5341
8.5	15.0987	11.1504
9	11.6073	9.1332
9.5	38.2131	20.6008
10	137.792	55.4234
10.5	28.3372	34.0716

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<i>11</i>	24.3922	23.6316
<i>11.5</i>	45.6333	63.6948
<i>12</i>	35.8398	20.6162
<i>12.5</i>	40.6807	57.1527
<i>13</i>	41.887	54.3208
<i>13.5</i>	22.5625	11.9077
<i>14</i>	19.9648	18.0313
<i>14.5</i>	9.32437	18.6975
<i>15</i>	9.94511	12.0127
<i>15.5</i>	1.76563	1.4175
<i>16</i>	3.20853	1.1882
<i>16.5</i>	1.4941	0.0000
<i>17</i>	4.25142	4.4408
<i>17.5</i>	1.35957	2.0977
<i>19</i>	6.48506	2.8641
Σ	518.242	450.987
Biomass		
<i>Length group (cm)</i>	<i>Ith quarter</i>	<i>IInd quarter</i>
<i>8</i>	0.05722	0.09188
<i>8.5</i>	0.05722	0.04594
<i>9</i>	0.05722	0.04594
<i>9.5</i>	0.2289	0.13782
<i>10</i>	0.97281	0.41346
<i>10.5</i>	0.28612	0.27564
<i>11</i>	0.28612	0.2297
<i>11.5</i>	0.57224	0.73504
<i>12</i>	0.51502	0.27564
<i>12.5</i>	0.68669	0.96474
<i>13</i>	0.74391	0.96474
<i>13.5</i>	0.45779	0.2297
<i>14</i>	0.45779	0.41346
<i>14.5</i>	0.2289	0.4594
<i>15</i>	0.28612	0.32158
<i>15.5</i>	0.05722	0.04594
<i>16</i>	0.11445	0.04594
<i>16.5</i>	0.05722	0.0000
<i>17</i>	0.17167	0.18376
<i>17.5</i>	0.05722	0.09188
<i>19</i>	0.28612	0.13782
Σ	6.638	6.11

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III.3.12 Conclusions

The analysis of the biological parameters of the whiting makes it possible to draw the following **conclusions**:

1. For the first quarter, the classes in the range of 7.5-8.5 cm have the lowest share in landings - under 3%. The class with a length of 10 cm has the highest percentage share in landings. For the second quarter, the size classes with the lowest percentage are 8-8.5 and 15.5-16 cm, and the classes with the highest percentage are in the range of 12.5 -13 cm.
2. In the first quarter, the highest percentage share - 40% is occupied by individuals in the age group 3-3+, followed by 2-2+. The lowest share are the age groups: 0-0+ and 5-5+. The second quarter shows that the age groups of 2-2+ and 3-3+ have the same share and significantly prevail over the others.
3. The parameters in the von Bertalanffy model are calculated as follows: $L_{\infty}=22.15$ cm; $K=0.224$ and $t_0=-0.497$. The results show that the experimental data do not match well with the analytical data, but the analytical data better represent the expected size composition by age, therefore in this case the growth parameters are assumed to be valid, growth rates calculated by ELEFAN GA, and will be updated after the end of the year, when more information about the species will be available.
4. A gradual increase in the average weight is observed across age groups. The 0-0+ age group has the lowest average weight, while the 5-5+ group has the highest average weight.
5. The lowest value for the average weight is in the 8 cm size class, and the highest is in the 19 cm size class.
6. The resulting model is statistically significant, the value of the scaling coefficient a in the length-weight relationship model is: $a= 0.00195$, and the allometric coefficient $b= 3.55$, which indicates positive allometric growth of the species in the first half of the year, or the increase in weight is proportional to or greater than the increase in length.
7. Active maturation of the reproductive products was observed, with the degree of maturity varying with increasing age groups and sex from I for zero-year-olds to IV for four- and five-year-old females and V for five-year-old male fish.

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IV. Biological monitoring of red mullet (*Mullus barbatus*) landings

IV.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze red mullet catches, as well as to form a database. The collection of biological samples of red mullet catches in **I-VI 2025** includes the following tasks:

1. *To collect and analyze the dynamics of length, weight and age distribution.*
2. *To determine the state of the of red mullet using the so-called state factor (Ricker, 1975).*
3. *Characteristics of the reproductive biology of red mullet.*
4. *Collection of data on ports of landing, sampling vessels, number of samples collected, number of specimens tested, geographical catch data.*

IV.2 Sampling

The sampling was carried out by the actively operating fishing fleet in Bulgaria.

IV.2.1 Geographic area coverage

Data of present analysis were collected from landing ports of Bulgarian Black Sea coast. **In I-VI 2025, 5 samples of red mullet containing 431 specimens** were collected. Information on the size of the catches was also collected.

IV.2.2 Sampling period

In I-VI 2025, the biological data on species were collected from a total of **5 landings** at the ports of **Nesebar, Varna and Balchik**. Information on the size of the catches was also collected. Ports and ships from which monitoring was carried out to collect biological data from landings are presented in **Table IV.2.2.1**.

Table IV.2.2.1 Ports and vessels from which monitoring was carried out to collect biological data from red mullet landings.

N	MUT	Harbor	RK	External marking	Catch	N	Coordinates
1	10.1.2025	Nesebar	ISHTAR	NS 1182	42 kg	108	42.6438 27.7598

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2	28.3.2025	Varna	SVETA ANNA - 1	BN 8265	5 kg	106	43.139600 28.102100
3	3.4.2025	Nesebar	BUREVESTNIK	BS 032	15 kg	97	42.656100 27.731000
4	29.6.2025	Balchik	VENI	VN 2998	6 kg	120	43.2879 28.401
						431	

IV.2.3 Statistical analysis of data

See section statistical analysis of sprat.

IV.3 Results

IV.3.1 Landings statistics

The graph shows the landings of mullet with OTM for the first half of 2025. The month of April has the lowest value. In February, no catches with OTM were recorded. In May-June (spring season) landings are significantly higher (**Fig. IV.3.1.1**).

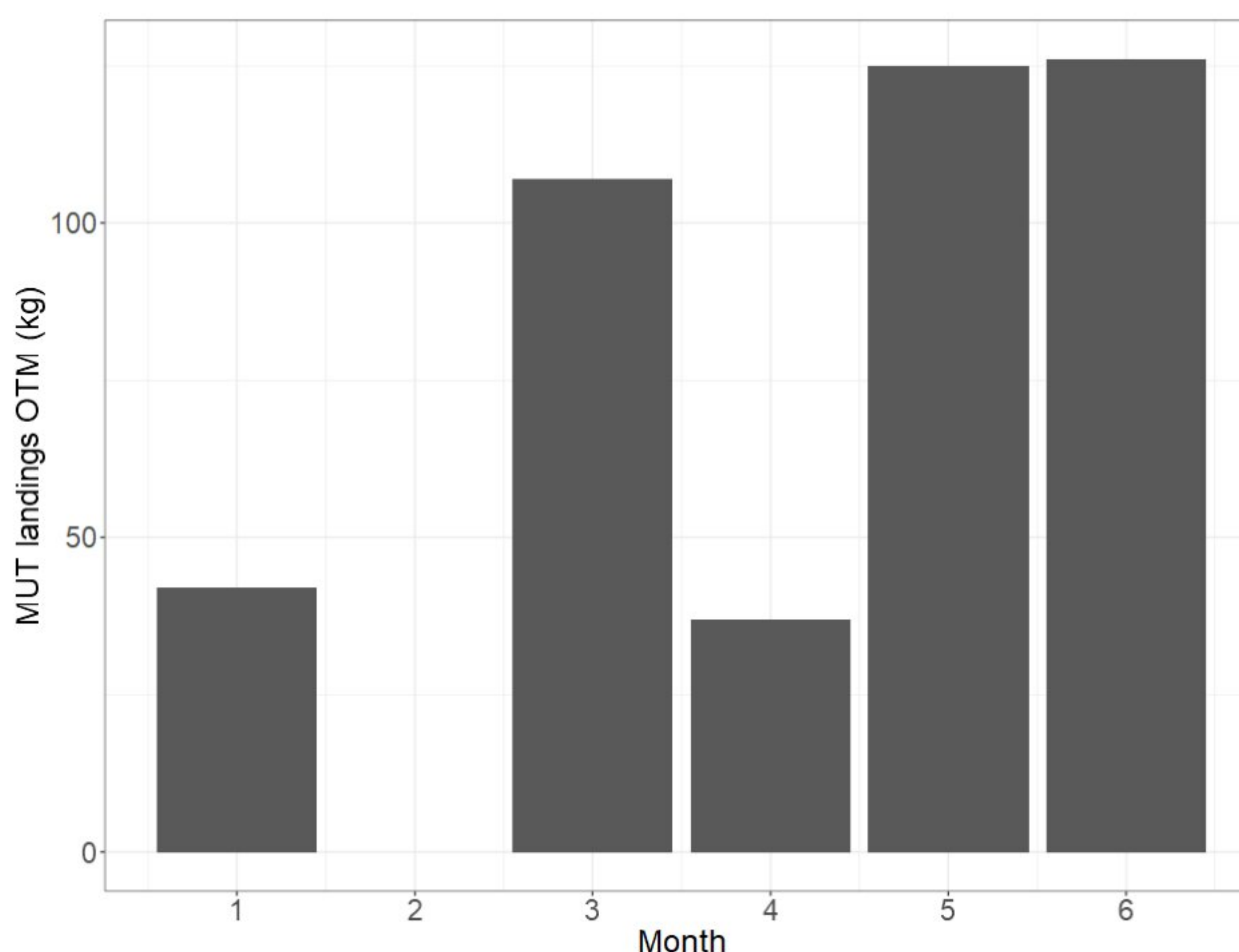


Fig. IV.3.1.1 Official statistics records for red mullet landings.

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IV.3.2 Length structure of landings

The graph shows that in both quarters the percentage distribution of catches by size classes is uneven. The highest values are for individuals in the size classes of 12.5 cm for the first and 12 cm for the second quarter. The lowest percentage values are for the size classes of 16.5 -18 cm (**Fig. IV.3.2.1**).

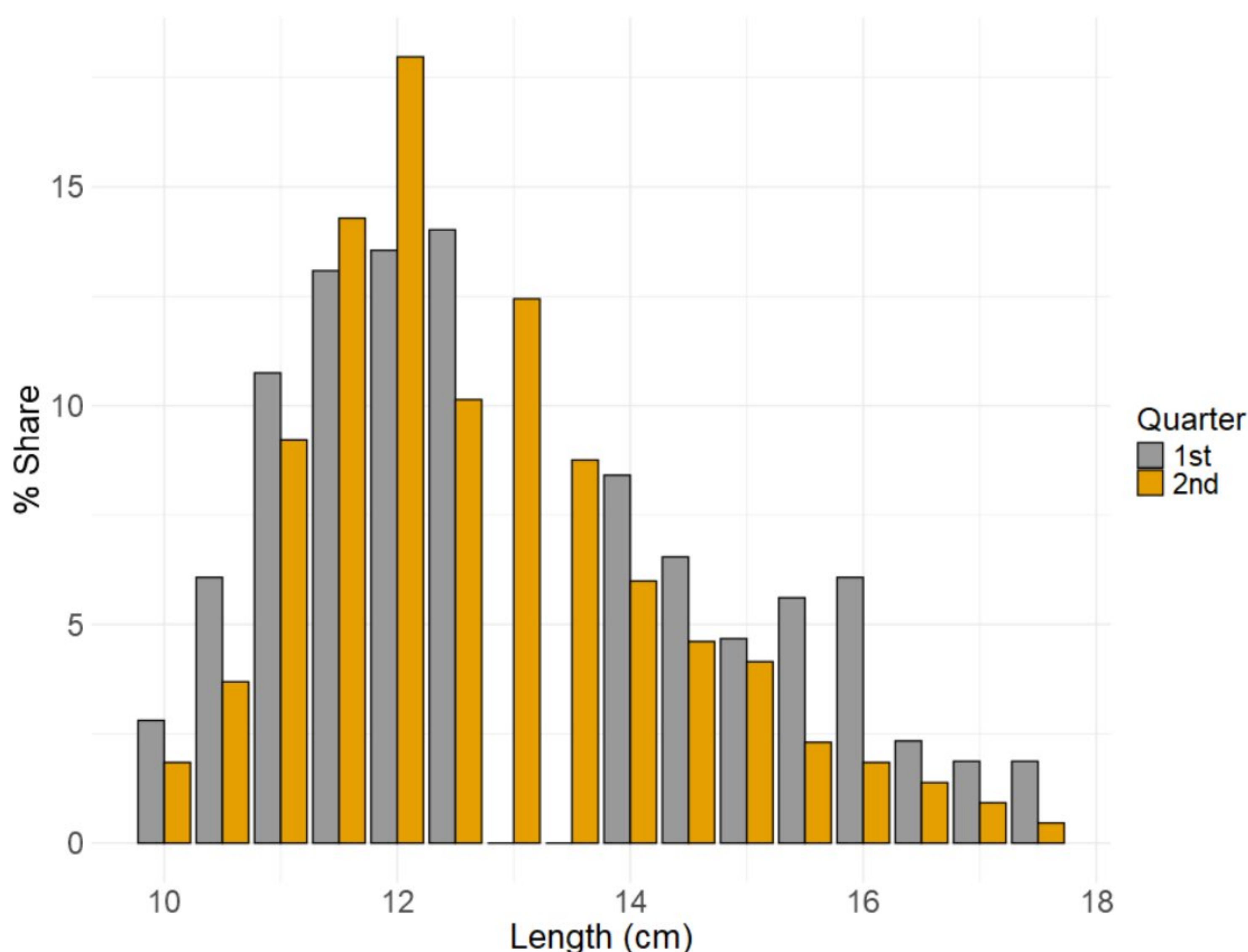


Fig.IV.3.2.1 Size structure and percentage share of length classes in the catch composition.

IV.3.3 Age structure of landings

The three age readers determine the age of the red mullet otoliths, and determinant 1 reads all otoliths twice. **Samples n=431 were used to determine age.** The graph shows an uneven distribution of catch values for mullet (%) for both quarters, with the age group 5-5+ having

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the lowest possible catch values, and 2-2+ and 3-3+ having the highest percentage representation in catches for the first and second quarters (Fig. IV.3.3.1).

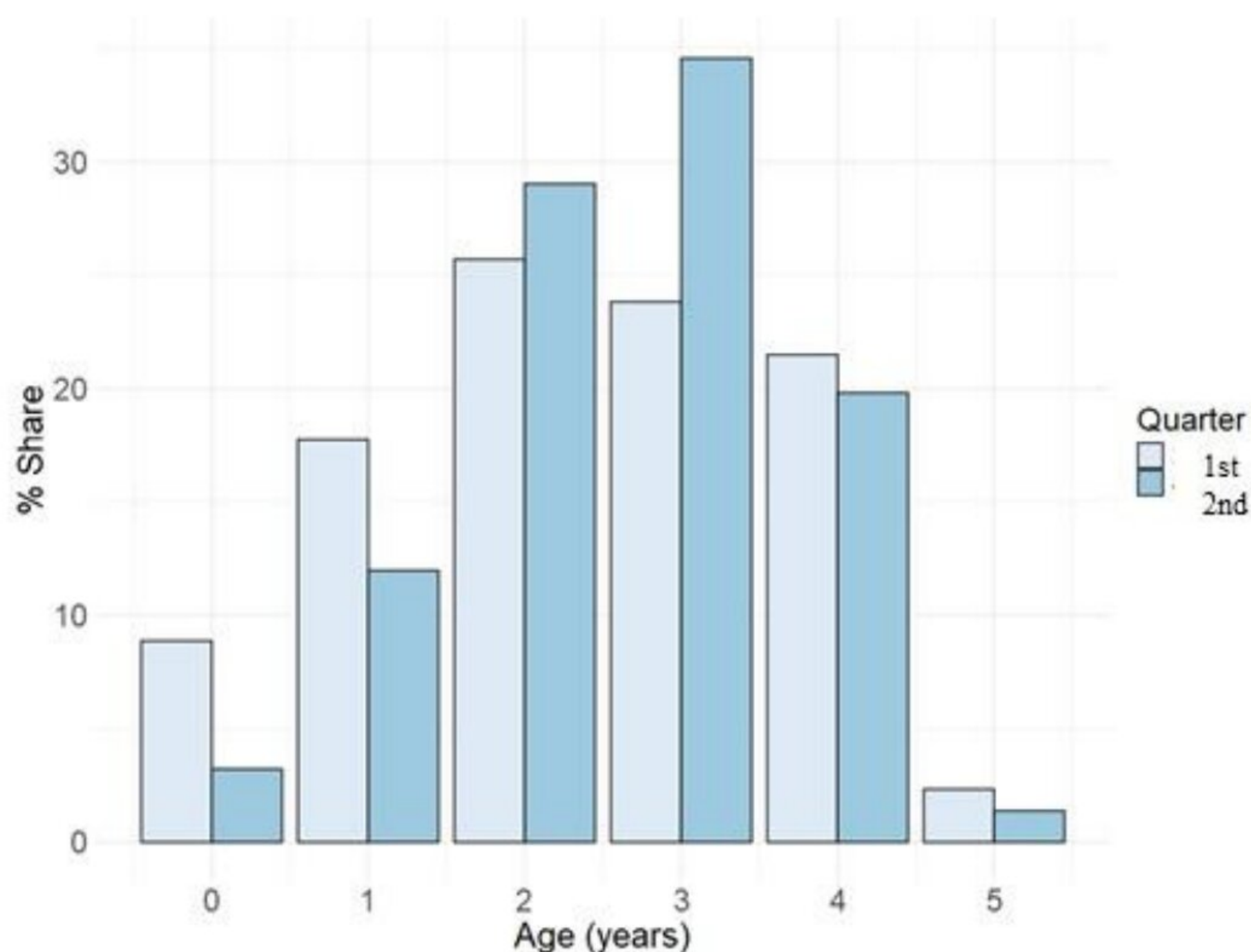


Figure IV.3.3.1 Percentage representation of red mullet age groups in the catch composition in the first and second semesters of 2025.

IV. 1.3.3.1 Frequency analysis RSA – response surface analysis

The growth parameters determined by RSA with initial conditions: a conditional interval of for the asymptotic length L_{∞} in the sample [15;18.5 cm] (based on a literature review of the characteristics and biological potentials of the species for the Black Sea) and the parameter that determines the growth rate to $L_{\infty} - K = \exp(seq(from \log(0.1), to \log(1))$ with an upper limit for $L_{\infty} = 18.5$ cm (Fig. IV. 1.3.3.1.1).

The parameters in the von Bertalanffy model were calculated as follows: $L_{\infty}=16.17$ cm; $K = 0.54$ and $t_0=-0.23$. The ages with their corresponding lengths were calculated using the latter (Table IV. 1.3.3.1.1, Figure IV. 1.3.3.1.2) and compared with the experimentally determined ones.

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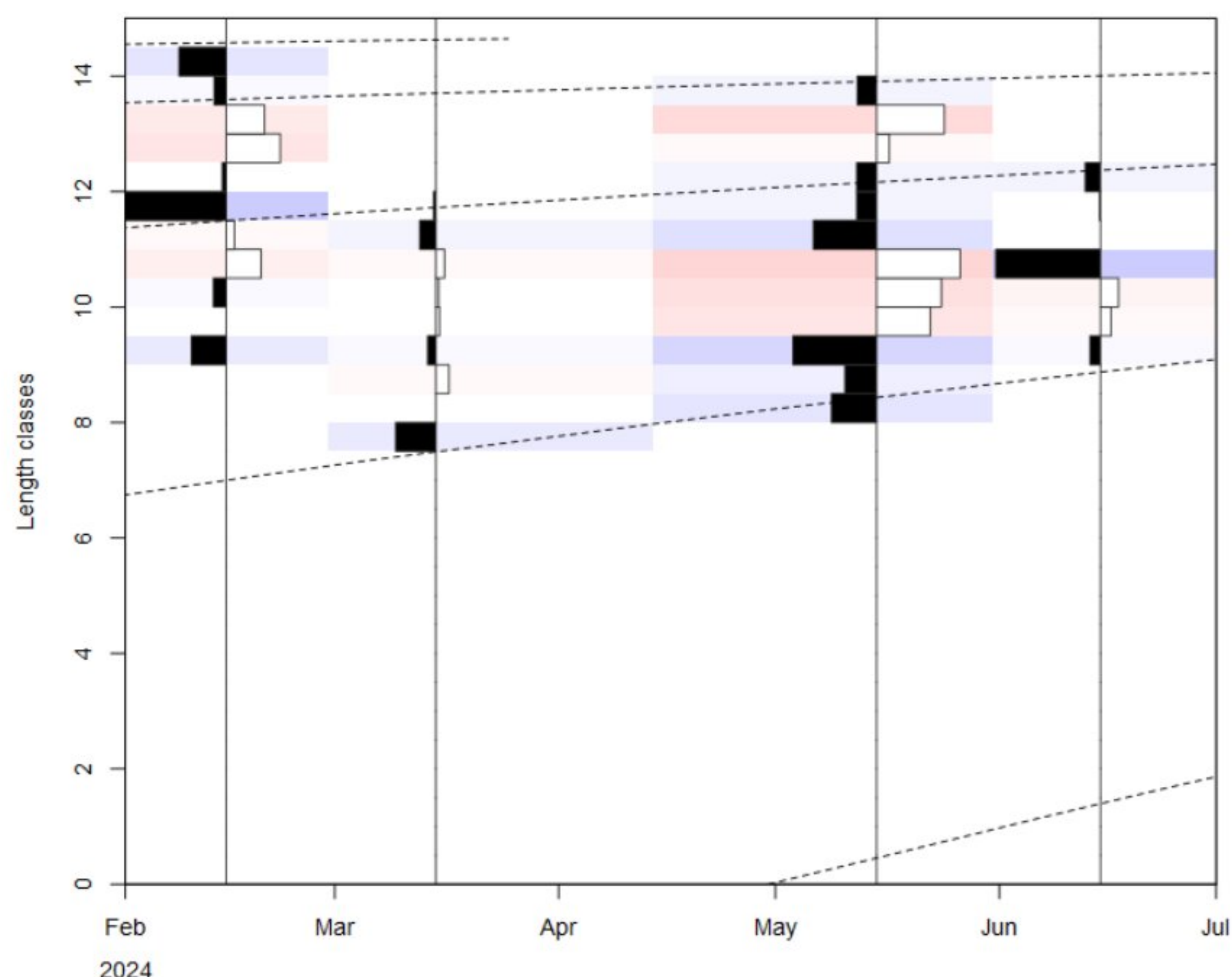


Figure IV. 1.3.3.1.2 Growth curves determined with ELEFAN RSA, visualized on the restructured data for the purpose of visualizing the tracking of cohorts over time **за първо шестмесечие.**

Table IV.1.3.3.1.1 Ages with their corresponding lengths for the studied species calculated using von Bertalanffy parameters obtained with RSA and compared with experimentally determined ages from otoliths **за първо шестмесечие..**

	ELEFAN RSA	Experimentally determined
age	La	L_{mean}
0	1.9	10.25
0.5	5.3	
1	7.9	11
1.5	9.8	
2	11.3	12
2.5	12.5	
3	13.3	13
3.5	14	
4	14.5	15
4.5	14.9	
5	15.2	17.25

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The results show that the experimental data do not match well with the analytical data, but the analytical data better represent the expected size composition by age, therefore in this case the growth parameters calculated by ELEFAN GA are considered valid, and will be updated after the end of the year, when more information about the species will be available (**Table IV. 1.3.3.1.2, Figure IV. 1.3.3.1.3**) and compared with the experimentally determined.

