2022

BIOLOGICAL MONITORING OF LANDINGS OF COMMERCIALLY IMPORTANT SPECIES

Scientific report on contract N71/15/03/2022 covering the results of 2022

EUROPEAN UNION
EUROPEAN FUND FOR MARITIME AFFAIRS AND FISHERIES

MINISTRY OF AGRICULTURE

MARITIME AFFAIRS AND FISHERIES PROGRAM

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BULGARIAN ACADEMY OF SCIENCES
INSTITUTE OF OCEANOLOGY VARNA

Project No. BG14MFOP001-3.003-0004, "Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy 2022", funded by the Maritime and Fisheries Program co-financed by the European Union through European Maritime and Fisheries Fund.

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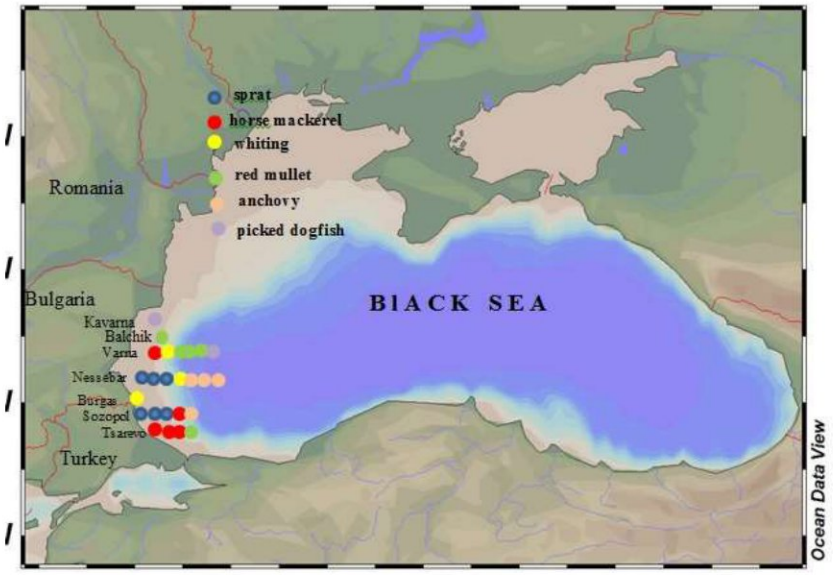
In connection with the implementation of **Contract No. 71 of 15.03.2022,** sampling was done for inclusion in the biological monitoring from the northern and southern coasts. The data of this analysis are collected from the landings in the ports of the Bulgarian Black Sea coast of the Black Sea.



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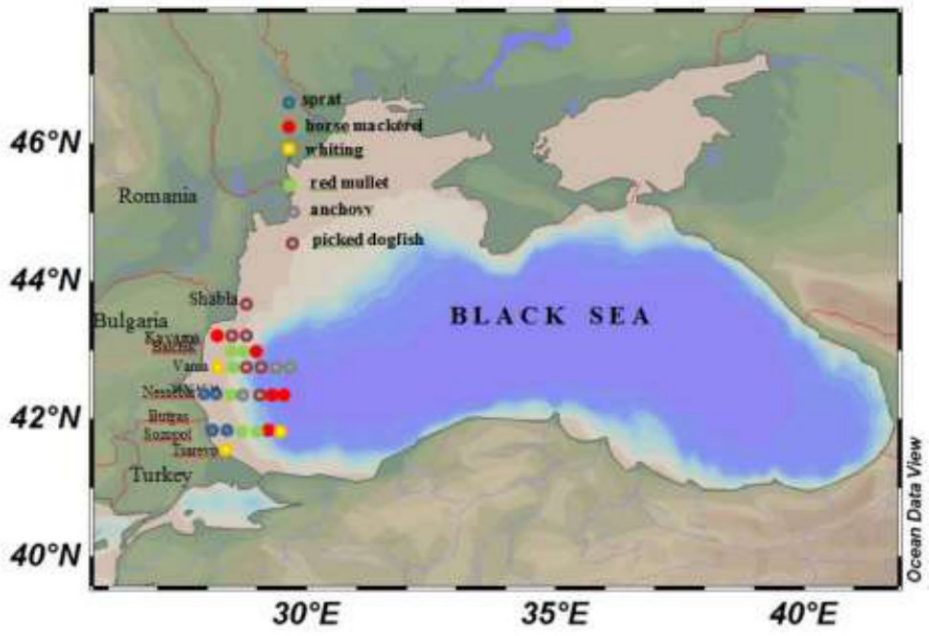

b

Figure 1. Sampling map of the Bulgarian Black Sea coast for the 1st and 2nd quarters **(a)** and 3rd and 4th quarter **(b)** of 2022.

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25 samples for the 1st and 2nd quarters are shown on the map 1a, with the dots showing the samples in a different color for each species. **Sprat - 6 landings** (3 in Nessebar and 3 in Sozopol); **Horse mackerel - 5 landings** (1 in Varna, 3 in Tsarevo and 1 in Sozopol); **Whiting - 3 landings** (1 in Varna, 1 in Nessebar and 1 in Burgas); **Red mullet -5 landings** (3 in Varna, 1 in Tsarevo and 1 in Balchik); **Anchovy - 4 landings** (3 in Nessebar and 1 in Sozopol); **Picked dogfish -2 landings** (1 in Varna and 1 in Kavarna);

27 samples for the 3rd and 4th quarte are shown on the map 1b, with the dots showing the samples in a different color for each species. **Sprat - 4 landings** (2 in Nessebar and 2 in Sozopol); **Horse mackerel - 5 landings** (1 in Balchik,1 in Kavarna, 2 in Nessebar and 1 in Sozopol); **Whiting - 3 landings** (1 in Varna, 1 in Sozopol and 1 in Tsarevo); **Red mullet -6 landings** (1 in Varna, 1 in Nessebar, 1 in Burgas, 1 in Sozopol and 2 in Balchik); **Anchovy - 3 landings** (2 in Varna and 1 in Nessebar); **Picked dogfish -6 landings** (2 in Varna and 1 in Nessebar 2 in Kavarna 1 in Shabla);

Biological catch data were collected from **14 vessels for the 1st and 2nd quarters**. Fishing vessels used in the biological monitoring study during the period I-VI, 2022:

I-VI			
№	**Fishing vessel**	**External marking**	**Fishing gear**
1.	VENI	VN 2998	OTM
2.	GONDOLA	VN4321	OTM
3.	ISHTAR	NS1182	OTM
4.	IRINA	VN 440	OTM
5.	KORSAR 2	VN 7643	OTM
6.	MEDUZA 3	BS288	OTM
7.	R/K 5	VN 8186	OTM
8.	R/K 28	BS22	OTM
9.	R/K 40	BS258	OTM
10.	R/K 26	BS219	OTM
11.	R/K37	BS255	OTM
12.	RUSANO	VN4445	LLS
13.	HARASIMOV MLADSHI	VN 422	OTM
14.	CIKLAMA V	AX215	OTM

During the 3rd and 4th quarter of 2022, biological catch data was collected **from 21 vessels**. Fishing vessels are used for biological monitoring research in the period VII-XII, 2022:

VII-XII			
№	**Fishing vessel**	**External marking**	**Fishing gear**
1	AMBAR	VN4496	LLS
2	BARBUN	VN7979	OTM
3	BS 041	BS 041	OTM
4	Veni	VN 2998	OTM
5	VN8112	VN8112	OTM
6	Electa	VN8042	OTM

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7	IVANNA	KV 6231	OTM
8	KIRILL 45	BS280	OTM
9	Corsar 2	VN7643	OTM
10	Leffer	VN 03	OTM
11	Priqtel	BS160	OTM
12	R/K 26	BS219	OTM
13	R/K 40	BS258	OTM
14	XERSON	BS210	OTM
15	CICLAMA V	AX215	OTM
16	VN 7822	VN 7822	LLD
17	VN 8112	VN 8112	LLS
18	Hishnik	KB 6262	LLS
19	KV 6245	KV 6245	LLS
20	Bumerang	VN 8250	LLS
21	Libra	VN 8311	LLD

In 2022, biological data from the catches was collected from a **total of 30 ships**. From the ships **VENI, CORSAR 2, R/K 26, R/K 40 and CYCLAMA V,** sampling was done in the 1st and 2nd six months. Fishing vessels used for biological monitoring research in 2022:

№	**Fishing vessel**	**2022**	**Sampling period 2022**
1	AMBAR		VII-XII
2	BARBUN		VII-XII
3	BS 041		VII-XII
4	Veni	I-VI	I-VI
	Veni	VII-XII	VII-XII
5	VN 8112		VII-XII
6	GONDOLA		I-VI
7	Electa		VII-XII
8	IVANA		VII-XII
9	IRINA		I-VI
10	ISHTAR		I-VI
11	KIRILL 45		VII-XII
12	CORSAR 2	I-VI	I-VI
	CORSAR 2	VII-XII	VII-XII
13	Leffer		VII-XII
14	MEDUZA 3		I-VI
15	Priqtel		VII-XII
16	R/K 26	I-VI	I-VI
	R/K 26	VII-XII	VII-XII
17	R/K 28		I-VI
18	R/K 37		I-VI
19	R/K 40	I-VI	I-VI
	R/K 40	VII-XII	VII-XII

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20	P/K 5		I-VI
21	RUSANO		I-VI
22	HARASIMOV MLADSHI		I-VI
23	XERSON		VII-XII
24	CICLAMA V	I-VI	I-VI
	CICLAMA V	VII-XII	VII-XII
25	VN 7822	LLD	VII-XII
26	VN 8112	LLS	VII-XII
27	Hishnik	LLS	VII-XII
28	KV 6245	LLS	VII-XII
29	Bumerang	LLS	VII-XII
30	Libra	LLD	VII-XII

Vessels and species monitored for collection of biological data from landings of sprat, horse mackerel, whiting, anchovy, red mullet and shark. **A total of 52 samples** were collected in 2022 from the species subject to biological monitoring.

№	Fishing vessel	Fishing vessels from which more than one sample was collected in 2022	Fishing gear	Species code
1	AMBAR	AMBAR	**LLS**	DGS[1]
2	BARBUN		OTM	MUT[1]
3	BS 041	BS 041	OTM	MUT[2] MUT[3] MUT[4]
4	Veni		OTM	ANE[1]
5	VN 8112		OTM	WHG[1]
6	VN 8112		**LLS**	DGS[2]
7	GONDOLA		OTM	MUT[5]
8	Electa		OTM	HMM[1] MUT[6]
9	IVANA		OTM	HMM[2]
10	IRINA		OTM	MUT[7]
11	ISHTAR	ISHTAR	OTM	SPR[1] SPR[2] WHG[2]
12	KIRILL 45		OTM	HMM[3] MUT[8]
13	CORSAR 2	CORSAR 2	OTM	HMM[4] MUT[9] MUT[10] WHG[3]
14	Leffer		OTM	ANE[2]
15	MEDUZA 3		OTM	HMM[5]
16	Priqtel		OTM	SPR[3] ANE[3]
17	R/K 26	R/K 26	OTM	SPR[4] SPR[5] HMM[6]
18	R/K 28		OTM	SPR[6]
19	R/K 37		OTM	SPR[7] ANE[4]
20	R/K 40	R/K 40	OTM	SPR[8],SPR[9] ANE[5] ANE[6]
21	R/K 5		OTM	ANE[7]
22	RUSANO		OTM	WHG[4]

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	RUSANO		**LLS**	DGS[3]
23	HARASIMOV MLADSHI		OTM	HMM[7]
24	XERSON		OTM	SPR[10] WHG[5]
25	CICLAMA V	CICLAMA V	OTM	HMM[8] HMM[9] HMM[10] MUT[11] WHG[6]
26.	VN 7822		**LLD**	DGS[4]
27.	Hishnik KV6262		**LLS**	DGS[5]
28.	KV 6245		**LLS**	DGS[6]
29.	Bumerang BN8250		**LLS**	DGS[7]
30.	Libra VN 8311		**LLD**	DGS[8]
				10 samples of sprat (SPR) 10 samples of horse mackerel (HMM) 6 samples of whiting (WHG) 11 samples of red mullet (MUT) 7 samples of anchovy (ANE) 8 samples of shark (DGS) **∑ 52 samples for 2022**

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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 **2022** 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 2022** were collected **10 samples with 1250 specimens.** Information on the size of the catches was also collected.

I.2.2 Sampling period

In 2022, the biological data on sprat were collected from a total of **10 landings at the ports of Nessebar(5) and Sozopol (5)**. 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 2.2.1.**

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

№	Date	Harbour	Species code SPR	Fishing vessel	Fishing gear	Catch	Coordinates	Area
1	28.1.2022	Sozopol	sprat	R/K 28 BS221	OTM	100	42.426200, 27.737700	south
2	4.2.2022	Nessebar	sprat	R/K40 BS258	OTM	290	42.646200, 27.727300	south
3	4.3.2022	Sozopol	sprat	R/K 26 BS219	OTM	552	42.504700, 28.011300	south

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4	3.4.2022	Sozopol	sprat	R/K 37BS255	OTM	2280	42.422600, 27.691300	south
5	4.5.2022	Nessebar	sprat	ISHTAR NS1182	OTM	420	42.656400, 27.731400	south
6	1.6.2022	Nessebar	sprat	ISHTAR NS 1182	OTM	1770	42.659700, 27.731400	south
7	1.6.2022	Nessebar	sprat	ISHTAR NS 1182	OTM	1770	42.659700, 27.731400	south
8	28.8.2022	Nessebar	sprat	P/K 40 БС258	OTM	2900	42.655700, 27.730600	south
9	10.9.2022	Sozopol	sprat	РК 26 БС219	OTM	240	42.422300, 27.691300	south
10	23.12.2022	Nessebar	sprat	РК 26 БС219	OTM	2424	42.422600, 27.691300	south

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). Oilly 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

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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: $GSI = \frac{GW}{SW} X\ 100$ 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 – condition factor, n – parameter in length-weight relationship.

Photo 1: Laboratory processing of *Sprattus sprattus* samples.

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 2022 year. January has the lowest value. During the first three months (winter season), reduced weight values of landings are observed. The landings are significantly higher in May, which is the highest value from all six months.
Catches in the 3rd quarter exceed those of the 4th quarter. Catches with OTM in July predominate. This is followed by a drastic drop in August and catches are very low in the following months, with no sprat catches in November.

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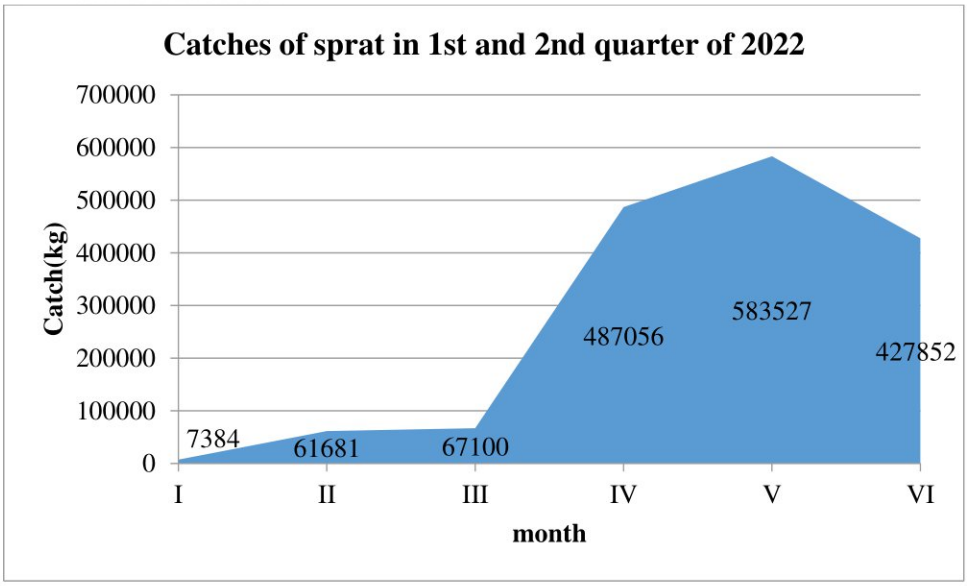

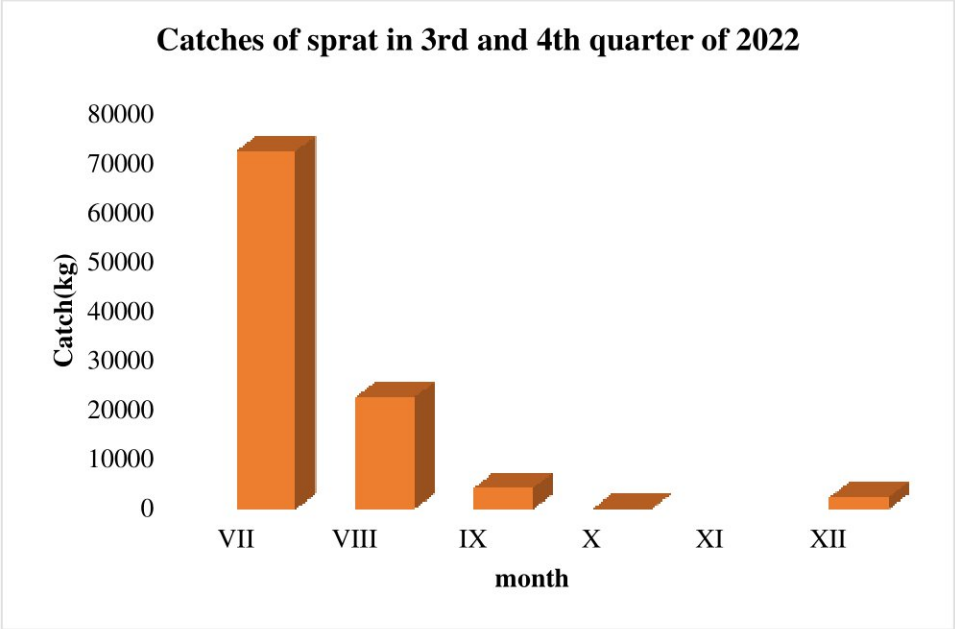

Fig 3.1.1 Official statistics records for sprat landings.

I.3.2 Length structure of landings

For the first quarter, classes with a length of 6.5cm and 11cm had the lowest value of landings - less than 5%. Classes in the range of 7cm to 10.5cm occupy a relatively higher percentage of landings - from 5% to 20% respectively. For the second quarter, the lowest percentage is the size class 7cm and the highest one is the class with 10.5 cm. The remaining classes fall within the range between 5 % and 15 %. In the 3rd quarter, the 9.5 cm size class predominated,

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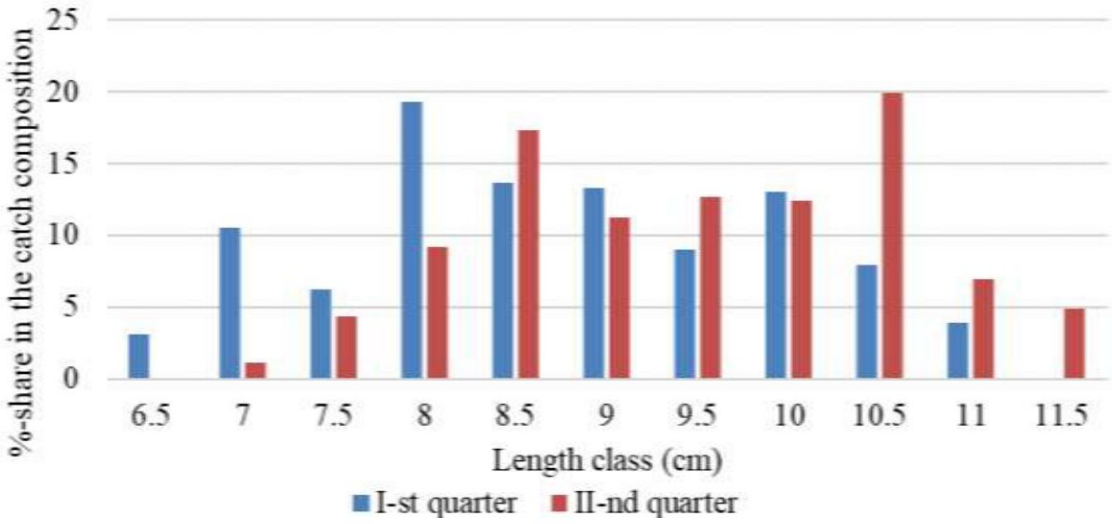
followed by the 10 cm and 10.5 cm size class. In the 4th quarter, the maximum was recorded at 11 cm, followed by 11.5 cm.



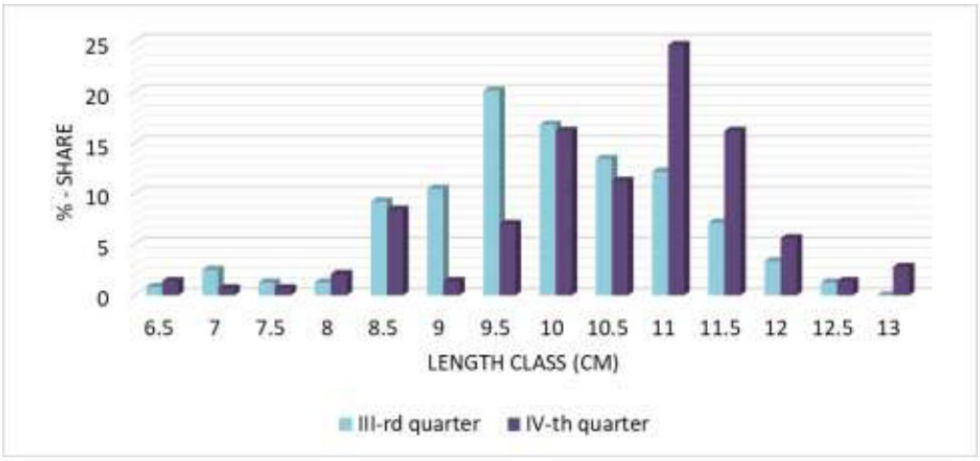


Fig 3.2.1 Size structure and percentage share of length classes in the catch composition.

I.3.3 Age structure of landings

The three readers determined the age of sprat otoliths, and reader 1 read all otoliths twice. Specimens (**n = 1250)** were used for age determination. During the first quarter the highest percentage - 40% - occupy individuals in age group 3-3+, followed by 2-2+. With the lowest value - about 5% are the age groups: 1-1+ and 4-4+ . The second quarter shows that the age groups of 2-2+ and 3-3+ have the same share - 40% and prevail significantly over the rest.

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Less than 5% are the age groups 0-0+ and 1-1+ . During this quarter, we see an increase in older individuals compared to the previous one.

In the 3rd and 4th quarters of 2022, maxima were recorded at age 3-3+, with 2-2+ year-old individuals in the 3rd quarter reaching 23%.

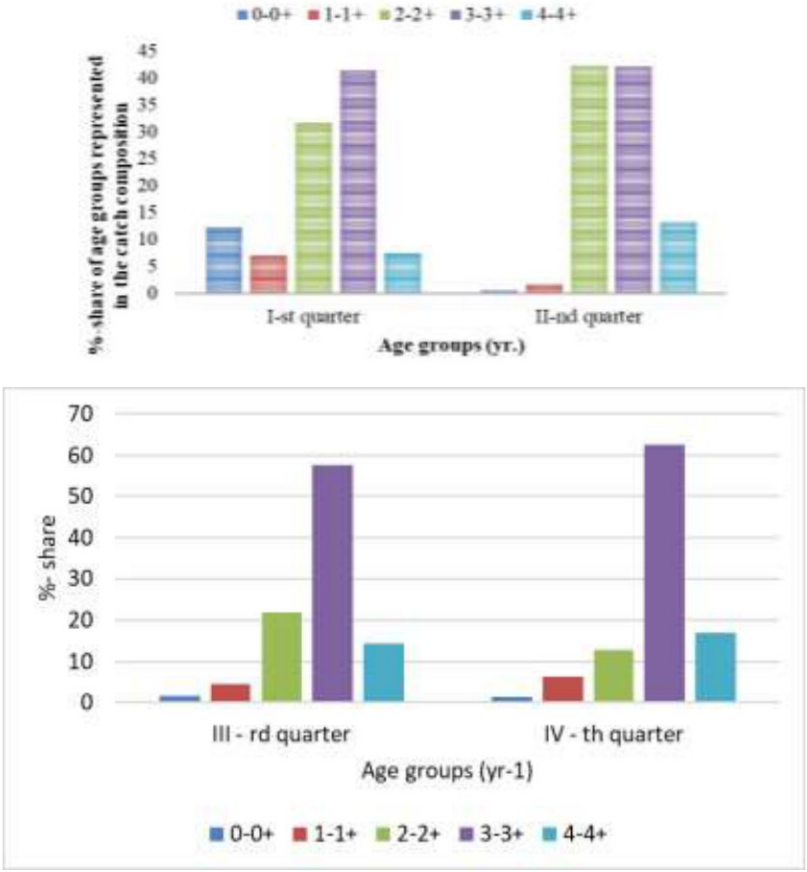

Fig.3.3. 1 Age structure and percentage share of age groups in the catch composition.

I.3.4 Condition factor

The graph shows that in the first quarter the highest value of condition coefficient is for size classes 9cm and 10.5 cm. The lowest value of condition coefficient is for the size class 6.5 cm. For the second quarter, the conditioning factor is highest in the size class of 9cm and lowest at a size class of 11.5 cm. For others it is approximately similar in values between 0.50 to 0.67 .

We report the best condition in the 3rd quarter in size class 6.5 cm (K = 0.77). In the 4th quarter, the condition factor did not show significant fluctuations and was within the range of 0.46-0.68. A sharp decrease in condition in the 4th was observed at size class 7 cm (K = 0.46).

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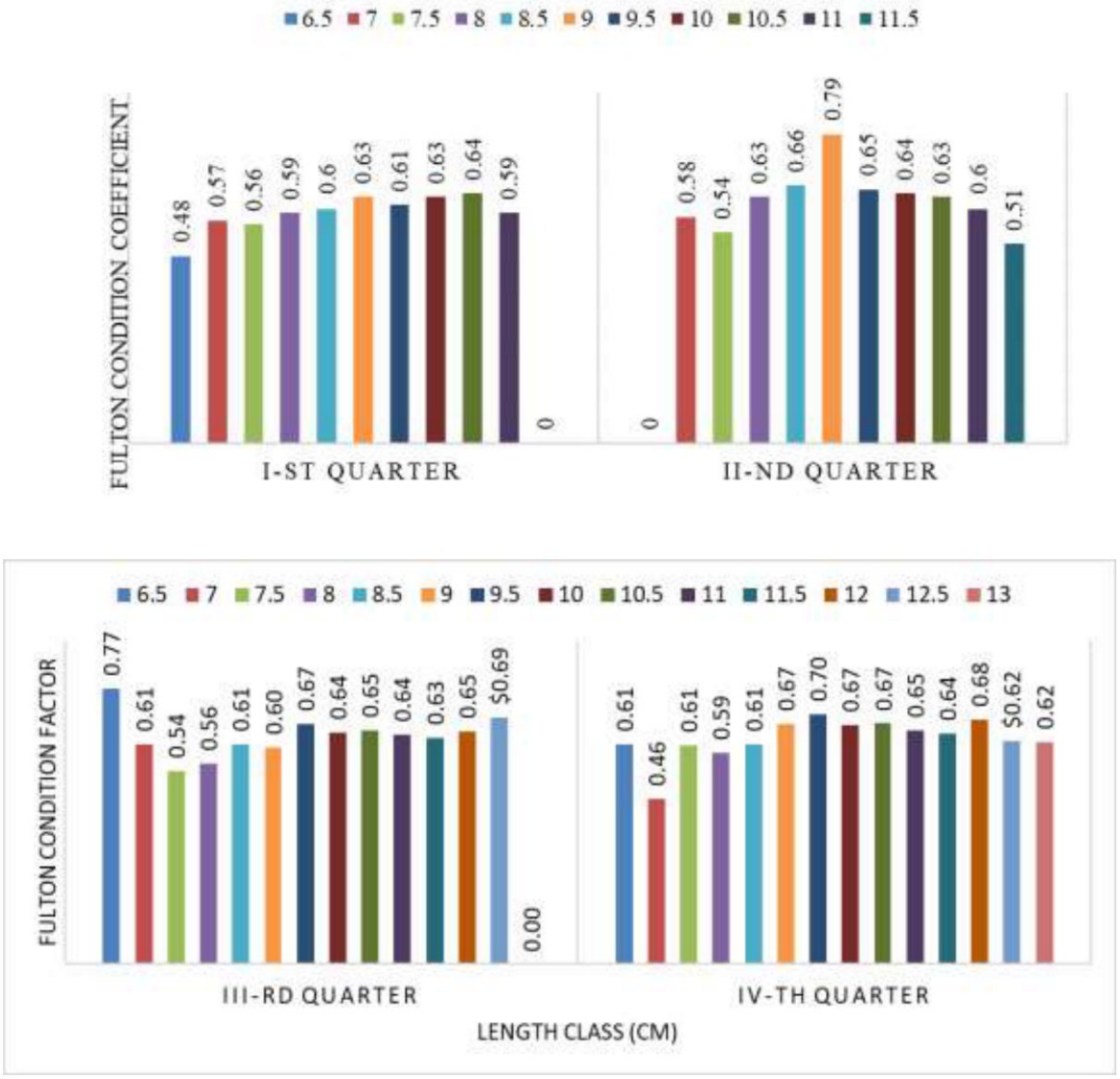

Fig. 3.4.1 Fulton condition coefficient values of sprat by length classes.