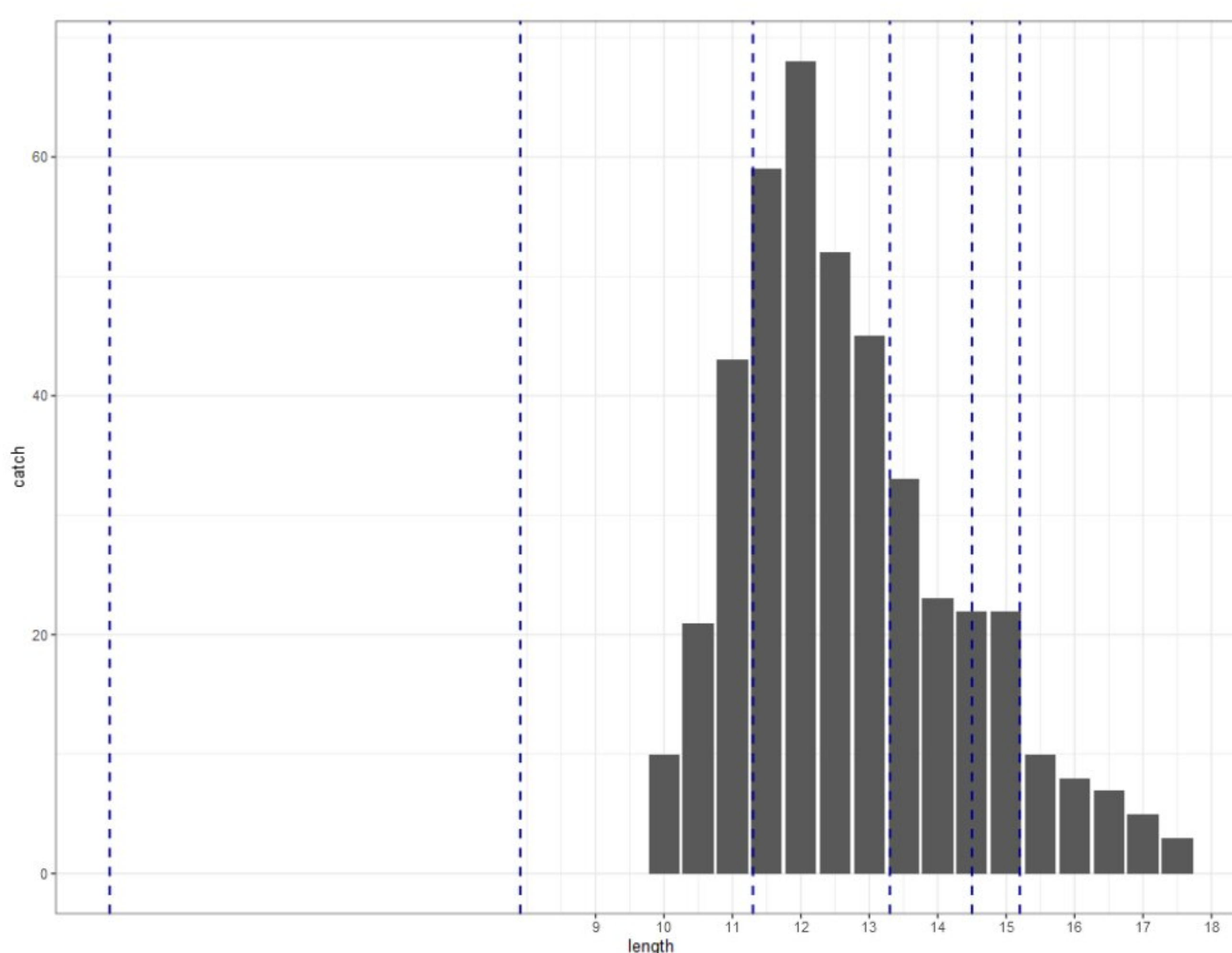


Figure IV. 1.3.3.1.3 Growth curves determined with ELEFAN RSA, visualized on the restructured data for the purpose of visualizing the tracking of cohorts over time.



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IV.3.4 Condition factor

The highest values are in the size classes of 10 cm, 10.5 cm and 12.0 cm. The lowest values of the factor are in the classes 14.0 and 17.5 cm (**Fig. IV.3.4.1**).

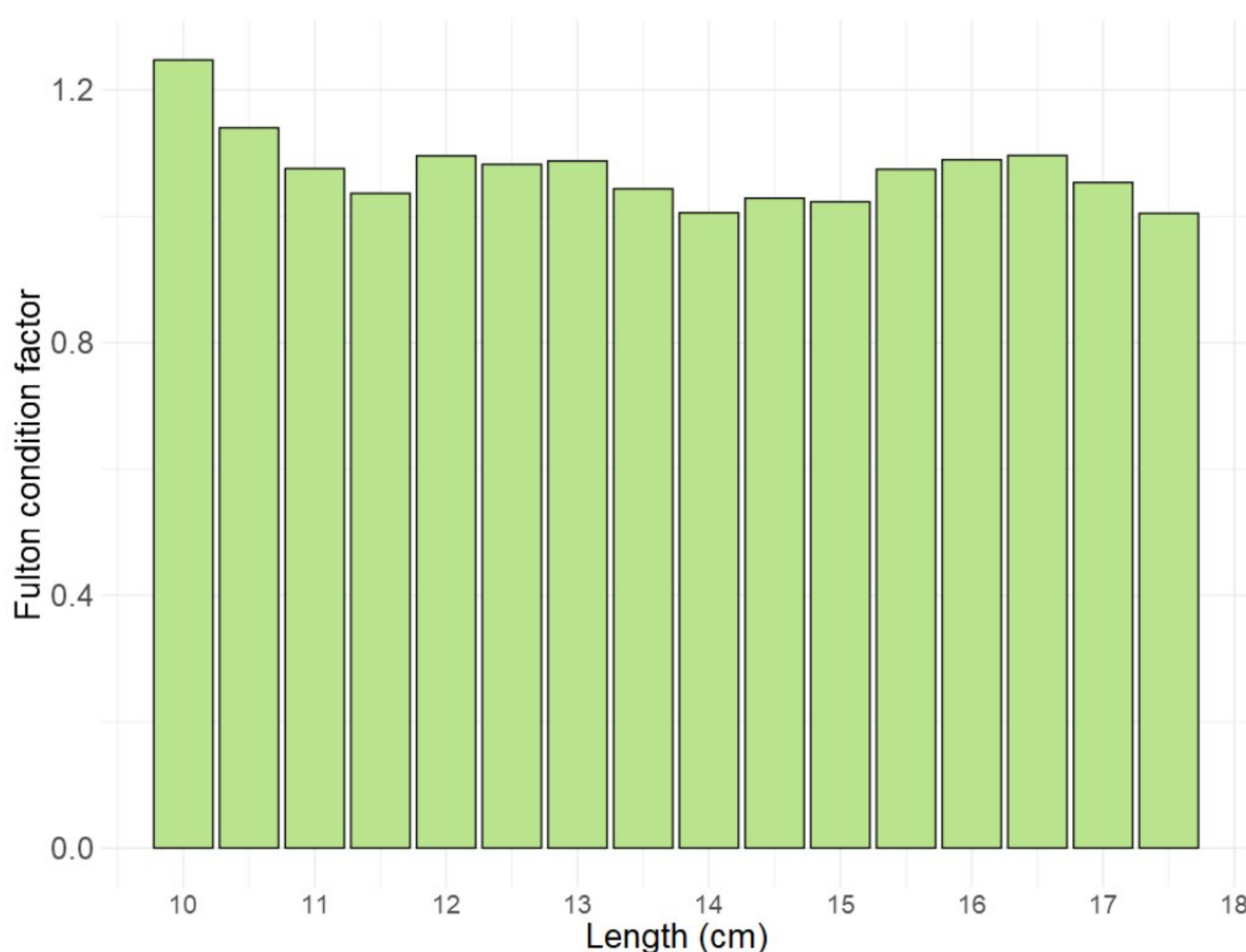


Figure IV.3.4.1 Fulton coefficient of red mullet by length classes.

In terms of condition by size group, the red mullet showed the best condition in the 4-4+ year olds. The condition factor in the other size groups showed similar values (**Fig. IV.3.4.2**).



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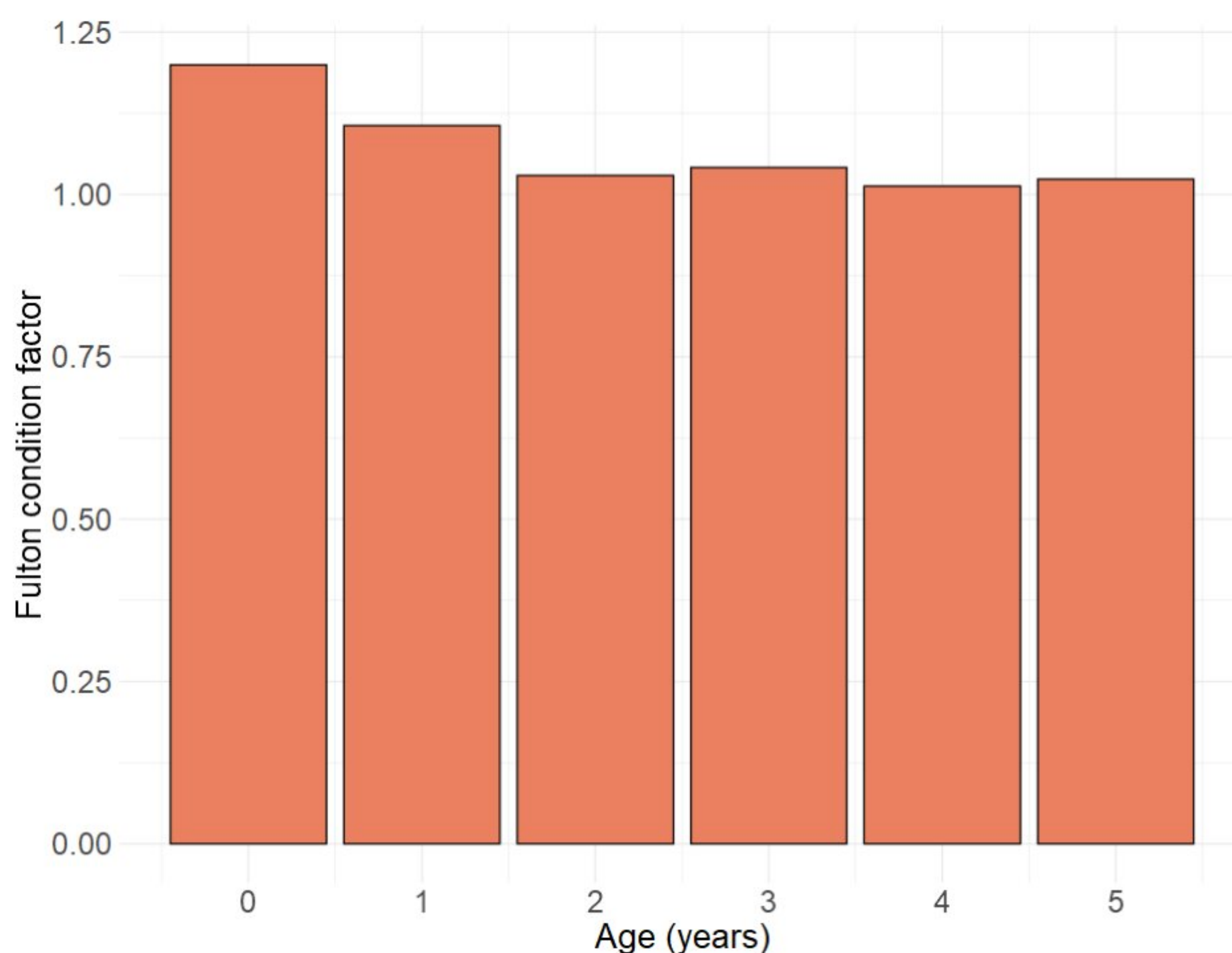


Figure IV.3.4.2 Condition factor of red mullet by age group for the first semester of 2025 .

IV.3.5 Weight structure of red mullet

The weight was measured on **431 specimens**. The largest size groups have the highest average weight (**Fig. IV. 3.5.1**).

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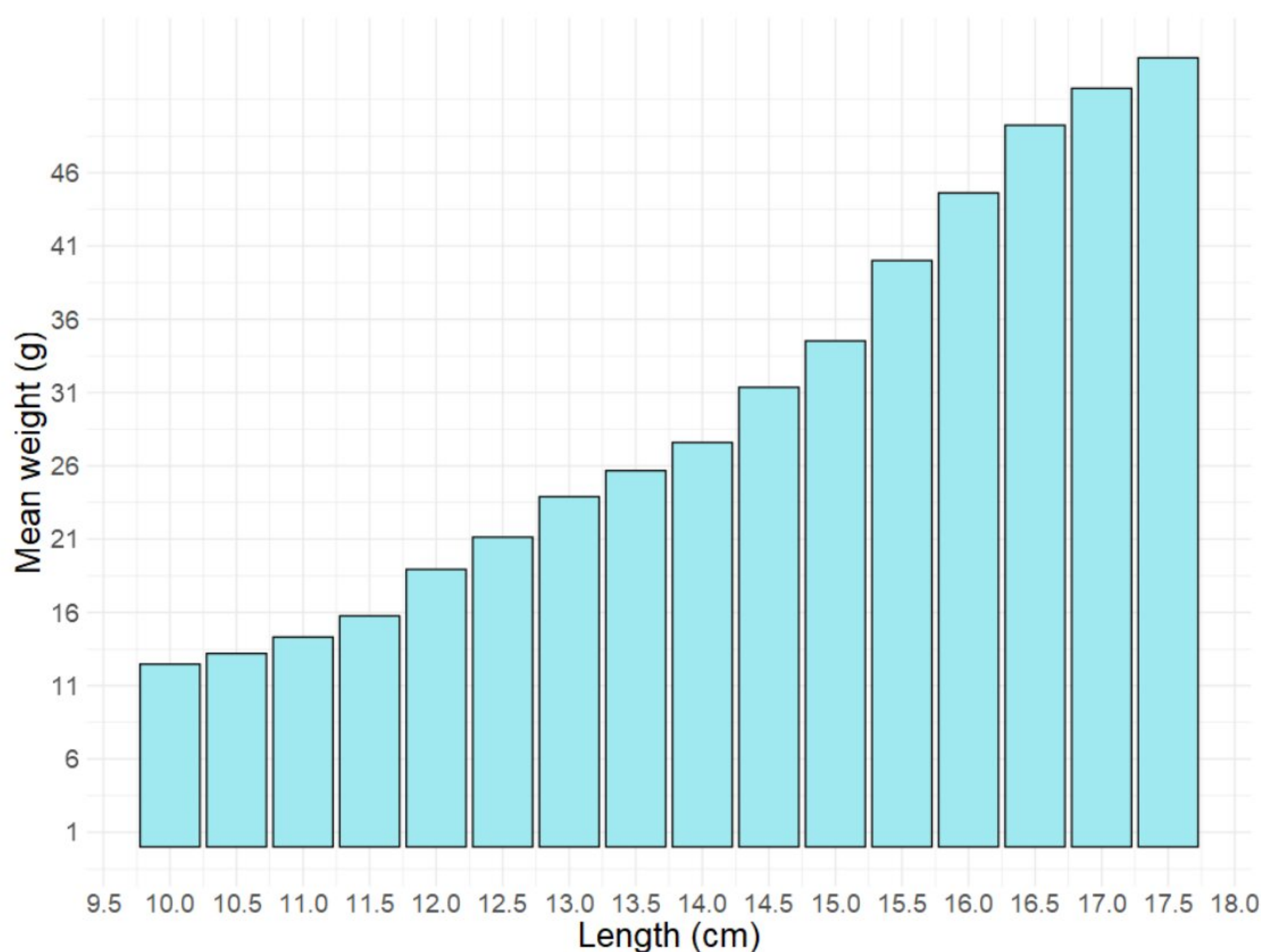


Figure IV.3.5.1 Distribution of average weight of red mullet by size classes for the first half of 2025.

The graph shows that the age group 5+ has the highest value, and the age group 0-0+ has the lowest. The relationship between the average weights and the age groups is directly proportional. Average weights of red mullet: (age 0+: 12.92g; 1-1+: 14.72g; 2-2+:17.78g; 3-3+: 22.88g; 4-4+: 34.18g; 5+: 52.54g) (**Fig. IV.3.5.2**).



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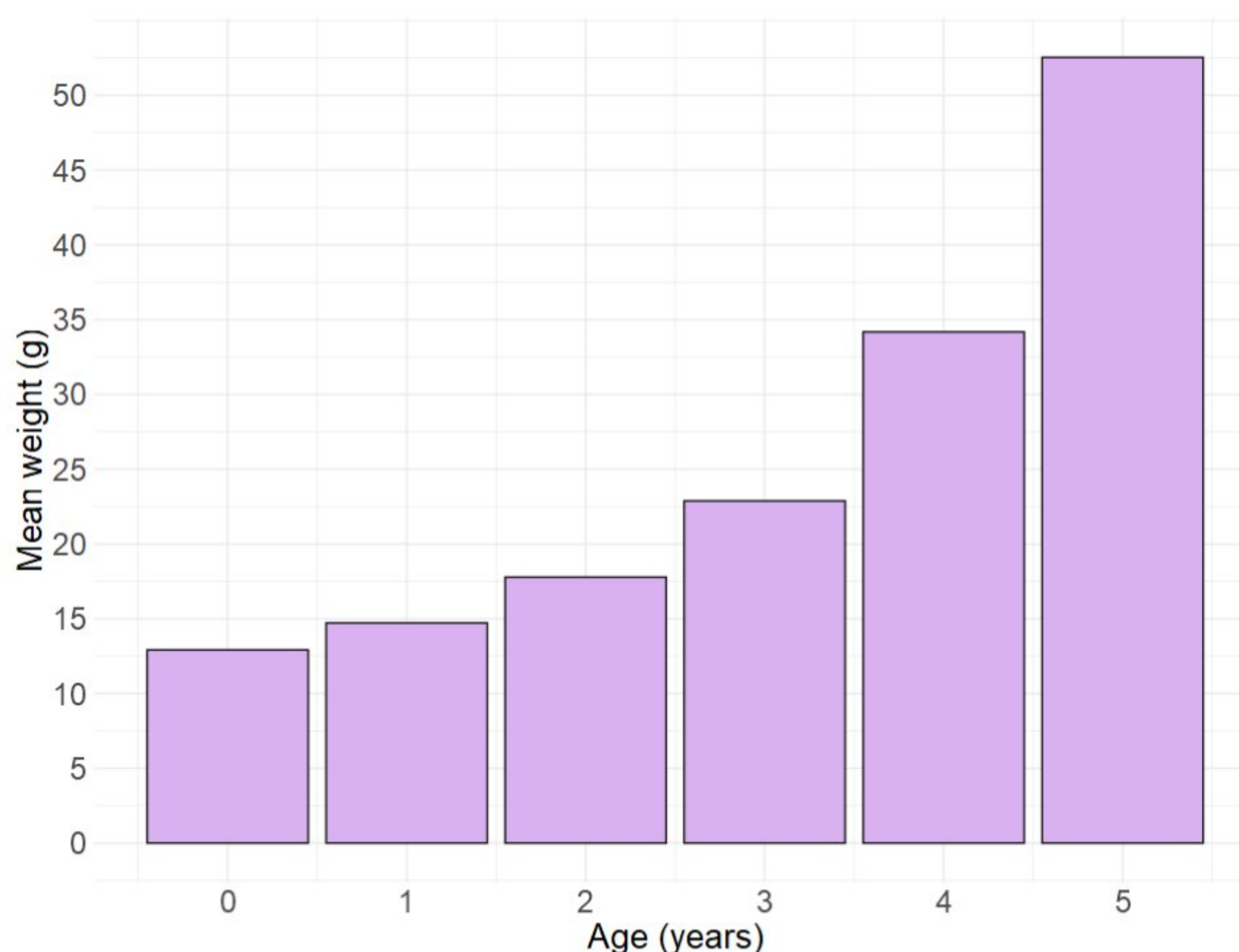


Figure IV.3.5.2 Average weights by age groups for the first semester of 2025.

IV.3.6 Length structure of red mullet by age groups

The length was measured on **431 fish**. Average lengths by age group increase with increasing age (**Fig. IV.3.6.1**).

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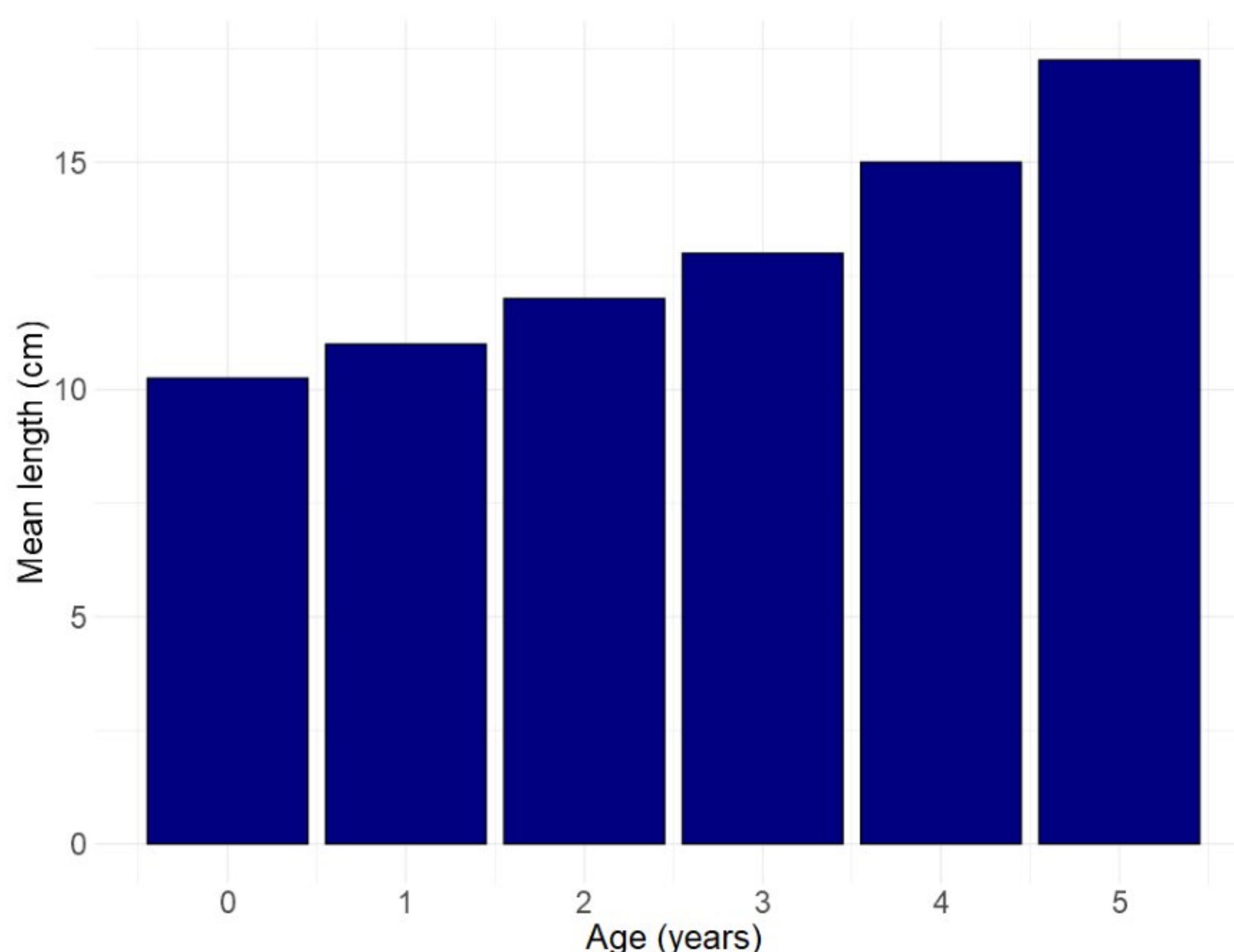


Figure IV.3.6.1 Size structure by age groups.

IV.3.7 Length-weight relationship

The resulting model (**Table IV.3.7.1**) is statistically significant, the value of the scaling coefficient a in the length-weight relationship model $W_i = aL_i^b$: **$a=0.0172$** and the allometry coefficient **$b=2.82$** , which indicates positive allometric growth of the species **in the first half of the year**, or the increase in weight is proportional to or greater than the increase in length.