The conditioning coefficient by age group is fairly evenly distributed for both the first and second quarters. In the first quarter, the highest values for age groups 2-2+ and 3-3+ and the lowest are about 0-0+, which is maintained for the second quarter.
By age in the 3rd quarter we registered the highest value in 0+ years (K = 0.68). In the 4th quarter, the values of the coefficient are similar, but the condition of the 0+ annual decline sharply.

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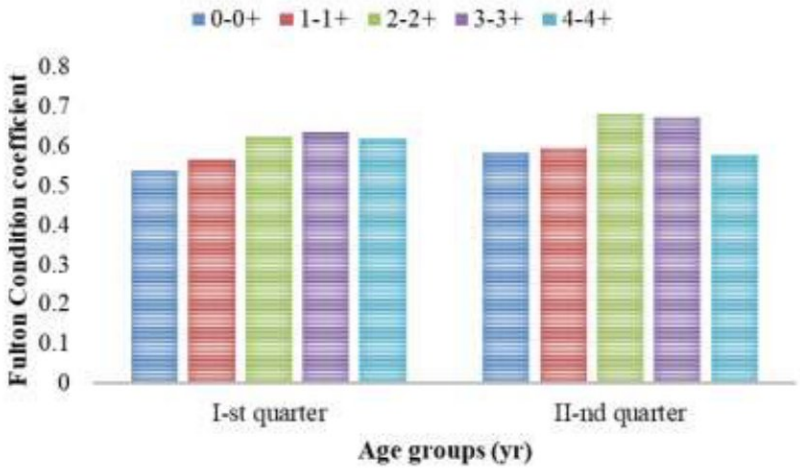

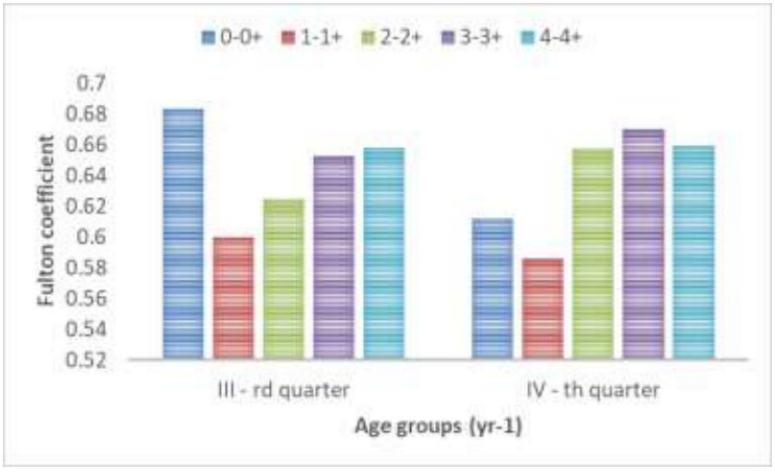

Fig.3.4.2 Fulton condition coefficient values of sprat by age groups.

I.3.5 Weight structure of sprat by age group

Weight was measured of **1250 specimens** . The graph shows the distribution of the average weight of Sprat by age group for two quarters. There has been a gradual increase in average weight relative to the age groups for both quarters. For the 0-0+ age group the average weight is lowest and for the group 4-4+ the highest average weight is observed.

The average weights by age in the 3rd and 4th quarters were similar, with a significant increase in the age group 4-4+years (**Fig.3.5.1**).

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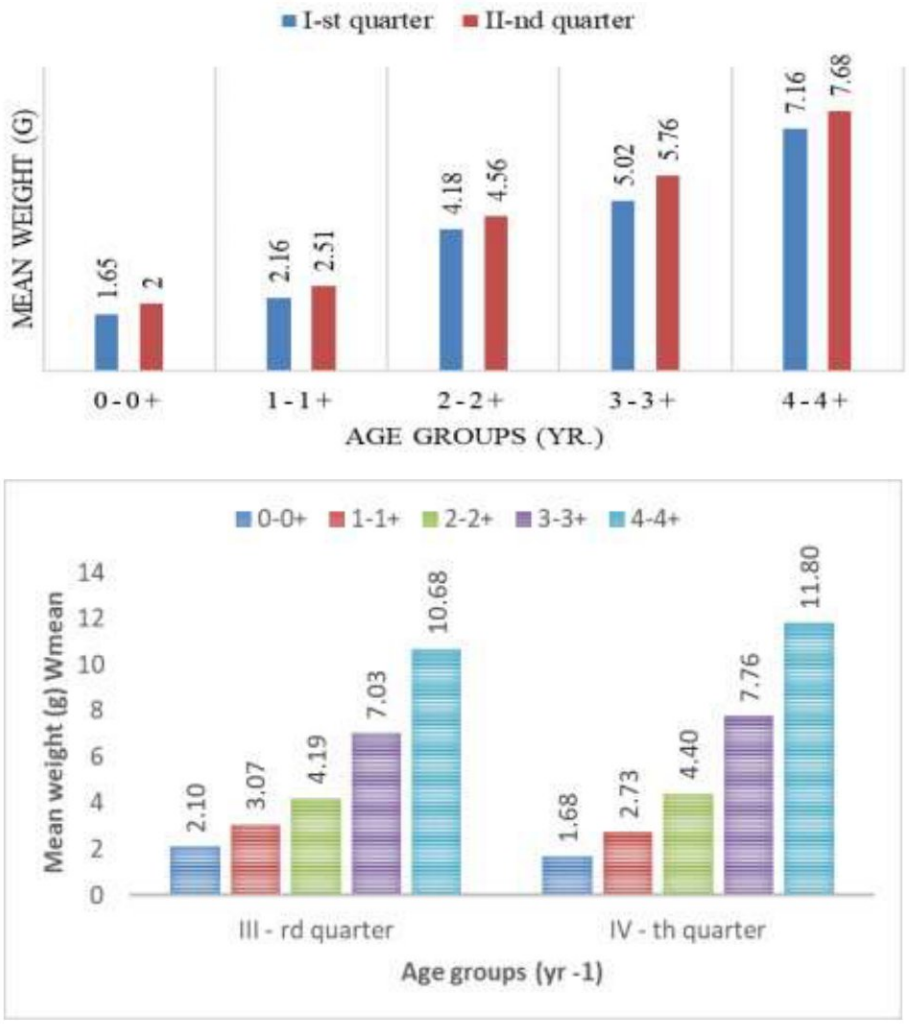

Fig.3.5.1 Distribution of the average weight of sprat by age groups.

I.3.6 Size structure of sprat by age group

Size was measured of **1250 specimens**. The graph shows the distribution of the size classes of sprat relative to the age groups. There has been a gradual increase in average length values relative to the age groups for both quarters. The lowest value for average length is in the age group 0-0+, and the highest is in the group 4-4+ years.
The average age sizes in the 3rd and 4th quarters were similar, with significant increases in the largest size groups: 11.75cm (3rd quarter) and 12.25cm (4th quarter). (**Fig.3.6.1**).

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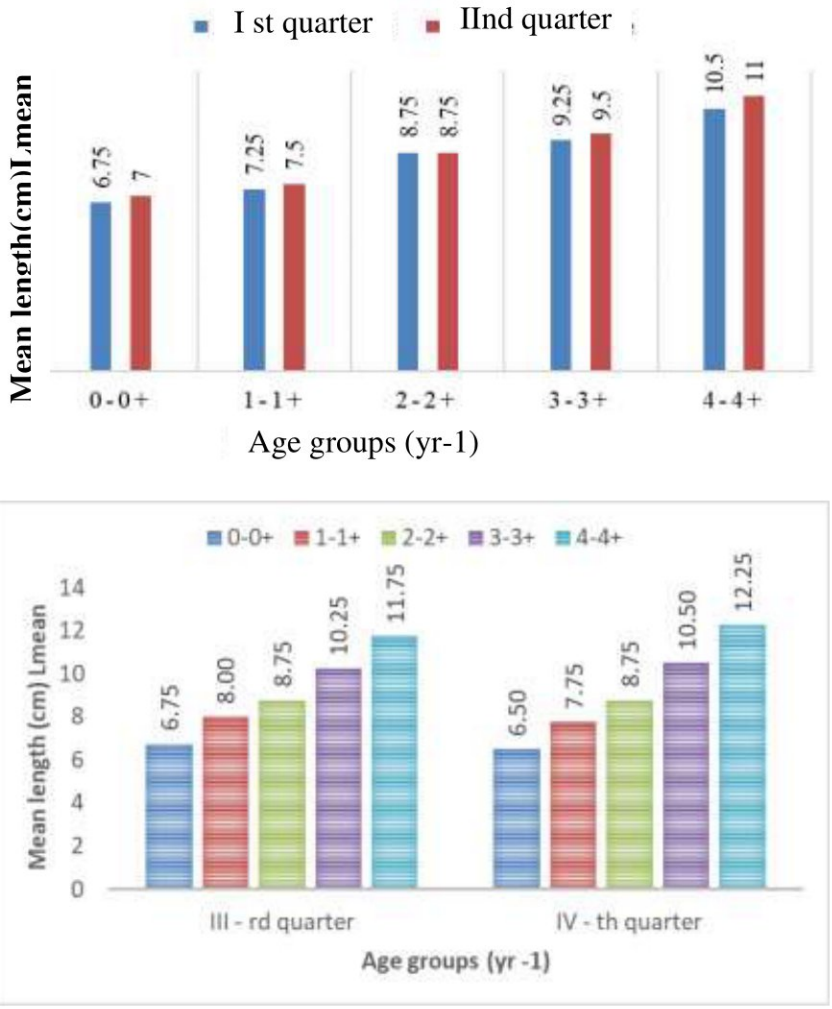

Fig.3.6.1 Mean length by age groups.

I.3.7 Length- weight relationship

The connection is exponential and completely in sync with the theoretical analytical model. The coefficient of allometry b is significantly greater than 3, which indicates positive allometry or the type indicates high weight growth rates with the increase in length in the first quarter of 2022. In the second quarter of 2022, the length-weight relationship of the sprat is described with the highest accuracy of approximation with a straight pattern, which is an indication that, as the length increases, the species increases proportionally and in weight.

The relationship is exponential and fully in sync with the theoretical analytical model. The allometry coefficient b is close to 3 for the third quarter and > from 3 for the fourth, indicating positive allometry or the type shows high rates of weight increase with the increase in length in the fourth quarter of 2022.

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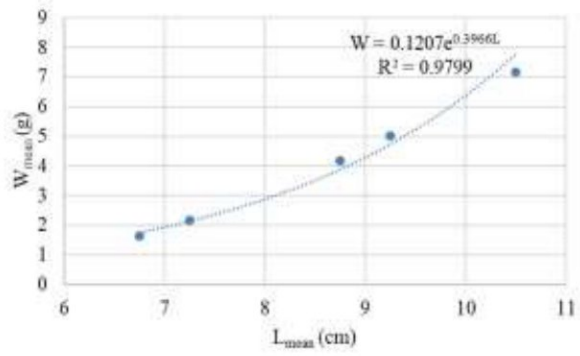
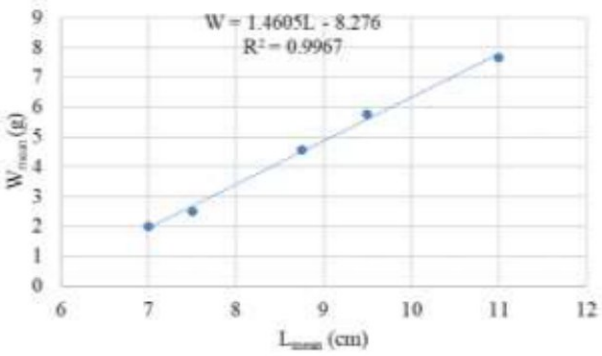


a



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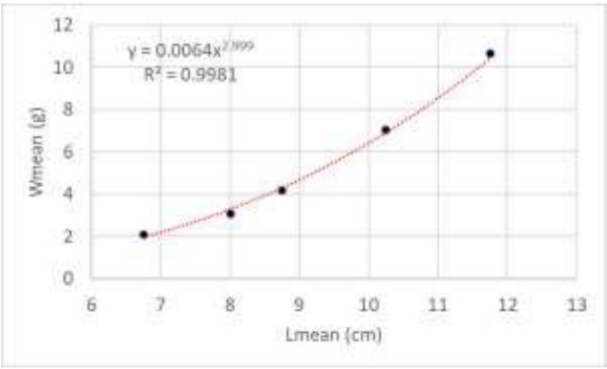
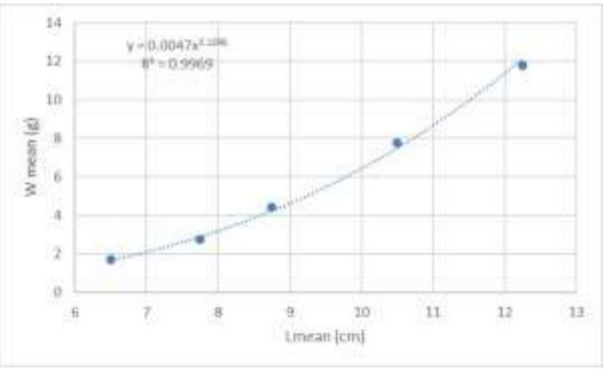


c



d

Figure 3.7.1 Length-weight relationship for the 1st quarter **(a)**, 2nd quarter **(b)** 3rd quarter **(c)** 4th quarter **(d)** of 2022.

I.3.8 Sex ratio

The sex ratio was determined of **350 individuals**. The ratio of males to females in the first quarter was 46%:54%. In the second quarter, the ratio was 41%:59% male to female.

The sex ratio in the 3rd and 4th quarter in males♂ was 34% and 64% (2% juvenile forms), i.e. there is almost a double increase. In females♀, the increase from 3 to 4 th quarter is less than 45 to 55%.

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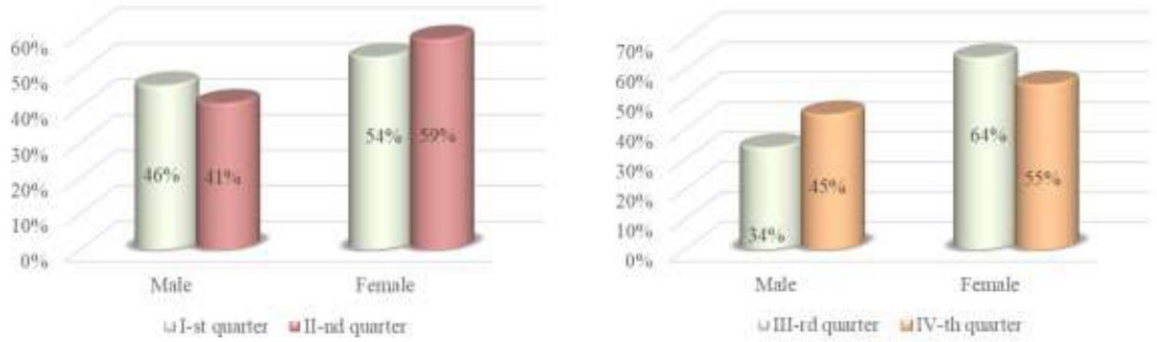
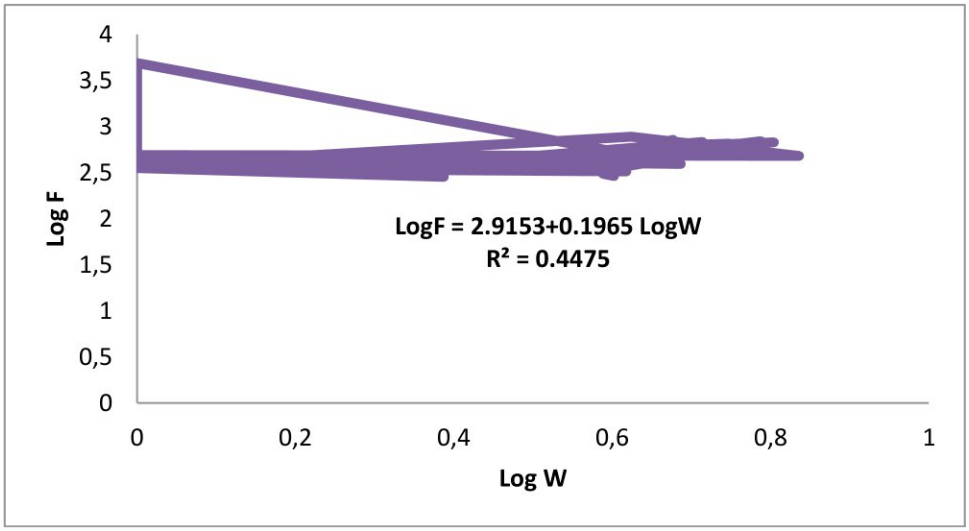


Fig.3. 8.1 Sex-ratio distribution of sprat.

I.3.9 Fertility

Fertility was determined on **500 specimens**. Batch fecundity (Log F) plotted vs. Sprat Length (Log L) show weak relation (R^2=0.4475 which prove weak dependence of fecundity on the individual sizes.



Proportional fertility (Log F) versus sprat weight (Log W) show a very strong relationship (R^2=0.99) which proves a very strong dependence of fertility on individual weights.

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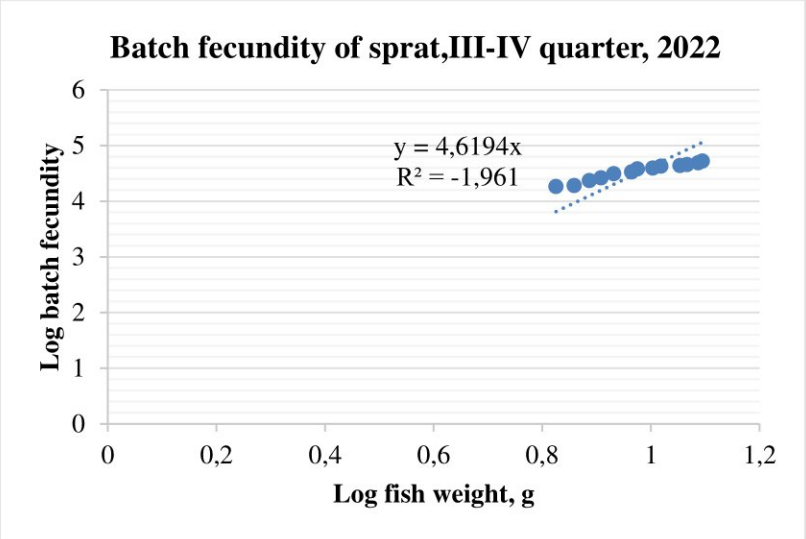
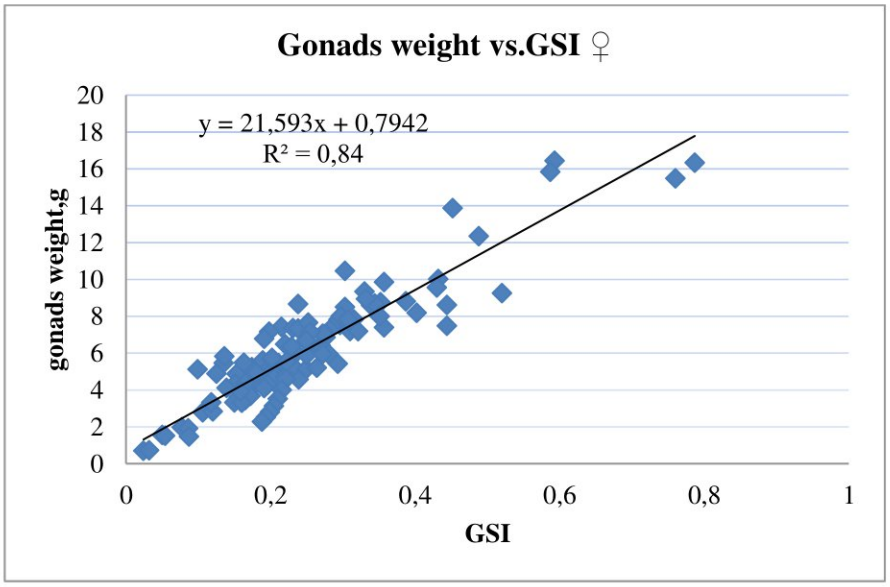


Figure 3.9.1 Batch fecundity (Log F) vs. sprat weight (Log W).

Very strong relation between GSI and weight of sprat (R^2 = 0.84). This fact clearly speaks that sprat is in active maturation.



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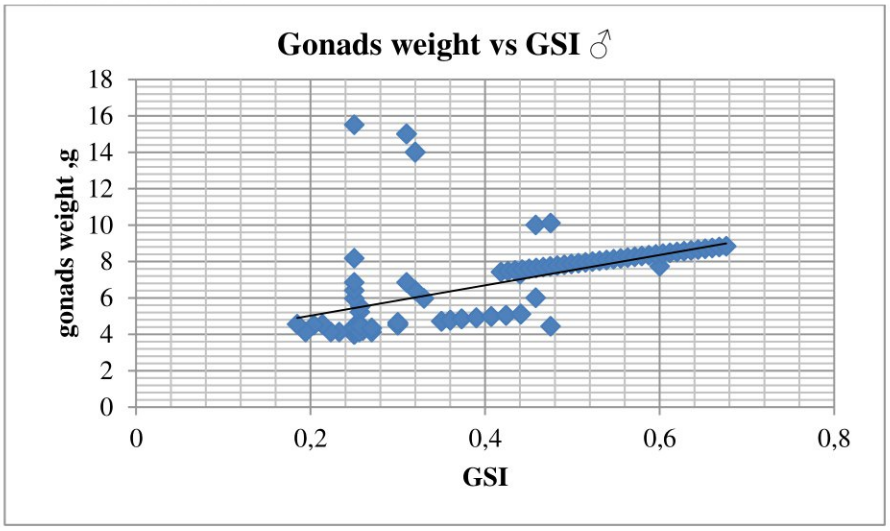
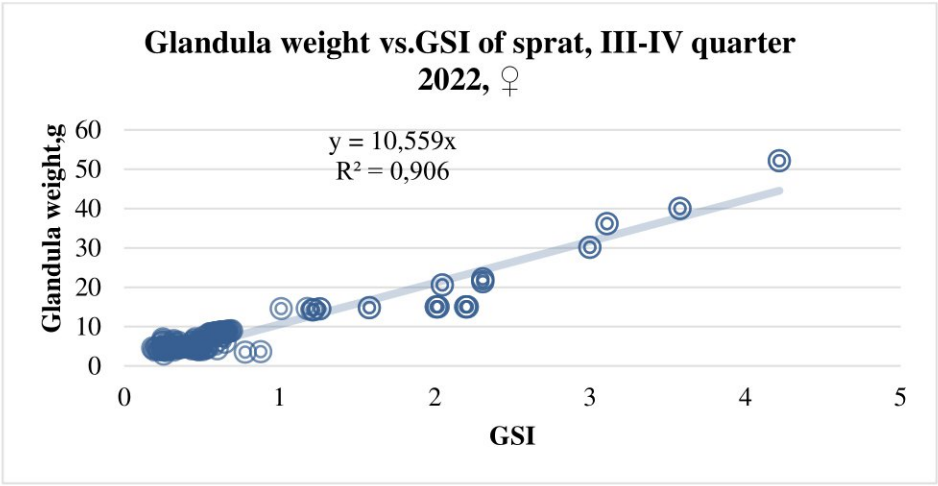


In III-IV quarter 2022, the relationship between the weight of the gonads and the gonadosomatic index was very good (R^2=0.96), which clearly shows that the active maturation of the gonads has begun, i.e. mass individuals are in the process of breeding **(Fig. 3.9.2).**



In males, the relationship between the weight of the gland to the GSI is also very strong with a deterministic rate of R^2 = 0.93.

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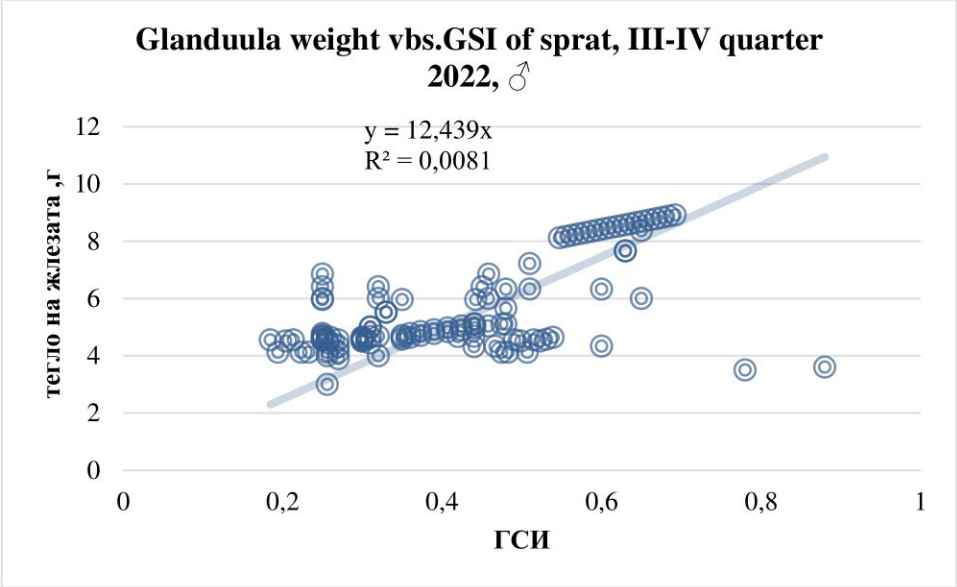

Figure 3.9.2 Dependence of gland weight on gonadosomatic index (GSI) for ♀♂.

For both sexes of the sprat, it is obvious that they are in an active phase of reproduction and partial discharge of the sexual products.

On table 3.9.1 were described the absolute and relative fecundity of the sprat with mean lengths and weights. Mean value of the absolute fecundity was estimated 35529 caviar grains. The average value of the relative fecundity was 3344.

Table 3.9.1 Absolute and relative fecundity of the sprat.

		I-VI			
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)♀**
6	1,29	6,08	na		9
6,5	1,61	6,61	16100	2435,7035	15
7	1,92	7,12	17995	2527,3876	44
7,5	2,36	7,63	22680	2972,4771	60
8	2,81	8,1	24500	3024,6914	58
8,5	3,70	8,54	28440	3330,2108	61
9	4,62	9,15	32661	3569,5082	77
9,5	5,12	9,4	35850	3813,8298	75
10	5,66	10,08	38200	3789,6825	58
10,5	6,93	10,39	41000	3946,102	27
11	8,27	11,055	40210	3637,2682	6

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11,5	9,05	11,55	41225	3569,2641	6
12	10,76	12,08	42090	3484,2715	3
12,5	13,40	12,44	41950	3372,1865	1
			average	**average**	
			35529	**3344,0449**	**500**

VII-XII					
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)♀**
6	1.15	6.22	na		10
6,5	1.45	6.69	18250	12,586	15
7	2.12	7.23	19023	8,973	25
7,5	2.55	7.71	23456	9,198	25
8	3.24	8.1	26111	8,059	25
8,5	3.66	8.55	31123	8,504	25
9	4.34	9.22	33456	7,709	25
9,5	4.88	9.45	37800	7,746	25
10	5.23	10.09	39234	7,502	25
10,5	5.45	10.44	42568	7,811	25
11	6.25	11	43567	6,971	6
11,5	8.35	11.66	45222	5,416	6
12	9.03	12.23	48900	5,415	1
12,5	10.1	12.45	52300	5,178	1
			average	**average**	
			35462.31	**7,77446**	**239**

I.3.10 Sexual maturity

600 specimens were examined to determine sexual maturity. The degree of sexual maturity of the sprat by size groups for the period January-March is presented in **Fig. 3.10.1.** The predominant stage of maturity of the sprat is IV-V (actively breeding), as the oldest groups have stage VI-II of sexual maturity (3 years).