Table IV.3.7.1 Results from modeling the length-weight relationship for the first semester.

Call:				
lm(formula = logW ~ logL, data = weight_1)				
Residuals:				
Min	1Q	Median	3Q	Max
-0.063698	-0.029364	-0.002853	0.023366	0.096699
Coefficients:				
Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	-4.06976	0.16994	-23.95	0.00000000000000923711 ***
logL	2.82143	0.06506	43.37	0.0000000000000000253 ***

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Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.04451 on 14 degrees of freedom
Multiple R-squared: 0.9926, Adjusted R-squared: 0.9921
F-statistic: 1881 on 1 and 14 DF, p-value: 0.0000000000000002526

IV.3.8 Sex ratio

The sex ratio is set at **250 individuals**. Females ♀ dominate over males ♂ (**Fig. IV 3.8.1**).

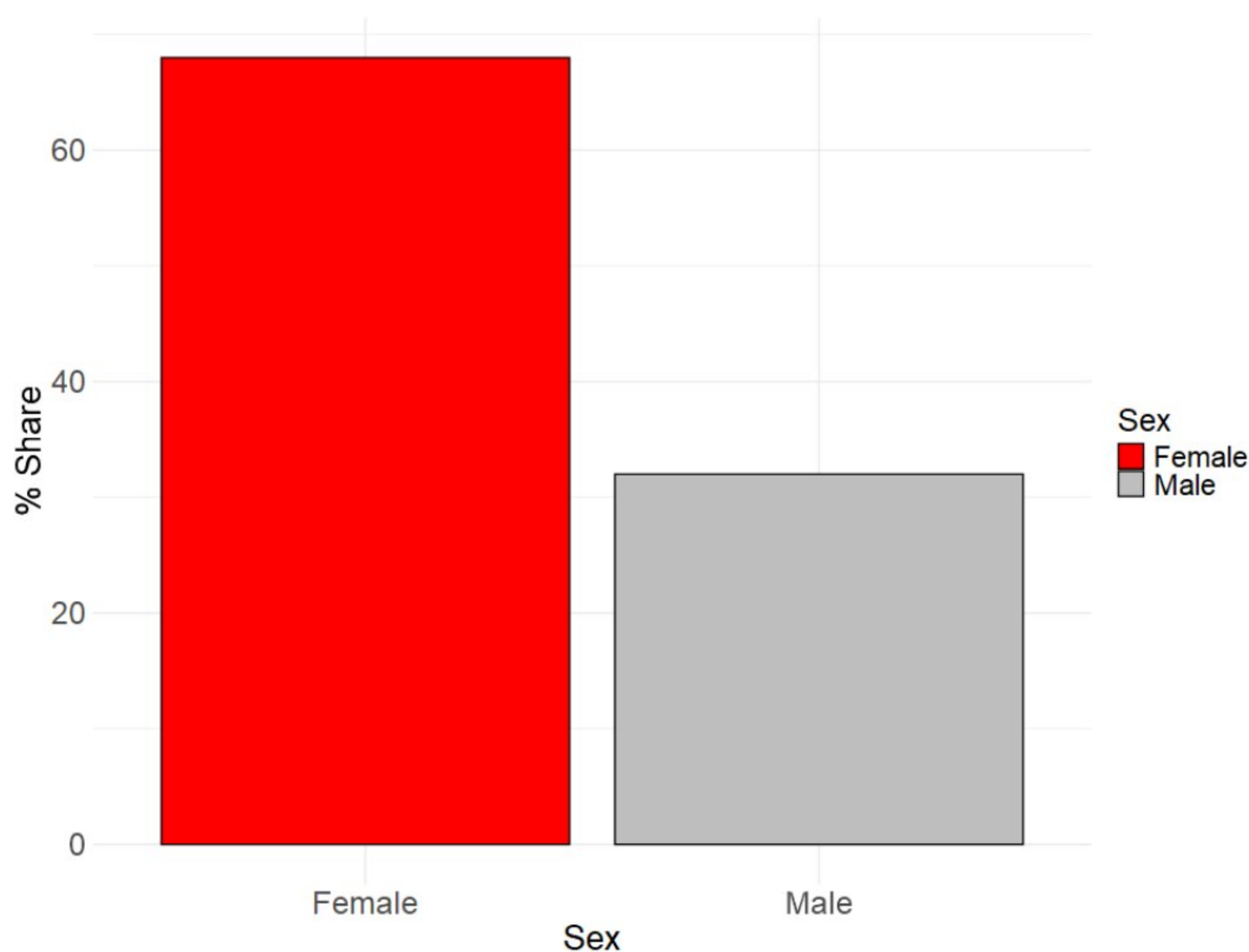


Figure IV 3.8.1 Sex ratio for the first semester of 2025.

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In size classes 11.0 cm for females and 10.5 and 13.5 for males are represented with higher percentage values. In terms of age, one-year-olds are represented with the highest percentage in both female and male specimens (**Figure II 3.8.2**).

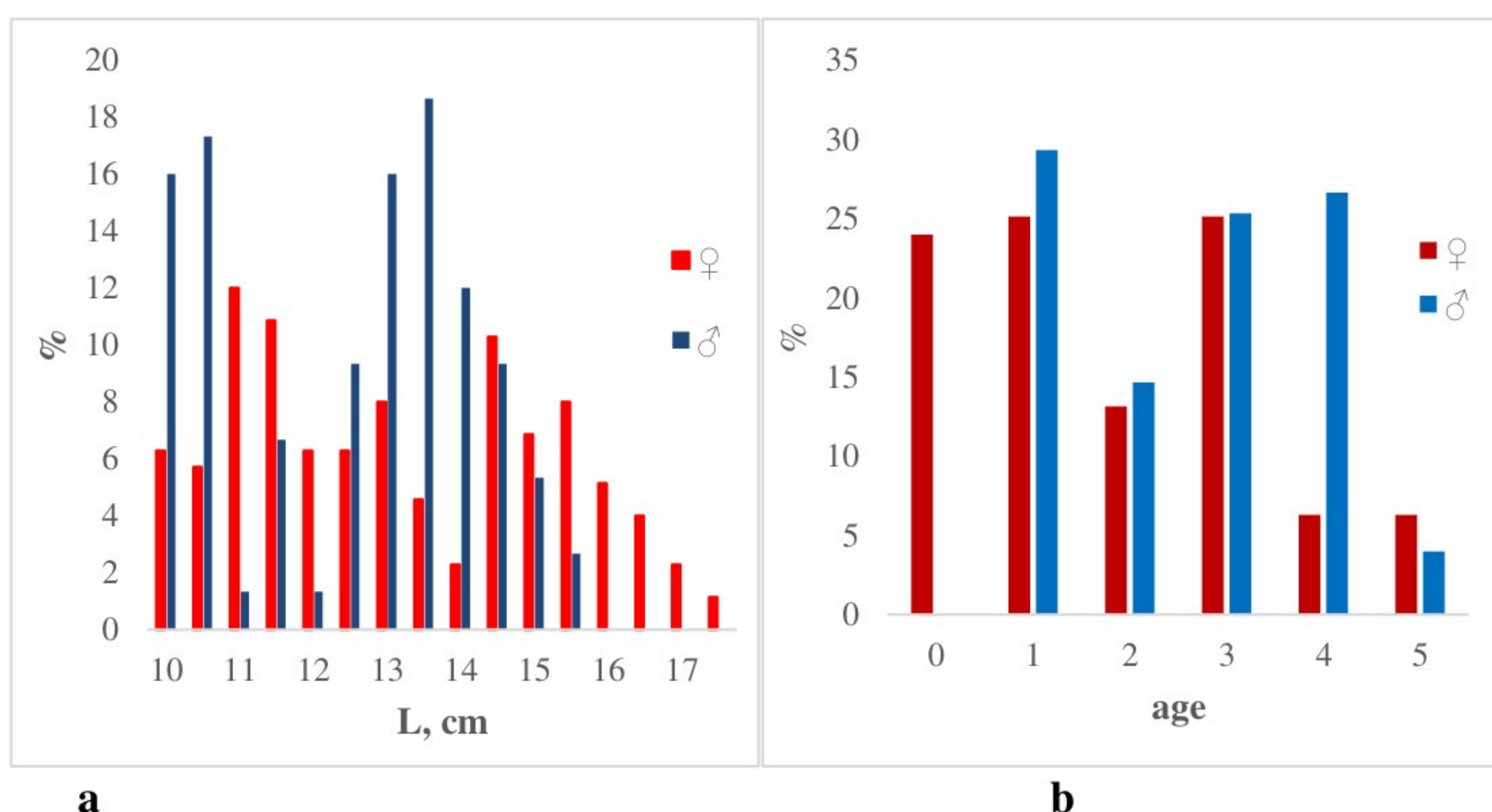


Figure IV.3.8.2 Sex ratio (%) of red mullet by length (a) and age (b) - female ♀ and male ♂.

IV. 3.9 Fecundity

250 specimens of red mullet were studied for fecundity. The relationship between the weight of the gland (ovaries) and the gonadosomatic index of the mullet shows a weak relationship ($R^2=0.6582$), (**Figure IV. 3.9.1**). The production coefficient during the study period shows a weak level of determinism, which is directly related to the active reproductive processes during the period of consideration.



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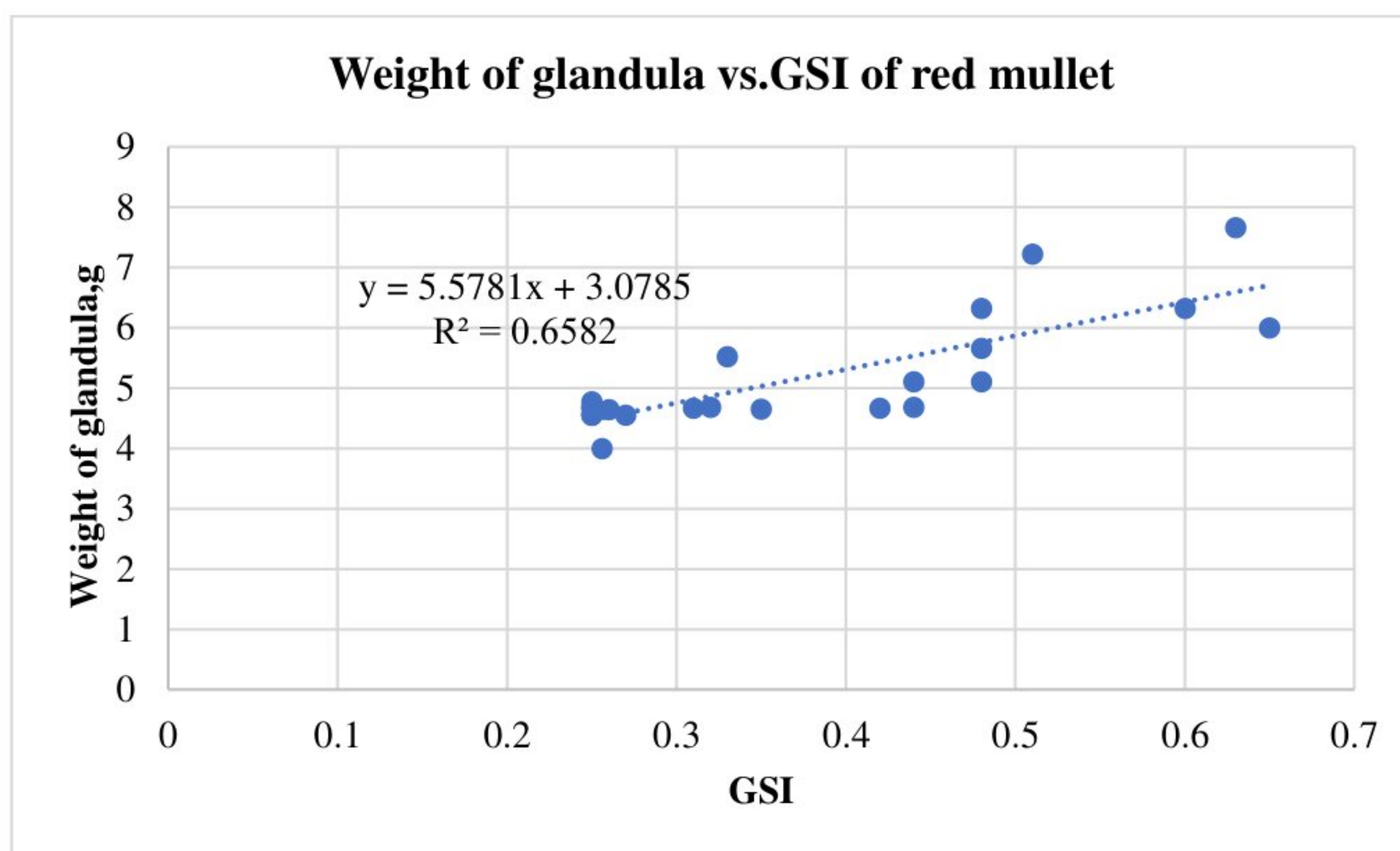


Figure IV.3.9.1 Dependence of log gland weight on log gonadosomatic index (GSI).

Table IV.3.9.1 describes the absolute and relative fecundity with average lengths and weights. The average absolute fecundity was estimated at 8102.684 eggs. The average relative fecundity was 534.685.

Table IV.3.9.1 Absolute and relative fertility of red mullet.

Size class	W average, g	Среден размер, (cm)	Absolute fertility F, caviar grains)	Relative fertility	N♀
7.5	5.036	7.62	5000	992.85147	10
8	6.154	8.15	5302	861.55346	10
8.5	6.33	8.44	6002	948.18325	10
9	6.98	9.01	6200	888.25215	10
9.5	8.98	9.5	6922	770.82405	10
10	10	10.12	7099	709.9	20
10.5	10.66	10.55	7212	676.54784	20

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11	13.28	11	7366	554.66867	20
11.5	16.6322	11.51	7800	468.96983	20
12	18.77	12.33	7866	419.07299	20
12.5	20	12.62	8150	407.5	20
13	23.21	13.05	8324	358.63852	10
13.5	28	13.44	9000	321.42857	10
14	29.66	14.21	9420	317.59946	10
14.5	30.99	14.21	9560	308.48661	10
15	34.68	15.11	10215	294.55017	10
15.5	35.669	15.49	10325	289.46704	10
16	37.75	16.25	10688	283.12583	10
16.5	40.0125	17	11500	287.41018	10
			average	average	
			8102.6842	534.6858	Σ 250

IV.3.10 Sexual maturity

250 specimens were used to determine sexual maturity. The red mullet is a summer-breeding species. Females have fewer age groups and mature gland at 2+ and 3+ years of age. During the first six months, the older age groups 3-3+ and 4-4+ years of age were at maturity stages VI-II and VI-II. At 5 years of age: stages VI-II for females and V for males; 2-2+ stages VI-II for females and II-III for males (**Fig. IV.3.10.1**).

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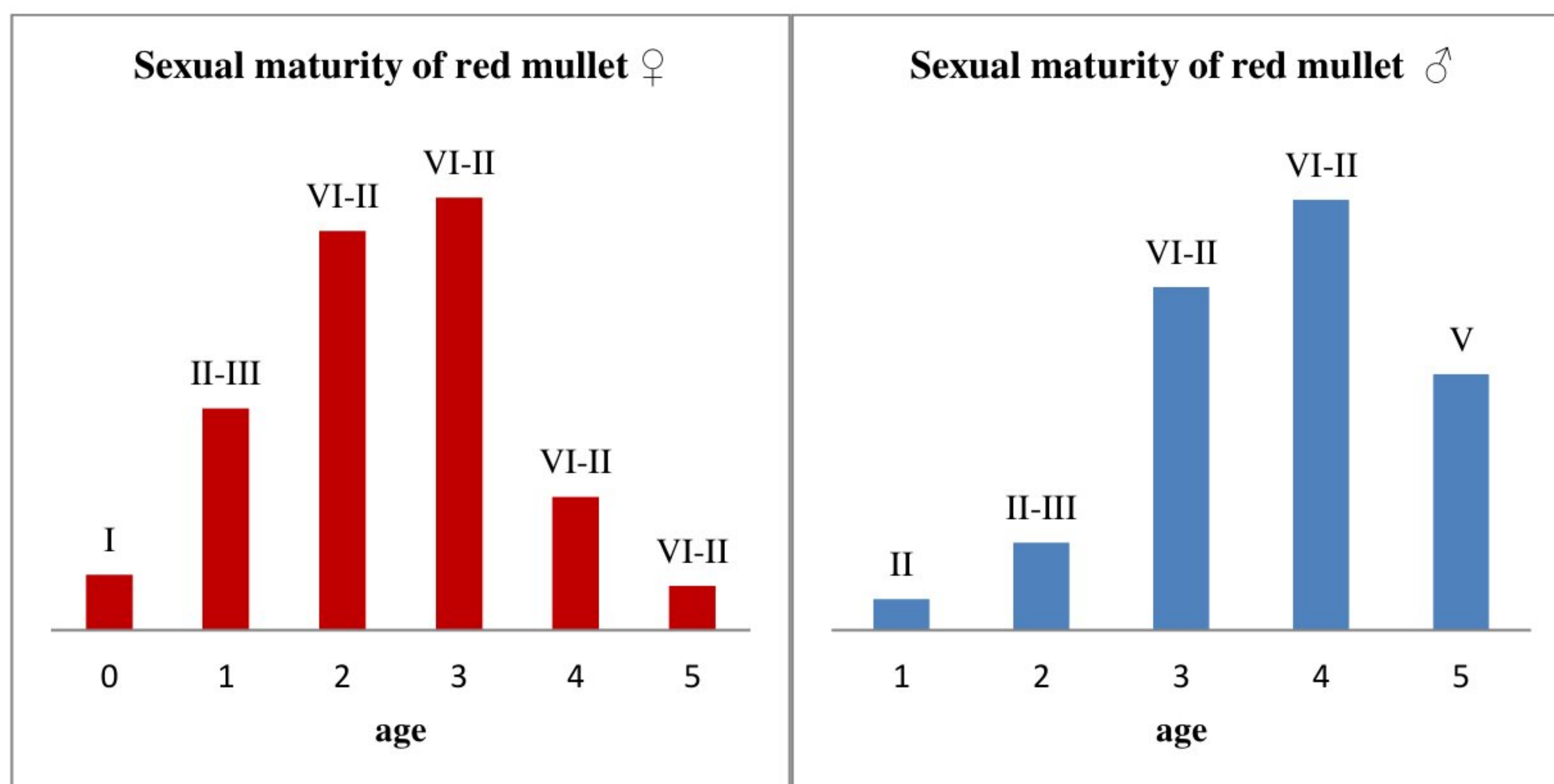


Figure IV.3.10.1 Sexual maturity by age for red mullet - female (♀) and male (♂).

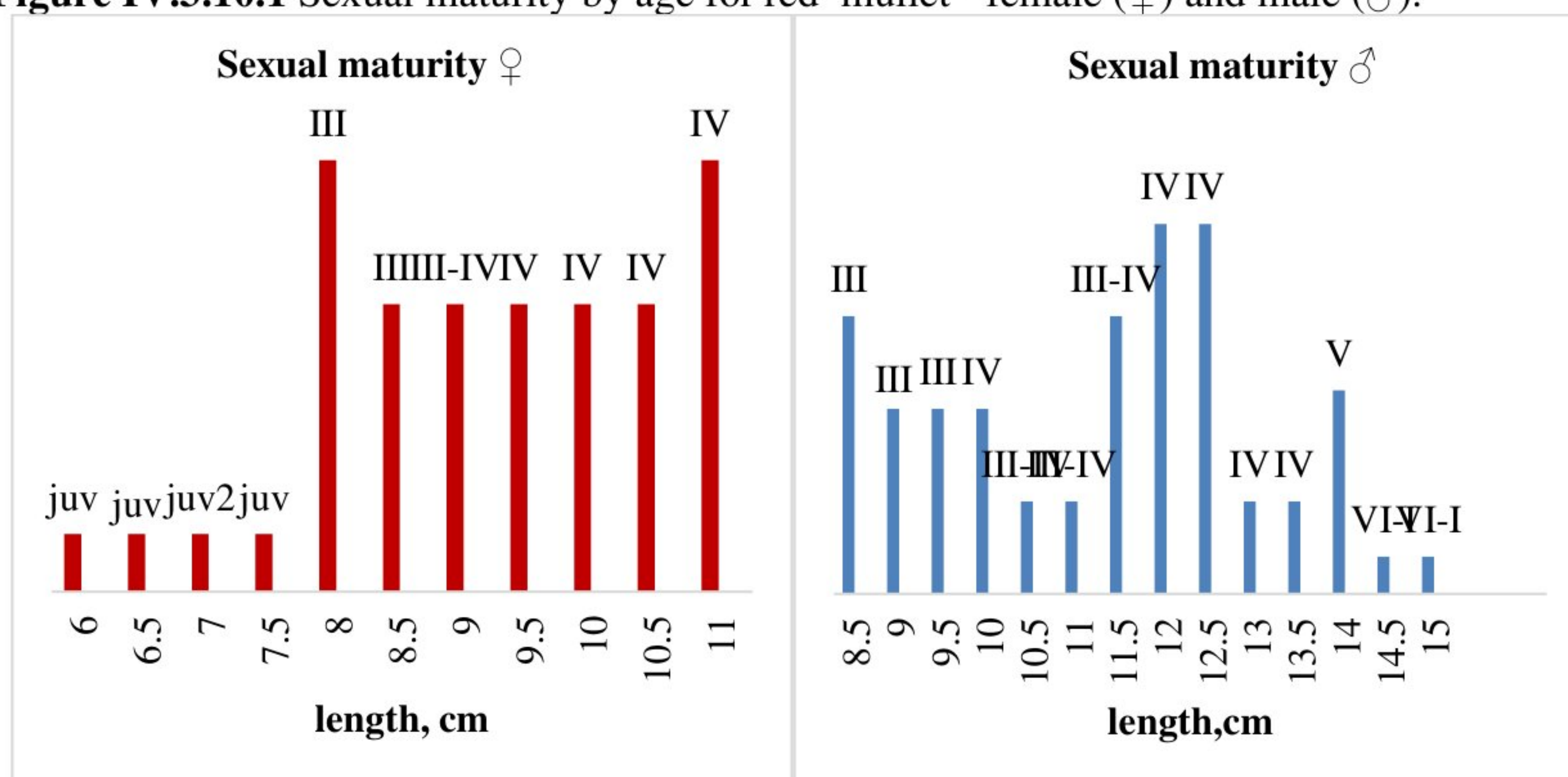


Figure IV.3.10.2 Sexual maturity by length (cm) of red mullet - female (♀) and male (♂).

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IV.3.11 Catch numbers and biomass by age and length

Monthly OTM catches (in kilograms) together with average weights were used to obtain the abundance and biomass of the species by quarter in the reported catches (**Table IV.3.11.1-2**).

Table IV.3.11.1 Catch at age with OTM matrix and biomass (kg) of red mullet.

<i>Catch at age</i>		
<i>Age groups (yr)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
0-0+	1.01586	0.72226
1-1+	1.75363	2.41616
2-2+	2.10201	4.81708
3-3+	1.48006	4.50151
4-4+	0.91869	1.70594
5-5+	0.06659	0.07518
Σ	7.33684	14.2381
<i>Biomass</i>		
<i>Age groups (yr)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
0-0+	0.01323	0.00929
1-1+	0.02646	0.03451
2-2+	0.03829	0.08361
3-3+	0.03551	0.09954
4-4+	0.03203	0.05707
5-5+	0.00348	0.00398
Σ	0.149	0.288

Table IV.3.11.2 Number of individuals in the catch by size class (for OTM) and biomass of the of red mullet.

<i>Catch in numbers</i>		
<i>Length classes (cm)</i>	<i>Ist quarter</i>	<i>IInd quarter</i>
10	0.34184	0.41313
10,5	0.67587	0.75894
11	1.1121	1.77955
11,5	1.20773	2.66911
12	1.09446	2.80624
12,5	0.9538	1.49112
13	0.52965	1.60122
13,5	0.37678	0.98781
14	0.24725	0.59178

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14.5	0.26414	0.39036
15	0.2629	0.32589
15.5	0.0856	0.15437
16	0.06133	0.11296
16.5	0.05677	0.08046
17	0.04069	0.05067
17.5	0.02593	0.02453
Σ	7.33684	14.2381
Biomass		
Length classes (cm)	Ist quarter	IInd quarter
10	0.00418	0.00531
10,5	0.00905	0.01062
11	0.01601	0.02654
11,5	0.0195	0.04114
12	0.02019	0.05176
12,5	0.02089	0.0292
13	0.01253	0.03583
13,5	0.00975	0.02522
14	0.00696	0.01725
14.5	0.00836	0.01327
15	0.00905	0.01194
15.5	0.00348	0.00664
16	0.00279	0.00531
16.5	0.00279	0.00398
17	0.00209	0.00265
17.5	0.00139	0.00133
Σ	0.149	0.288

IV. 3.12 Conclusions

The analysis of the biological parameters allows us to draw the following **conclusions**:

1. The highest values are for individuals in the size classes of 12.5 cm for the first and 12 cm for the second quarter of 2025. The lowest percentage values are for the size classes of 16.5 -18 cm.
2. The parameters in the von Bertalanffy model for red mullet were calculated as follows: L_{∞} =16.17 cm; $K = 0.54$ and $t_0=-0.23$. The ages with their corresponding lengths were calculated using the latter.
3. In terms of condition by size group, the red mullet showed the best condition in the 4-4+ year olds. The condition factor in the other size groups showed similar values.

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4. The resulting model is statistically significant, the value of the scaling coefficient a in the length-weight relationship model is: **$a=0.0172$** , and the allometric coefficient **$b=2.82$** , which indicates negative allometric growth of the species in the first half of the year, or the increase in weight is not proportional to the increase in length.
5. Females ♀ dominate over males ♂. Females also predominate over males in average length.
6. Females have fewer age groups and mature gland at 2+ and 3+ years of age. During the first six months, the older age groups 3-3+ and 4-4+ years of age were at maturity stages VI-II and VI-II. At 5 years of age: stages VI-II for females and V for males; 2-2+age have stages VI-II for females and II-III for males.

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V. Biological monitoring of anchovy (*Engraulis encrasicolus*)

V.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze anchovy catches, as well as to form a database. The collection of biological samples of anchovy catches in I-VI **2025** includes the following tasks:

1. To collect and analyze the dynamics of length, weight and age distribution.
2. To determine the state of the of anchovy using the so-called state factor (Ricker, 1975).
3. Characteristics of the reproductive biology of anchovy.
4. Collection of data on ports of landing, sampling vessels, number of samples collected, number of specimens tested, geographical catch data.

V.2 Sampling

The sampling was carried out by the actively operating fishing fleet in Bulgaria.

V.2.1 Geographic area coverage

Data of present analysis were collected from Bulgarian Black Sea coast. In **I-VI 2025**, **3 samples with 448 specimens** were collected and processed. Information on the size of the catches was also collected.

V.2.2 Sampling period

In **I-VI 2025**, the biological data for the species were collected from a total of **3 landings at the ports of Nesebar and Sozopol**. Ports and ships from which monitoring was carried out to collect biological data from landings are presented in **Table V.2.2.1**.

Table V.2.2.1 Ports and ships from which monitoring was carried out to collect biological data of anchovy landings.

N	ANE	Sampling ports	RK	External marking	Catch/kg	N	Coordinates
1	3.2.2025	Sozopol	RK 37	BS255	200	160	42.115600 27.628300
2	21.3.2025	Nesebar	RK 40	BS258	1116	147	42.6438 27.7598
3	3.4.2025	Sozopol	Valnabor	BS2330	300	141	42.449600 27.638300
						448	

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V.2.3 Statistical analysis of data

See section statistical analysis of sprat.

V.3 Results

V.3.1 Landings statistics

The month of April has the lowest value. During the first three months, reduced landing weight values are observed, with the exception of January, when the catch is highest. In May and June, there are no catches of anchovy with OTM (**Fig. V.3.1.1**).

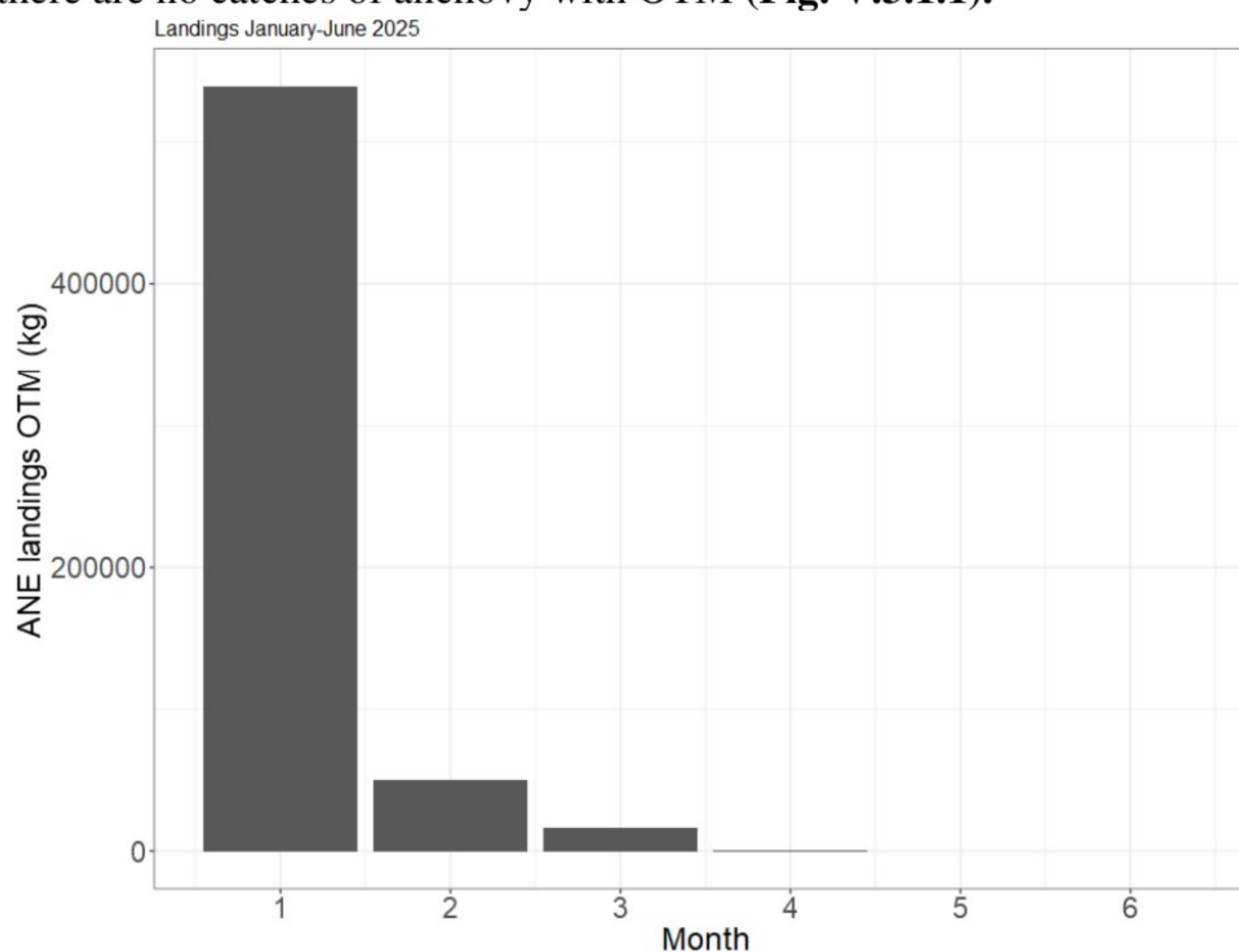


Figure V.3.1.1 Anchovy landing statistics.

V.3.2 Length structure of landings

The highest values are for individuals in the size classes of 11-11.5 in the first and 9.5 - 10.0 cm in the second quarter, and the lowest percentage values are for the size classes of 12, 12.5 and 13 cm (**Fig. V.3.2.1**).

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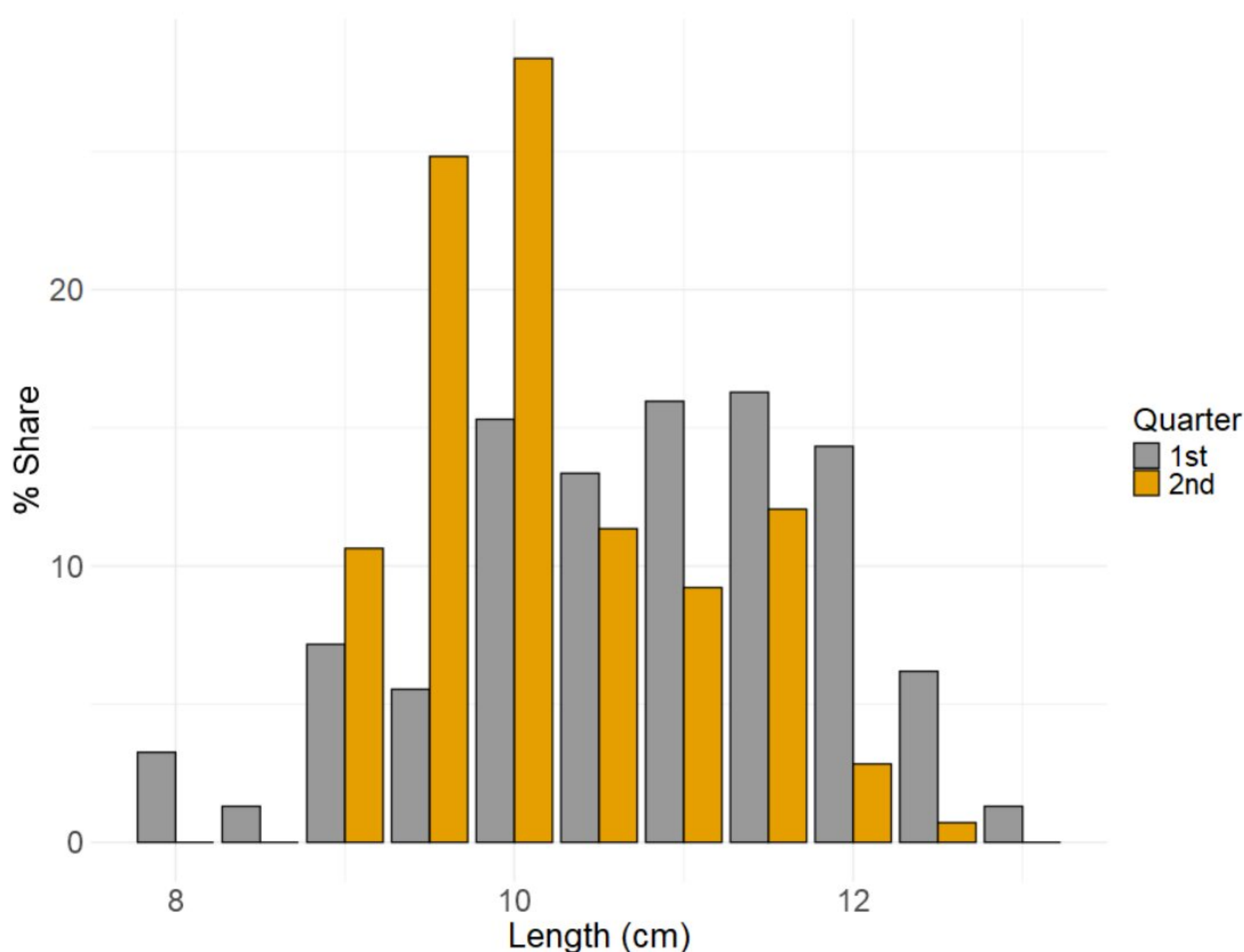


Figure V.3.2.1 Percentage representation of anchovy size classes in the composition of catches.

V.3.3 Age structure of landings

448 fish were used for age determination. In the first half of 2025, the share of zero and four-year-old specimens was the lowest. In the first quarter, two and three-year-olds showed a predominance in catches. In the second quarter, one and two-year-olds were represented with the highest percentage of participation (**Fig. V.3.3.1**).

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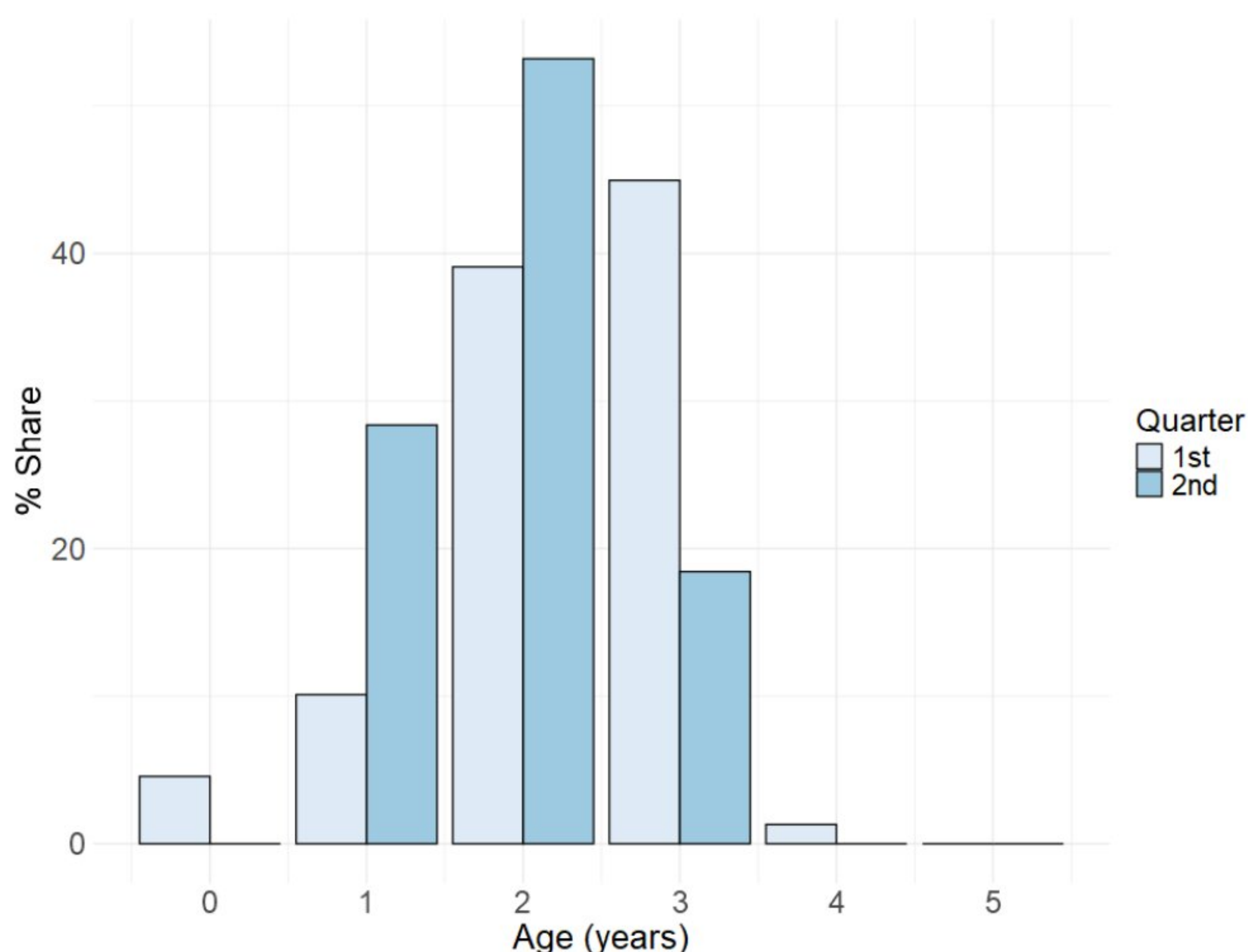


Figure V.3.3.1 Percentage representation of anchovy age groups in the catch composition in the first and second semesters of 2025.

V.1.3.3.1 Frequency analysis RSA – response surface analysis

Growth parameters determined by RSA with initial conditions: conditional interval of for the asymptotic length L_{∞} in the sample [12;15 cm] (based on a literature review on the characteristics and biological potentials of the species for the Black Sea) and the parameter that determines the growth rate to L_{∞} - $K = \exp(seq(from \log(0.1), to \log(1)))$ with an upper limit for $L_{\infty} = 15$ cm (**Figure V.1.3.3.1.1**).

The parameters in the von Bertalanffy model were calculated as follows: **$L_{\infty}=14.11$ cm; $K = 0.44$ and $t_0=-0.80$** . The ages with their corresponding lengths (**Table V.1.3.3.1.1**) were calculated using the latter and compared with the experimentally determined ones.

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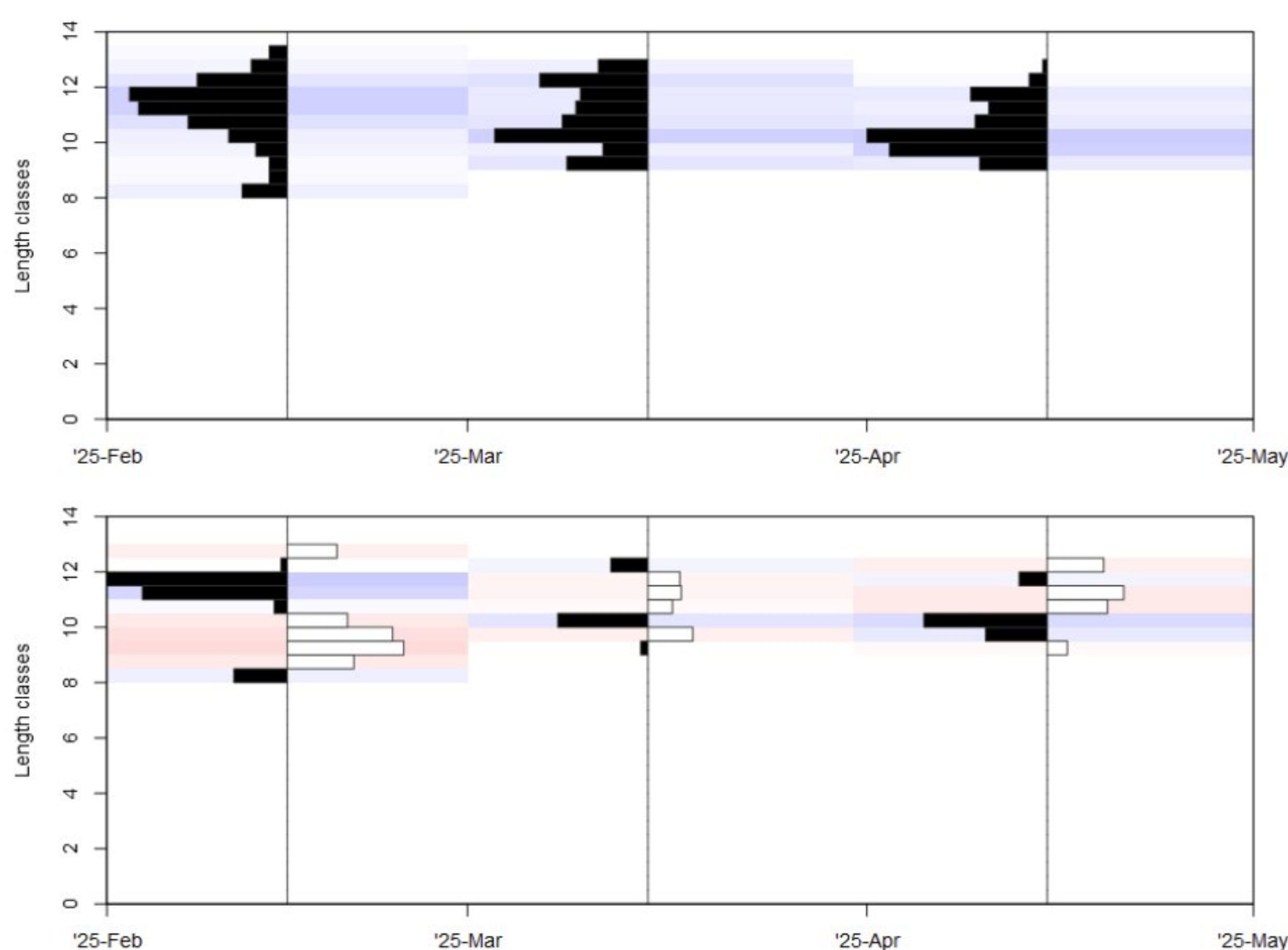


Figure V.1.3.3.1.1 Size-frequency samples, visualized as (top diagram) number of individuals in size class and (bottom diagram) the restructured data for the purposes of frequency analysis and determination of growth parameters.

V.1.3.3.2 Frequency analysis ELEFAN with simulated annealing (ELEFAN SA)

The growth parameters determined under initial conditions: a conditional interval of for the asymptotic length $[L_{\infty}]_{\text{guess}}=13.75$ cm and a search for the value of L_{∞} in the interval $[L_{(\infty\text{guess})} \cdot 0.8 \div L_{(\infty\text{guess})} \cdot 1.2]$, and for K in the interval $[0 \div 1]$. The parameters in the von Bertalanffy model were calculated as follows: **$L_{\infty}=14.77$ cm; $K = 0.35$ and $t_0=-0.19$** . The ages with their corresponding lengths were calculated using the latter (Table V.1.3.3.3.1).

V.1.3.3.3 Frequency analysis ELEFAN – Genetic algorithm (ELEFAN GA)

The growth parameters determined under initial conditions: conditional interval of for the asymptotic length $[L_{\infty}]_{\text{guess}}=13.75$ cm and search for the value of L_{∞} in the interval $[L_{(\infty\text{guess})} \cdot 0.8 \div L_{(\infty\text{guess})} \cdot 1.2]$, a for K in the interval $[0 \div 1]$. The parameters in the von Bertalanffy model were calculated as follows: **$L_{\infty}=14.18$ cm; $K = 0.421$ and $t_0=-0.86$** . The ages with their corresponding lengths were calculated using the latter (Table V.1.3.3.3.1).