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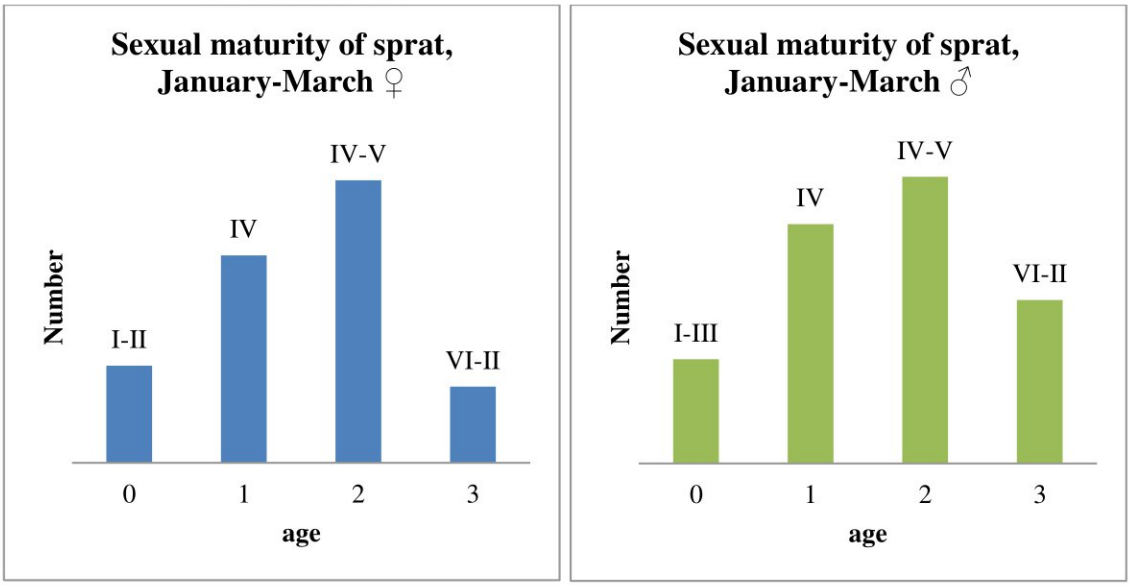
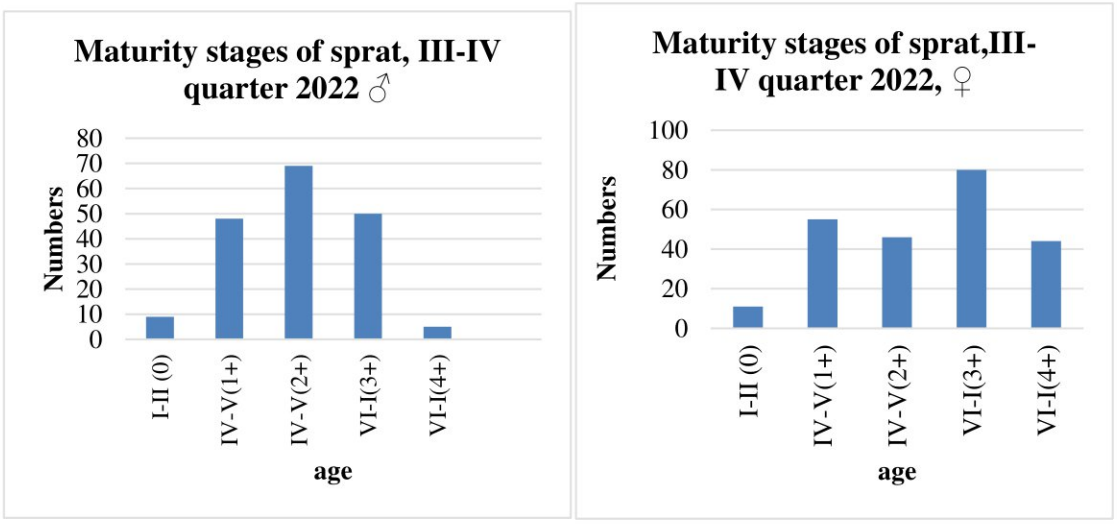


a



b

Figure 3.10.1 Sex maturity by age – females ♀ and males ♂ for I-VI**(a)** и VII-XII**(b)** quarter.

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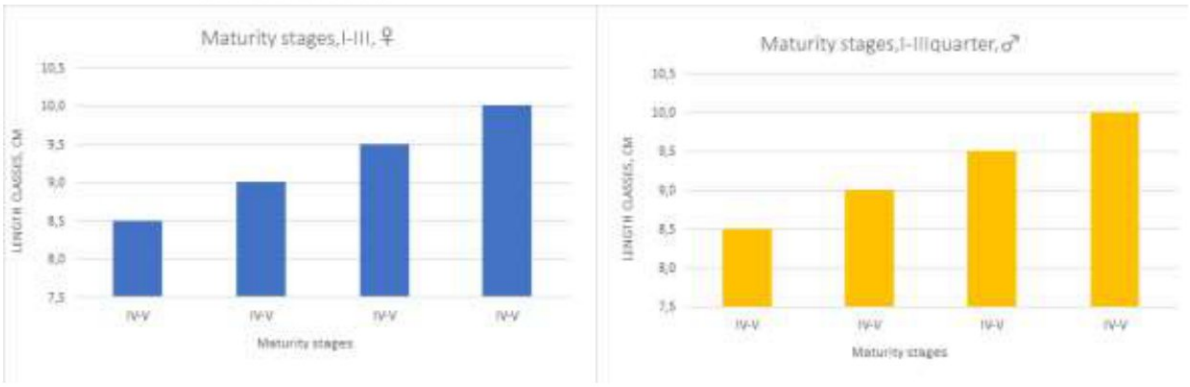
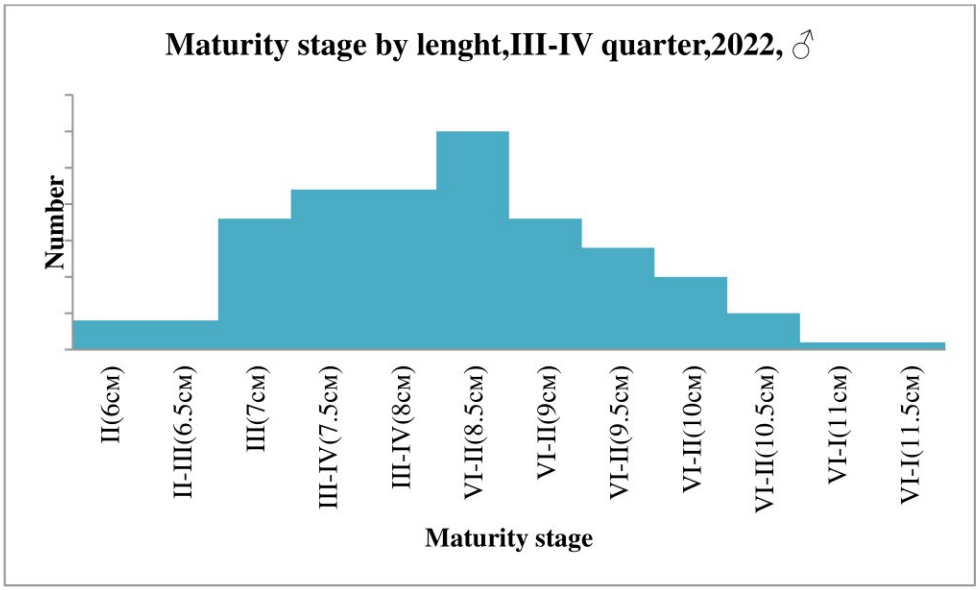


Figure 3.10.2 Sex maturity by length(cm) –females ♀ and males ♂for I-IIIquarter.

In males males and females, the degree of maturity showed that those measuring 6-7 cm possess non-mature glands in phase II¬¬ III. Individuals measuring 8.5 to 10.5 cm in November 2022 had fully mature glands (VI-II), which indicates a massive, active reproduction of the species during the period under review. In individuals of size classes 11-11.5cm, the glands were flowing in degree of maturity VI-II **(Fig.3.10.2).**



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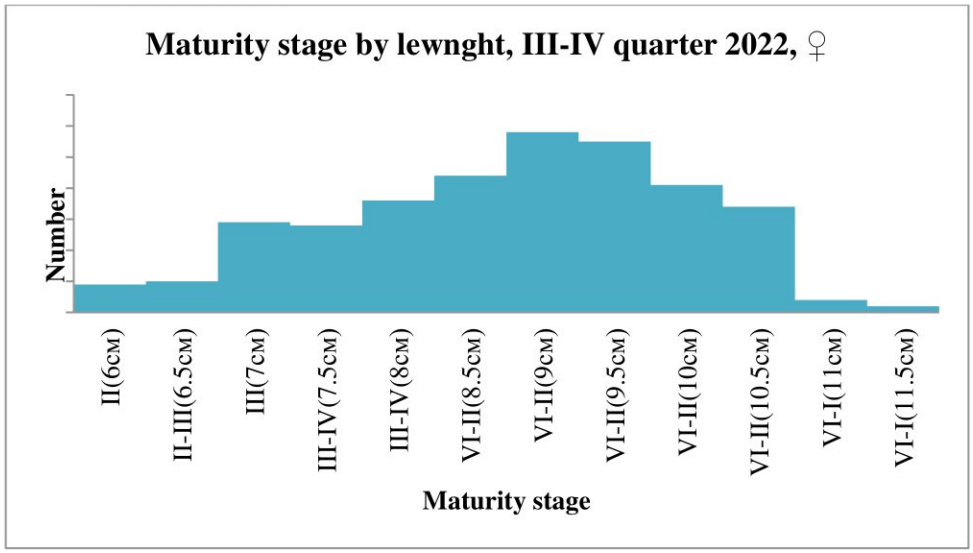

Figure 3.10.3 Sex maturity by length(cm) –females ♀ and males ♂ for III-IVquarter .

I.3.11 Catch numbers and biomass by age and length

Monthly catches (in tonnes) together with mean weights of sprat were used to derive the monthly catch numbers. The share (%) by age groups and catch numbers were used to create catch-at-age matrix for selected months by age groups **(Table 3.11.1).**

Table 3.11.1 Catch at length (10^{-6}) and catch at age (10^{-6}) matrix and biomass (kg) of sprat.

Length classes (см)	Catch in numbers *10-3			Biomass (kg)		
	Ist quarter	IInd quarter	Total	Ist quarter	IInd quarter	Total
6.5	3158.93	0.00	**3158.93**	4264.56	0.00	**4264.56**
7	7185.33	7392.78	**14578.11**	14298.81	17668.75	**31967.56**
7.5	3344.75	22926.58	**26271.33**	8529.12	66257.81	**74786.93**
8	7656.95	41475.94	**49132.89**	26339.92	141349.99	**167689.91**
8.5	4971.44	65310.80	**70282.25**	18563.37	265031.24	**283594.61**
9	3943.59	29706.90	**33650.49**	18061.66	172270.31	**190331.96**
9.5	2354.78	34399.33	**36754.12**	12291.96	194356.24	**206648.20**
10	2845.18	29650.18	**32495.36**	17810.80	189939.05	**207749.86**
10.5	1457.88	41918.10	**43375.97**	10786.82	304785.93	**315572.75**
11	671.94	13279.37	**13951.30**	5267.98	106012.50	**111280.48**
11.5	0.00	9637.09	**9637.09**	0.00	75092.18	**75092.18**
Age groups (yr)	**Catch in numbers *10^{-3}**			**Biomass (kg)**		
	Ist quarter	IInd quarter	Total	Ist quarter	IInd quarter	Total
0-0+	10196.05	4417.19	**14613.23**	16807.38	8834.37	**25641.75**

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1-1+	4414.64	10560.24	**14974.88**	9532.54	26503.12	**36035.67**
2-2+	10310.81	142354.00	**152664.81**	43147.29	649326.54	**692473.83**
3-3+	11232.79	111916.38	**123149.17**	56442.68	644909.35	**701352.03**
4-4+	1436.50	26449.25	**27885.75**	10285.11	203190.62	**213475.73**

Length class (cm)	**Catch number by lenght *10^{-3}**			**Biomass (kg)**		
	3rd trimester	**4th trimester**	**Total**	**3rd trimester**	**4th trimester**	**Total**
6,5	392,288	0	392,288	0,392288	0	0,392288
7	1373,00789	68,2909091	1441,298799	1,37300789	0,068290909	1,441298799
7,5	4511,31164	250,4	4761,711637	4,511311637	0,2504	4,761711637
8	17849,1026	523,563636	18372,6662	17,84910256	0,523563636	18,3726662
8,5	22556,5582	682,909091	23239,46728	22,55655819	0,682909091	23,23946728
9	22752,7022	500,8	23253,50217	22,75270217	0,5008	23,25350217
9,5	15691,5187	204,872727	15896,39146	15,69151874	0,204872727	15,89639146
10	11572,4951	136,581818	11709,07689	11,57249507	0,136581818	11,70907689
10,5	1765,29586	68,2909091	1833,586767	1,765295858	0,068290909	1,833586767
11	784,575937	45,5272727	830,1032096	0,784575937	0,045527273	0,83010321
11,5	196,143984	22,7636364	218,9076206	0,196143984	0,022763636	0,218907621
Age groups (yr)	**Catch number by age *10^{-3}**			**Biomass (kg)**		
	3rd trimester	**4th trimester**	**Total**	**3rd trimester**	**4th trimester**	**Total**
0-0+	7971,54309	169,837989	8141,381075	13,9223	0,318690909	14,24099091
1-1+	14689,574	448,302886	15137,87692	42,76135	1,206472727	43,96782273
2-2+	7280,01464	221,375585	7501,390227	31,8224	0,728436364	32,55083636
3-3+	1478,73606	43,6618214	1522,397881	7,9556	0,182109091	8,137709091
4-4+	408,119015	9,32935917	417,4483742	2,98335	0,068290909	3,051640909

I.3.12 Conclusions

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

1) January has the lowest value in terms of catches and landings. Landings were significantly higher and exceeded 600.00 t in May, the highest value in 1st six months. In comparison, the winter season is weaker than the spring season in terms of value. Catches in the 3rd quarter exceed those of the 4th quarter. Catches with OTM in July predominate. This is followed by a drastic drop in August and catches are very low in the following months, with no sprat catches in November.
2) For the first quarter, the classes with a length of 6.5 cm and 11 cm have the lowest value of the catch - below 5%. Classes in the range of 7 cm to 10.5 cm occupy a relatively higher

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percentage of landings - from 5% to 20%, respectively. For the second quarter, the lowest percentage is the 7 cm size class, and the highest is the 10.5 cm class. The remaining classes fall between 5% and 15%. In the 3rd quarter, size class 9.5 cm predominates followed by size class 10 cm and 10.5 cm. In the 4th quarter, a maximum was recorded at 11 cm, followed by 11.5 cm. The remaining size classes had a subordinate role in catches.

3) The first quarter the highest value of the condition coefficient is for size classes 9 cm and 10.5 cm. The lowest value of the condition coefficient is for the size class 6.5 cm. For the second quarter, the conditioning coefficient was highest in the 9 cm size class and lowest in the 11.5 cm size class. For others, it is roughly similar in values between 0.50 and 0.67.We report the best condition in the 3rd trimester in size class 6.5 cm (K = 0.77). In the 4th quarter, the condition factor did not show significant fluctuations and was within the range of 0.46-0.68. A sharp decline in condition in the 4th was observed at the 7 cm size class (K=0.46).

4) Fulton's factor by age group is relatively evenly distributed for both the first and second trimesters. In the first quarter, the highest values are for the age groups 2-2+ and 3-3+, and the lowest are around 0-0+, which is also maintained in the second quarter. By age, in the 3rd quarter, we recorded the highest value in the 0+ year olds (K=0.68). In the other age groups, the coefficient varied from 0.6 to 0.66. In the 4th quarter, the coefficient values are similar, but the condition of the 0+ year olds drops sharply.

5) In the first quarter, the highest percentage - 40% - is occupied by individuals in the age group 3-3+, followed by 2-2+. With the lowest value - about 5% are the age groups: 1-1+ and 4-4+. The second quarter shows that the age groups 2-2+ and 3-3+ have the same share - 40% and significantly prevail over the others. Less than 5% are the age groups 0-0+ and 1-1+. This quarter we are seeing an increase in older fish compared to previous.

6) There is a smooth increase in average weight by age group for both trimesters. For the age group 0-0+ the mean weight was the lowest and for the group 4-4+ the highest mean weight was observed.

7) Average weights for age in the 3rd and 4th trimesters were similar, with a significant increase recorded in the 4-4+ year age group.

8) The relationship between gland weight and GSI of male sprats shows a linear negative trend with a good coefficient of determination (R^2= 0.83). There is a smooth increase in the values of the average length in relation to the age groups for both quarters. The lowest value of the average length is in the age group 0-0+, and the highest is in the group 4-4+ years.

9) The ratio of male to female individuals in the first quarter is 46%:54%. In the second quarter, the ratio was 41%:59% male to female. The sex ratio in the 3rd and 4th trimester in male ♂ is 34% and 64% (2% juvenile forms), i.e. there is almost a double increase. In females, the increase from the 3rd to the 4th trimester is less than 45 to 55%.

10) The male specimen of the studies during the first six months showed a weak correlation between the weight of the gonads and the Gonado somatic index. In the III-IV quarter, 2022, the relationship between the weight of the gonads and the gonadosomatic index was very good (R^2=0.96), which clearly indicates that the active maturation of the gonads has begun, i.e. mass individuals are in the process of reproduction.

11) The GSI as a measure of sexual maturity indicates that sprat in the period January-June 2022 were at relatively good maturity (female), which corresponds to the end of the season of active maturation of the species (January-March).

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12) Average absolute fecundity was estimated at 35,529 spawn. The average value of relative fertility is 3344.16. The mean absolute fecundity was estimated at 3,35,462 spawners. The average value of relative fertility is 7.7744.

13) A large part of the individuals have stage IV-V gonads in females and males. The latter show maturation stage VI-II at age 3-3+y^{-1}. The predominant maturity stage of trizona is IV-V (actively breeding), as the oldest groups have VI-I stages of sexual maturity (3-4 years in females and 3-3+ years in males).

14) In male and female individuals, the degree of maturity showed that those measuring 6-7 cm possessed immature glands in phase II¬III. Individuals measuring 8.5 to 10.5 cm size classes in November 2022 had fully mature glands (VI-II), which indicates massive, active reproduction of the species during the considered period. In the individuals of size classes 11-11.5cm, the glands were flowing at maturity stage VI-II.

15) The relationship is exponential and completely in sync with the theoretical analytical model. The allometry coefficient b was e close to 3 for the third quarter and > of 3 for the fourth quarter, indicating positive allometry or the species showing high rates of weight gain with length growth in the fourth quarter of 2022.

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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 2022 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 carried out by the actively operating fishing fleet in Bulgaria.

II.2.1 Geographic area coverage

Data of present analysis were collected from landing ports of Bulgarian Black Sea coast. In 2022, **10 samples with 1664 specimens** were collected and processed. Information on the size of the catches was also collected.

II.2.2 Sampling period

In 2022, the biological data on sprat were collected from a total of **10 landings at the ports of Varna (1), Balchik (1), Kavarna (1), Nesebar (1), Sozopol (3) and Tsarevo (3)**. 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 2.2.1.**

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

	Date	Sampling ports	HMM	Fishing vessel	Fishing gear	Catch, kg	Coordinate	Region
1	3.01.2022	Sozopol	HMM	MEDUZA 3 BS288	OTM	1900	42.392300, 27.966000	south
2	6.2.2022	Tsarevo	HMM	CIKLAMA V AX215	OTM	20	42.170200, 27.848300	south
3	4.3.2022	Tsarevo	HMM	CIKLAMA V AX215	OTM	15	42.101262, 27.505402	south
4	16.4.2022	Tsarevo	HMM	CIKLAMA V AX215	OTM	3	42.170200, 27.848300	south
	V, 2022	-						
5	15.6.2022	Varna	HMM	HERASIMOV MLADSHI VN422	OTM	80	43.366200, 28.386800	north
6	14.7.2022	Balchik	HMM	Korsar 2 VN7643	OTM	18	43.403900, 28.167800	north

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7	16.8.2022	Kavarna	HMM	IVANA KV 6231	OTM	16	43.367000, 28.379500	north
8	12.10.2022	Nesebar	HMM	Kiril 45 BS 280	OTM	45	42.656100, 27.731000	south
9	9.11.2022	Sozopol	HMM	ElektaVN 8042	OTM	50	42.421600, 27.691800	south
10	15.12.2022	Sozopol	HMM	R/K 26 BS 219	OTM	1356	42.422300, 27.691300	south

.

Photo 2.1: Laboratory processing of samples of *Trachurus mediterraneus ponticus.*

II.2.3 Statistical analysis of data

See section statistical analysis of sprat

II.3 Results

II.3.1 Landings statistics

In January, the highest catch with OTM of Black Sea horse mackerel with OTM was realized in the Bulgarian waters of the Black Sea (3024 kg) for the 1st and 2nd quarters **(Figure 3.1.1)**. Catches in the 4th quarter exceeded those of the 3rd quarter. Catches with OTM in November and December predominate.

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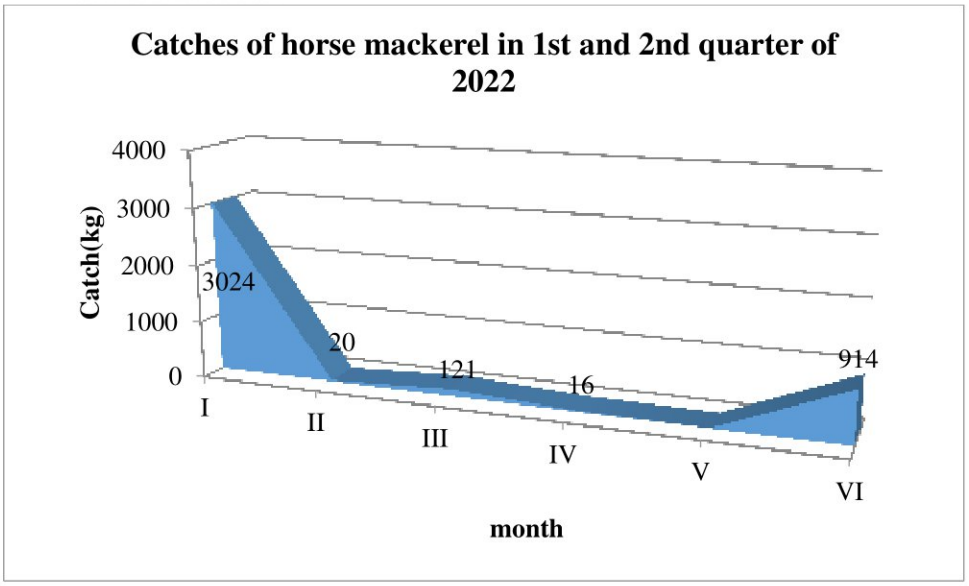

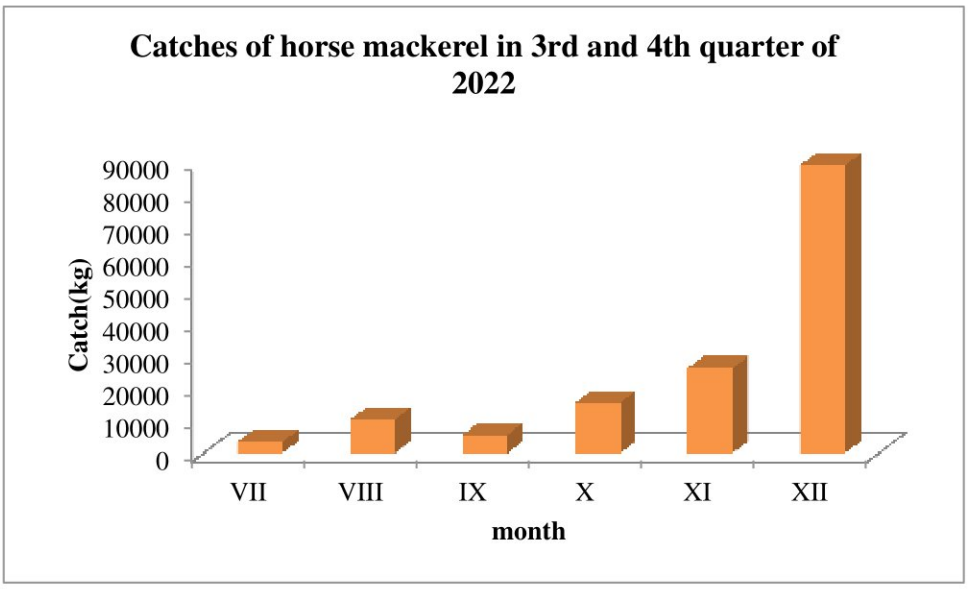

Figure 3.1.1 Official statistics records for horse mackerel landings.

II.3.2 Length structure of landings

The size composition of the captured horse mackerel individuals in 1st and 2nd quarter, covers size groups from 9.5 to 16.5 cm, and the percentage participation of individuals from each size group in the number is presented in **fig. 3.2.1**. From the distribution of fish by size classes for 1st and 2nd quarter, it is found that the least represented size groups are 9.5 cm with 0.199% and 16.5 cm with 0.398%. **Figure 3.2.1** shows that over 13.45% of individuals have

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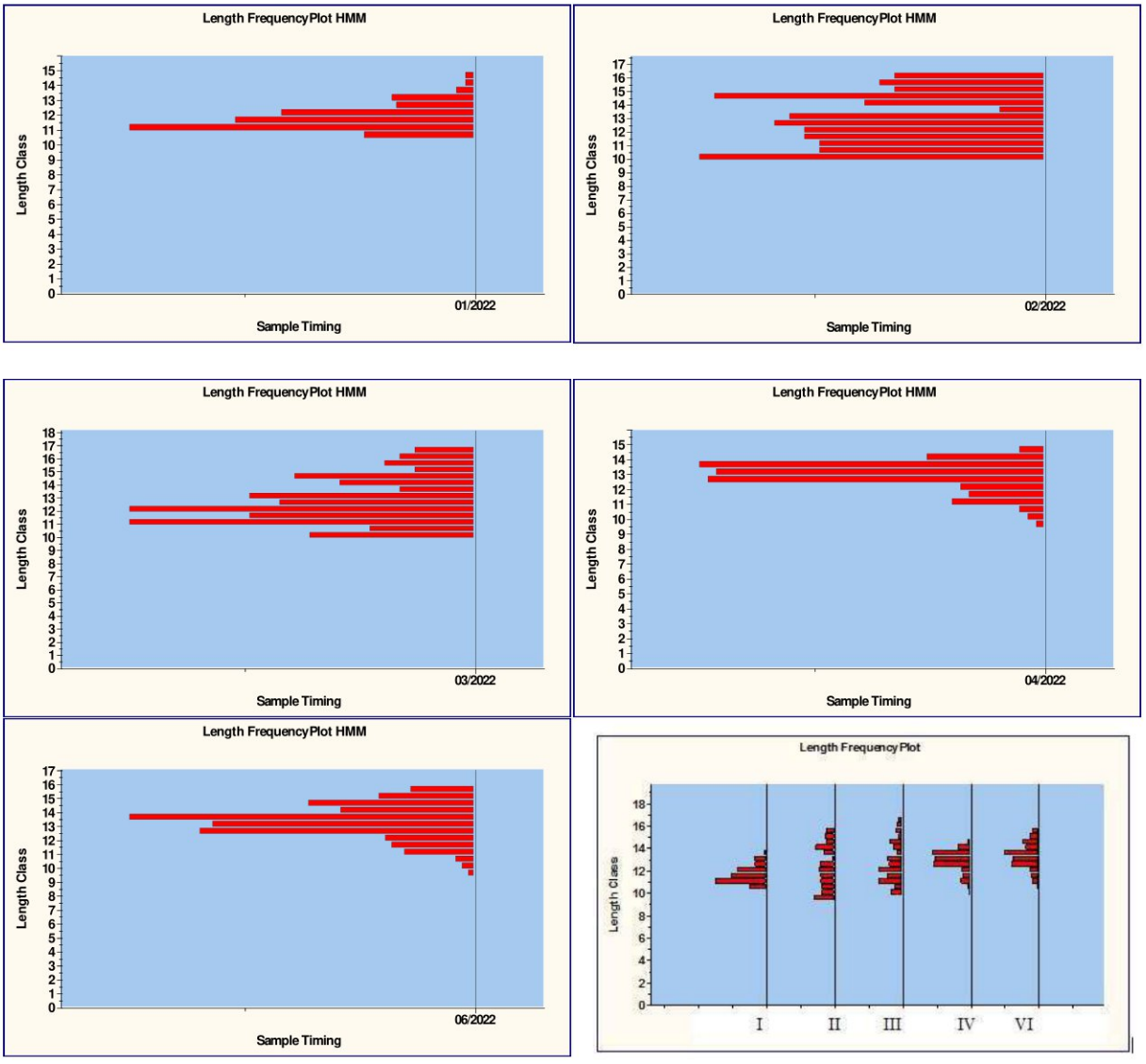
an absolute length of 11 cm and 12.5 cm are represented by 13.5% of the total number of specimens caught.

The size composition of caught safrid individuals in 3rd and 4 th, covering size groups from 8.5 to 16.5 cm, and the percentage participation of individuals from each size group in the number is presented in **fig. 3.2.1.** From the distribution of fish by size classes for 3rd and 4 th quarter of 2022, it is found that the least represented size groups are 16.5 cm with 0.30% and the highest percentage is 13.0 cm with 24.85%.



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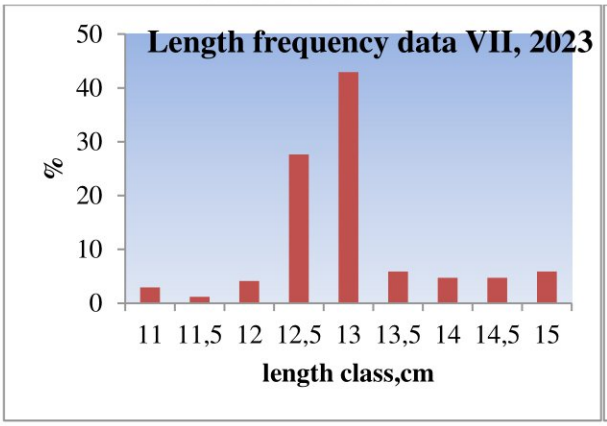

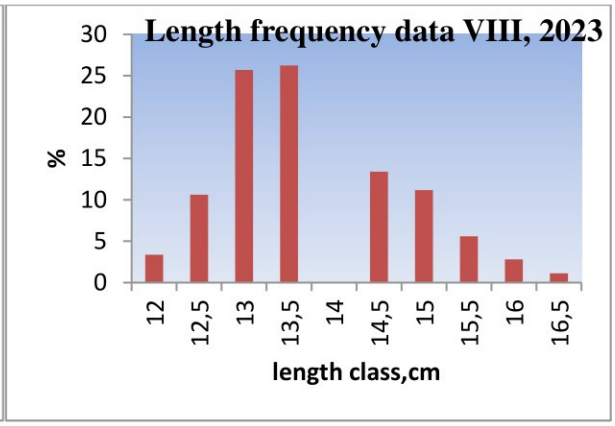

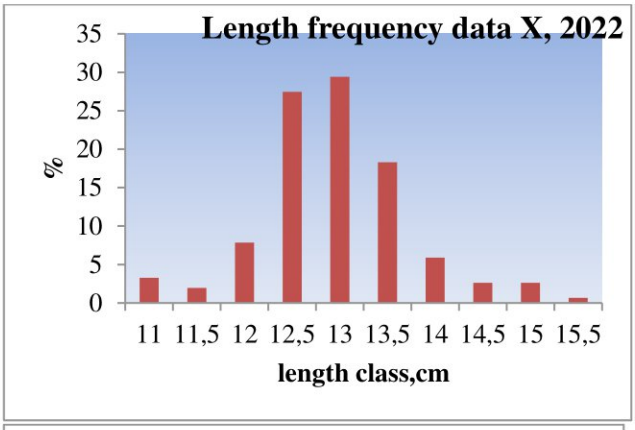

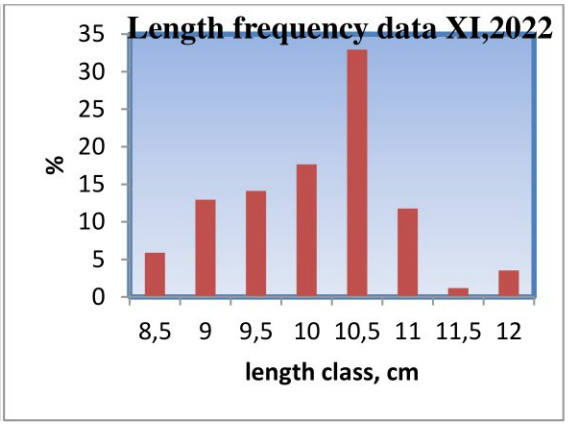

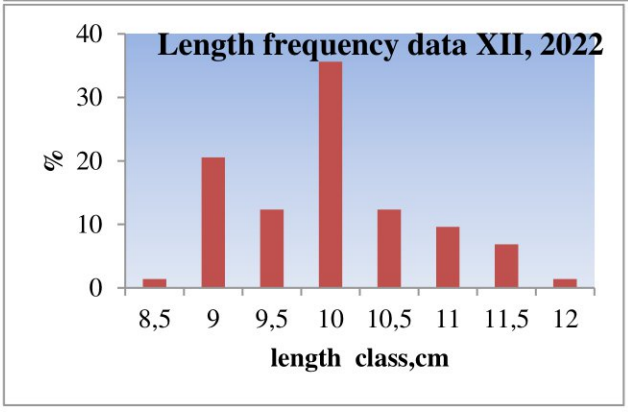

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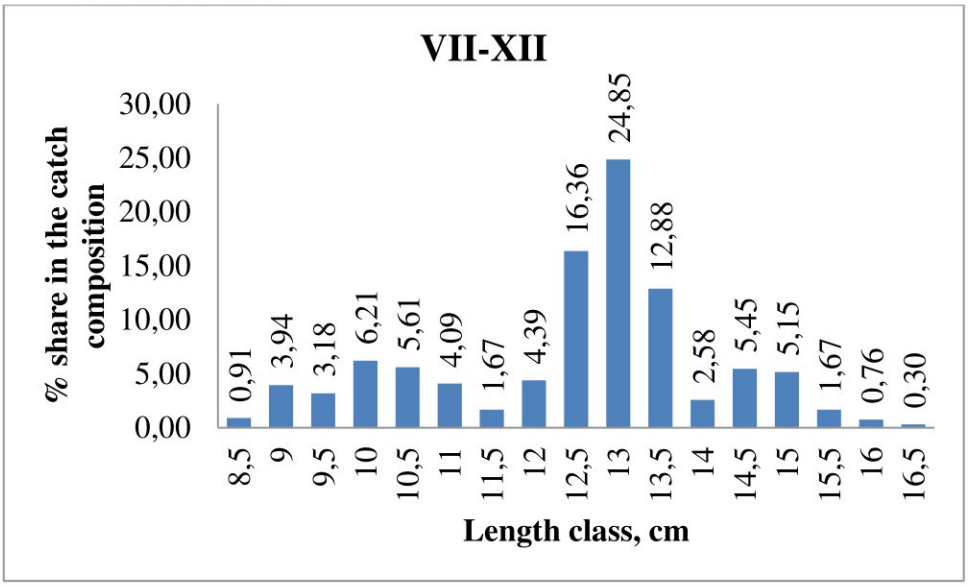

Figure 3.2.1 Histogram of length frequency data of horse mackerel landings.

II.3.3 Age structure of landings

The three readers determined the age of horse mackerel otoliths, and reader 1 read all otoliths twice. Specimens **(n = 1664)** were used for age determination.

The age structure of January and February is formed by 5 and 6 age groups, respectively - 1, 2, 3,4 and 5 (January) and 1, 2, 3, 4,5 and 6 years old (February. In March, a significant participation of one-year-old fish In April, 2- and 3-year-old fish significantly predominate, the participation of 1- and 4-year-old fish decreases.The age structure of horse mackerel caught in the month of June is made up of four age groups: three and four-year-olds have the highest percentage of participation. One-year-old fish have the lowest participation rate - 11.81%.

The age structure from July and November is formed by 5 age groups, respectively -0, 1, 2, 3, and 4 years old. August saw a significant turnout of two-year-old fish. In October and November, the 3-year-olds significantly predominate. The age structure of horse mackerel caught in December is made up of four age groups, with three-year-old fish having the lowest participation rate - 15.07%.

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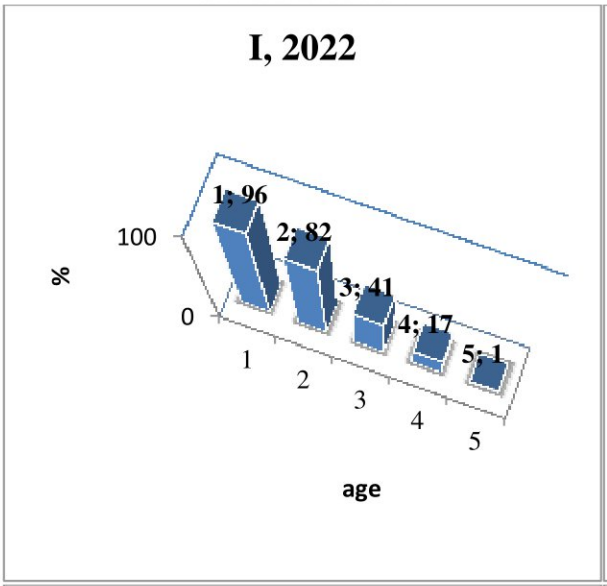

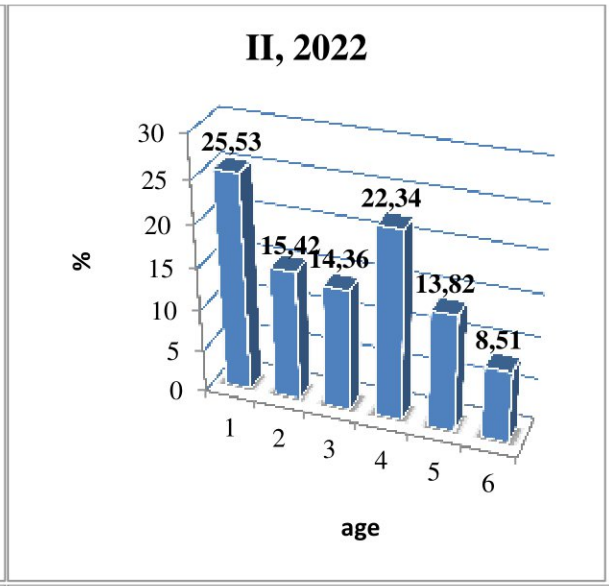

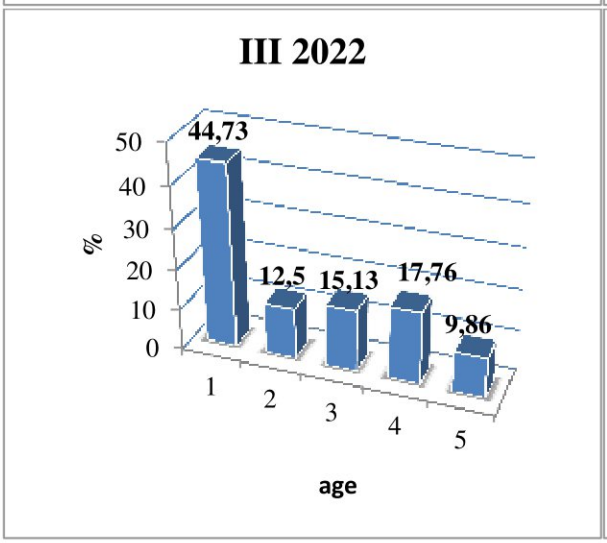

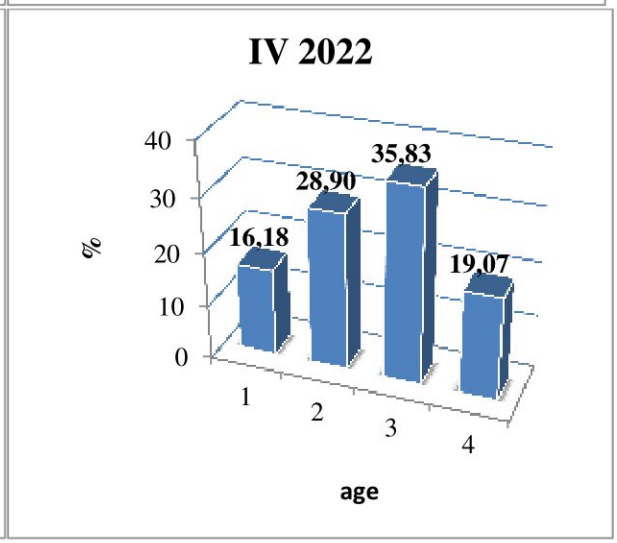

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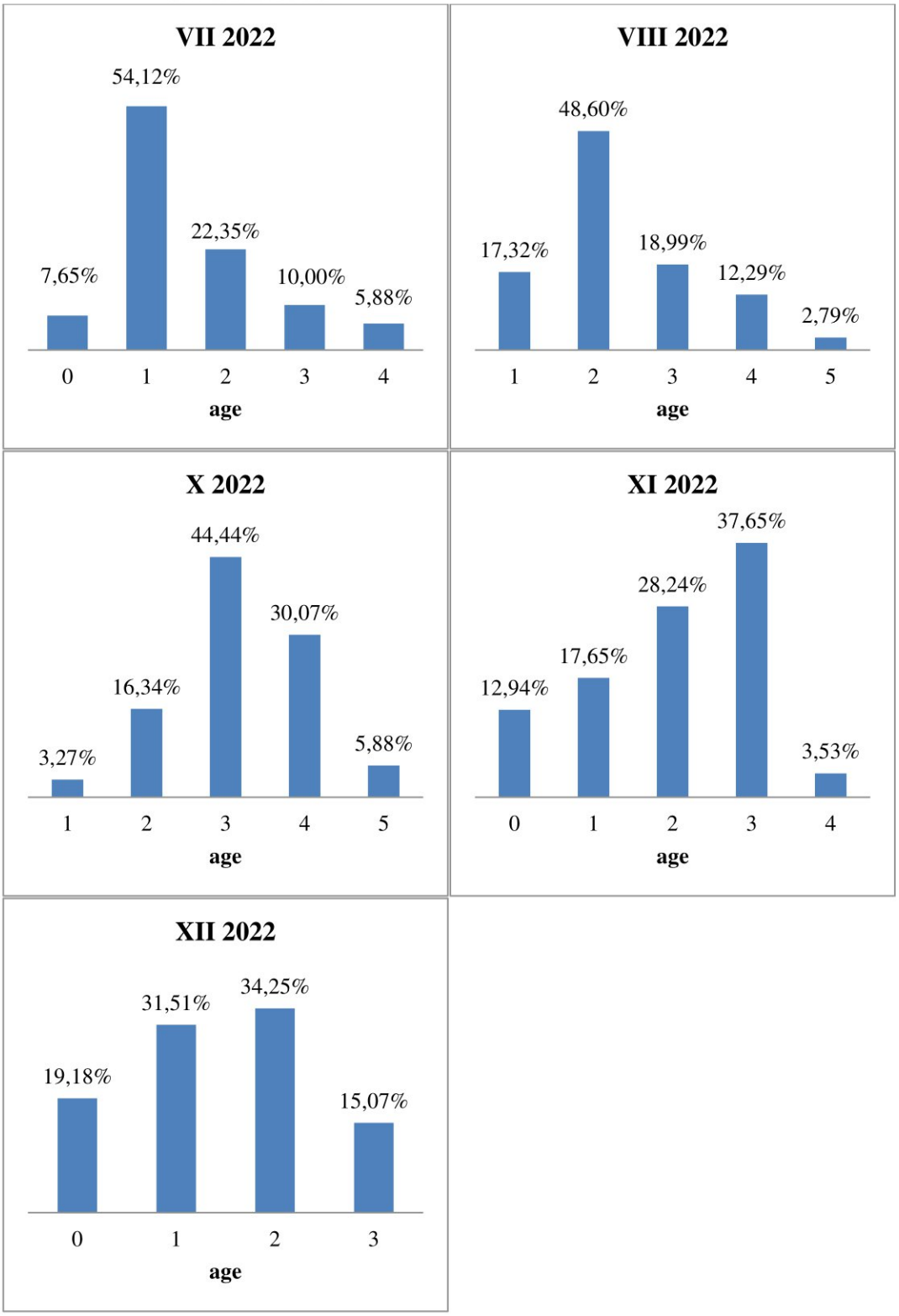

Figure 3.3.1 Age distribution of horse mackerel.

The summary graph for the 1st and 2 nd quarters of 2022 shows a close participation of 1, 2, 3 and four-year-olds as the distribution of age groups is as follows: one-year-old -26.89%, two-year-old- 24.30%, three-year-old- 22.41% and four-year old- 20.61 %. Older age classes are present with a small percentage in the catches of five-year-olds -3.78% and six-year-olds - 1.99%, respectively (**Figure 3.3.2**).
The summarized graph for the 3rd and 4th quarter of 2022, shows a close participation of 1- and 3-year-olds, as the distribution of age groups is as follows: zero-year-olds - 5.76%, one-year-olds - 25.15%, two-year-olds - 30.15%, three-year-olds - 24.55% and four-year-olds - 12.27%. The older age classes are present with a small percentage in the five-year catches, respectively -2.12% (Figure 3.3.2).

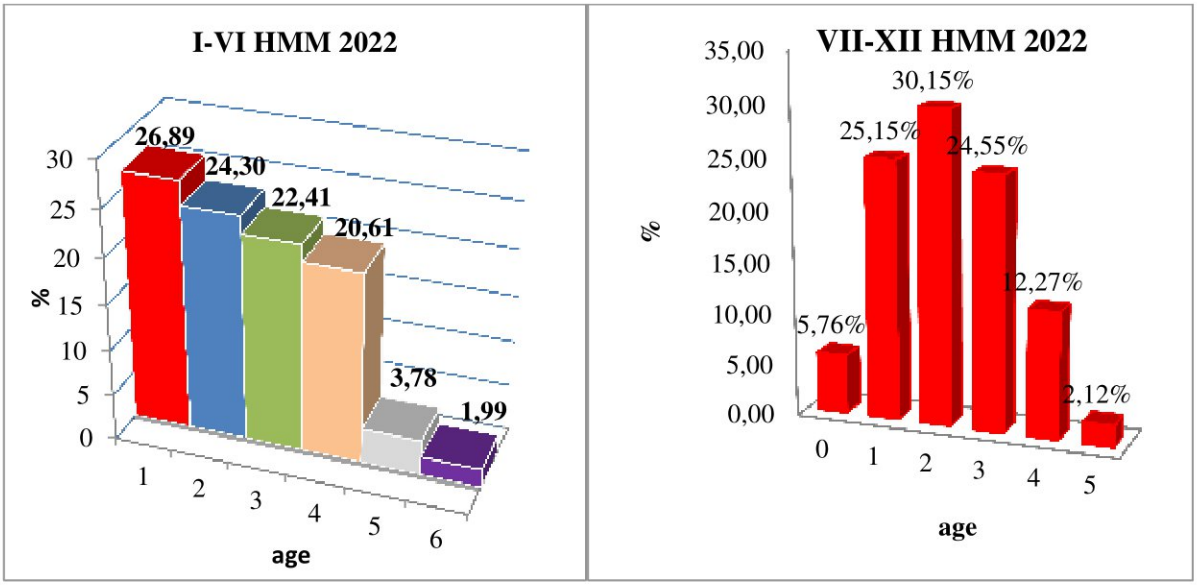

Figure 3.3.2 Age distribution of horse mackerel.

II.3.4 Condition factor

The fluctuation of condition factor by age group shows differences (**Figure 3.4.2**). The highest average values of K in the month of January were registered in the 1-year-old fish (1.025), the 4-year-old fish showed the lowest values (0.737). The Fulton coefficient values in February are the highest in the 1 year (0.832). In the month of June, the highest values were recorded in the individuals belonging to age 4-4+ (1.181), and the lowest mean values of (c.f) were observed in 1-1+ (0.831). The fluctuation of cond. factor by age group shows differences, (**Figure 3.4.2).** The highest average values of K in the month of October were registered in 1-year-old (0.961) and 2-year-old (1.251) fish.

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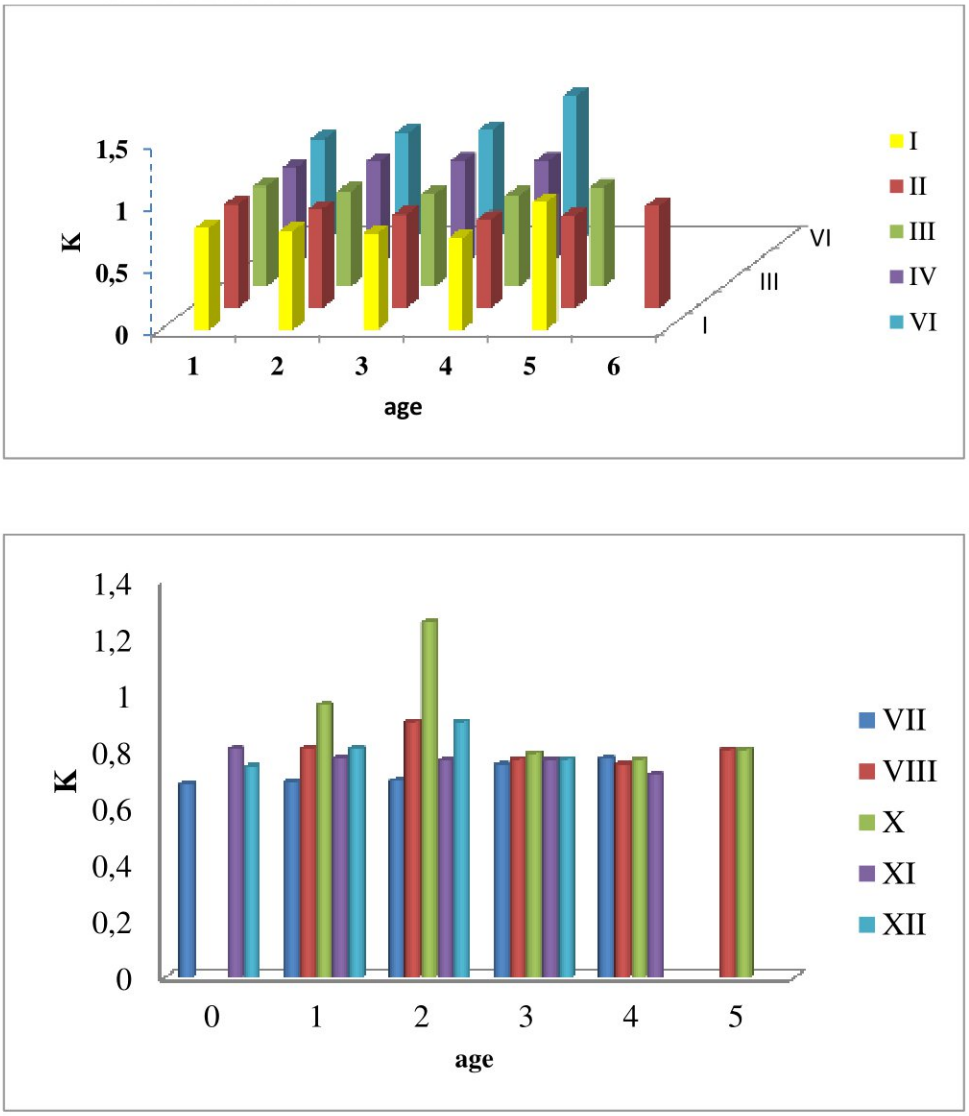

Figure 3.4.1 Condition factor of horse mackerel by age groups.

II.3.5 Weight structure of horse mackerel

The weight was measured on **1664 specimens**. Six-year-old fish in 1st and 2nd quarters of 2022, showed the highest weight, and one-year-old fish showed the lowest weight. Five-year-old fish showed the highest weight in the 3rd and 4th quarter of 2022, and zero-year-old fish showed the lowest weight.

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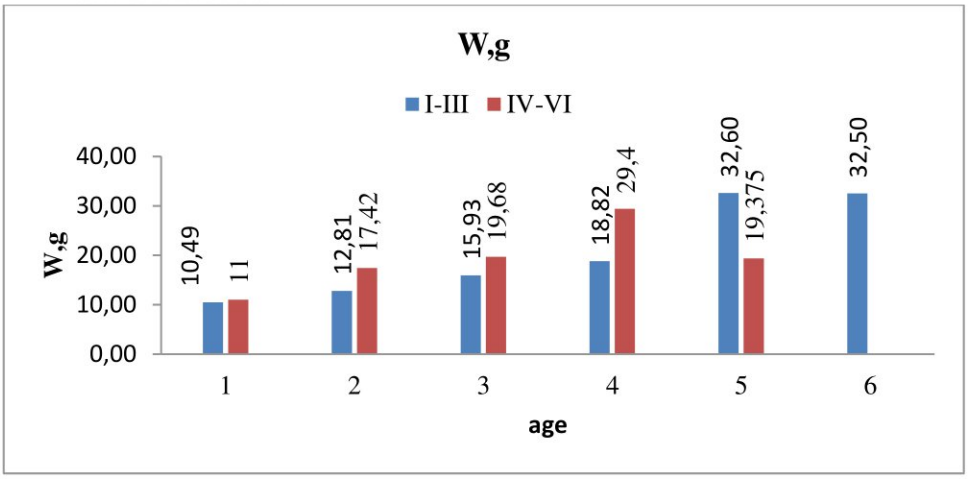

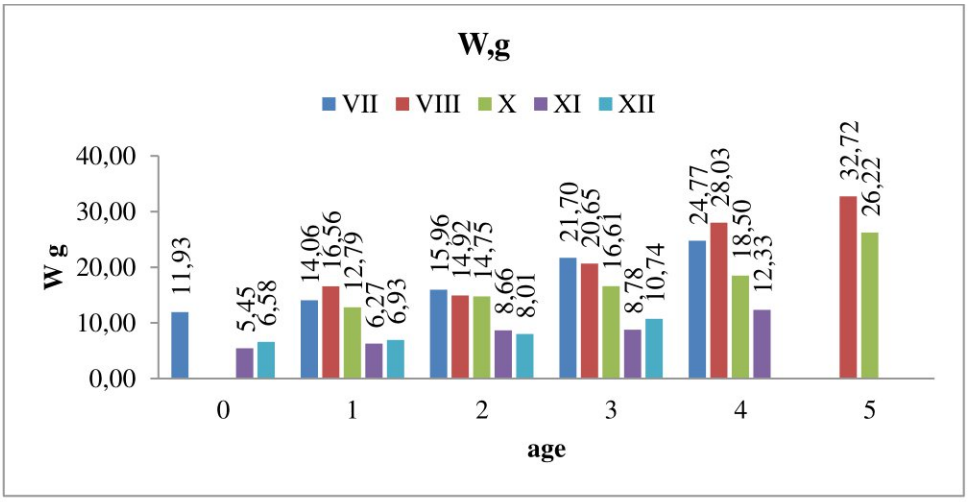

Figure 3.5.1 Average horse mackerel weights by age.

II.3.6 Size structure of horse mackerel by age group

The fish length was measured of **1664 specimens**. The senior age groups show the highest values in terms of average lengths.

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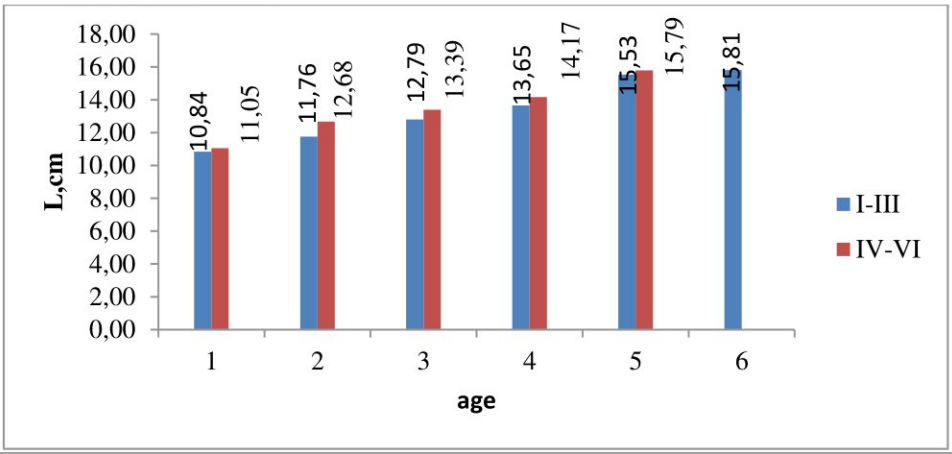

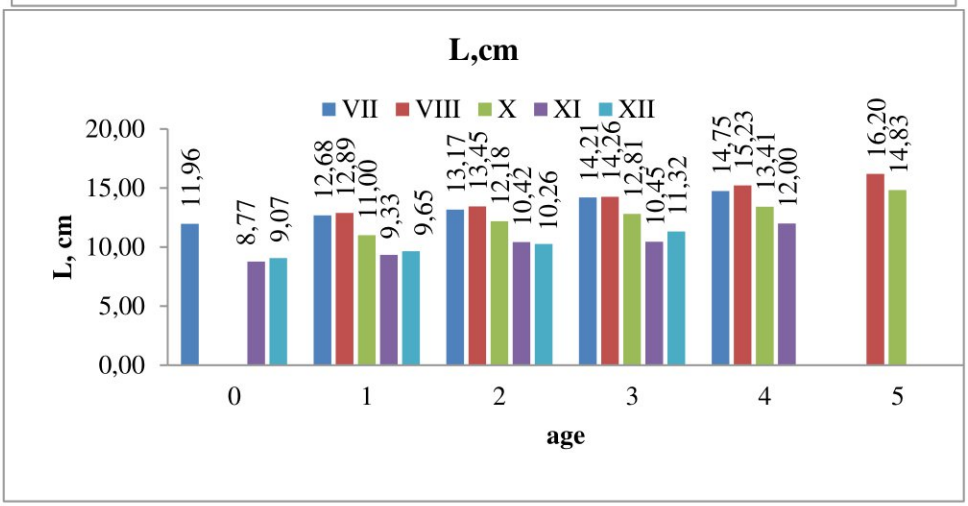

Figure 3.6.1 Average horse mackerel lengths by age.

II.3.7 Length- weight relationship

It follows from the analysis that the growth in the horse mackerel is allometric ($n \neq 3$), i.e. is not the same in terms of linear and weight growth. In all observed cases of horse mackerel growth, it is allometric ($n \neq 3$), as (b = 2.9641) in VII-XII, 2022, the coefficient of allometry approaches a value of 3, an indicator of isometric growth. The results of the modeling of the length-weight relationship are presented in **Table 3.7.1**, and the graphical presentation of the model in **Fig. 3.7.1.**

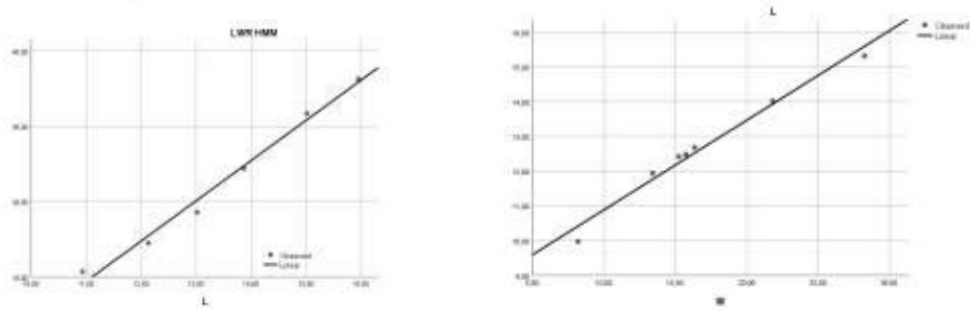

Fig. 3.7.1 Representation of the length-weight model for horse mackerel on a scatter plot.