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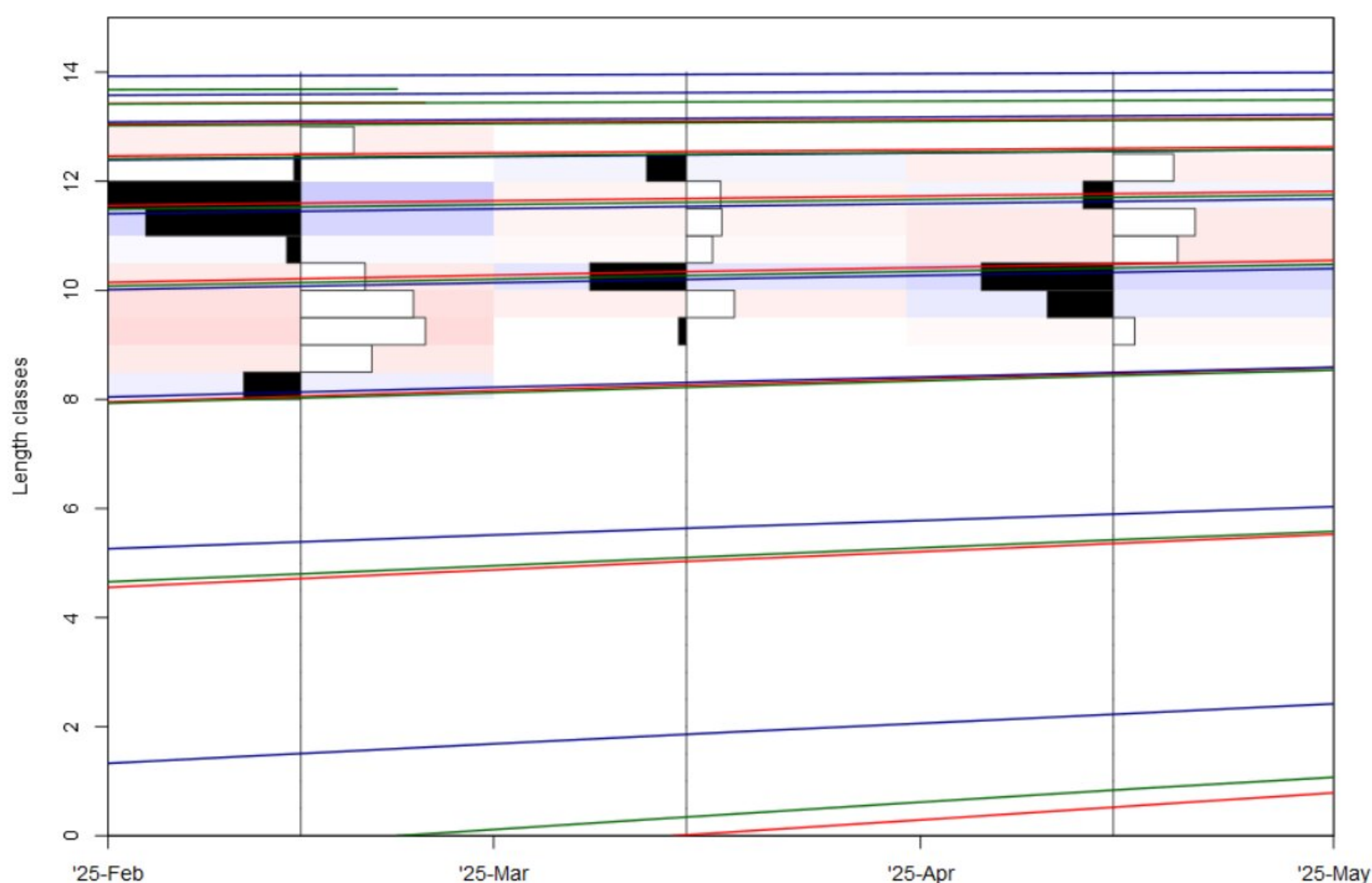


Figure V.1.3.3.1 Growth curves (in red for growth parameters determined with ELEFAN RSA, in blue for ELEFAN SA, and in green for ELEFAN GA), visualized on the restructured data for the purpose of visualizing the tracking of cohorts over time.

Table V.1.3.3.1 Ages with their corresponding lengths for the studied species calculated using von Bertalanffy parameters obtained with ELEFAN RSA, ELEFAN SA and ELEFAN GA and compared with the experimentally determined ages from otoliths.

	ELEFAN RSA	ELEFAN SA	ELEFAN GA	Experimentally determined
възраст	La	La	La	L _{mean}
0	4.2	0.9	4.3	8.25
0.5	6.1	3.1	6.2	
1	7.7	5	7.7	9.25
1.5	9	6.5	8.9	
2	10	7.8	9.9	10.25
2.5	10.8	8.9	10.7	

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3	11.5	9.9	11.4	11.5
3.5	12	10.6	11.9	
4	12.4	11.3	12.3	13
4.5	12.7	11.9	12.7	
5	13	12.3	13.0	n/a

The results show a good approximation of ELEFAN RSA and ELEFAN GA to the experimental data and the following growth parameters can be accepted as valid for the studied period: the parameters in the von Bertalanffy model are calculated as follows: $L_{\infty}=14.15$ cm; $K = 0.43$ and $t_0=-0.83$.

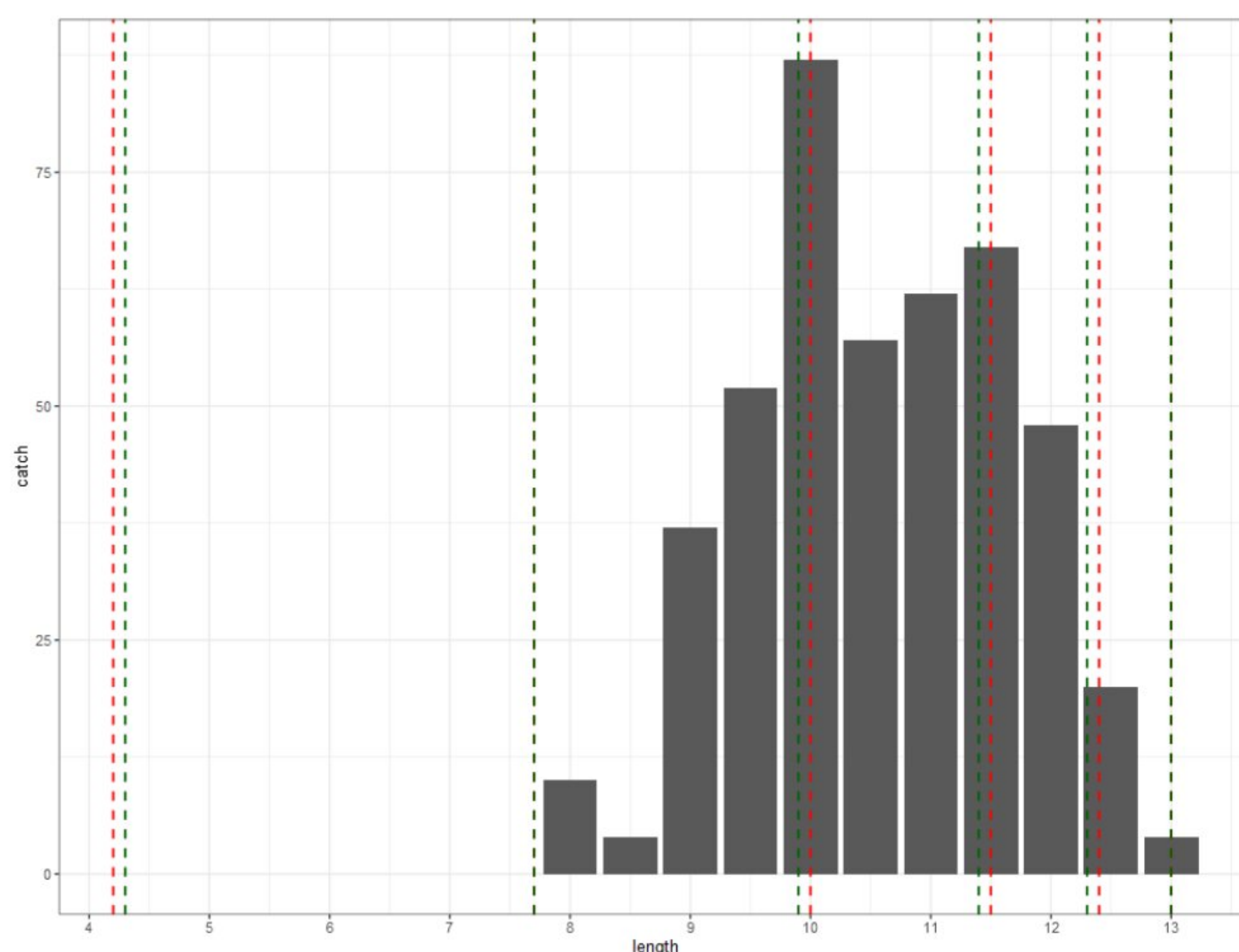


Figure V.1.3.3.2 Growth curves determined with ELEFAN RSA, and ELEFAN GA visualized on the restructured data for the purpose of visualizing the tracking of cohorts over time.



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V. 3.4 Condition factor

The anchovy condition factor from the research period shows relatively low values at the 8.5 cm size class, and the highest values were recorded at the 11.5-12-12.5 cm size classes (**Fig. V.3.4.1**).

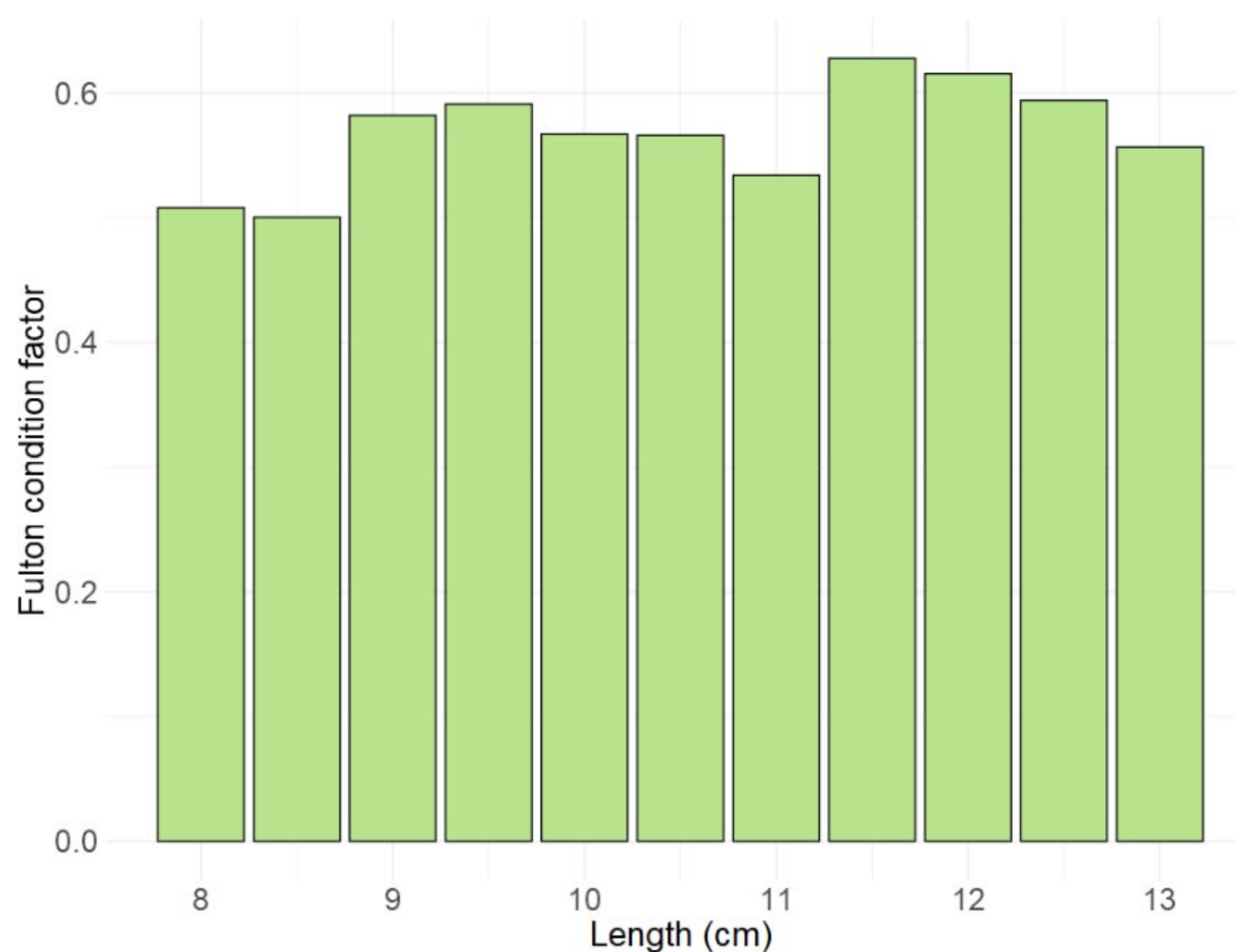


Figure V.3.4.1 Fulton condition factor by anchovy size classes for the first semester of 2025.

During the first half of the year, the condition factor has the highest values in the age groups 1-1 and 2-2+. It has the lowest value in the age group 0+ (**Fig. V.3.4.2**).



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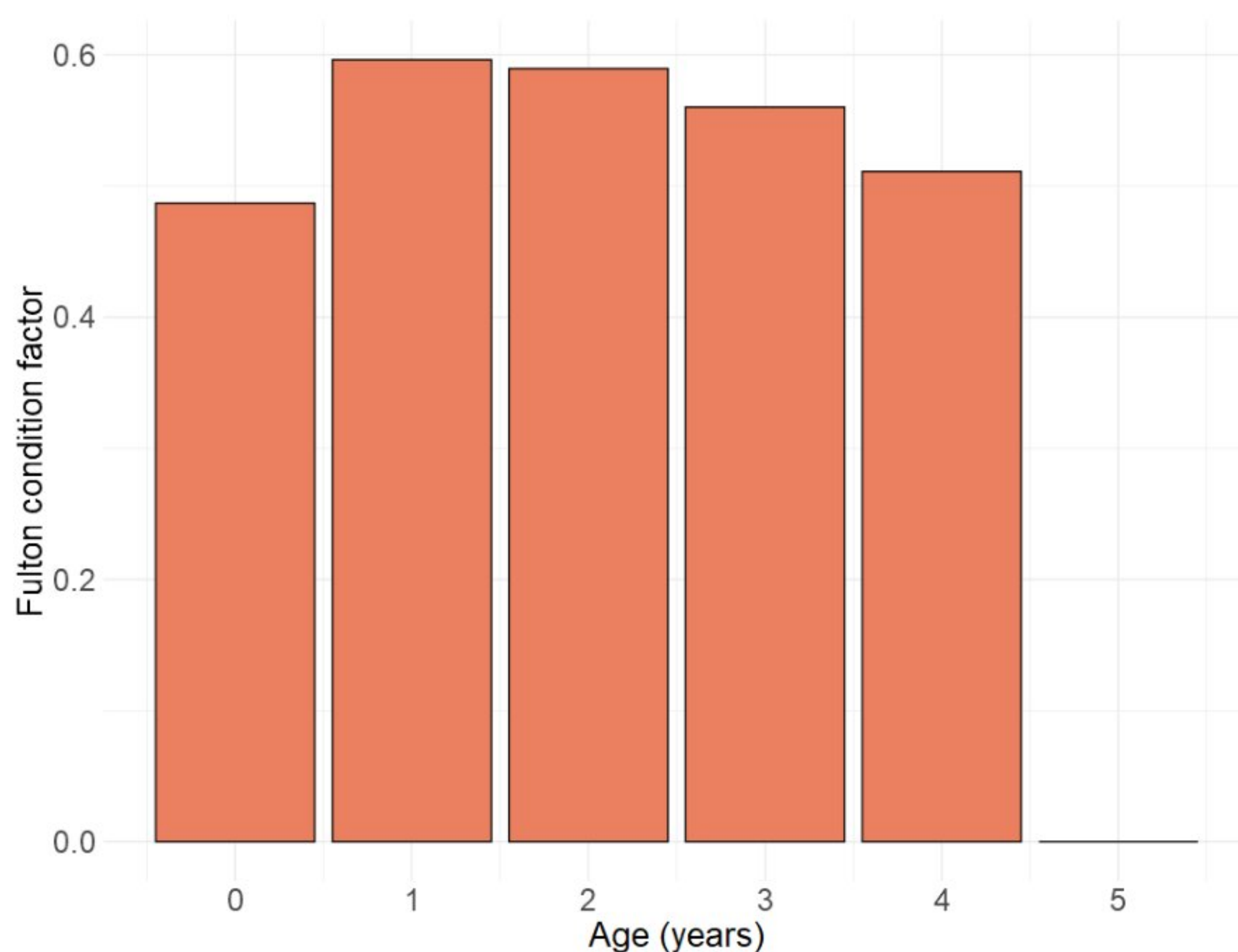


Figure V.3.4.2 Fulton condition factor by age group of anchovy for the first semester of 2025.

V3.5 Weight structure of anchovy

The **weight of 448 fish was measured**. In the first and second quarters, the graph shows that the age group 4-4+ has the highest value, and the age group 0-0+ has the lowest value for both quarters. The relationship between the average weights and the age groups is directly proportional. The average weights by age groups are: 0+ (2.73g), 1-1+ (4.72g), 2-2+ (6.35g), 3-3+ (8.52g), 4-4+ (11.22g) (**Fig. V.3.5.1**).



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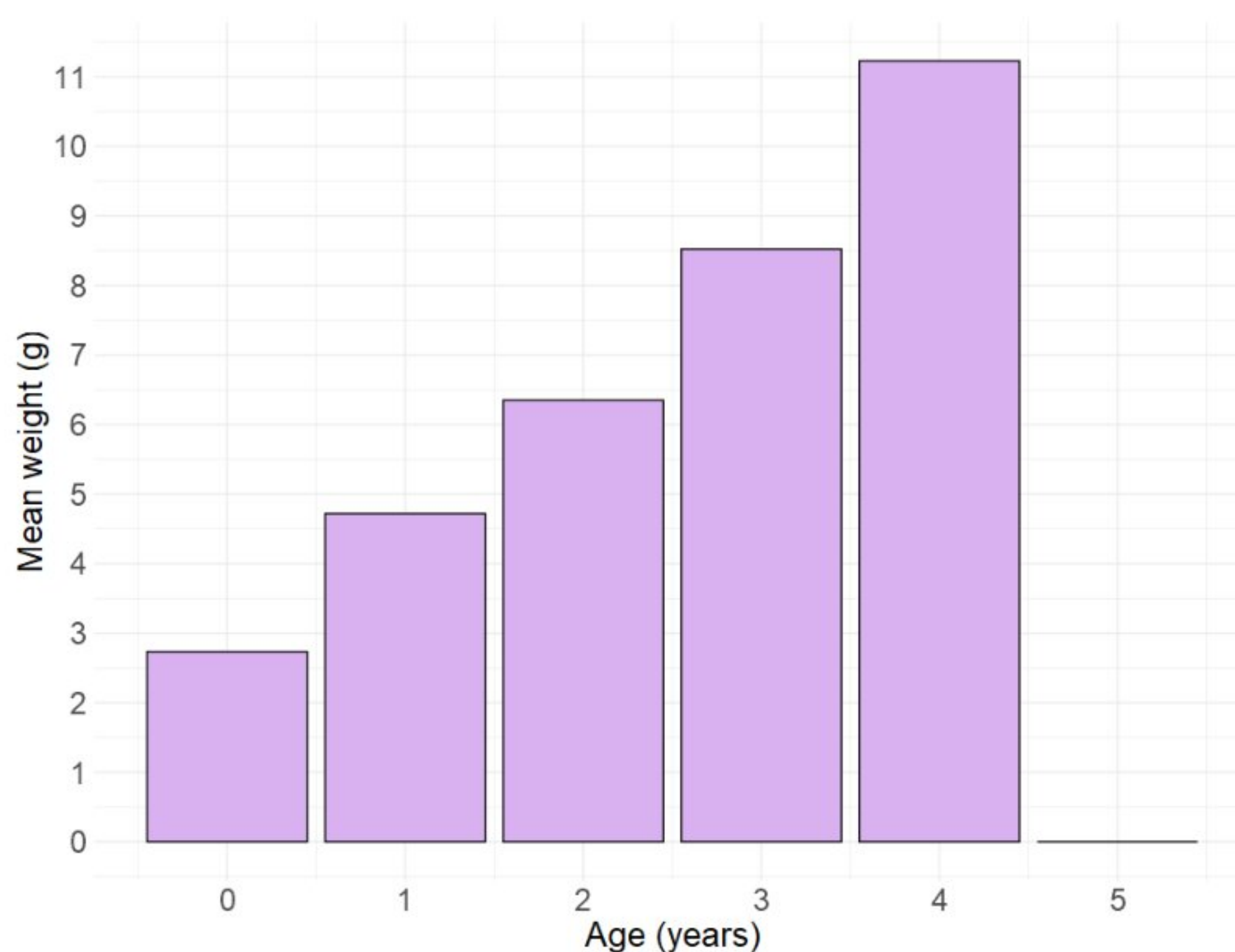


Figure V.3.5.1 Distribution of average anchovy weight by age groups for first semester of 2025.

The relationship between average weights and size groups is also directly proportional, with the largest size classes 13cm also having the largest measured average weight value 12.22g (**Fig. V.3.5.2**).

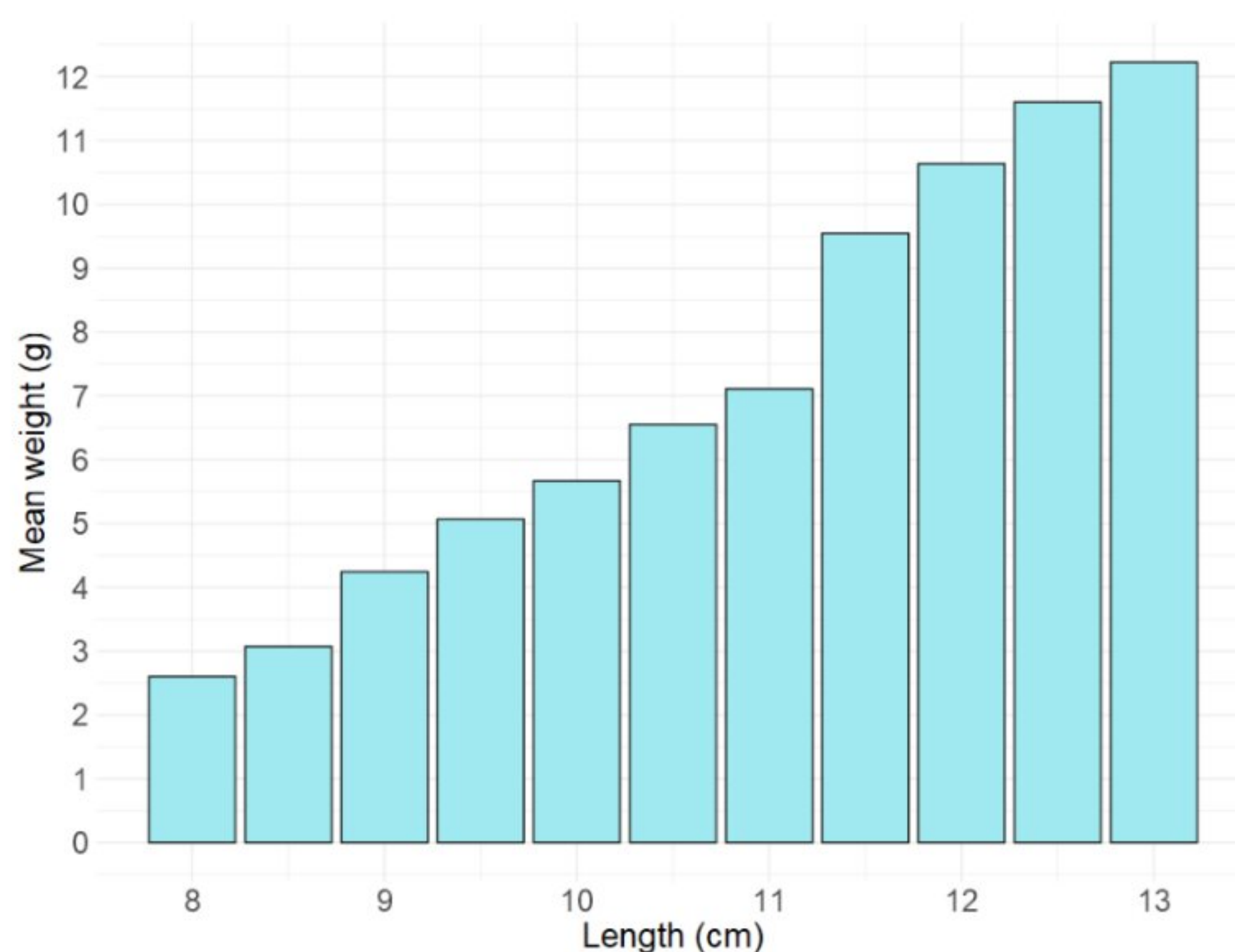


Fig. V.3.5.2 Distribution of average anchovy weight by size groups for first semester of 2025.

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V.3.6 Size structure of whiting by age group

The length of **448 fish** was measured. A gradual increase in the average length values was observed with respect to the age groups. The lowest average length value was in the age group 1-1+, and the highest was in the group 4-4+ years (**Fig. III.3.6.1**).