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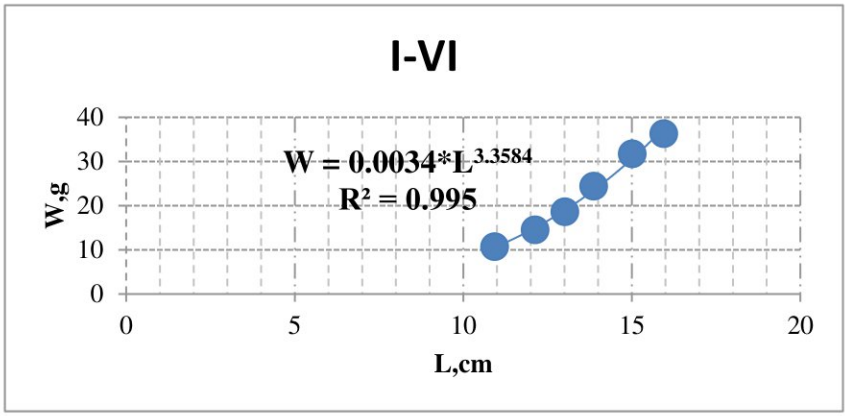
Table 3.7.1 Results of modeling the length-weight relationship.

I-VI, 2022	
	HMM
	LWR model
Parameter estimates a and b	*a=0.0034;* *b=3.3584*
LWR model	$W = 0.0034*L^{3.3584}$
Statistical significance (α=0.05)	*R=0,993* R^2*=0,985*

VII-XII, 2022	
	HMM
	LWR model
Parameter estimates a and b	*a=0.0087;* *b=2.9641*
LWR model	$W = 0.0087*L^{2.9641}$
Statistical significance (α=0.05)	*R=0,9994* R^2*=0,977*



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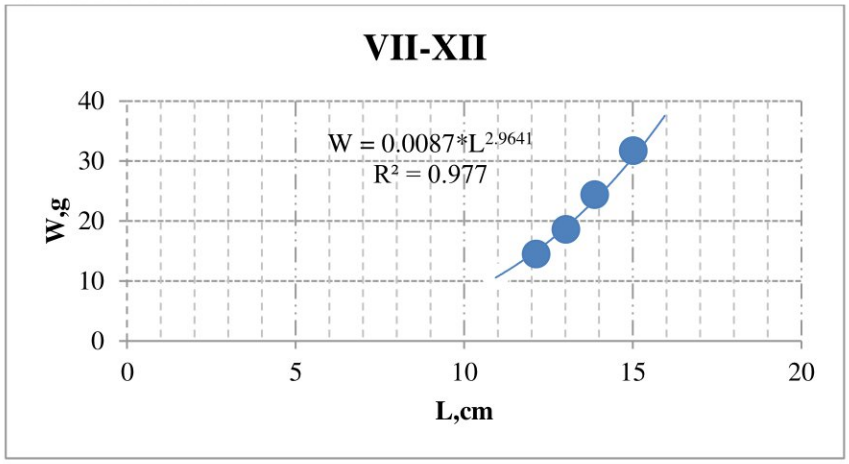

Figure 3.7.2 Length (L) - weight(W) relationship of horse mackerel.

II.3.8 Sex structure

At **300 specimens**, the sex ratio is determined. Females (♀) prevailed followed by male (♂) specimens **(Figure 3.8.1)**.

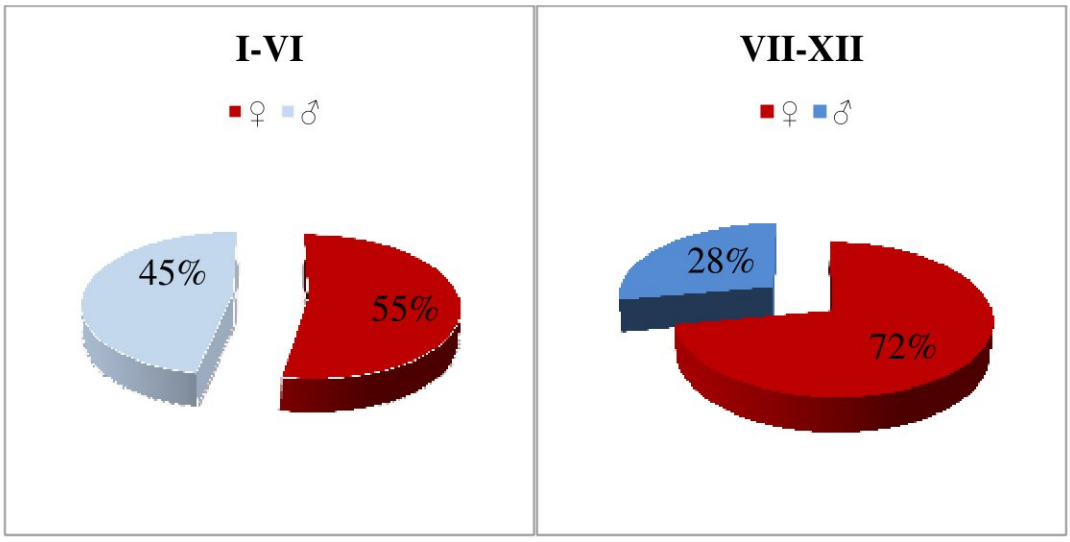

Figure 3.8.1 Sex ratio of horse mackerel (♀:♂).

Mean lengths of female ♀ were higher in 2, 3 and 4-year-old fish in the first six months and in all age groups in the second six months of 2022 (**Figure 3.8.2**). One-year-old fish show similar values during the researched period of the first six months -L♀=10.931cm L♂=10.989cm.

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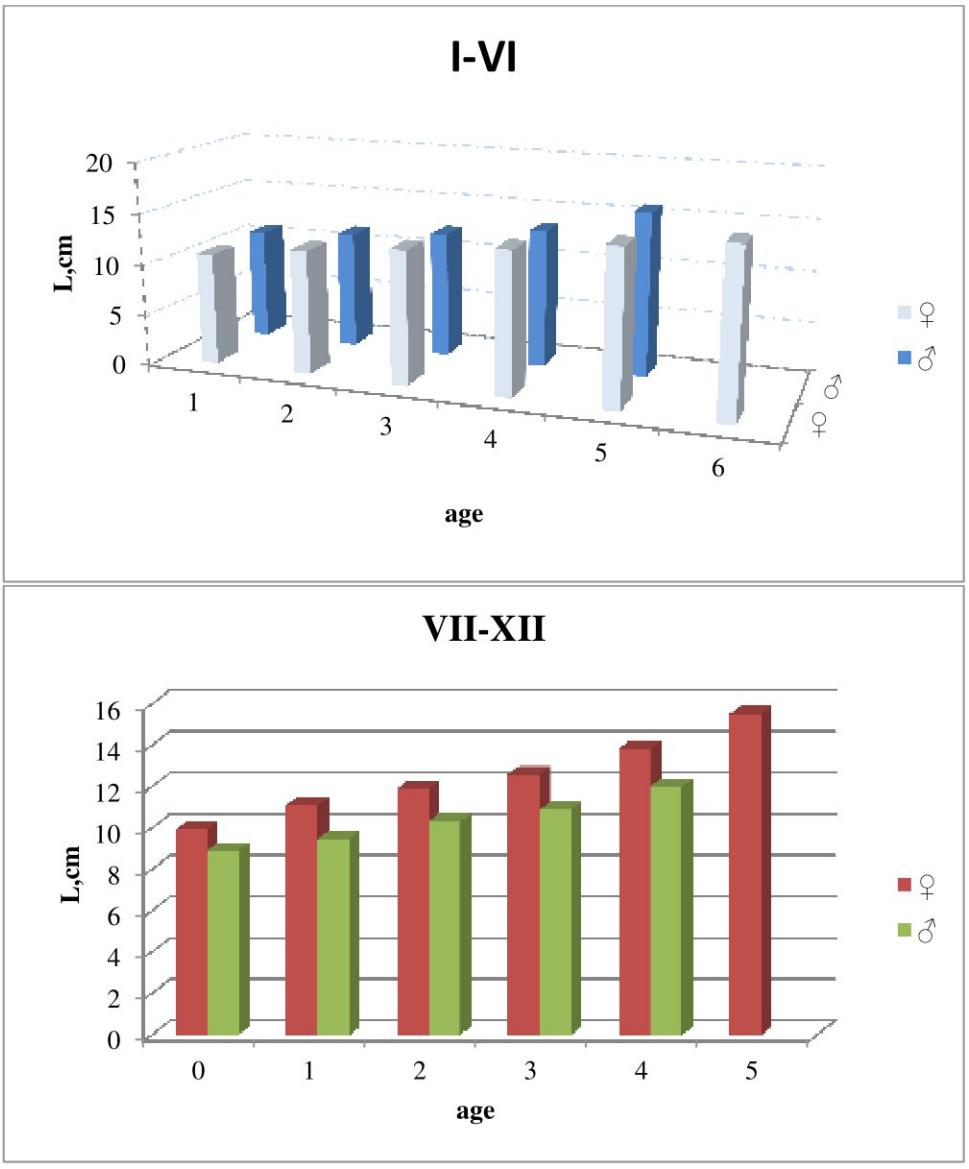

Figure 3.8.2 Sex ratio(♂♀) by size and age of horse mackerel.

II.3.9 Fertility

Fertility was determined on **150 specimens**. Batch fecundity (Log F) plotted vs. horse mackerel weight (Log W) show strong relation (R^2=0,8623), which prove strong dependence of fecundity on the individual weight.

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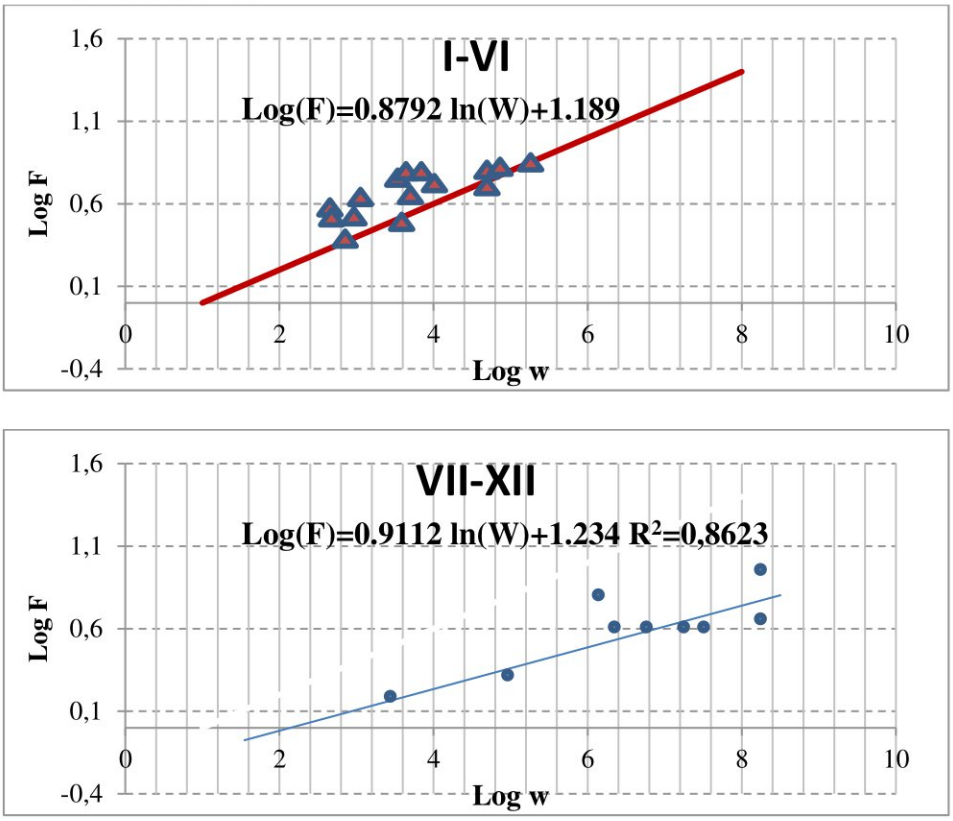
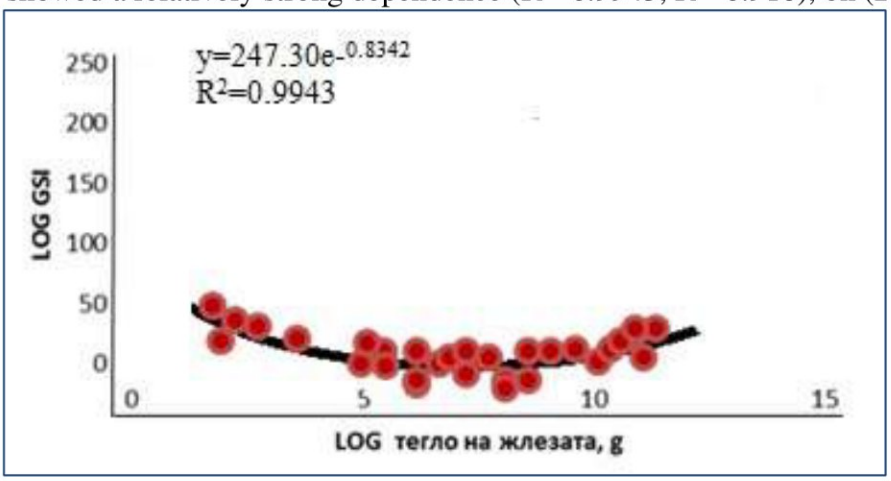


Figure 3.9.1 The relation between batch fecundity (Log F) plotted vs. horse mackerel weight (Log W).

In 2022 the relationship between the weight of the gland (ovary) and the Gonado-somatic index and showed a relatively strong dependence (R^2=0.9943, R^2=0.916), on (**Figure 3.9.2**).



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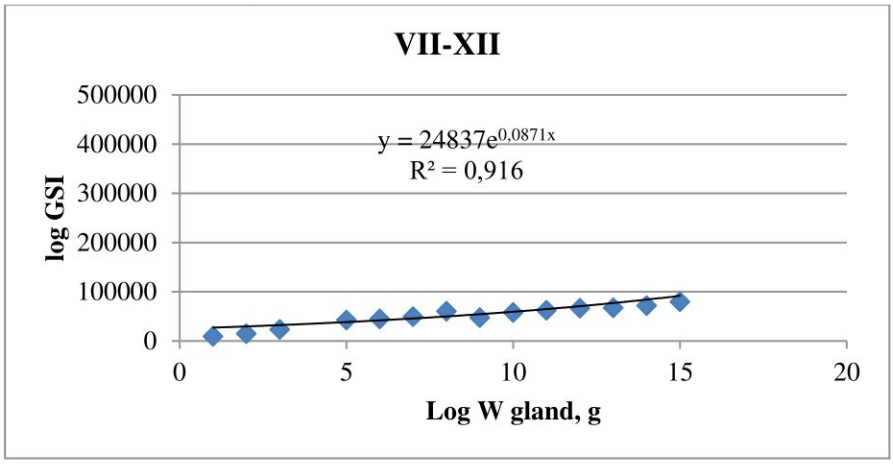

Figure 3.9.2 The relation between Log W gland plotted vs GSI.

On **table 3.9.1** were described the absolute and relative fecundity of the horse mackerel with mean lengths and weights. Mean value of the absolute fecundity was estimated 72471 and 31405 caviar grains for the two six months of 2022. The average value of the relative fecundity was 4685 и 2586 .

Table 3.9.1 Absolute and relative fertility.

I-VI					
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)♀**
9,5	6	9,43	9257	1542,83333	7
10	8	10,98	14700	1837,5	8
10,5	10,143725	11,48	23038	2271,15785	11
11	10,716132	11,45	392451	36622,4503	9
11,5	12,187171	11,79	42200	3462,65761	8
12	13,630378	12,78	44650	3275,7713	8
12,5	15,585474	12,785	49215	3157,74797	8
13	18,049451	14,15	60212	3335,94642	7
13,5	21,779439	14,34	47220	2168,0999	6
14	22,729064	14,24	57760	2541,23971	6
14,5	28,853846	14,23	62000	2148,76033	5
15	34,137931	15,245	66350	1943,58586	5
15,5	35,777778	15,424	67110	1875,74534	5
16	36,034091	16,02	71452	1982,90003	4
16,5	37,675	16,945	79452	2108,87857	3
			72471,13	4685,0183	**100**

VII-XII

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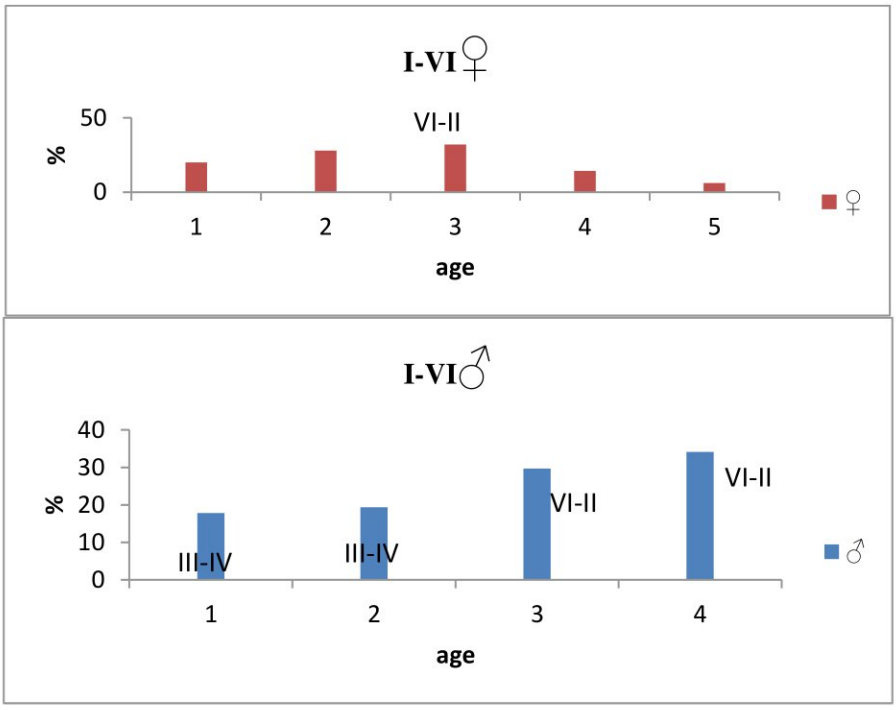
Size class	Average body weight (W, g)	Medium size	Absolute fertility F, caviar grains)	Relative fertility	Number (n)♀
8	5,45	8,04	7257	1331,5596	7
8,5	6,27	8,55	8700	1387,5598	2
9,5	8,66	9,47	9785	1129,9076	4
10	8,78	10,78	15600	1776,7654	9
10,5	12,33	11,34	25033	2030,2514	4
11	10,32	11,53	36245	3512,1124	3
11,5	12,11	11,96	45604	3765,8134	3
12	13,78	12,88	49656	3603,4833	7
12,5	15,54	13,01	50921	3276,7696	6
13	16,09	14,44	65255	4055,6246	5
			31405,6	2586,9847	**50**

II.3.10 Sexual maturity

300 specimens have been assigned sexual maturity. In June, we watched mass mature sex products in over 80% of the female subjects surveyed. In the first six months of 2022 , study specimens showed a degree of running gonads (VI-II), with a small percentage of 20% being in grade (III-IV). In the second six months of 2022, examined specimens showed a degree of flowing gonads (VI-II).



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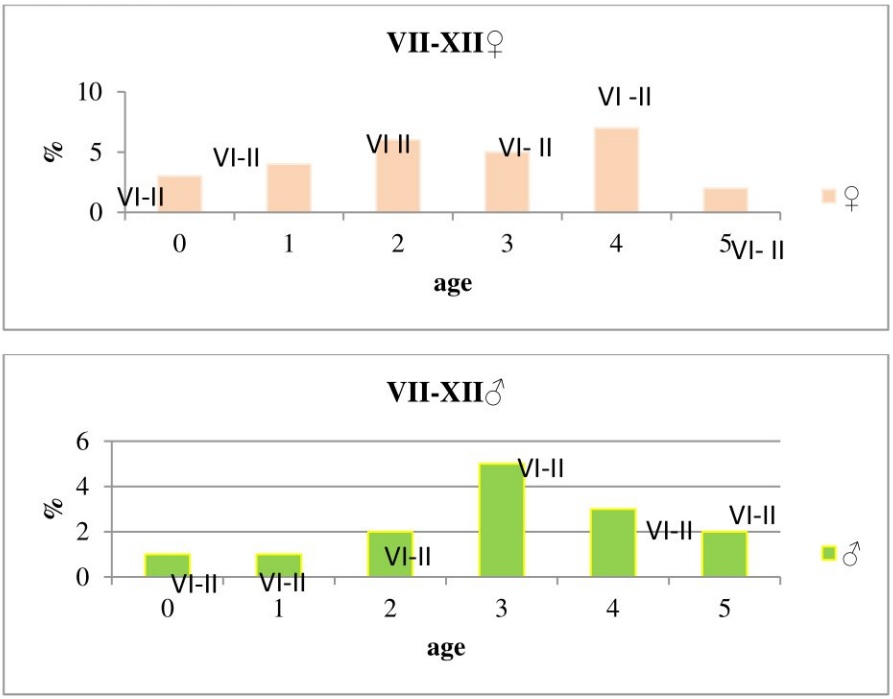
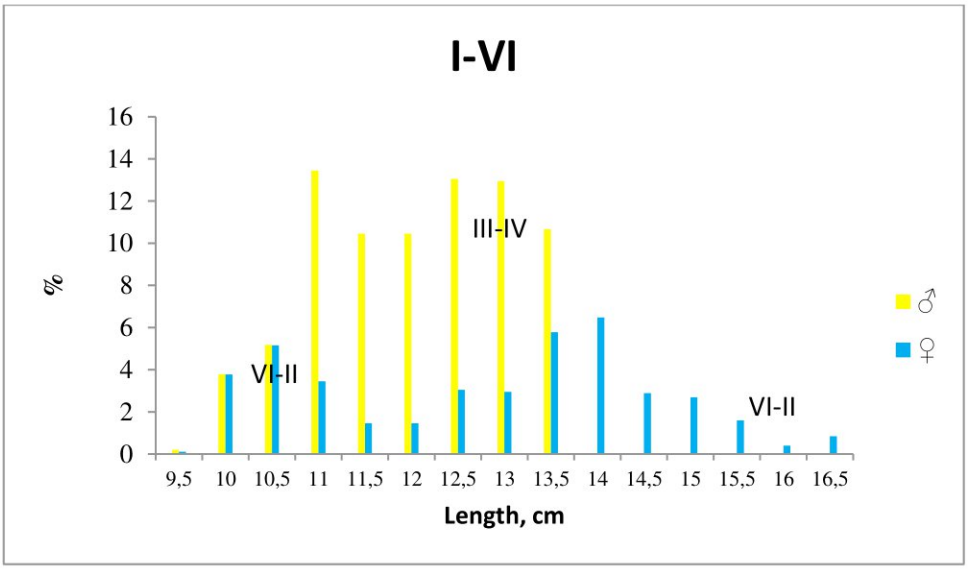


Figute 3.10.1 Sexual maturity by age of horse mackerel - female ♀ and male ♂.



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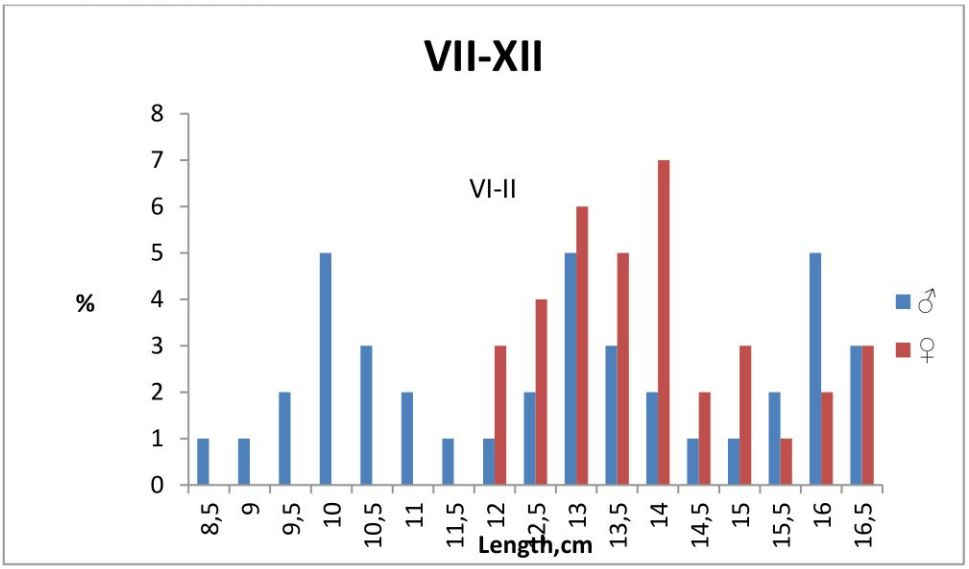

Figute 3.10.2 Sexual maturity by length(cm) of horse mackerel - female ♀ and male ♂.

II.3.11 Catch numbers and biomass by age and length

Monthly catches (in tonnes) together with mean weights of horse mackerel were used to derive the monthly catch numbers. The share (%) by age groups and catch numbers were used to create catch-at-age matrix for selected months by age groups **(Table 3.11.1).**

Table 3.11.1 Catch at age (10^{-6}) matrix and biomass (kg) of horse mackerel.

Catch-at-Age *10^{-3} (in thousands)		
Age groups	**Ist quarter**	**IInd quarter**
1	49,331	319641,850
2	44,580	288861,524
3	41,109	266368,208
4	37,820	245058,752
5	6,943	44986,631
6	3,654	23677,174
∑	**183,437**	**1188594,139**
Biomass (kg)		
Age groups	**Ist quarter**	**IInd quarter**
1	528614203,7	3425,194783
2	646374905,7	4188,233951
3	764768971,7	4955,377047
4	922423310,2	5976,90998
5	220227292,2	1426,979008
6	132591316,5	859,1352304
∑	**3215**	**20831,83**

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Catch-at-Age *10^{-3} (in thousands)		
Age groups	**IIIrd quarter**	**IVth quarter**
0	0,071793	0,479038
1	0,313624	2,092641
2	0,375971	2,508648
3	0,306066	2,042216
4	0,153033	1,021108
5	0,02645	0,176488
∑	**1,246937**	**8,32014**
Biomass (kg)		
Age groups	**IIIrd quarter**	**IVth quarter**
0	0,587953	3,923092
1	4,206986	28,07095
2	5,732973	38,25303
3	5,005576	33,3995
4	3,339727	22,28419
5	0,747286	4,986233
∑	**19,6205**	**130,917**

Monthly catches (in tonnes) together with mean weights of horse mackerel were used to derive the monthly catch numbers. The share (%) by length groups and catch numbers were used to create catch at length matrix for selected months by age groups **(Table 3.11.2).**

Table 3.11.2 Catch at length (10^{-6}) matrix and biomass (kg) of horse mackerel.

Catch-at-length *10^{-3} (in thousands)		
Length groups (cm)	**Istquarter**	**II ndquarter**
9,5	0,365	2367,717
10	6,943	44986,631
10,5	9,501	61560,653
11	24,665	159820,925
11,5	19,184	124305,164
12	19,184	124305,164
12,5	23,935	155085,490
13	23,752	153901,632
13,5	19,550	126672,881
14	10,597	68663,805
14,5	11,876	76950,816
15	5,298	34331,902
15,5	4,933	31964,185
16	2,923	18941,739
16,5	0,731	4735,435
∑	**183,437**	**1188594,139**

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Biomass (kg)		
Length groups (cm)	**Ist quarter**	**II nd quarter**
9,5	2,192475	14,2063
10	55,5427	359,893
10,5	96,37274	624,4543
11	264,3171	1712,662
11,5	233,8006	1514,928
12	261,4873	1694,326
12,5	373,0308	2417,081
13	428,7072	2777,84
13,5	425,7787	2758,864
14	240,8591	1560,664
14,5	342,6656	2220,327
15	180,8792	1172,02
15,5	176,4942	1143,608
16	105,3385	682,5484
16,5	27,53383	178,4075
∑	**3215**	**20831,83**

Catch-at-length *10^{-3} (in thousands)		
Length groups (cm)	**IIIrd quarter**	**IVth quarter**
8,5	0,011336	0,388273
9	0,049122	1,903547
9,5	0,039675	1,676634
10	0,077461	3,819701
10,5	0,069904	4,26092
11	0,051011	3,377788
11,5	0,020782	1,727059
12	0,05479	5,067722
12,5	0,204044	19,8927
13	0,309845	34,28052
13,5	0,16059	20,74993
14	0,032118	4,525652
14,5	0,068015	10,89182
15	0,064236	11,37086
15,5	0,020782	4,134858
16	0,009446	1,966579
16,5	0,003779	0,882439
∑	**1,246937**	**130,917**
Biomass (kg)		
Length groups (cm)	**IIIrd quarter**	**IVth quarter**
8,5	0,05819	0,388273

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9	0,285284	1,903547
9,5	0,251277	1,676634
10	0,572458	3,819701
10,5	0,638583	4,26092
11	0,506228	3,377788
11,5	0,258834	1,727059
12	0,759498	5,067722
12,5	2,981314	19,8927
13	5,137614	34,28052
13,5	3,109787	20,74993
14	0,678258	4,525652
14,5	1,632355	10,89182
15	1,704148	11,37086
15,5	0,61969	4,134858
16	0,294731	1,966579
16,5	0,132251	0,882439
∑	**19,6205**	**130,917**

II.3.12 Conclusions

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

1) In the catches, the horse mackerel is represented by individuals with a length of L8.5 to L16.5 cm. From the distribution of fish by size classes for 1st and 2 nd quarter of 2022, it is found that the least represented size groups are 9.5 cm with 0.199% and 16.5 cm with 0.398% and over 13.45% of individuals have an absolute length of 11 cm and 12.5 cm are represented by 13.5% of the total number of specimens caught. From the distribution of fish by size classes for 3rd and 4th quarter, 2022, it is established that the least represented size groups are 16.5 cm with 0.303% and the highest percentage is 13.0 cm with 24.85%.
2) The age composition of the studied specimens includes from 0 to 6 year old individuals. The age composition for 1st and 2nd quarter 2022 shows close participation of 1,2, 3 and four-year-olds as the distribution of age groups is as follows: one-year-old -26.89%, two-year-old- 24.30%, three-year-old- 22.41% and four-year-old- 20.61%. Older age classes are present with a small percentage in the catches of five-year-olds -3.78% and six-year-olds -1.99%, respectively. In the 3rd and 4 th quarter of 2022, close participation of 1- and 3-year-olds was observed, with the distribution of age groups being as follows: zero-year-olds-5.76%, one-year-olds -25.15%, two-year-olds- 30.15%, three-year-olds- 24.55% and four-year-olds- 12.27%. Older age classes are present with a small percentage in the five-year catches, respectively -2.12%.
3) The highest average values of K in the month of January were registered in the 1-year-old fish (1.025), the 4-year-old fish showed the lowest values (0.737). The Fulton

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coefficient values in February are the highest in the 1 year (0.832). In the month of June, the highest values were recorded in the individuals belonging to age 4-4+ (1.181), and the lowest mean values of (c.f) were observed in 1-1+ (0.831).The highest average values of K in the month of October were registered in 1-year-old (0.961) and 2-year-old (1.251) fish.

4) Female (♀) outnumbered male (♂) specimens.

5) Average lengths of female ♀ are higher. One year fish show close values during the first six months of study period.

6) Analysis of the relationship between size (L) and weight (W) of the mackerel shows that the increase is allometric. In all observed cases of horse mackerel growth, it is allometric (n≠3), as (b = 2.9641) in VII-XII, 2022, the coefficient of allometry approaches a value of 3, an indicator of isometric growth.

7) The relationship between the weight and fertility of the mackerel in the 2022 showed a relatively strong dependence and a relatively low dependence of fertility on individual weights.

8) In June, mass mature sex products were observed in over 80% of the females ♀ studied. The specimens showed a rate of flowing gonads (VI-II) as a small percentage -20% were in grade (III-IV). In the second six months, examined specimens showed a degree of flowing gonads (VI-II).

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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 2022 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 2022, **6 samples with 373 specimens** were collected and processed. Information on the size of the catches was also collected.

III. 2.2 Sampling period

In 2022, the biological data for the species were collected from a total of **6 landings at the ports of Varna, Nessebar, Burgas,Sozopol and Tsarevo**. 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 2.2.1.**

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

	Date	Sampling ports	WHG	Fishing vessel	Fishing gear	Catch/ kg	Coordinate	Region
1	4.3.2022	Nessebar	WHG	ISHTAR NS 1182	OTM	140	42.660700, 27.732400	south
2	3.4.2022	Varna	WHG	RUSANO VN 4445	OTM	145	43.139600, 28.102100	north
3	14.5.2022	Burgas	WHG	KORSAR BS 141	OTM	700	42.447800, 27.700500	south
4	25.7.2022	Tsarevo	WHG	CIKLAMA V	OTM	60	42.170509,	south

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				AX215			27.858900	
5	3.8.2022	Varna	WHG	VN 8112 VN 8112	OTM	28	42.287300, 28.044300	north
6	20.10.2022	Sozopol	WHG	XersonBS210	OTM	1250	42.423000, 27.691800	south

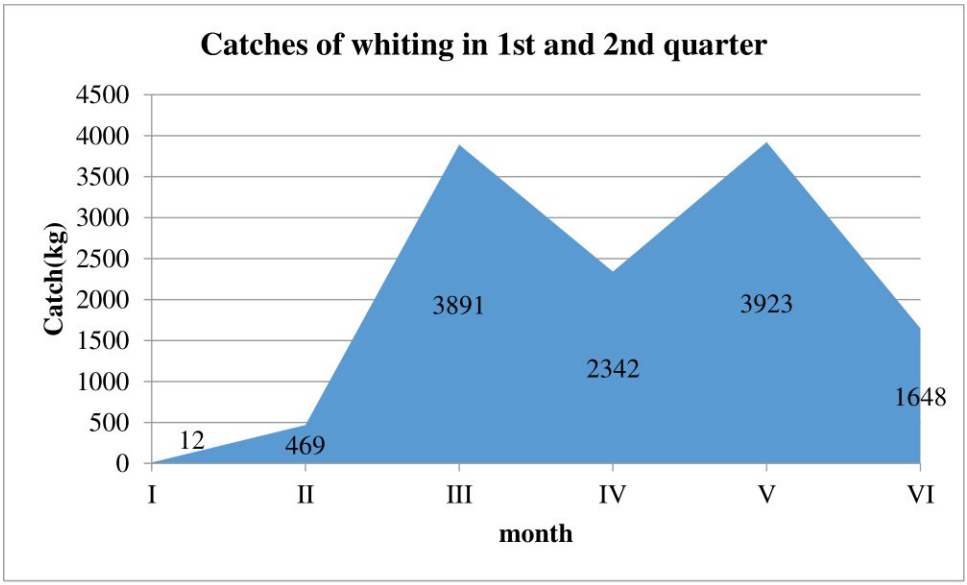
III. 2.3 Statistical analysis of data

See section statistical analysis of sprat.

III.3 Results

III.3.1 Landings statistics

The whiting catches with OTM ranged from 12 kg in January and 3923 kg in May 2022 in 1st and 2 nd quarter (**Figure 3.1.1**). Catches with OTM in August predominate in 3rd and 4th quarter.



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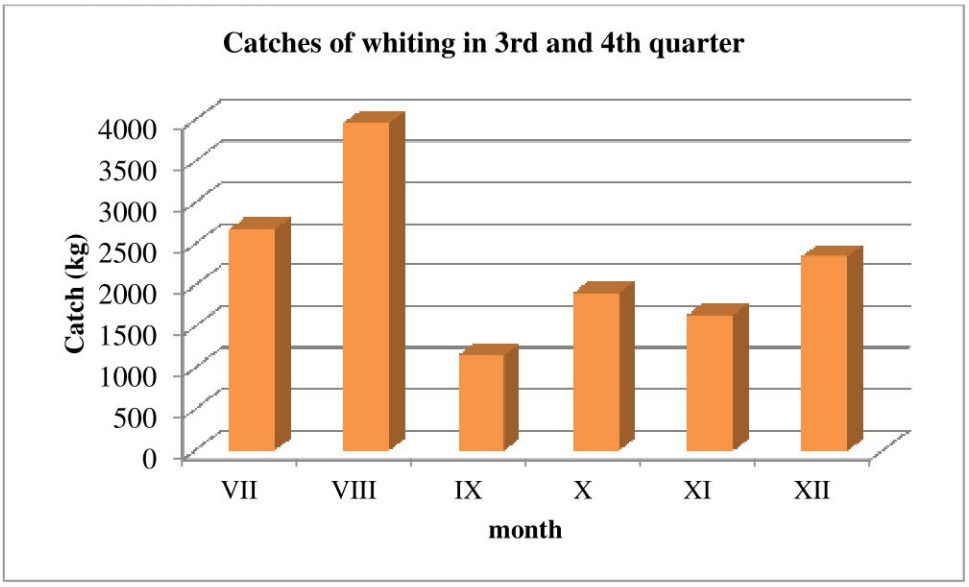
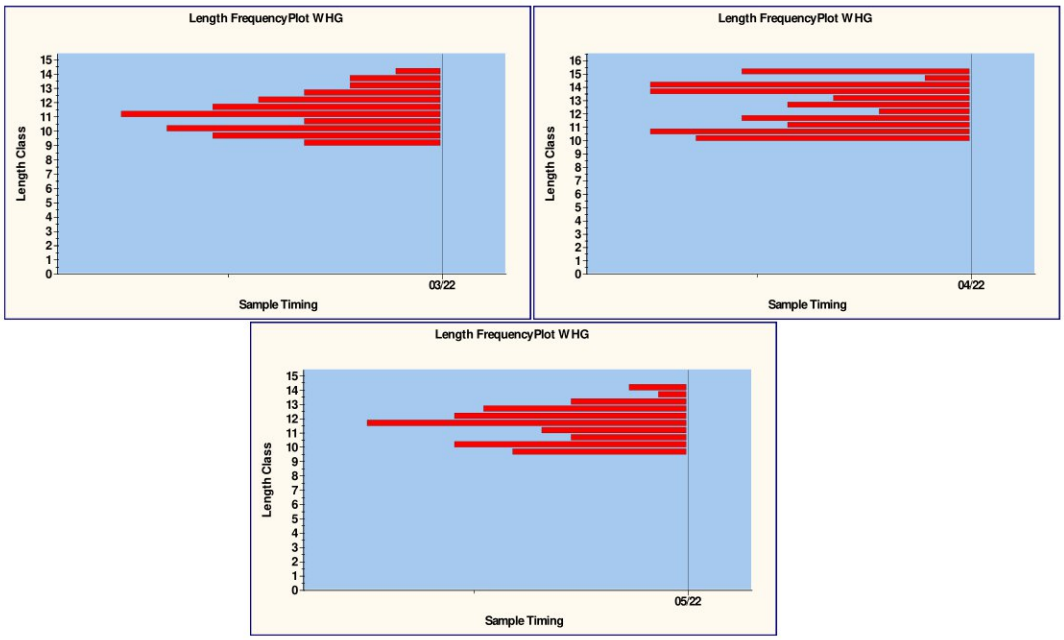


Figure 3.1.1 Landings statistics of whiting.

III.3.2 Length structure of landings

In the catches of the Bulgarian area on the Black Sea in the 1st and 2nd quarter of 2022, the size composition is represented by individuals with a body length of 9.0 cm to 15.0 cm. In the landings during the study period 12.5 cm prevailed in a size group .



In the catches from the Bulgarian waters of the Black Sea in the 3rd and 4th quarters of 2022, the size composition is represented by individuals with a body length of 9.0 cm to 16.5 cm.

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The graph shows that the percentage distribution of catches by size class is uneven. Individuals in the size classes 11.5 cm, 12.5 and 15.5 cm have the highest values, and the size classes of 9-9.5 cm have the lowest percentage value.

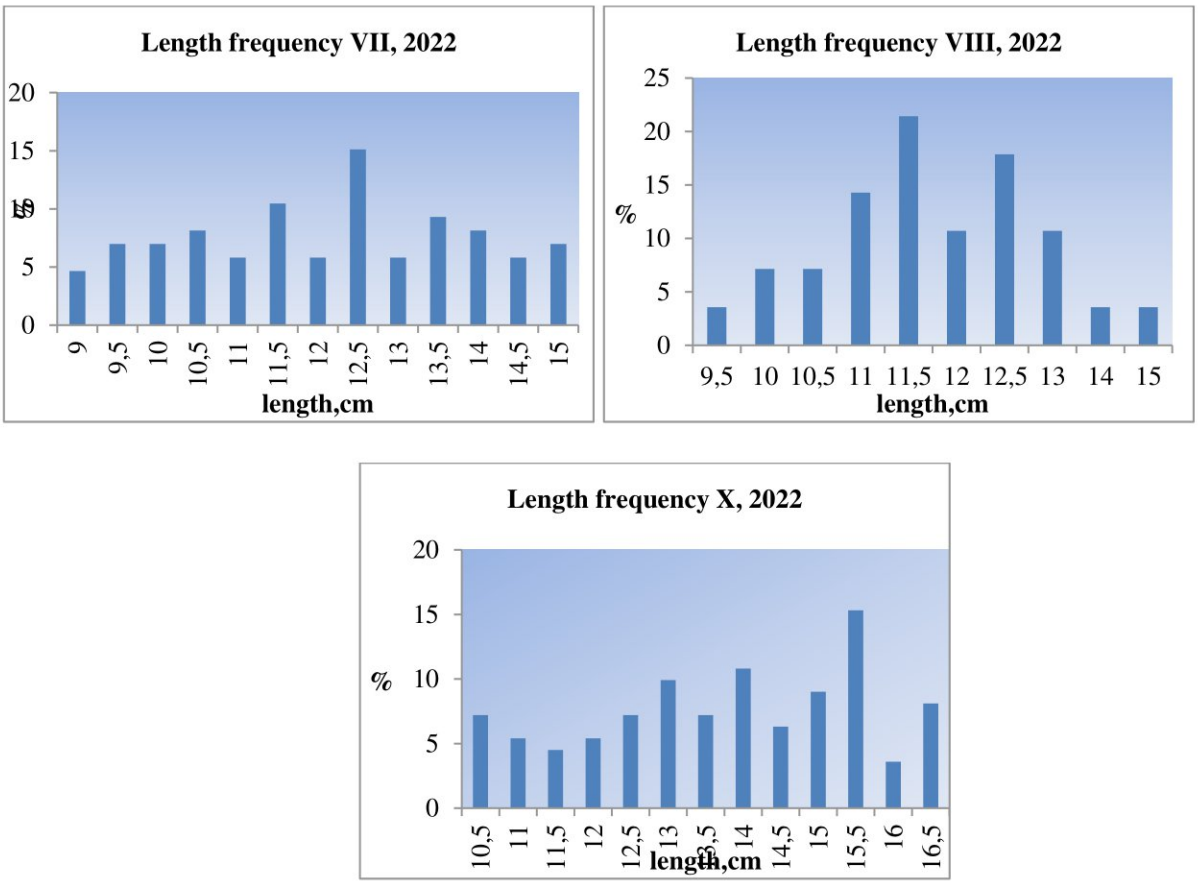

Figure 3.2.1. Histogram of length frequency data of whiting .

From the distribution of individuals by size groups in the 1st and 2nd quarter of 2022, it is found that the 11.5 cm groups are represented most massively with 14.19 %. Fish with a body length in the 10.5 cm range represent 13.52% of the catch, followed by 11.0 cm with 10.82%. Whiting with a body length in the range of 9 cm are 3 pieces, which represents 2.03%. Fish with a length of 14.5 cm are represented with the smallest percentage in the catch 0.67%. Figure 3.2.3 shows the distribution dynamics of the measured specimens.

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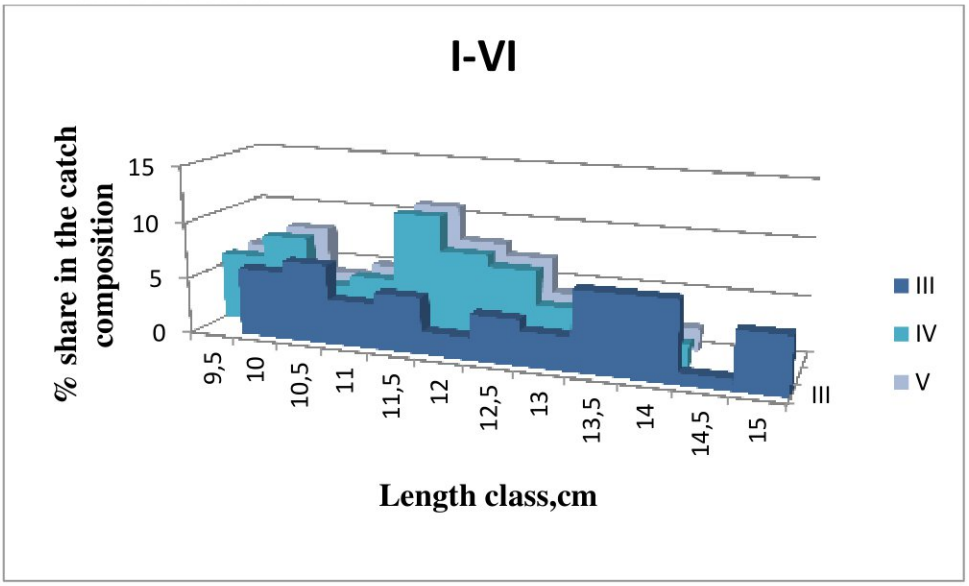

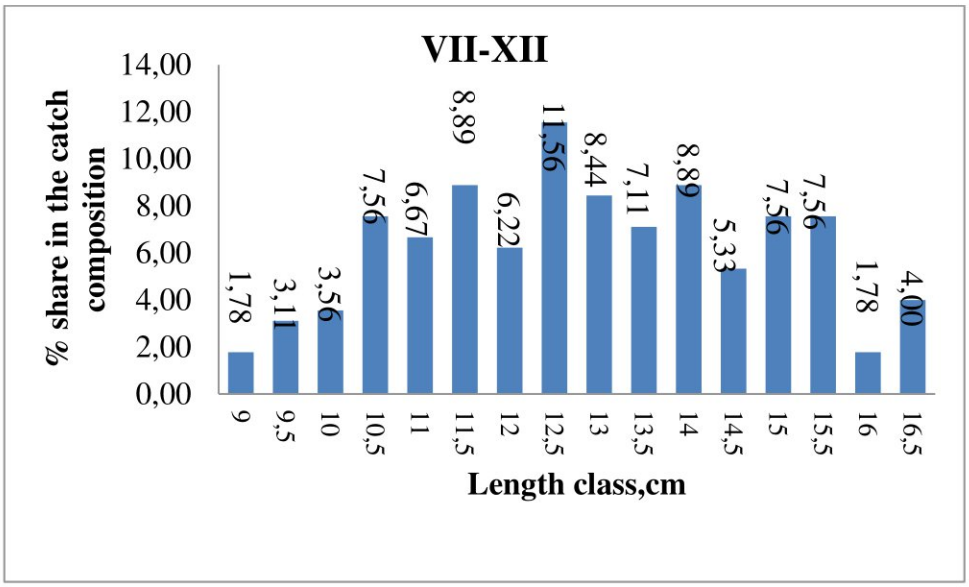

Figure 3.2.2 Frequency of the length from landings.

III.3.3 Age structure of landings

Three ichthyologists determined the age of of whiting, with one ichthyologist examining the otoliths twice. Specimens **(n = 373)** were used for age determination. The age structure of the whiting is represented by four age classes - 1,2,3 and 4 (**Figures 3.3.1**). In April, May and June, two-year-old fish are present with the highest percentage in catches, three-year-old and four-year-old fish are present the most in April. The graph (**Figures 3.3.1)**, shows a smooth rise in whiting catch values for the month of July, with the 1-1+ age group having the lowest

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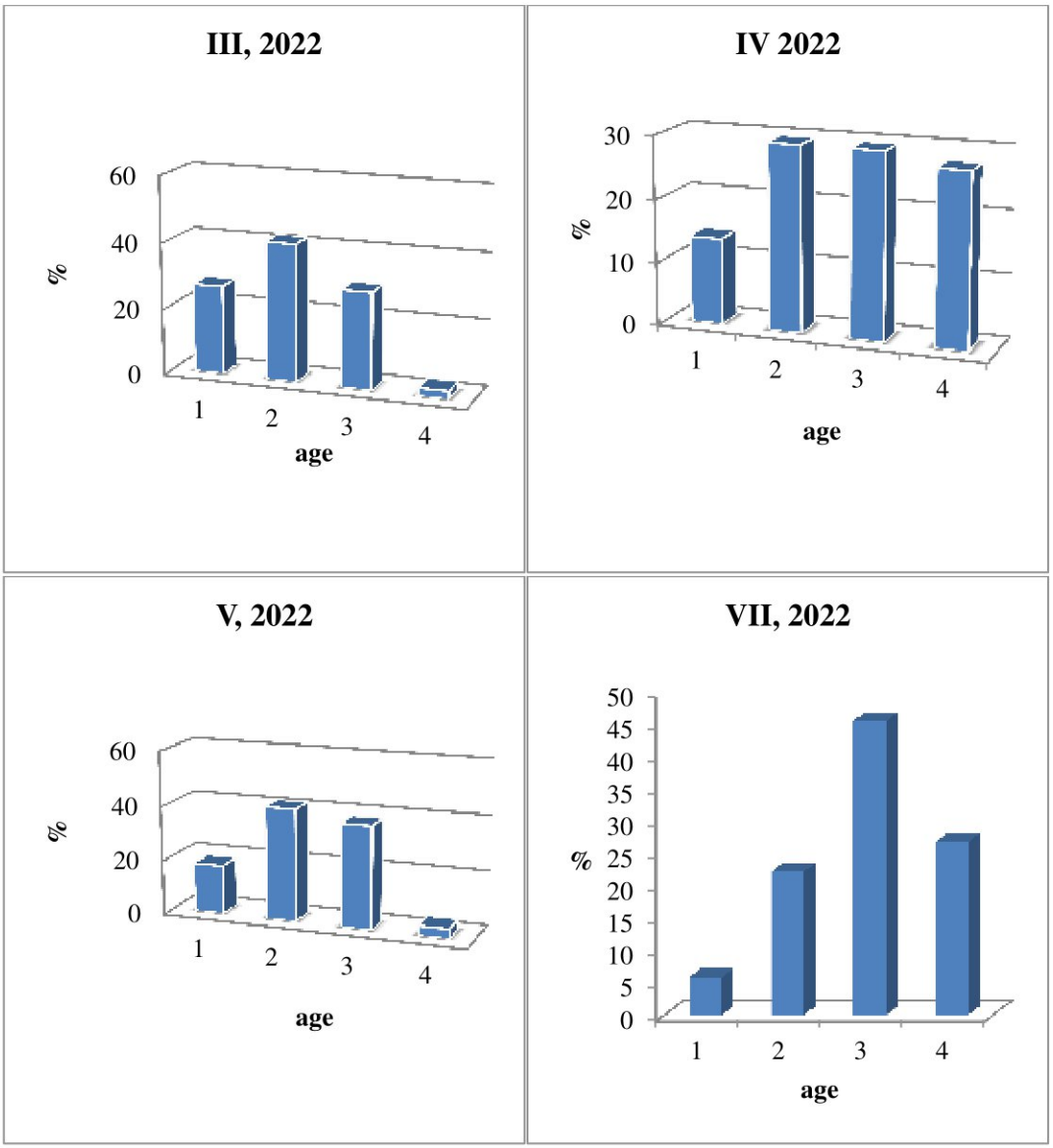
possible catch values and the 3-3+ having the highest catch percentage performance. Catch results are best presented in groups 3+ and 4+ for August and 1+ and 2+ for October.



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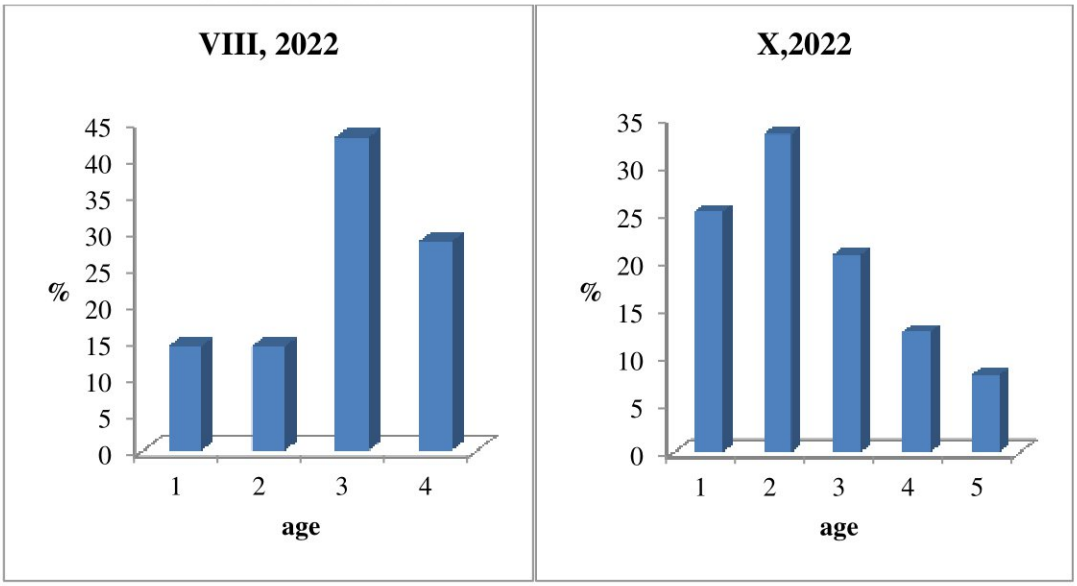
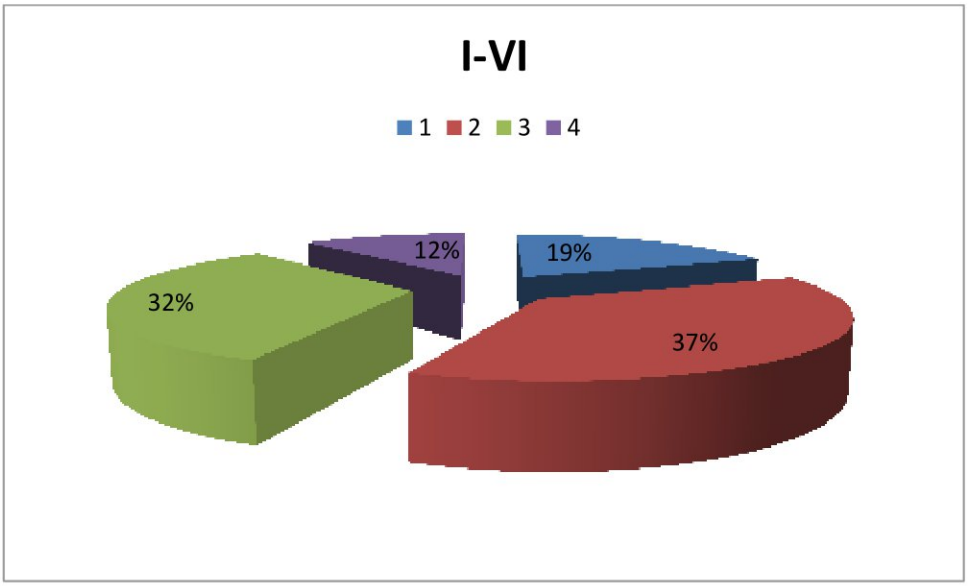


Figure 3.3.1 Age distribution of whiting.

The predominant age is 2-2+ y^{-1} (through 1st and 2nd quarter) and 3-3+ y^{-1} (through 3rd and 4th quarter), followed by 32% participation in the catch of 3-3+ y-1 and 26% of 2-2+ y-1 age groups.



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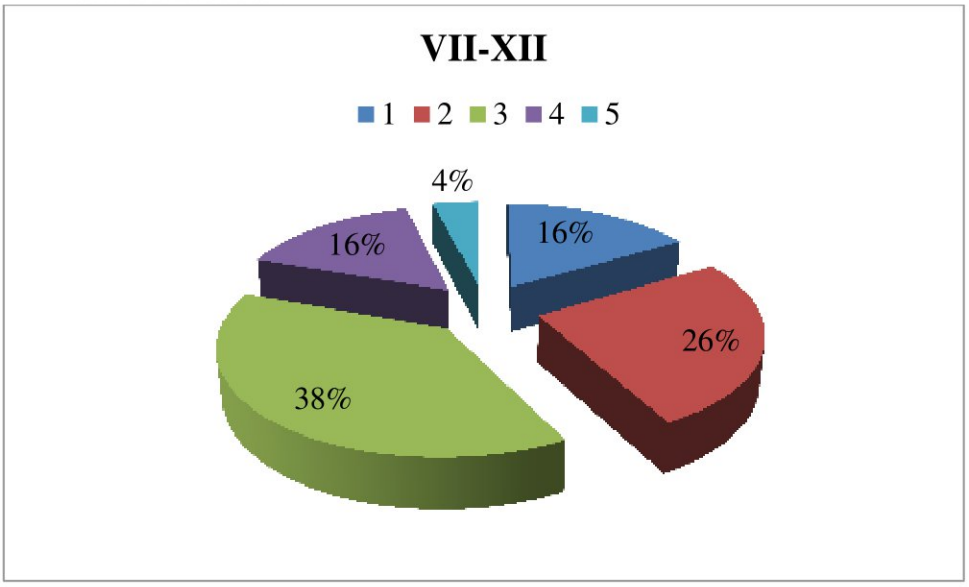
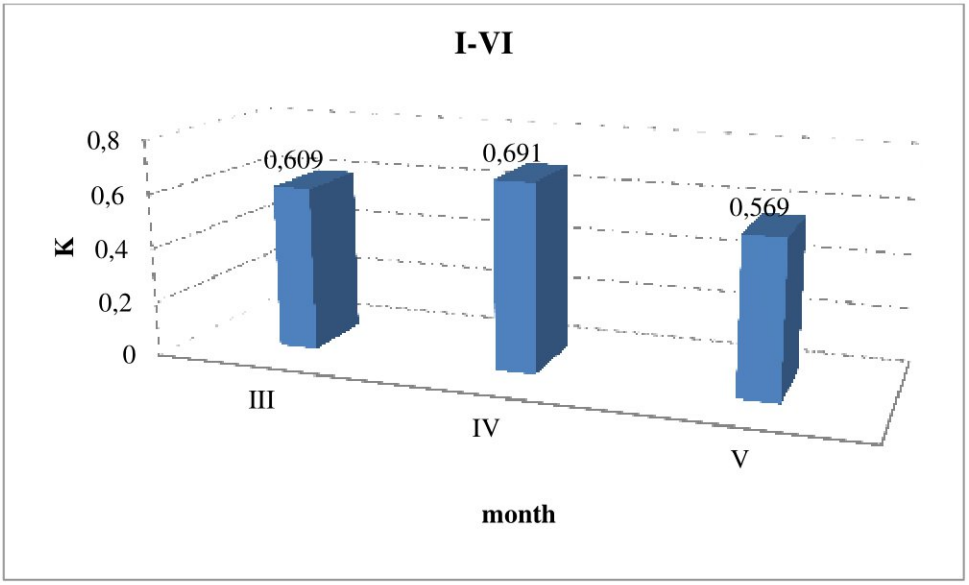


Figure 3.3.2 Age distribution of whiting.