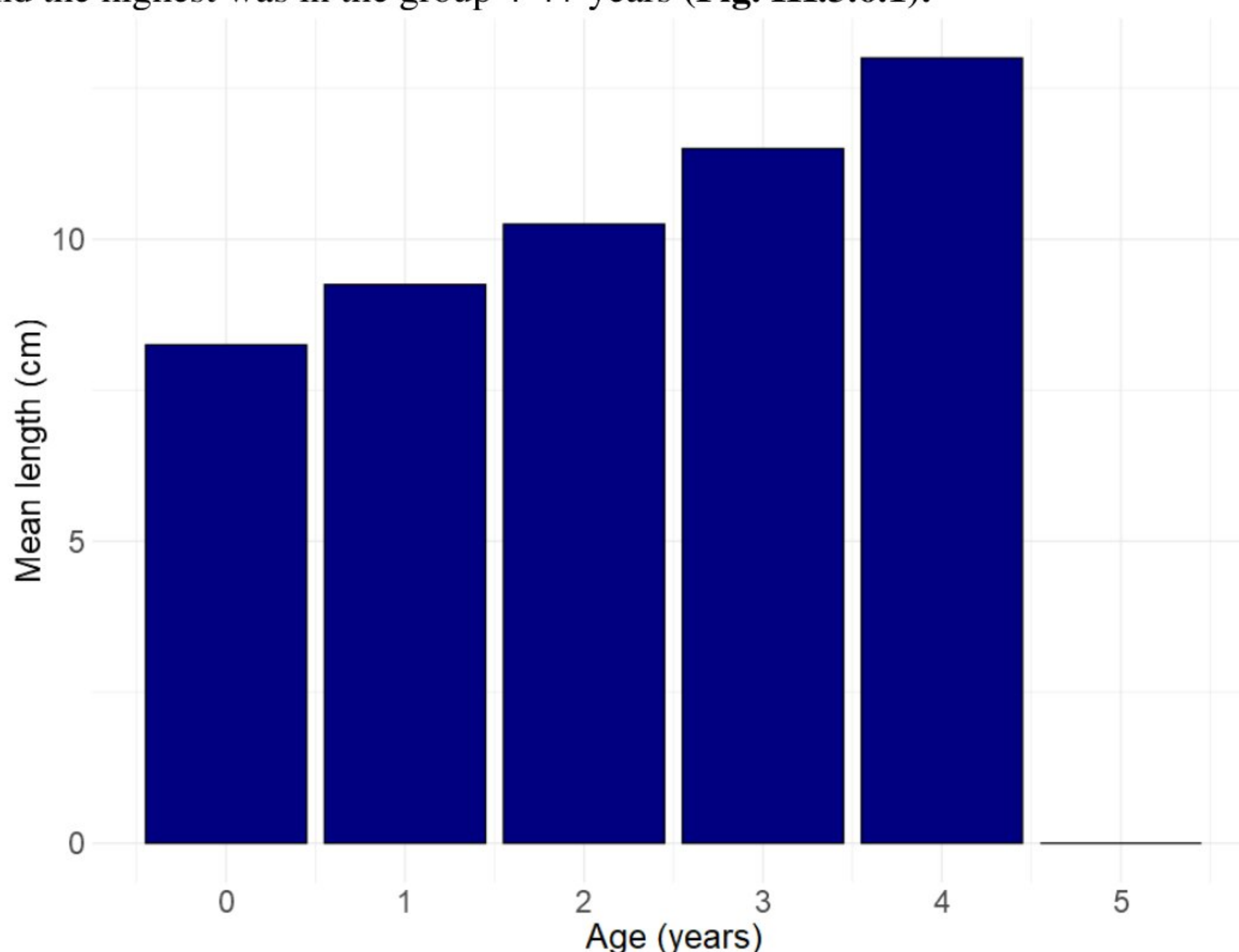


Figure III.3.6.1 Size structure of anchovy by age groups.

V.3.7 Length- weight relationship

The resulting model (**Table V.3.7.1**) is statistically significant, the value of the scaling coefficient a in the length-weight relationship model $W_i = aL_i^b$ e: **$a=0.003$** , and the allometry coefficient **$b=3.27$** , which indicates positive allometric growth of the species **in the first half of the year**, or the increase in weight is proportional and greater than the increase in length.

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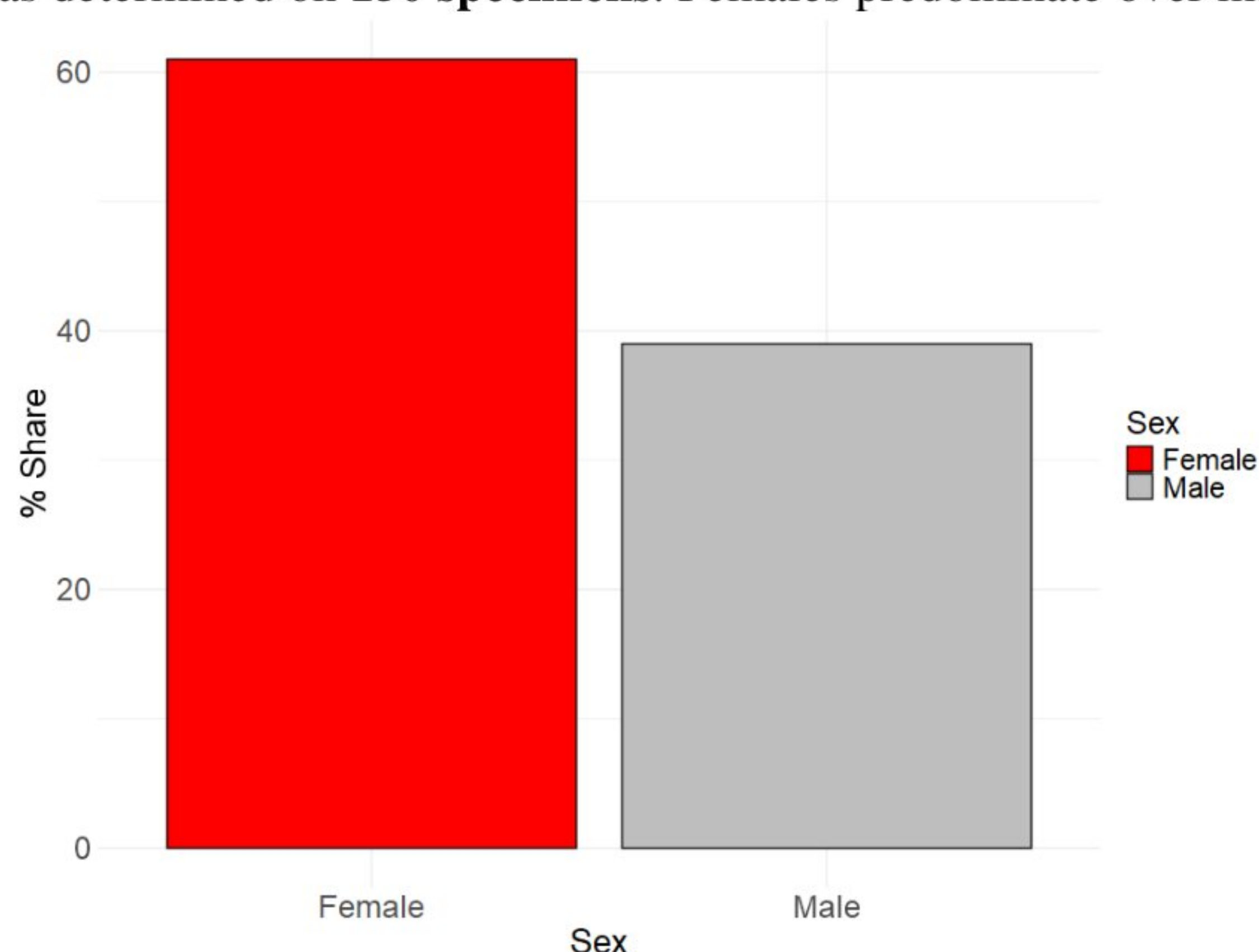
Table V.3.7.1 Results of modeling the length-weight relationship during the first semester.

Call:				
lm(formula = logW ~ logL, data = weight_1)				
Residuals:				
Min	1Q	Median	3Q	Max
-0.077951	-0.053963	-0.001935	0.055350	0.075564
Coefficients:				
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-5.8068	0.2864	-20.27	0.0000000008058 ***
logL	3.2704	0.1222	26.77	0.0000000000685 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error: 0.062 on 9 degrees of freedom				
Multiple R-squared: 0.9876, Adjusted R-squared: 0.9862				
F-statistic: 716.7 on 1 and 9 DF, p-value: 0.0000000006848				

V.3.8 Sex ratio

The sex ratio was determined on **150 specimens**. Females predominate over males 62% :38%.



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Figure V.3.8.1 Sex structure of anchovy during the first half of the year.

In size classes 9.0 cm for females and 8.0 cm for males are represented with higher percentage values. In terms of age, one-year-olds are represented with the highest percentage in both female and male specimens (**Figure V. 3.8.2**).

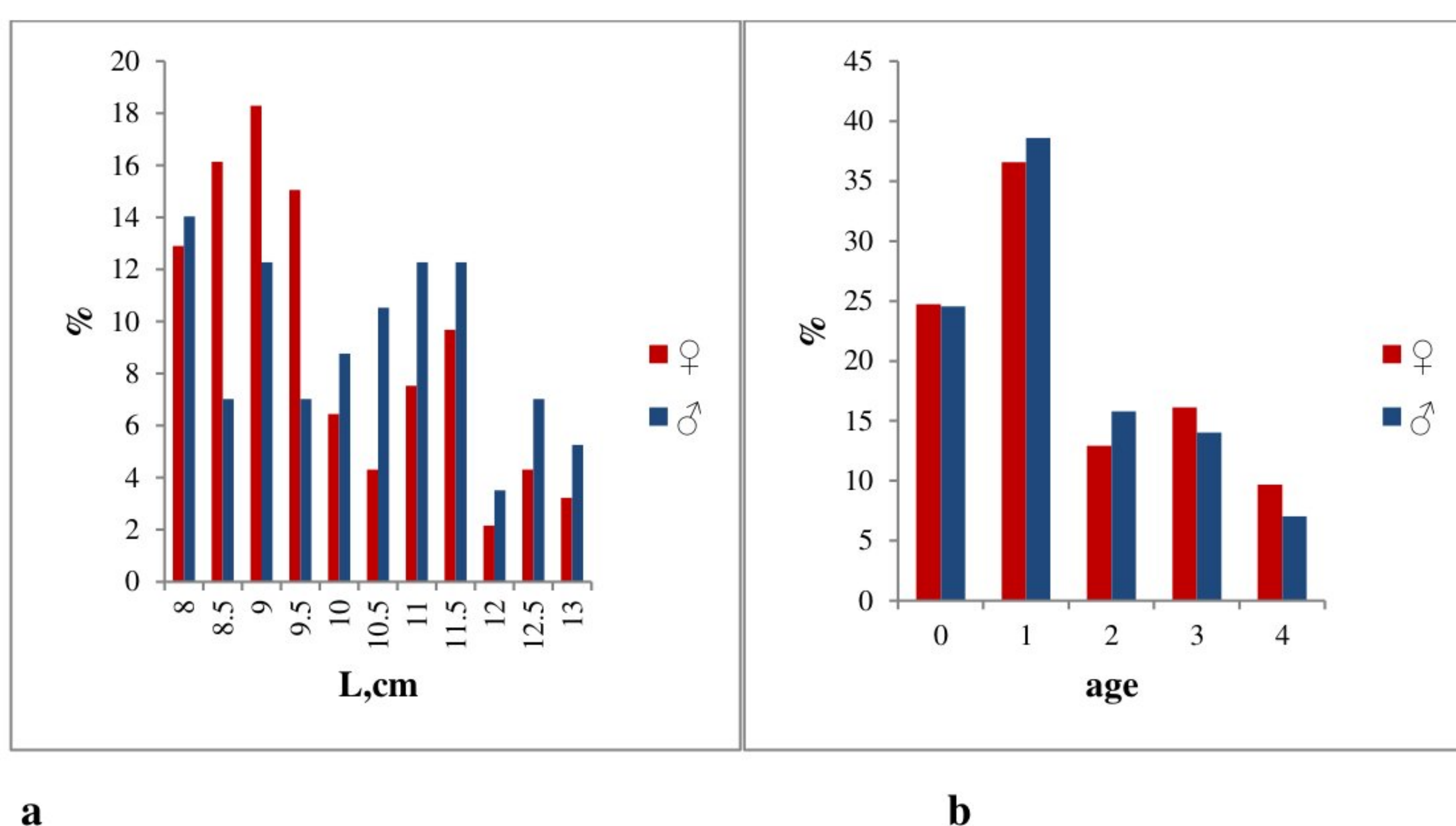


Figure V.3.8.2 Sex ratio (%) by size (a) and age (b) of anchovy.

V.3.9 Fertility

Fertility was determined on **250 specimens**. During the first six months, the gonadosomatic index was not strongly dependent on the weight of the gonads ($R^2=0.1079$), which is associated with the not-high percentage of maturation of the females (**Figure V.3.9.1**).



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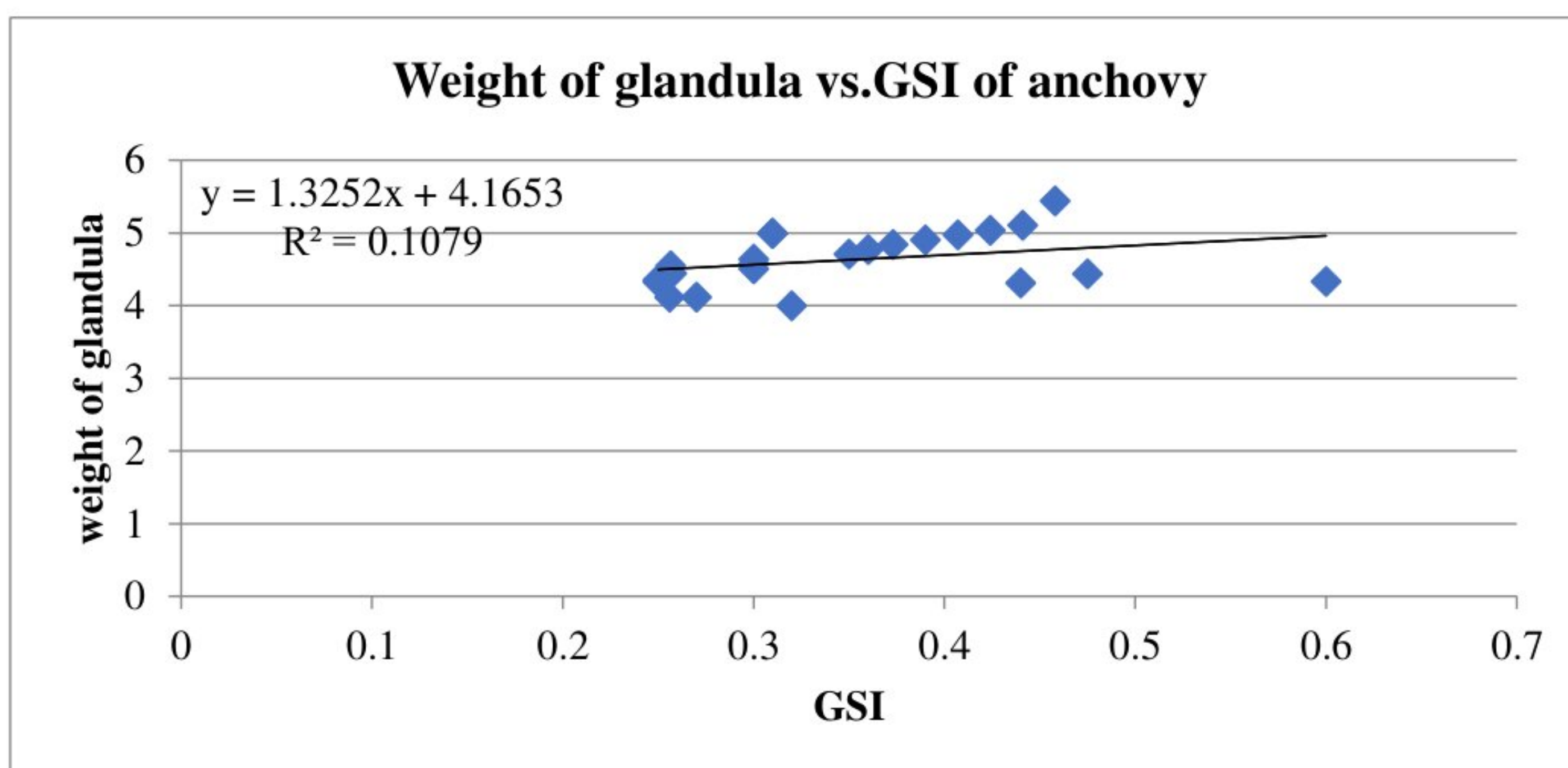


Figure V. 3.9.1 Dependence of gland weight on gonadosomatic index (GSI).

The average absolute fecundity was estimated at 33168.132 eggs in the first half of the year. The average relative fecundity was 9775.412 for the first half of the year (**Table V.3.9.1**).

Table V.3.9.1 Absolute and relative fertility.

Size class	W average, g	L average,cm	Absolute fertility F, caviar grains)	Relative fertility	N♀
6	1.44	6.01	na		2
6.5	2.29	7.12	16258	7099.5633	12
7	2.48	7.59	25650	10342.742	26
7.5	3.05	8.26	27411	8987.2131	28
8	3.66	8.61	33696	9206.5574	29
8.5	4.58	8.63	33985	7420.3057	40
9	5.12	9.22	37114	7248.8281	39
9.5	5.37	9.4	41252	7681.9367	38

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10	6.12	10.25	42333	6917.1569	23
10.5	7.12	10.58	42898	6025	7
11	8.05	11.22	42895	5328.5714	3
11.5	9.15	11.68	42999	4699.3443	1
12	10.22	10.14	41004	4012.1331	1
12.5	11.41	11.21	3690.7099	42111	1
			average	average	250
			33168.132	9775.4117	

V.3.10 Sexual maturity

Sexual maturity was determined on **250 specimens**. The studied specimens showed a degree of flowing gonads from I for zero-year-olds to VI-II degree for four- and five-year-old fish (Fig. V. 3.10.1).

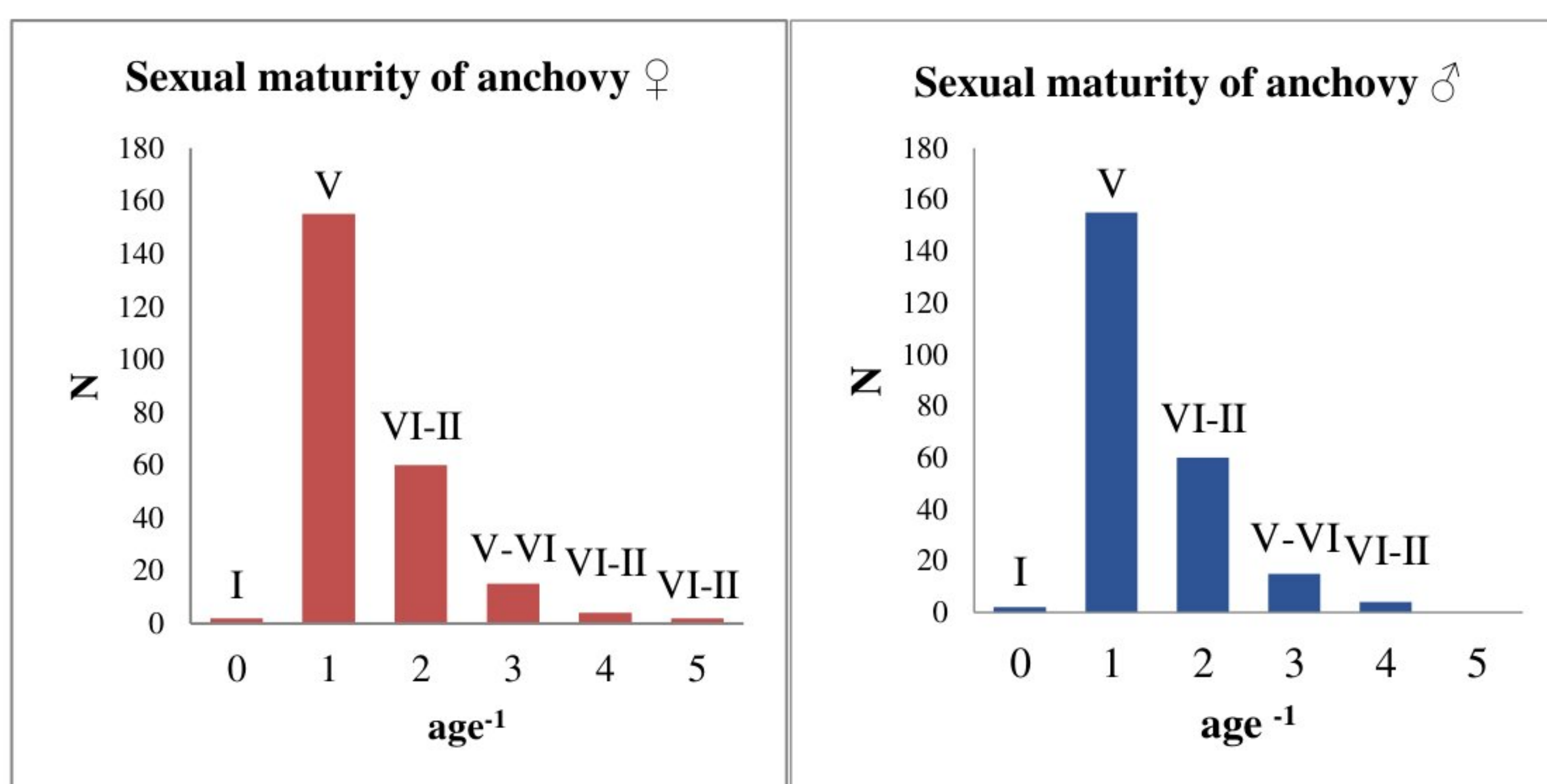


Figure V.3.10.1 Sexual maturity by age of anchovy - female (♀) and male (♂).

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Sexual maturity along the length of the anchovy showed a mass V-III degree of maturity in the studied specimens (**Fig. V.3.10.2**).