III.3.4 Condition factor

Fulton's condition factor is relatively evenly distributed. The highest values are observed in August (**Fig. 3.4.1**).



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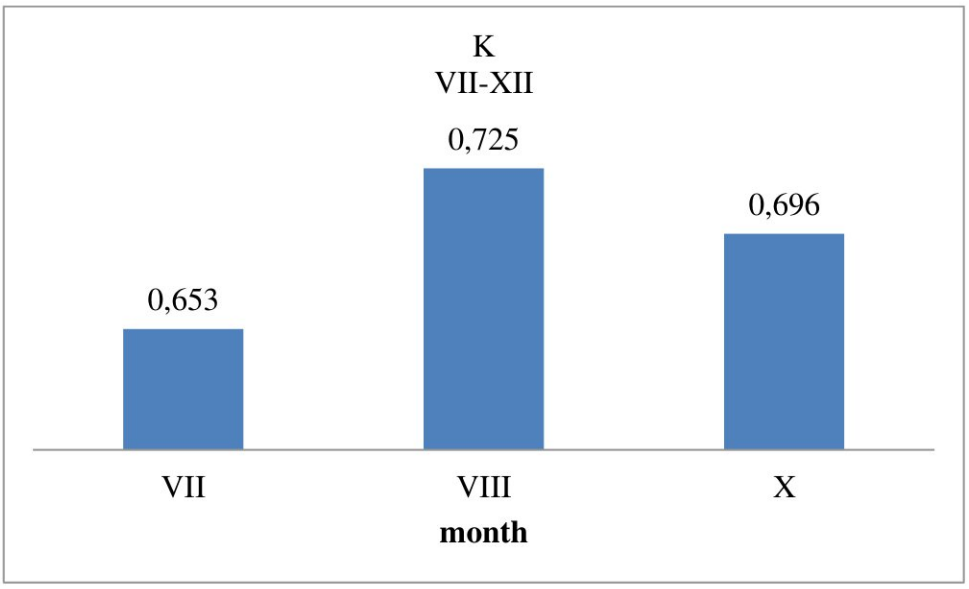

Figure 3.4.1 Mean condition factor of whiting, 2022.

III.3.5 Weight structure of whiting

Weight was measured of **373 specimens**. Four-year-old fish showed the highest weight. and the lowest weight was shown by the one-year-olds.

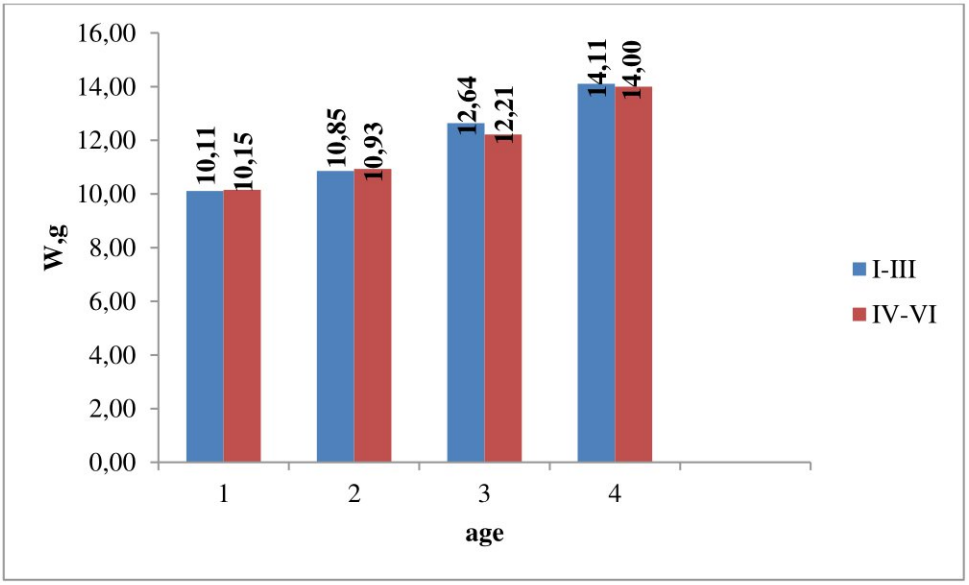

Figure 3.5.1. Weight structure by age group .

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In VII-XII, the graph shows the distribution of average weight by age group. There is a gradual increase in average weight across age groups. Age group 1+ has the lowest mean weight and group 5+ has the highest mean weight.

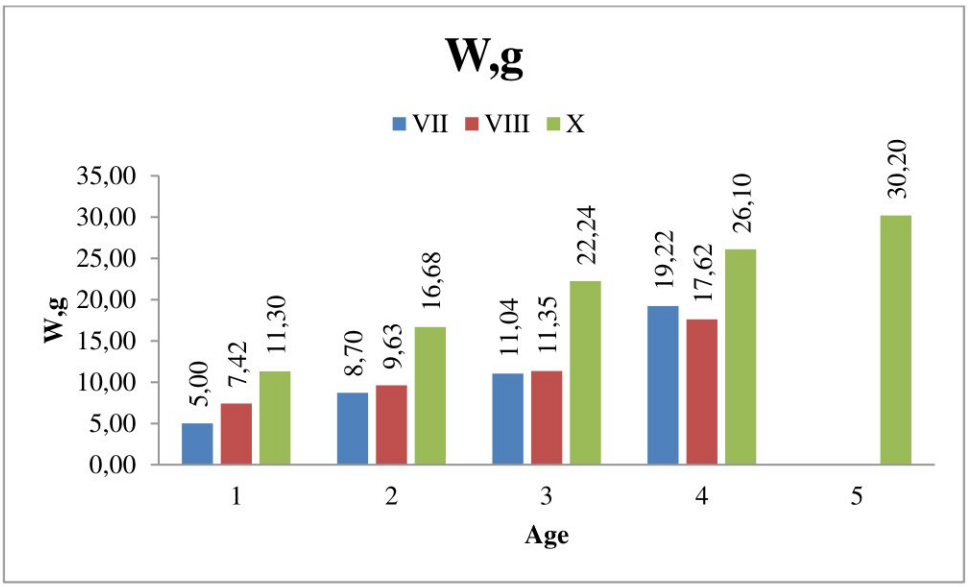
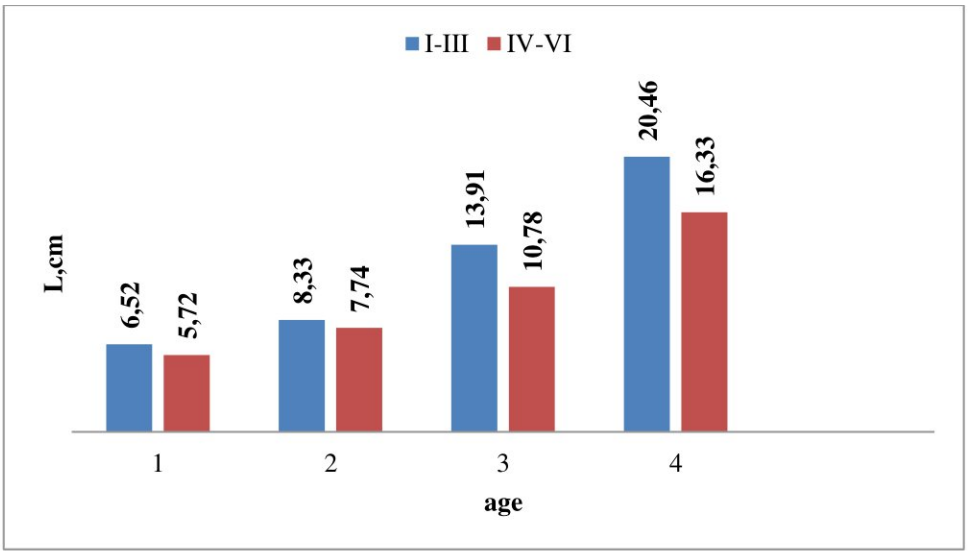


Figure 3.5.1. Weight structure by age group .

III.3.6 Size structure of whiting by age group

The fish length was measured of **373 specimens**. The analysis of the size structure in annual terms shows that the average length values by age group vary differently over the study period (**Figure 3.6.1**). In the second semester of 2022, the lowest value for average length was in the 1+ age group and the highest in the 5+ year group (**Figure 3.6.1**).



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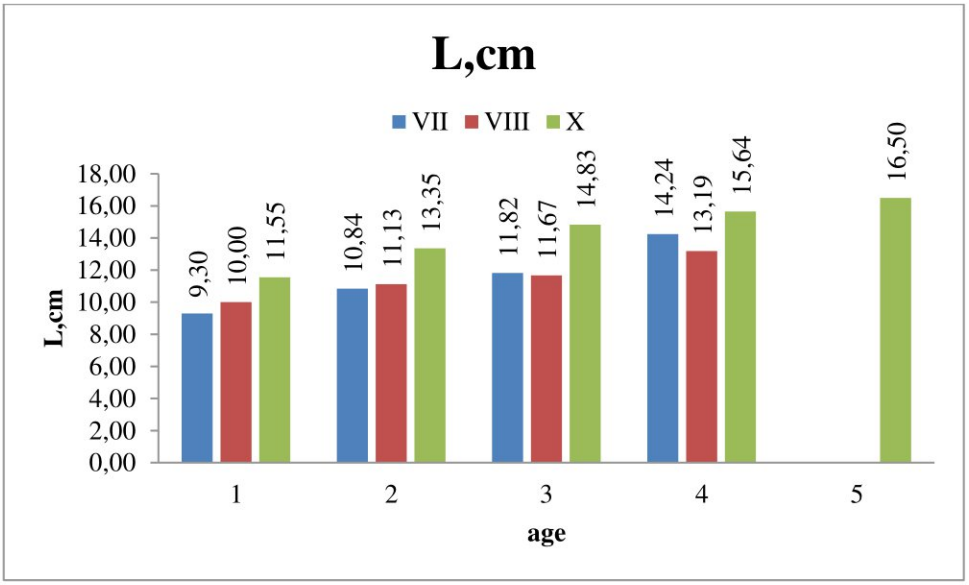

Figure 3.6.1. Length structure by age groups.

III.3.7 Length- weight relationship

It follows from the analysis that the growth in the whiting is allometric ($n \neq 3$), i.e. is not the same in terms of linear and weight growth. In all observed cases of whiting growth, it is allometric ($n \neq 3$), as ($b=2.9885$) in VII-XII, 2022, the coefficient of allometry approaches a value of 3, an indicator of isometric growth. The results of the modeling of the length-weight relationship are presented in **Table 3.7.1**, and the graphical presentation of the model in **Fig. 3.7.1.**

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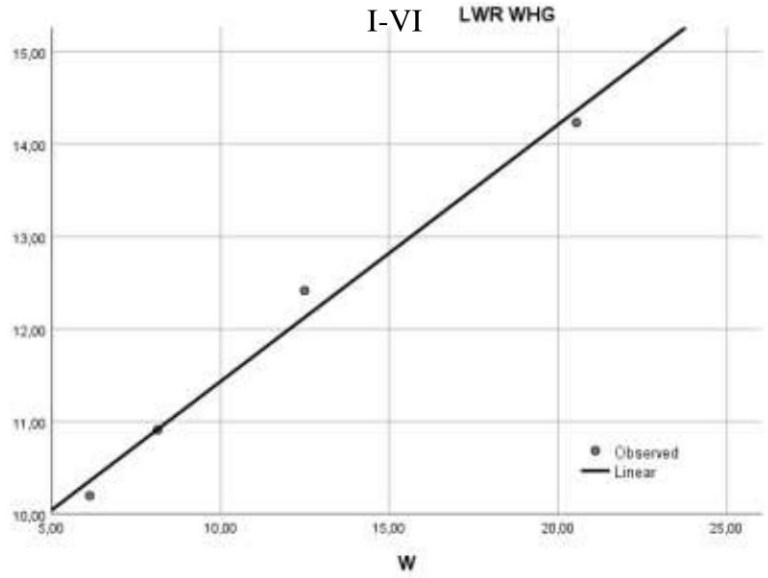

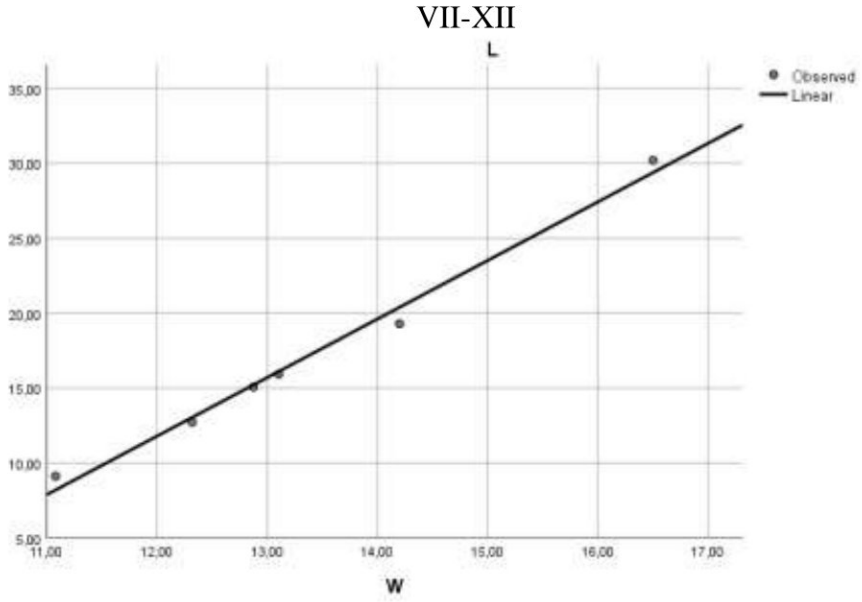

Fig. 3.7.1 Representation of the length-weight model for whiting on a scatter plot.

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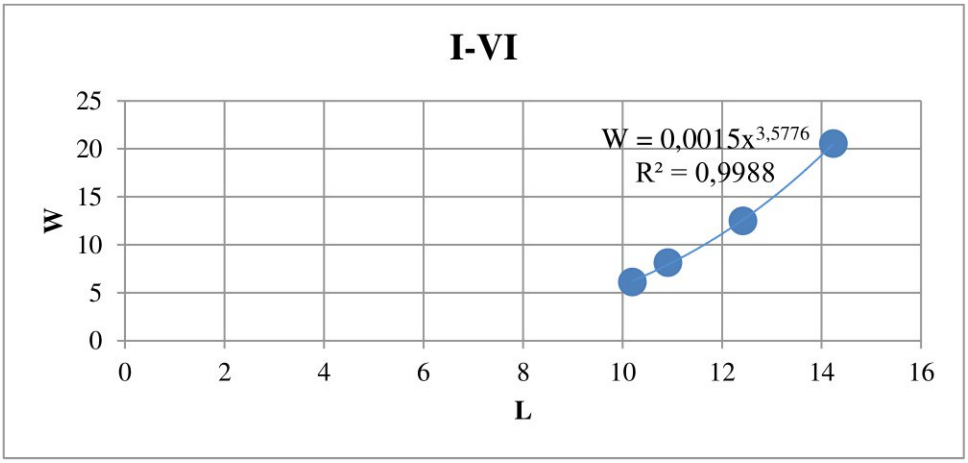
Table 3.7.1 Length-weight relation parameters.

I-VI	
	WHG
	LWR model
Parameter estimates a and b	*a=0.0015;* *b=3.5776*
LWR model	$W = 0.0015*L^{3.5776}$
Statistical significance (α=0.05)	*R=0,990* R^2*=0,987*

VII-XII	
	WHG
Parameter estimates a and b	*LWR model* *a=0.007;* *b=2.9885*
LWR model	$W = 0.007*L^{2.9885}$
Statistical significance (α=0.05)	*R=0,990* R^2*=0,9975*



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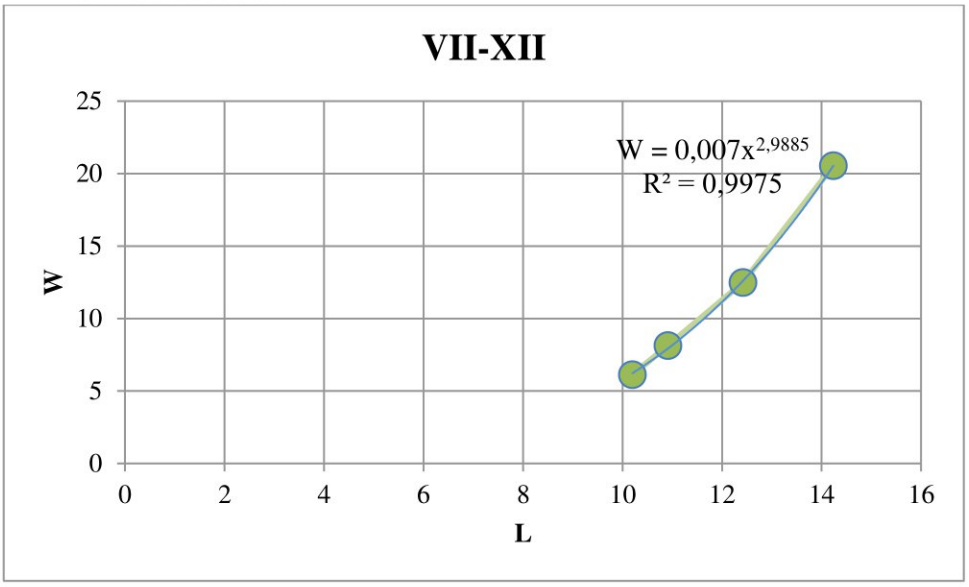
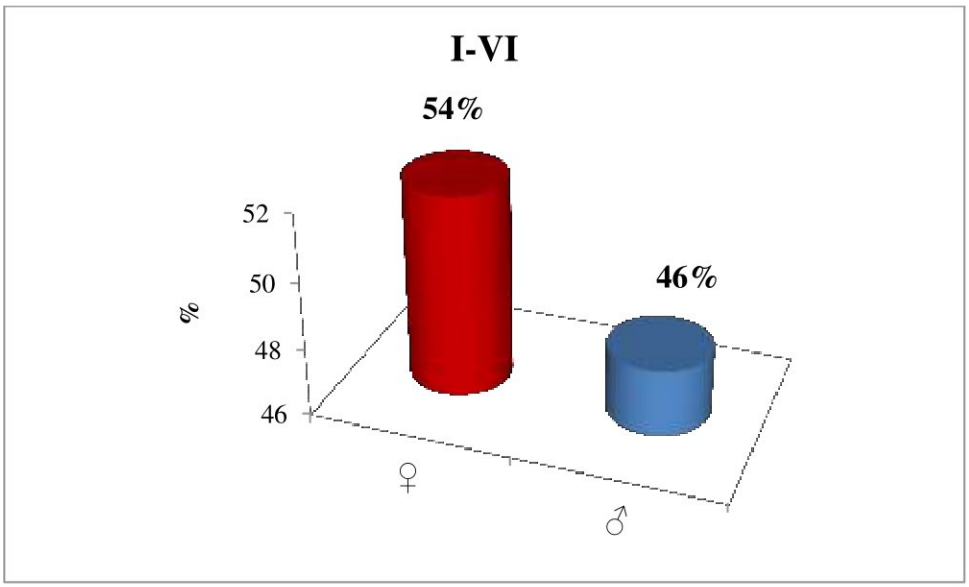


Figure 3.7.2 Length-weight relationship.

III.3.8 Sex ratio

The sex ratio was determined of **150** specimens. Sex of the determined specimens, 54% and 76% was female and 46% and 24% was male **(Figure 3.8.1)**.



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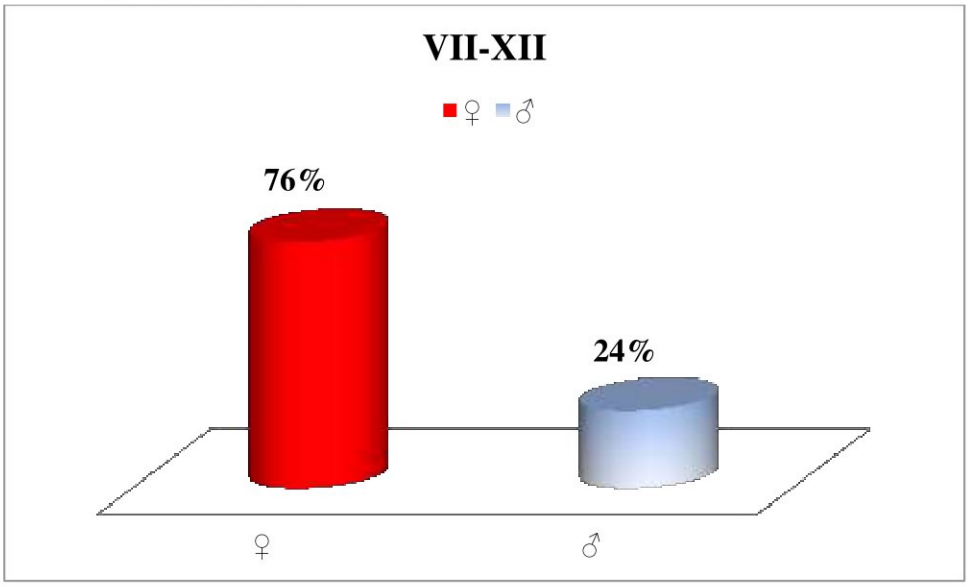
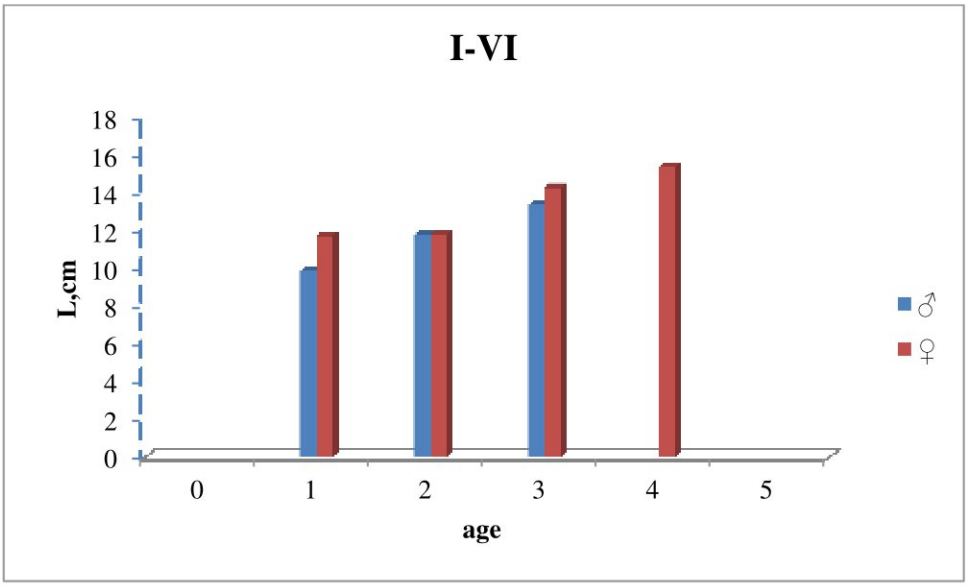


Figure 3.8.1 Sex ratio of whiting (*Merlangius merlangus*) caught in the Bulgarian Black Sea waters.

The mean lengths in females by age group were higher, with the exception of two-year specimens, in which males showed close values of lengths (1st and 2 nd quarter) (**Figure 3.8.2**). Average lengths for females and males by age groups are close (3rd and 4 th quarter).



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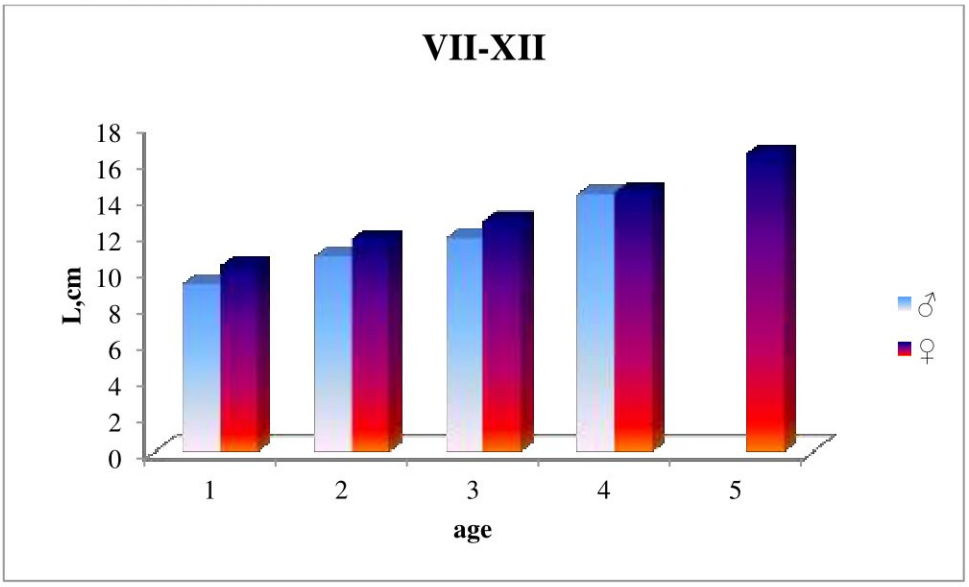
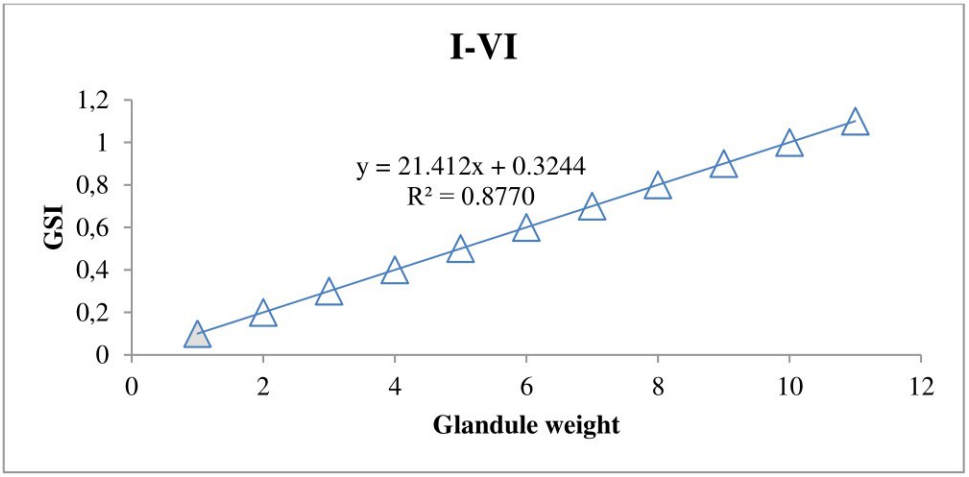


Figure 3.8.2 Sex ratio by size and age of whiting.

III.3.9 Fertility

Fertility was determined on **150 specimens**. Gonado somatic index is highly dependent on the on the sexual glands weights (R^2=0.8770) (R^2=0.8980), which is correlated with the high maturation of females in the late spring and summer spawning processes of whiting **(Figure 3.9.1)**.



Project No. BG14MFOP001-3.003-0004, "Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy 2022", funded by the Maritime and Fisheries Program co-financed by the European Union through European Maritime and Fisheries Fund.

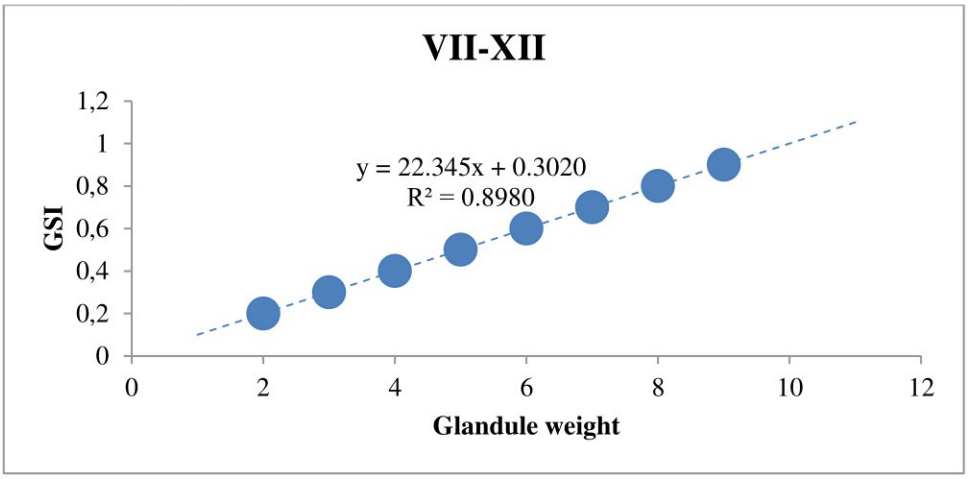
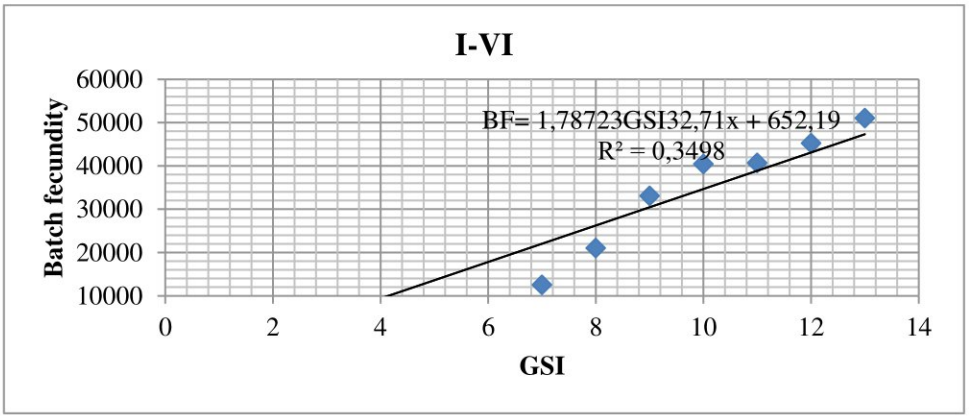


Figure 3.9.1 Glandule weight (g) vs.GSI for whiting.