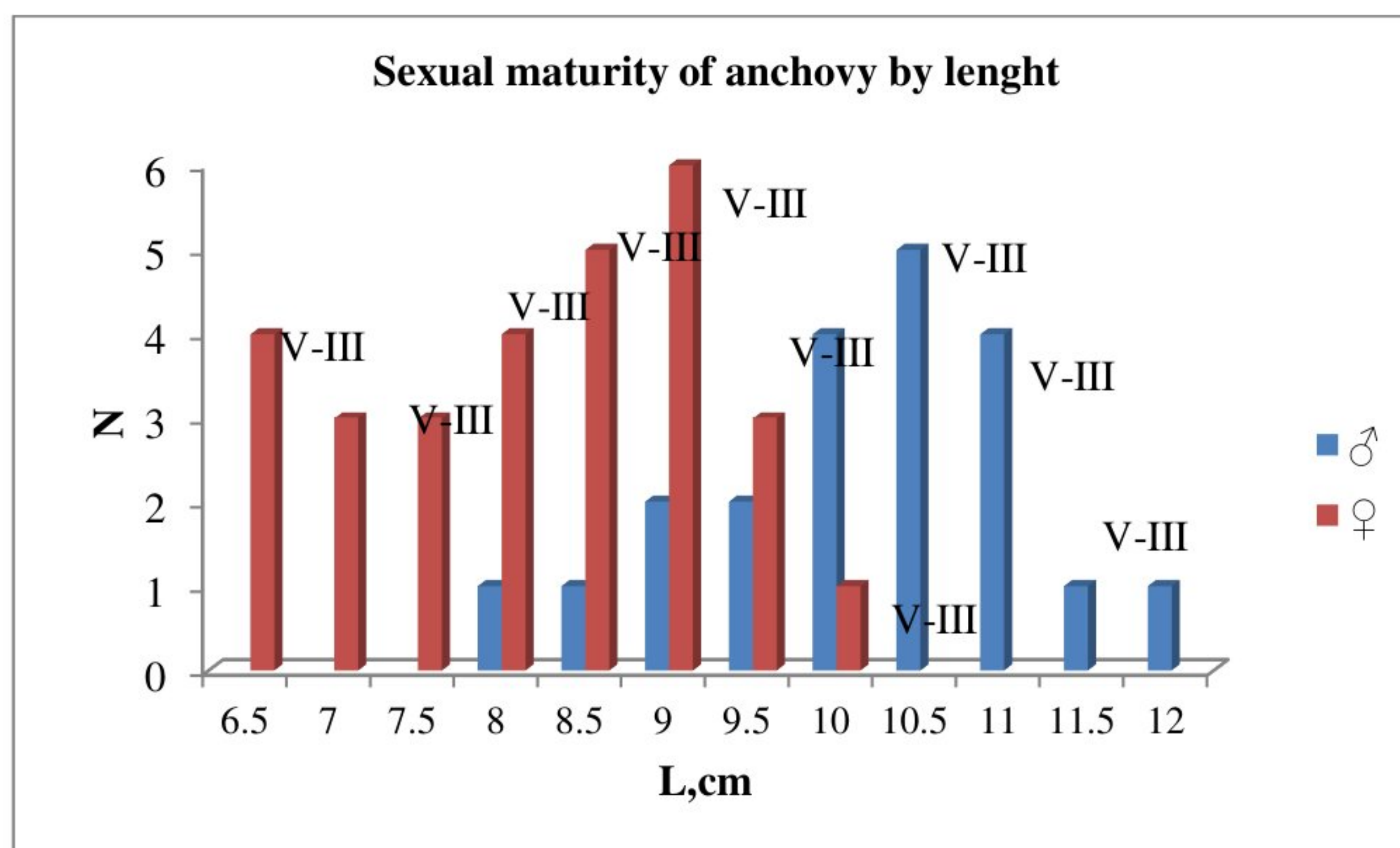


Figure V.3.10.2 Sexual maturity in length (cm) of anchovies - female ♀ and male ♂.

V.3.11 Catch numbers and biomass by age and length

Monthly OTM catches (in kilograms) together with average weights were used to obtain the abundance and biomass of the species by quarter in the reported catches (**Table V.3.11.1-2**).

Table V. 3.11.1 Catch matrix by age and biomass (kg) of anchovy with OTM.

Age groups	Catch at age	
	I th quarter	II nd quarter
0-0+	10093.0	
1-1+	14010.05	17.0213
2-2+	36703.75	25.7671
3-3+	31912.88	6.5103
4-4+	702.4678	
Σ	93422.15	49.2986
Biomass (kg)		

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Age groups	<i>Ith</i> quarter	<i>IInd</i> quarter
0-0+	27.6044	
1-1+	61.1239	0.0851
2-2+	236.609	0.1596
3-3+	272.1	0.0553
4-4+	7.88696	
Σ	605.324	0.3000

Table V.3.11.2. Number of individuals in the catch by size class (for OTM) and biomass of the of the anchovy.

<i>Catch in numbers</i>		
<i>Length group (cm)</i>	<i>Ith</i> quarter	<i>IInd</i> quarter
8	7583.613	
8.5	2566.951	
9	10815.07	7.1435
9.5	7072.517	14.0544
10	18327.68	15.0631
10.5	12796.41	5.5018
11	13238.59	3.1796
11.5	9958.291	3.5137
12	7484.819	0.6947
12.5	2981.953	0.1478
13	596.2546	
Σ	93422.15	49.2986
<i>Biomass (kg)</i>		
<i>Length group (cm)</i>	<i>Ith</i> quarter	<i>IInd</i> quarter
8	19.7174	
8.5	7.88696	
9	43.3783	0.0319
9.5	33.5196	0.0745
10	92.6718	0.0851
10.5	80.8413	0.0340
11	96.6152	0.0277
11.5	98.587	0.0362
12	86.7565	0.0085
12.5	37.463	0.0021
13	7.88696	
Σ	605.324	0.3000

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V.3.12 Conclusions

The analysis of the biological parameters of the anchovy makes it possible to draw the following conclusions:

1. The highest values are for individuals in the size classes of 11-11.5 in the first and 9.5 - 10.0 cm in the second quarter, and the lowest percentage values are for the size classes of 12, 12.5 and 13 cm.
2. In the first half of 2025, the share of zero and four-year-old specimens is the lowest. In the first quarter, two and three-year-olds show a predominance in catches. In the second quarter, one and two-year-olds are represented with the highest percentage of participation.
3. The parameters in the von Bertalanffy model are calculated as follows: **$L_{\infty}=14.11$ cm; $K = 0.44$ and $t_0=-0.80$.**
4. The anchovy condition factor from the study period shows relatively low values at the 8.5 cm size class, and the highest values were recorded at the 11.5-12-12.5 cm size classes.
5. In the first and second quarters, the graph shows that the age group 4-4+ has the highest value, and the age group 0-0+ has the lowest value for both quarters. The relationship between the average weights and the age groups is directly proportional.
6. The resulting model is statistically significant, the value of the scaling coefficient a in the length-weight relationship model is: **$a=0.003$** , and of the allometry coefficient **$b=3.27$** , which indicates positive allometric growth of the species in the first half of the year, or the increase in weight is proportional and greater than the increase in length.
7. The studied specimens showed a degree of flowing gonads from I for zero-year-olds to VI-II degree for four- and five-year-old fish.

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VI. Biological monitoring of picked dogfish (*Squalus acanthias*) landings

VI.1 Objectives

The study examines the population structure of specimens caught by Bulgarian fishermen.

VI.2 Sampling

The sampling was carried out by the actively operating fishing fleet in Bulgaria.

VI.2.1 Geographic area coverage

Shark specimens were measured and weighed on board fishing vessels.

VI.2.2 Sampling period

In I-VI 2025, to study the population dynamics of the shark, **50 specimens** were processed, to establish the size, weight and gender composition of the catches. Ports and ships from which monitoring was carried out to collect biological data from picked dogfish landings are presented in **Table VI. 2.2.1**.

Table VI.2.2.1 Ports and vessels from which monitoring was carried out to collect biological data from spiny dogfish landings.

N	DGS	Sampling ports	RK	External marking		Catch	N	Coordinates
1	8.3.2025	Asparuhovo Keya	IVA - 1	VN 8194	LLD	42	10	43.184100 27.899000
2	17.3.2025	Nesebar	VN 8112	VN 8112	LLS	59	10	42.646200 27.727300
3	6.4.2025	Varna	PYCAHO	VN4445	LLD	1503	20	43.425100 27.899000
4	18.6.2025	Kavarna	VN 7822	VN 7822	LLD	142	10	43.367000 28.379500
							50	

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VI.3. Landings statistics of spiny dogfish

Official shark catch statistics for I-VI 2025 are presented in **Figure VI. 3.1**. The highest catch is in April (LLD) and in March (LLS).

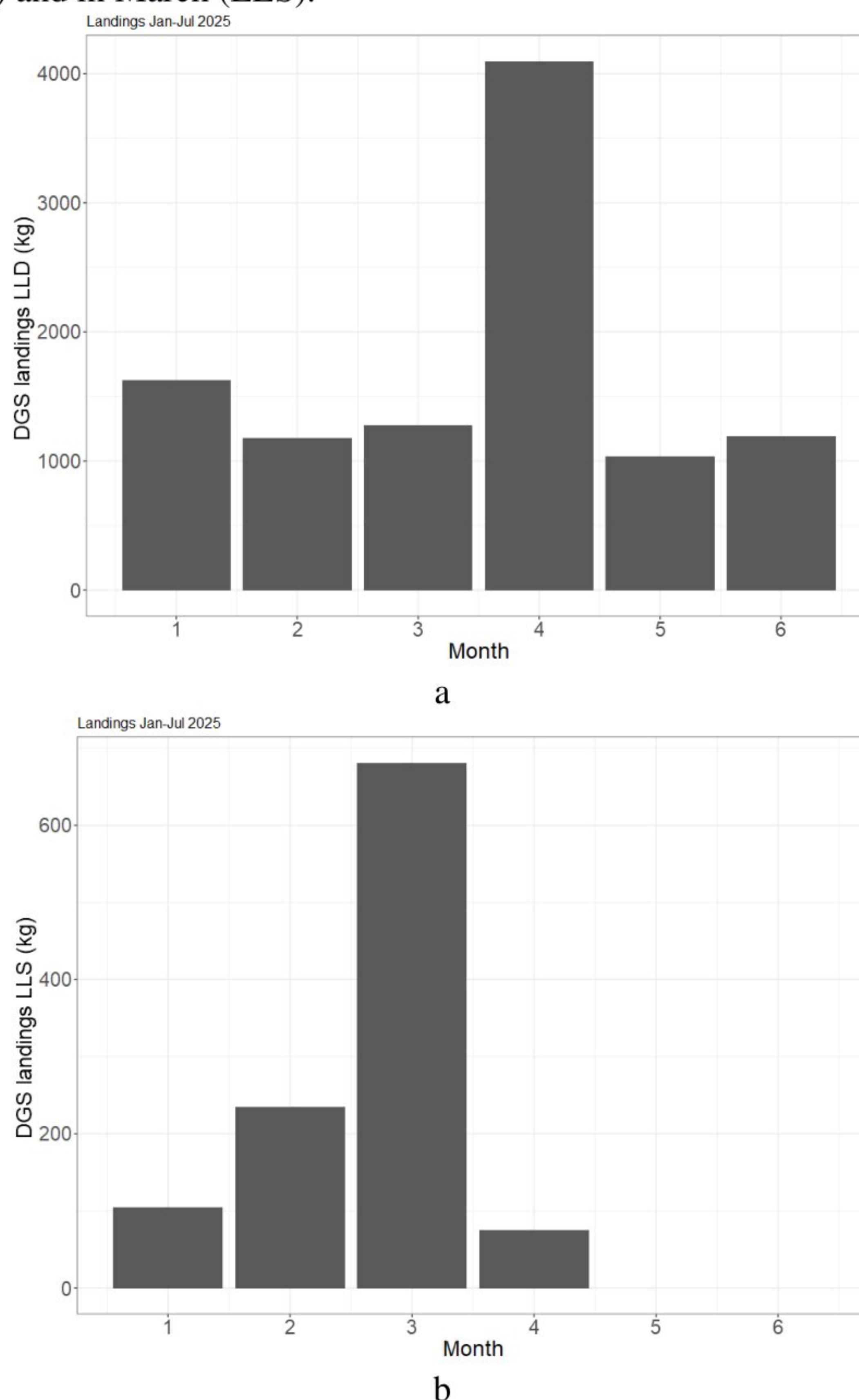


Figure VI.3.1 Official statistics on shark landings (LLD (a) и LLS (b) for the first half of 2025.

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VI.4 Results

VI.4.1 Sex, size and weight structure

The average size of a male shark is 120.24 cm, and the average length of females is 120.95 cm). Average weights of 5.00 kg have been recorded for females, while the average weights measured for males are 6.035 kg (**Table VI. 4.1.1**).

Table VI.4.1.1 Descriptive statistics of biological parameters (weights and lengths) of female and male specimens in the sample (minimum, maximum, mean and median of total length and weight of specimens in the samples during the first 6 months of 2025.

Sex	N	L_{mean}	Std. dev	L_{min}	L_{max}	W_{mean}	Std. dev	W_{min}	W_{max}
F	30	120.95	3.72	113	125	5.99	0.4	5.3	7.3
M	20	120.245	2.83	115	124	6.035	0.48	5.5	7.3

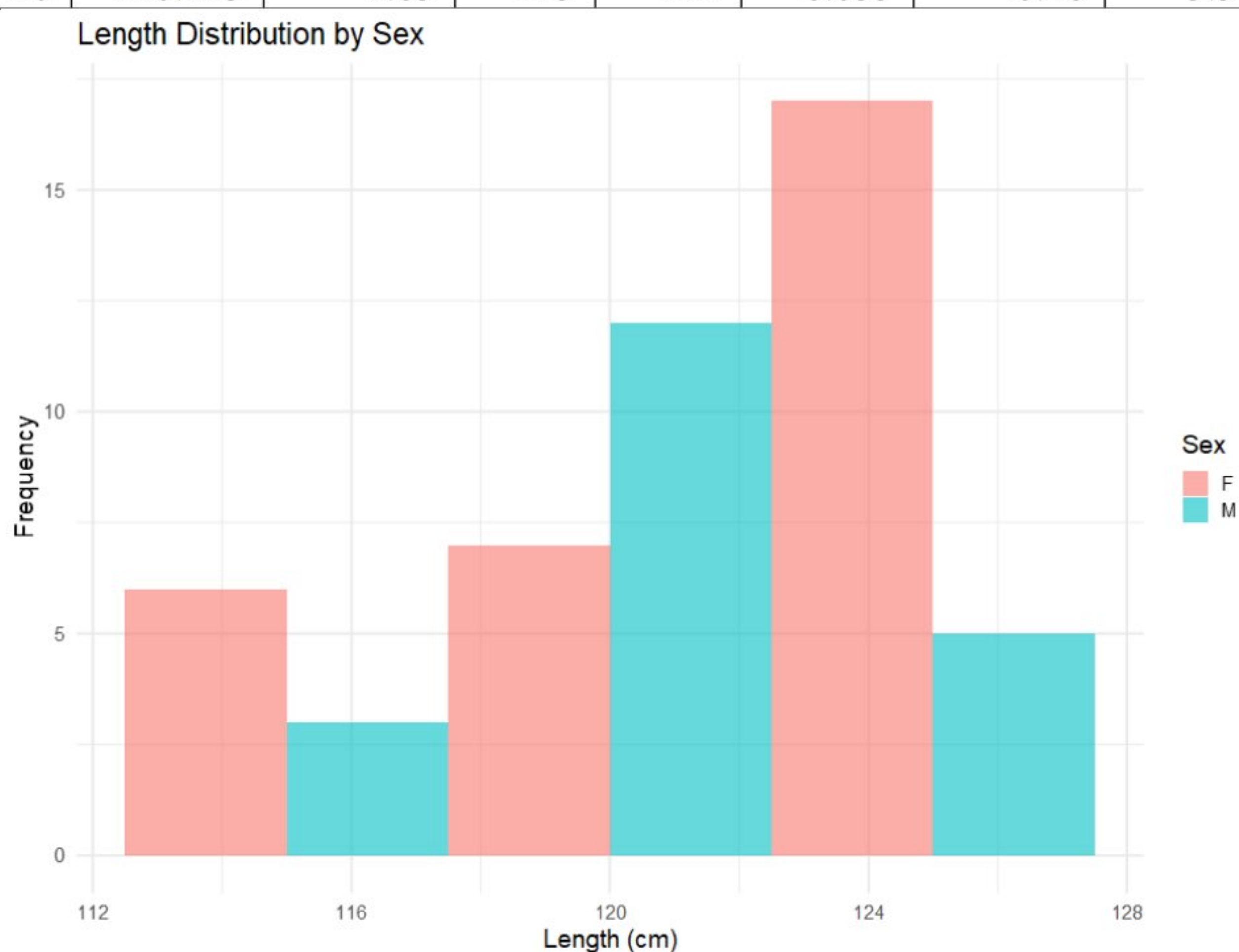


Figure VI.4.1.1 Distribution of total length of individuals in the sample by sex in the first half of 2025.

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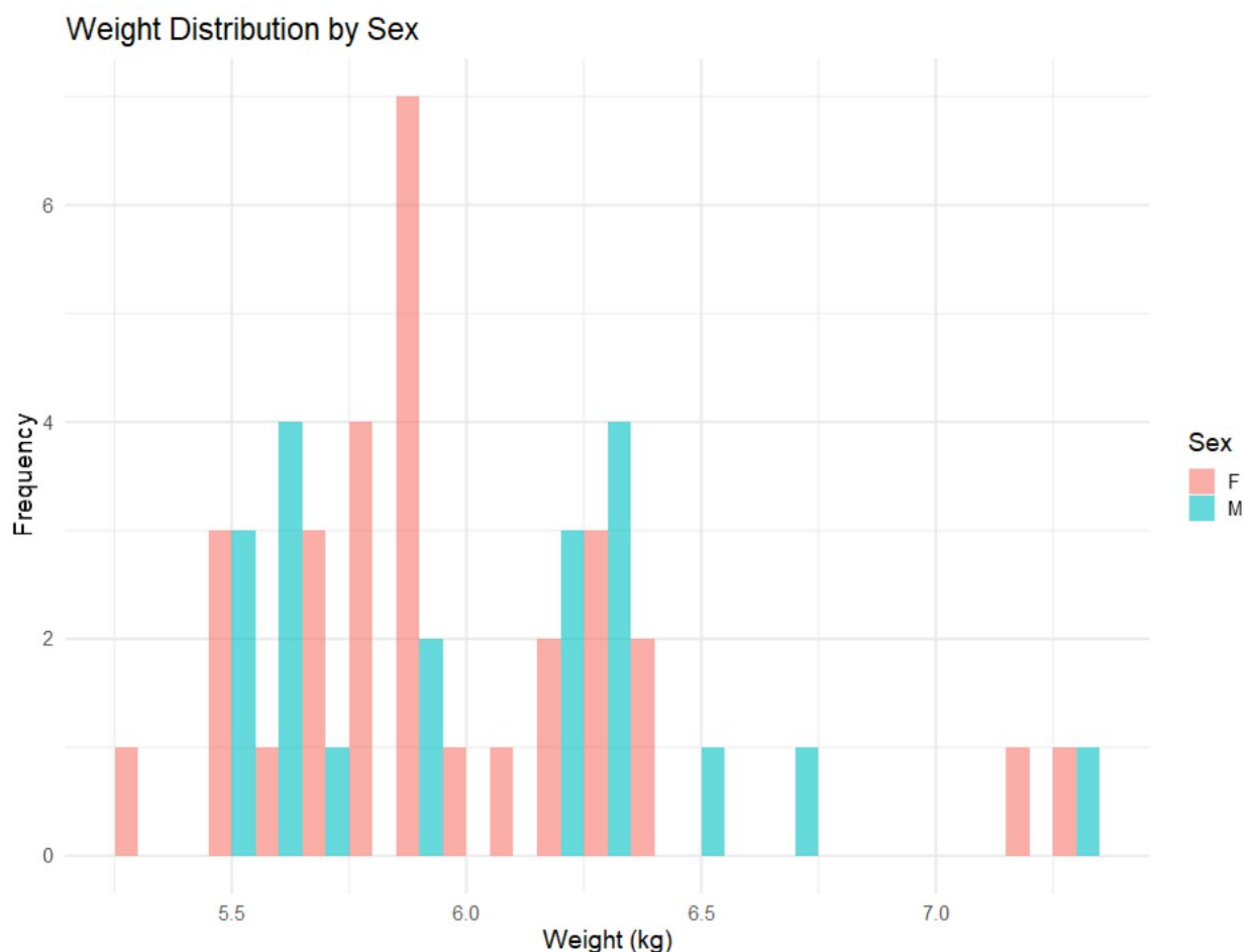


Figure VI.4.1.2 Distribution of weights of specimens in the sample by sex in the first half of 2025.

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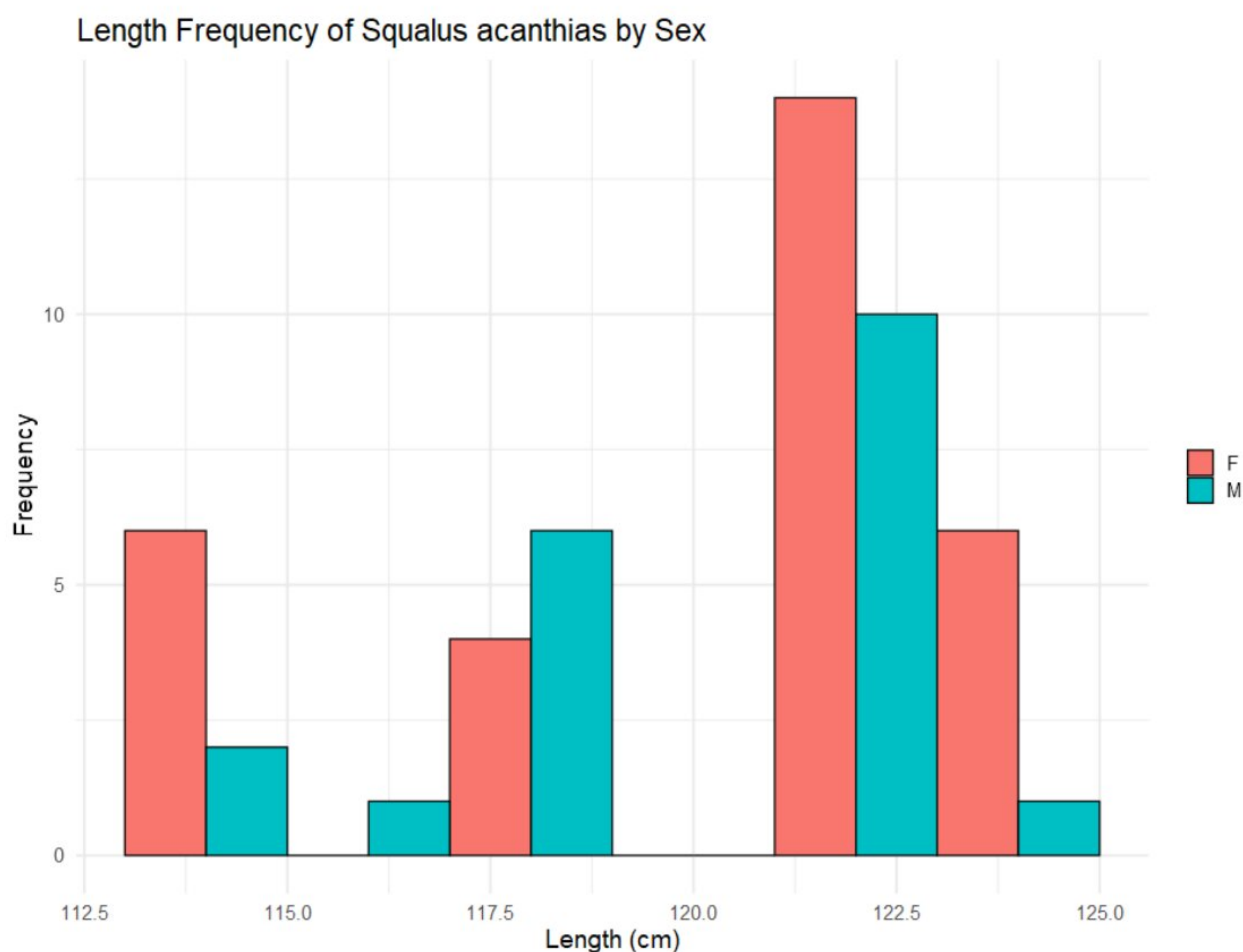


Figure VI.4.1.3 Histogram of distribution by sex and total length of specimens in the sample from the Bulgarian sector of the Black Sea for the first half of 2025.

VI.4.2 Sex structure and length-weight relationship

The sex ratio was determined on **50 specimens** (January-June). Male specimens predominated with 75%, and females were represented with 25% (**Figure VI.4.2.1**).

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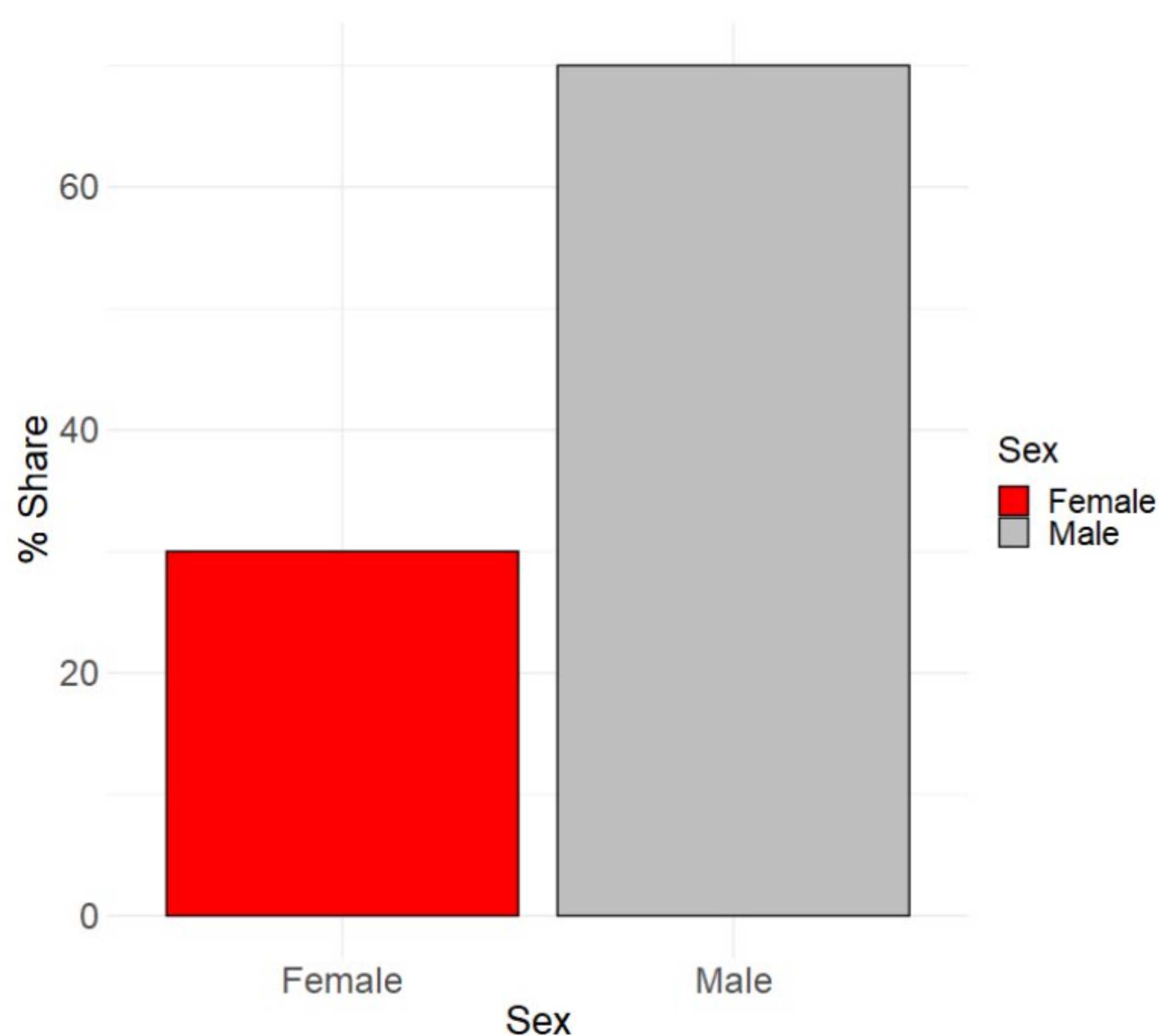


Figure VI.4.2.1 Sex ratio of sharks from the Bulgarian sector of the Black Sea in the first six months of 2025.

The Fulton condition factor (condition) of the specimens in the sample shows better condition of females compared to males, which is expected for the species. (**Fig. VI.4.2.2**).

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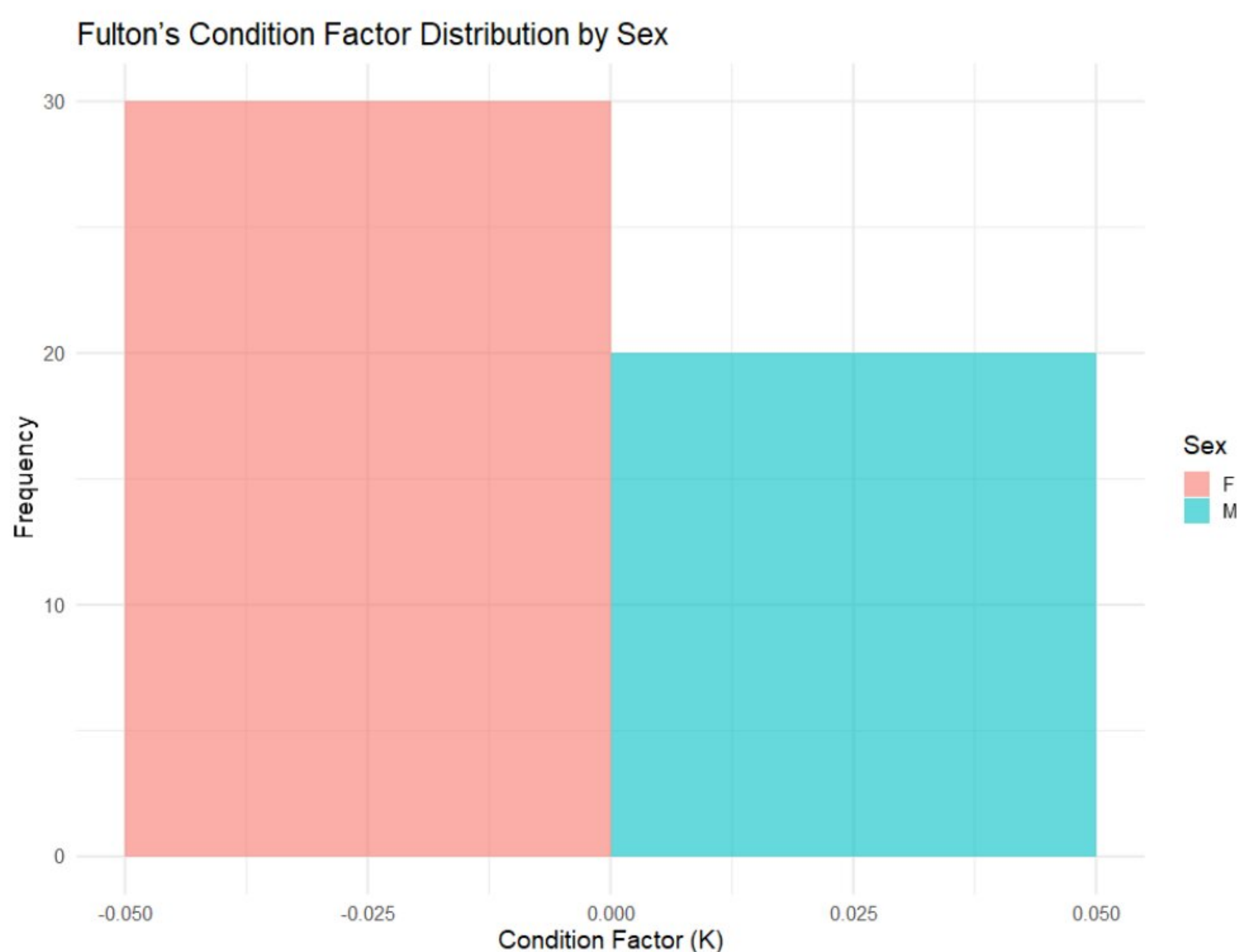


Figure VI.4.2.2 Fulton condition factor (condition) of the specimens in the sample.

An attempt was made to determine the length-weight relationship – the GAM model shows that the length-weight relationship is not well described by a linear relationship and the model does not approximate well compared to the traditional log-log LWR model (which is the standard in fisheries science, but is not applicable to the shark).

The weak determinism may be due to the fact that the length range in the data (113–125 cm) so the weight does not change significantly. Some variation is related to sex (as seen, the mean values for male and female fish differ slightly). Most of the variation in weight is not explained by length using this model ($R^2 \sim 0.23$) (**Figure VI.4.2.3**).



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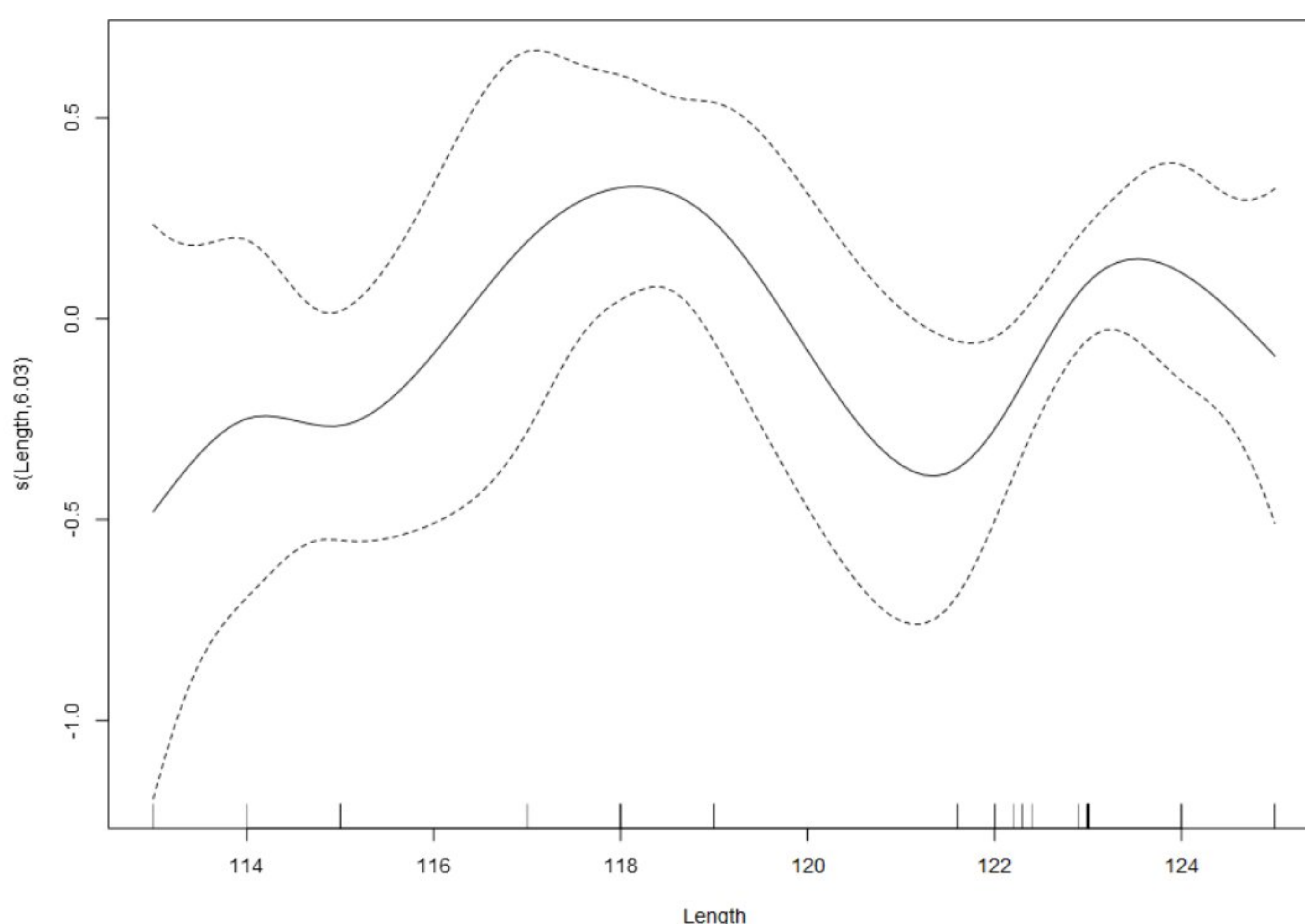


Figure VI.4.2.3 Length-weight relationship of *Squalus acanthias* using a Generalized Additive Model (GAM). The graph shows the smoothed length-weight relationship (LWR) curve for *Squalus acanthias* in the Black Sea, modeled using a generalized additive model (GAM). The smoothed curve represents the relationship between the total length of the specimens in the sample (cm) and weight (kg). The dashed curves show the standard error around the predicted curve, reflecting the uncertainty in the model predictions.

VI.4.3 Sexual maturity

Sexual maturity was determined in **30 specimens**. During the study period, females were observed to be sexually mature with visible embryos.

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VI.5 Conclusion

- 1) The average size of a male shark is 120.24 cm, and the average length of females is 120.95 cm. Average weights of 5.99 kg have been recorded for females, while the average weight measured for males is 6.035 kg in the first half of 2025.
- 2) In the first half of 2025 males predominated (the ratio of males to females was 75% : 0.25%).
- 3) An attempt was made to determine the length-weight relationship – the GAM model shows that the length-weight relationship is not well described by a linear relationship and the model does not approximate well compared to the traditional log-log LWR model (which is the standard in fisheries science, but is not applicable to the shark).
- 4) During the study period, females were sexually mature with visible embryos.
- 5) The *Fulton* condition factor of the specimens in the sample shows better condition of females compared to males, which is expected for the species.

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VII. Anex

Sprattus sprattus

	Number of specimens from the study I-VI,2025	Number of specimens from the study VII- XII,2025	Number of specimens from the study I-XII,2025	Number of specimens Contract 156/28/03/2025 EAFA/IO-BAS
<i>length</i>	818			1250
<i>weight</i>	818			1250
<i>age</i>	818			1250
<i>sex ratio</i> ♀♂	250			500
<i>fecundity</i>	250			500
<i>sexual maturity</i>	250			500

Trachurus mediterraneus ponticus

	Number of specimens from the study I-VI,2025	Number of specimens from the study VII-XII,2025	Number of specimens from the study I-XII,2025	Number of specimens Contract 156/28/03/2025 EAFA/IO-BAS
<i>length</i>	765			1500
<i>weight</i>	765			1500
<i>age</i>	765			500
<i>sex ratio</i> ♀♂	140			250
<i>fecundity</i>	140			100
<i>sexual maturity</i>	140			250

Merlangius merlangus euxinus

	Number of specimens from the	Number of specimens from the	Number of specimens from the	Number of specimens Contract
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	study I-VI,2025	study VII-XII,2025	study I-XII,2025	156/28/03/2025 EAFA/IO-BAS
<i>length</i>	249			250
<i>weight</i>	249			250
<i>age</i>	249			250
<i>sex ratio</i> ♀♂	100			100
<i>fecundity</i>	100			100
<i>sexual maturity</i>	50			100

Mullus barbatus

	Number of specimens from the study I-VI,2025	Number of specimens from the study VII-XII,2025	Number of specimens from the study I-XII,2025	Number of specimens Contract 156/28/03/2025 EAFA /IO-BAS
<i>length</i>	431			500
<i>weight</i>	431			500
<i>age</i>	431			500
<i>sex ratio</i> ♀♂	250			250
<i>fecundity</i>	250			не по-малко от 100
<i>sexual maturity</i>	250			250

Engraulis encrasicolus

	Number of specimens from the study I-VI,2025	Number of specimens from the study VII-XII,2025	Number of specimens from the study I-XII,2025	Number of specimens Contract 156/28/03/2025 EAFA/IO-BAS
<i>length</i>	448			500
<i>weight</i>	448			500
<i>age</i>	448			250
<i>sex ratio</i>	150			250
<i>fecundity</i>	250			100
<i>sexual maturity</i>	250			250

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Squalus acanthias

	Number of specimens from the study I-VI,2025	Number of specimens from the study VII-XII,2025	Number of specimens from the study I-XII,2025	Number of specimens Contract 156/28/03/2025 EAFA/IO-BAS
length	50			100
weight	50			100
sex ratio ♀♂	50			30
sexual maturity	30			30

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BILATERAL PROTOCOL

Today, 31.03. 2025, in connection with the implementation of Art. 10, para. 7 of Agreement No. D – 156 of 28.03.2025 for the implementation of biological monitoring (collection of biological samples) of the industrial catches of sprat, anchovy, horse mackerel, red mullet, whiting and Black Sea shark in no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2025, and no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2026, between the Executive Agency for Fisheries and Aquaculture (EAFA) and the Institute of Oceanology – Bulgarian Academy of Sciences (IO – BAS), the undersigned:

Maria Hristova Yankova
(name, surname and family name)



PERSONAL DATA PROTECTION LAW

in the position of Associate Professor at the Institute of Information Technology – BAS

and Yordan Raev Raev
(name, surname and family name)

in the position of Chief Inspector at NAFA,
we certify with our signatures that biological samples were collected from
the landings at the port of Nessebar



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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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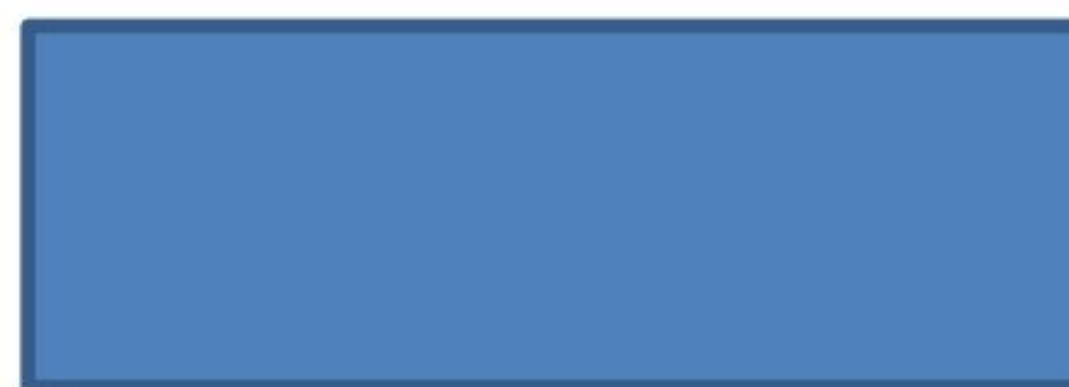


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BILATERAL PROTOCOL

Today, 3.04. 2025, in connection with the implementation of Art. 10, para. 7 of Agreement No. D – 156 of 28.03.2025 for the implementation of biological monitoring (collection of biological samples) of the industrial catches of sprat, anchovy, horse mackerel, red mullet, whiting and Black Sea shark in no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2025, and no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2026, between the Executive Agency for Fisheries and Aquaculture (EAFA) and the Institute of Oceanology – Bulgarian Academy of Sciences (IO – BAS), the undersigned:

Maria Hristova Yankova
(name, surname and family name)



PERSONAL DATA PROTECTION LAW

in the position of Associate Professor at the Institute of Information Technology – BAS

and Yordan Raev Raev
(name, surname and family name)

in the position of Chief Inspector at NAFA,
we certify with our signatures that biological samples were collected from
the landings at the port of Nessebar



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BILATERAL PROTOCOL

Today, 28.05. 2025, in connection with the implementation of Art. 10, para. 7 of Agreement No. D – 156 of 28.03.2025 for the implementation of biological monitoring (collection of biological samples) of the industrial catches of sprat, anchovy, horse mackerel, red mullet, whiting and Black Sea shark in no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2025, and no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2026, between the Executive Agency for Fisheries and Aquaculture (EAFSA) and the Institute of Oceanology – Bulgarian Academy of Sciences (IO – BAS), the undersigned:

Maria Hristova Yankova
(name, surname and family name)



PERSONAL DATA PROTECTION LAW

in the position of Associate Professor at the Institute of Information Technology – BAS

and Ivan Petkov
(name, surname and family name)

in the position of Chief Inspector at NAFA,
we certify with our signatures that biological samples were collected from

the landings at the port of Nessebar



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BILATERAL PROTOCOL

Today, 27.06. 2025, in connection with the implementation of Art. 10, para. 7 of Agreement No. D – 156 of 28.03.2025 for the implementation of biological monitoring (collection of biological samples) of the industrial catches of sprat, anchovy, horse mackerel, red mullet, whiting and Black Sea shark in no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2025, and no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2026, between the Executive Agency for Fisheries and Aquaculture (EAFA) and the Institute of Oceanology – Bulgarian Academy of Sciences (IO – BAS), the undersigned:

Maria Hristova Yankova
(name, surname and family name)



PERSONAL DATA PROTECTION LAW

in the position of Associate Professor at the Institute of Information Technology – BAS
and Diyan Panayotov Mitkov

(name, surname and family name)

in the position of Chief Inspector at NAFA,
we certify with our signatures that biological samples were collected from

the landings at the port of Kavarna



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BILATERAL PROTOCOL

Today, 3.04. 2025, in connection with the implementation of Art. 10, para. 7 of Agreement No. D – 156 of 28.03.2025 for the implementation of biological monitoring (collection of biological samples) of the industrial catches of sprat, anchovy, horse mackerel, red mullet, whiting and Black Sea shark in no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2025, and no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2026, between the Executive Agency for Fisheries and Aquaculture (EAFA) and the Institute of Oceanology – Bulgarian Academy of Sciences (IO – BAS), the undersigned:

Maria Hristova Yankova
(name, surname and family name)

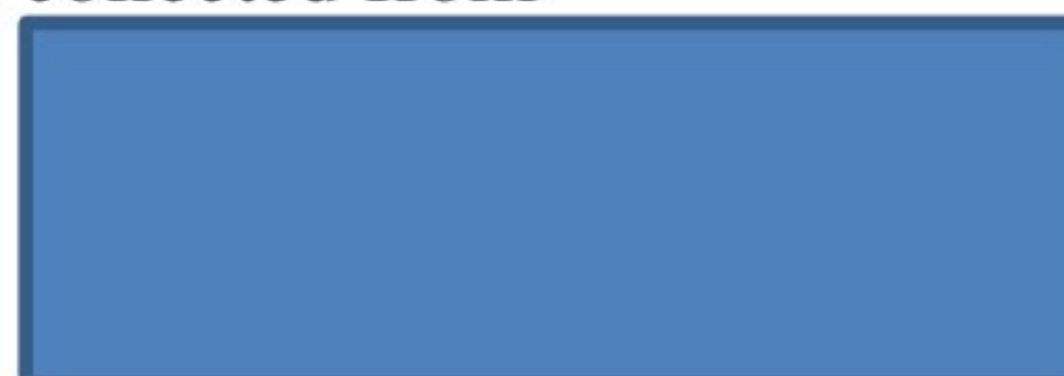


PERSONAL DATA PROTECTION LAW

in the position of Associate Professor at the Institute of Information Technology – BAS

and Yordan Raev Raev
(name, surname and family name)

in the position of Chief Inspector at NAFA,
we certify with our signatures that biological samples were collected from
the landings at the port of Nessebar



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BILATERAL PROTOCOL

Today, 29.06. 2025, in connection with the implementation of Art. 10, para. 7 of Agreement No. D – 156 of 28.03.2025 for the implementation of biological monitoring (collection of biological samples) of the industrial catches of sprat, anchovy, horse mackerel, red mullet, whiting and Black Sea shark in no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2025, and no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2026, between the Executive Agency for Fisheries and Aquaculture (EAFA) and the Institute of Oceanology – Bulgarian Academy of Sciences (IO – BAS), the undersigned:

Maria Hristova Yankova
(name, surname and family name)



PERSONAL DATA PROTECTION LAW

in the position of Associate Professor at the Institute of Information Technology – BAS

and Zdravko Stefanov Gaydarjiev
(name, surname and family name)

in the position of Chief Inspector at NAFA,
we certify with our signatures that biological samples were collected from

the landings at the port of Balchik



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BILATERAL PROTOCOL

Today, 18.06. 2025, in connection with the implementation of Art. 10, para. 7 of Agreement No. D – 156 of 28.03.2025 for the implementation of biological monitoring (collection of biological samples) of the industrial catches of sprat, anchovy, horse mackerel, red mullet, whiting and Black Sea shark in no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2025, and no less than 36 (8 for Black Sea shark and 28 for all other species) landings in 2026, between the Executive Agency for Fisheries and Aquaculture (EAFA) and the Institute of Oceanology – Bulgarian Academy of Sciences (IO – BAS), the undersigned:

Maria Hristova Yankova
(name, surname and family name)



PERSONAL DATA PROTECTION LAW

in the position of Associate Professor at the Institute of Information Technology – BAS

and Georgi Mihaylov Atanasov

(name, surname and family name)

in the position of Chief Inspector at NAFA,
we certify with our signatures that biological samples were collected from
the landings at the port of Kavarna



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