Batch fecundity of whiting from the researched period correlated low with GSI(R^2 = 0.3498) (R^2 = 0.4451) **(Figure 3.9.2)**.



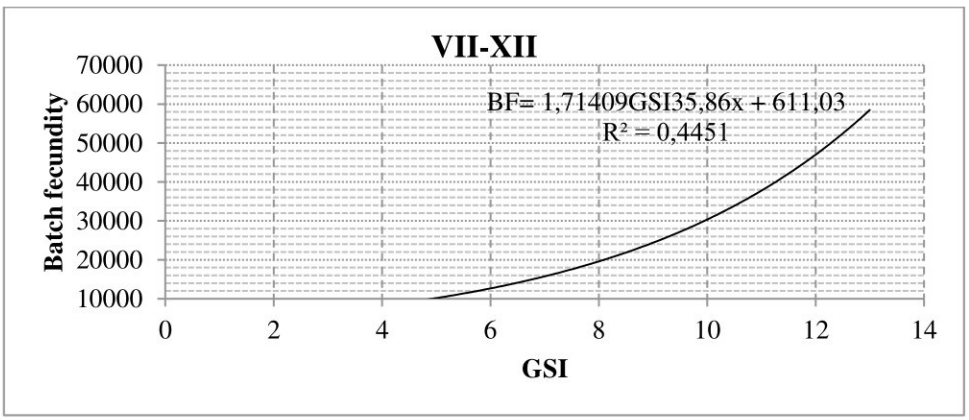


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Figure 3.9.2 Batch fecundity vs. GSI for whiting.

Absolute fertility increases with increasing length, weight and age (**Table 3.9.1**).

Table 3.9.1 Absolute and relative fertility.

I-VI					
Size class	Average body weight (W, g)	Medium size	Absolute fertility F, caviar grains)	Relative fertility	Number (n)
9	3,970	8,99	4599	1158,438287	3
9,5	4,056	9,51	6600	1627,073061	10
10	7,106	9,89	7600	1069,454217	10
10,5	5,840	10,48	7112	1217,808219	8
11	8,732	11,22	7335	840,0257677	9
11,5	9,093	11,54	9306	1023,387097	9
12	10,831	12,05	12500	1154,049064	9
12,5	12,661	12,57	21020	1660,160217	10
13	13,361	13,01	33045	2473,222453	9
13,5	18,232	13,49	40400	2215,88416	9
14	19,043	14,05	40660	2135,167778	8
14,5	20,010	14,55	45215	2259,62019	1
15	24,440	15,1	51012	2087,234043	5
			average	average	100
			22031,08	1609,348	

VII-XII					
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)**
9	6,64	8,99	53889	8115,813253	4
9,5	8,358	9,51	54006	6461,593683	5
10	7,326	9,89	79002	10783,78378	4
10,5	8,974	10,48	78924	8794,740361	7
11	11,102	11,22	70458	6346,424068	4
11,5	12,1	11,54	90908	7513,057851	3
12	14,3	12,05	127003	8881,328671	9
12,5	16,719	12,57	20020	1197,440038	5
13	22,241	13,01	31025	1394,94627	9
			average	average	50
			67248,33	6609,90	

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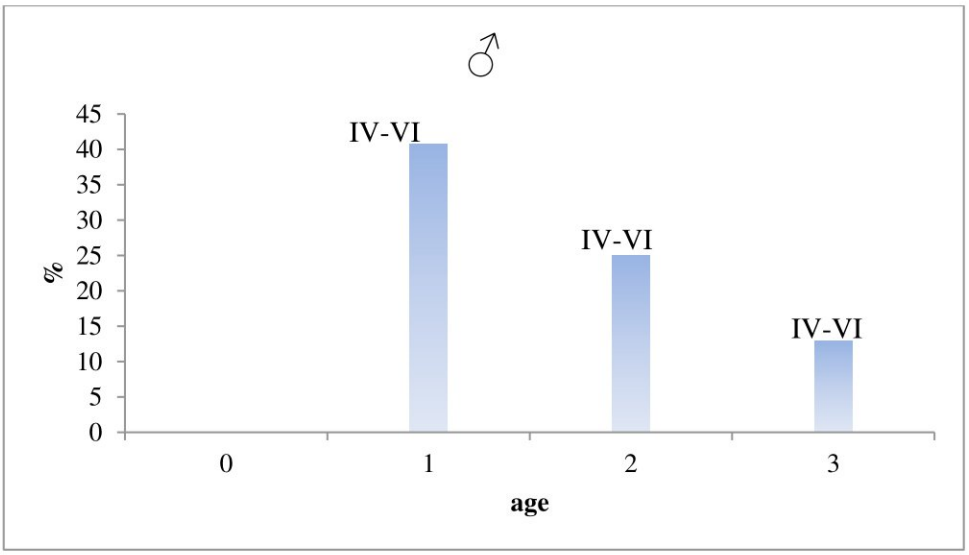
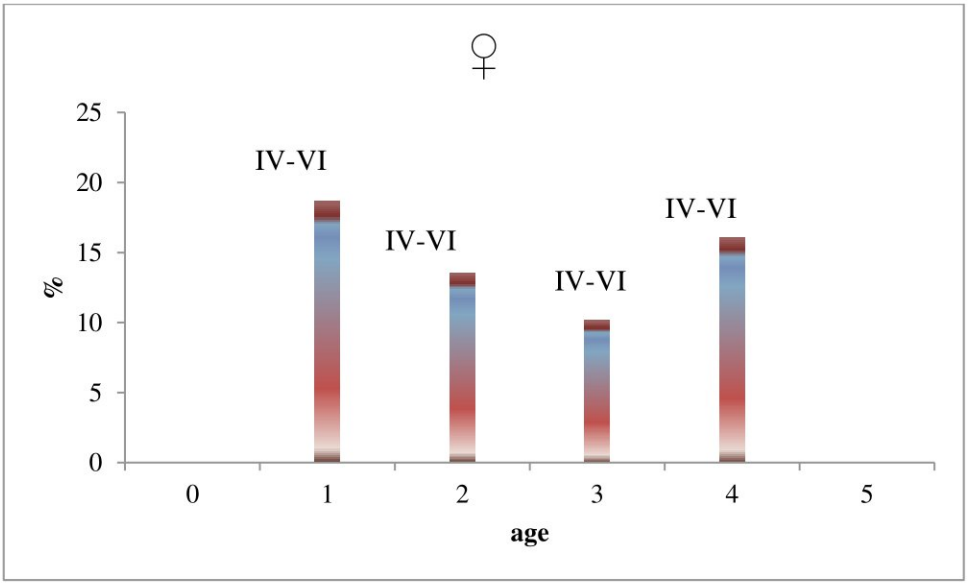
III.3.10 Sexual maturity

Sexual maturity was determined on **150 specimens**. During this period it is actively used in sexual products, with 100% of the degree of maturity being IV-VI.





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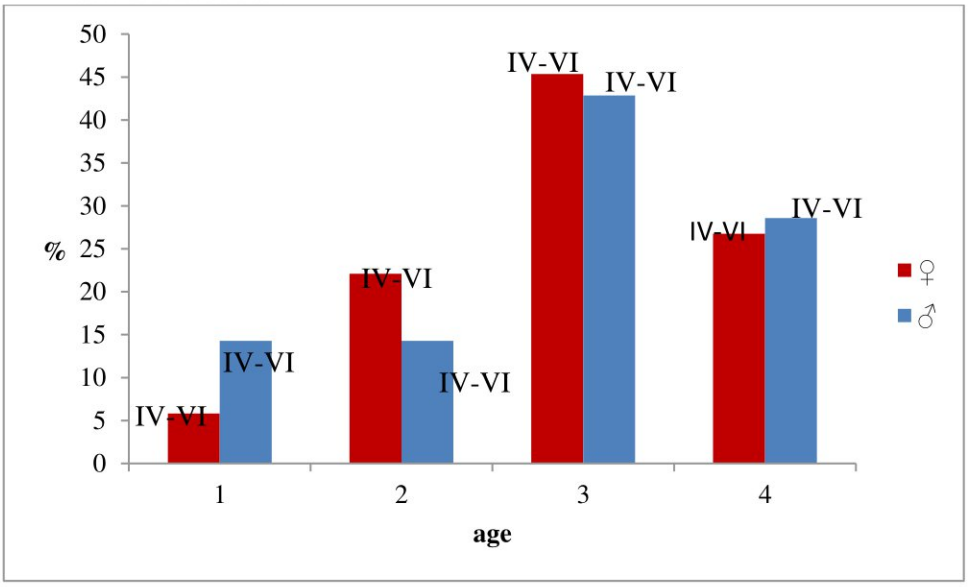
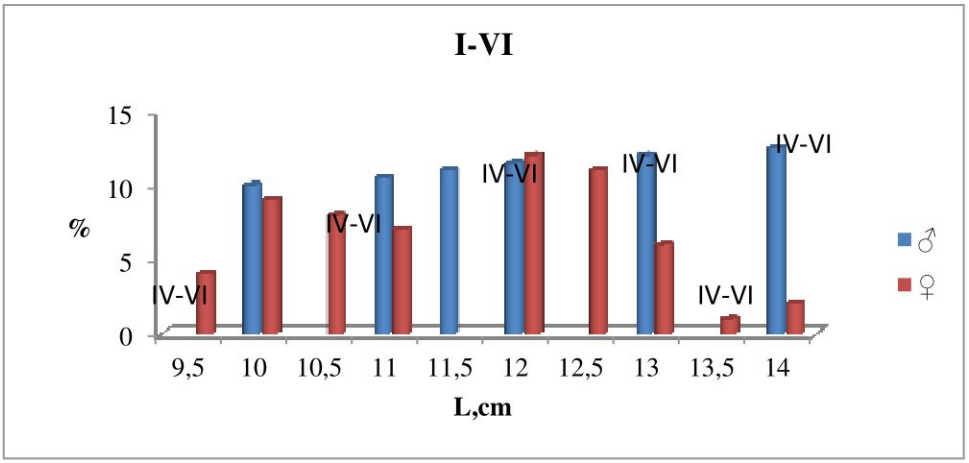


Figure 3.10.1 Sexual maturity by age of whiting - female♀ and male ♂.



Project No. BG14MFOP001-3.003-0004, "Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy 2022", funded by the Maritime and Fisheries Program co-financed by the European Union through European Maritime and Fisheries Fund.

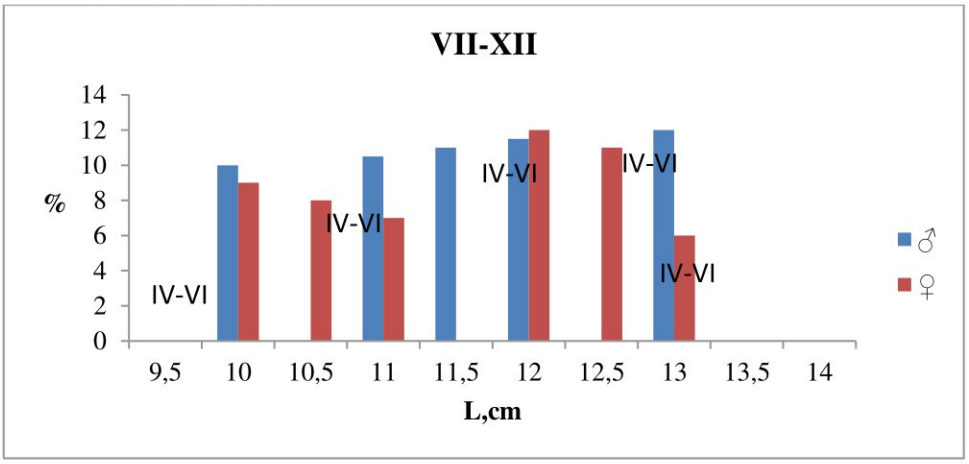


Figure 3.10.2 Sexual maturity along the length (cm) of whiting - female ♀ and male ♂.

III.3.11 Catch numbers and biomass by age and length

Monthly catches (in tonnes) together with mean weights of whiting were used to derive the monthly catch numbers. The share (%) by age groups and catch numbers were used to create catch-at-age matrix for selected months by age groups **(Table 3.11.1).**

Table 3.11.1 Catch at age (10^{-6}) matrix and biomass (kg) of whiting.

Catch-at-Age $*10^{-3}$ (in thousands)		
Age groups	**Ith quarter**	**IInd quarter**
1	82,02092287	153,664198
2	161,1125271	301,84039
3	140,6072963	263,42434
4	49,79841746	93,2961205
∑	**433,5391637**	**812,225049**
Biomass (kg)		
Age groups	**Ith quarter**	**IInd quarter**
1	502,11	940,69
2	1310,78	2455,72
3	1756,04	3289,90
4	1023,06	1916,69
∑	**4592,00**	**8603,00**

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Catch-at-Age *10^{-3} (in thousands)		
Age groups	**IIIrd quarter**	**IVth quarter**
1	0,085042552	0,064494
2	0,133309947	0,101098
3	0,197666473	0,149904
4	0,080445658	0,061007
5	0,020686026	0,015688
∑	**0,517150656**	**0,392191**
Biomass (kg)		
Age groups	**IIIrd quarter**	**IVth quarter**
1	0,775404	0,588042
2	1,696139	1,286299
3	3,148344	2,387605
4	1,552394	1,177287
5	0,624718	0,473767
∑	**7,797**	**5,913**

Monthly catches (in tonnes) together with mean weights of whiting were used to derive the monthly catch numbers. The share (%) by length groups and catch numbers were used to create catch at length matrix for selected months by age groups **(Table 3.11.2).**

Table 3.11.2 Catch at length (10^{-6}) matrix and biomass (kg) of whiting.

Catch-at-length *10^{-3} (in thousands)		
Length group (cm)	**Ith quarter**	**IInd quarter**
9	8,787956022	16,4640213
9,5	32,22250541	60,368078
10	41,01046143	76,8320992
10,5	58,58637348	109,760142
11	46,86909878	87,8081134
11,5	61,51569215	115,248149
12	41,01046143	76,8320992
12,5	41,01046143	76,8320992
13	26,36386806	49,3920638
13,5	29,29318674	54,8800709
14	29,29318674	54,8800709
14,5	2,929318674	5,48800709
15	14,64659337	27,4400354
∑	**433,5391637**	**812,225049**
Biomass (kg)		
Length group (cm)	**Ith quarter**	**IInd quarter**
9	34,8881854	65,362164
9,5	130,706199	244,87488
10	291,437915	546,00183

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10,5	342,144421	640,99923
11	409,255112	766,72947
11,5	559,382694	1047,9898
12	444,201884	832,20139
12,5	519,251028	972,80414
13	352,250571	659,93285
13,5	534,073381	1000,5735
14	557,830155	1045,0812
14,5	58,6156667	109,81502
15	357,962742	670,63447
∑	**4592,00**	**8603,00**

Catch-at-length *10^{-3} (in thousands)		
Length group (cm)	**IIIrd quarter**	**IVth quarter**
9	0,009193789	0,006972
9,5	0,016089132	0,012201
10	0,018387579	0,013945
10,5	0,039073605	0,029632
11	0,03447671	0,026146
11,5	0,045968947	0,034861
12	0,032178263	0,024403
12,5	0,059759631	0,04532
13	0,0436705	0,033118
13,5	0,036775158	0,027889
14	0,045968947	0,034861
14,5	0,027581368	0,020917
15	0,039073605	0,029632
15,5	0,039073605	0,029632
16	0,009193789	0,006972
16,5	0,020686026	0,015688
∑	**0,517150656**	**0,392191**
Biomass (kg)		
Length group (cm)	**IIIrd quarter**	**IVth quarter**
9	0,044958	0,034094
9,5	0,081733	0,061984
10	0,120806	0,091616
10,5	0,280548	0,212759
11	0,297534	0,22564
11,5	0,495086	0,375457
12	0,374877	0,284295
12,5	0,754167	0,571936
13	0,607457	0,460676
13,5	0,576267	0,437023
14	0,831578	0,630643

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14,5	0,548869	0,416245
15	0,911587	0,691319
15,5	0,988562	0,749695
16	0,258254	0,195851
16,5	0,624718	0,473767
∑	**7,797**	**5,913**

III.3.12 Conclusions

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

1) In the catch from the Bulgarian waters of the Black Sea, the size composition is represented by individuals with a body length of 9.0 cm to 16.5 cm. In the landings during the studied period 1st and 2 nd quarter, the size group 10.5 cm predominates with a total of 13.52%. In 3rd and 4 th quarter, the percentage distribution of catches by size classes is uneven. Individuals in the 11.5 cm, 12.5 and 15.5 cm size classes have the highest values, and the 9-9.5 cm size classes have the lowest percentage value.
2) The age structure of the mejida is represented by four age classes: 1-4 year old fish. The predominant age was 2-2+ y^{-1}, followed by 32% participation in the catch of 3-3+ y^{-1} age groups. The predominant age is 2-2+ y^{-1} (through1st and 2 nd quarter) and 3-3+ y^{-1} (through 3rd and 4 th quarter), followed by 32% participation in the catch of 3-3+ y-1 and 26% of 2-2+ y^{-1} age groups.
3) Analysis of the Fulton's condition factor is relatively evenly distributed. The highest values are observed in August.
4) The relationship between the size (L) and the weight (W) of the specimens examined is described by the equation: $W = 0.0015*L^{3.5776}$;$W = 0.007*L^{2.9885}$ In all observed cases of whiting growth, it is allometric (n≠3), as (*b=2.9885*) in VII-XII, 2022, the coefficient of allometry approaches a value of 3, an indicator of isometric growth.
5) Female (♀) specimens prevailed by 54% and 76%, followed by males (♂) by (46%) and 24%.
6) The average lengths in females by age group are higher, with the exception of two-year-old specimens where close values are observed (during the 1st and 2nd quarter). Average lengths for females and males by age groups are close (during the 3rd and 4 th quarter).
7) Gonado- somatic index is highly dependent on the weight of the gonads (R^2=0.8770) (R^2=0.8980), which is associated with the high maturation rate of females in late spring and summer and the breeding process of the species.
8) Active maturation of sex products has been observed and in 100% the maturity rate is IV-VI.

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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 2022** 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 **2022**, **11 samples of red mullet containing 608 specimens** were collected. Information on the size of the catches was also collected

IV.2.2 Sampling period

In 2022, the biological data on species were collected from a total of **11 landings** at the ports of **Varna(4), Tsarevo(1), Balchik (3) Nessebar (1) and Sozopol (2).** 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 2.2.1**.

Photo 2.2.1. : Catch of *Mullus barbatus* with pelagic trawl.

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

	Date	Harbor	Species code MUT	Fishing vessel	Fishing gear	catch	Coordinates	Area
	Jan 2022	No landings with OTM						
1	27.2.2022	Varna	Red mullet	KORSAR 2 VN 7643	OTM	2	43.366200, 28.386800	north
2	28.3.2022	Balchik	Red mullet	KORSAR 2 VN 7643	OTM	70	43.410400, 28.349600	north
3	7.4.2022	Varna	Red mullet	ГОНДОЛА VN4321	OTM	3	43.366200, 28.386800	north
4	17.5.2022	Tsarevo	Red mullet	CIKLAMA VAX215	OTM	6	42.101262,27.505402	south
5	20.6.2022	Varna	Red mullet	IRINA VN 440	OTM	72	43.624300, 28.869800	north
6	16.7.2022	Balchik	Red mullet	BS 041	OTM	156	42.449600, 27.638300	северен
7	4.8.2022	Balchik	Red mullet	BS 041	OTM	390	43.403900, 28.167900	северен
8	1.9.2022	Varna	Red mullet	BARBUN VN 7979	OTM	10	43.184100, 27.899000	северен
9	10.10.2022	Nessebar	Red mullet	KIRIL 45BS280	OTM	62	42.656100, 27.731000	южен
10	19.11.2022	Sozopol	Red mullet	BS 041	OTM	198	42.449600, 27.638300	южен
11	13.12.2022	Sozopol	Red mullet	Elekta VN8042	OTM	90	42.421600, 27.691800	южен

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 red mullet with OTM in kilograms for the first half of 2022. The month of February has the lowest value. In the second quarter landings are significantly higher than the first quarter.

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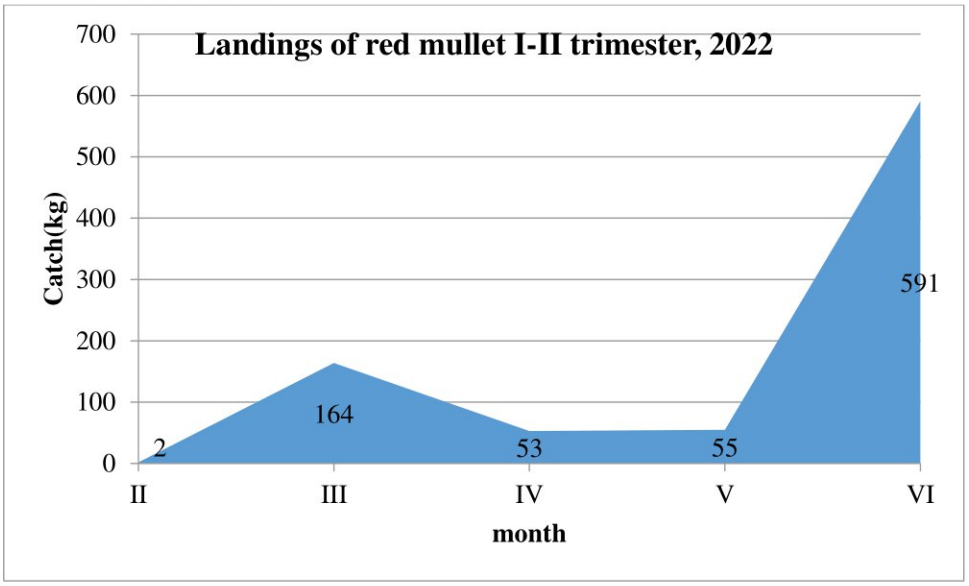

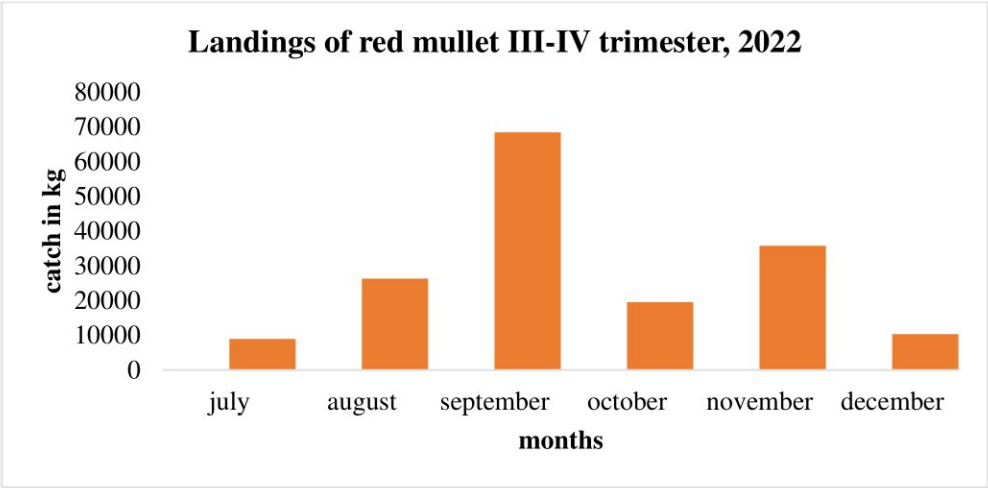

Fig.3.1.1 Official statistics records for red mullet landings.

In the second half of 2022, red mullet catches were low, with a peak recorded in September (68394.2 kg). In July and December, the catches varied between 8923 and 10313.7 kg.

IV.3.2 Length structure of landings

The graph shows that in both quarters the percentage distribution of catches by size class is uneven, with some size classes lacking catch data. The highest values are catches in the size classes from 10 cm and 14 cm, and with the lowest percentage are size classes of 9, 9,5 and 15 and 15,5 cm.

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In the 3rd quarter of 2022, the size distribution was from 6 to 11.00 size group, in contrast to the 4th quarter, where a significant increase in individual sizes (8.5 to 15 cm) was observed. In the 4th quarter, size groups from 6 to 8.00 cm are missing.

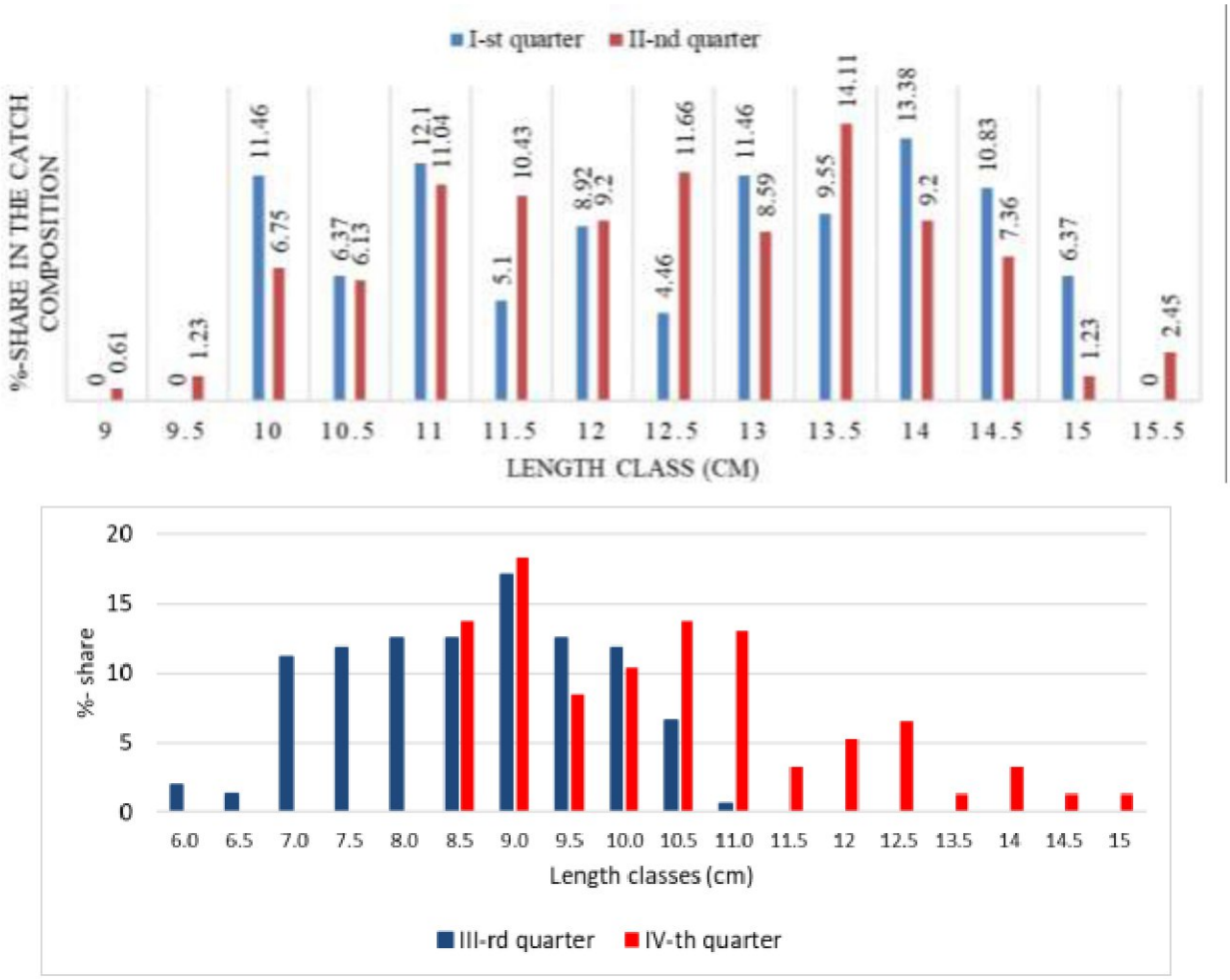

Fig.3.2.1 Size structure and percentage share of length classes in the catch composition.

IV.3.3 Age structure of landings

The three readers determined the age of red mullet otoliths, and reader 1 read all otoliths twice. Specimens **(n = 608)** were used for age determination. The graph shows a smooth rise in Red mullet catch values (%) for both quarters, with the 0-0+ age group having the lowest possible catch values and 3-3+ having the highest catch percentage. Results for catches are best represented in groups 1-1+, 2-2+ and 3-3+.

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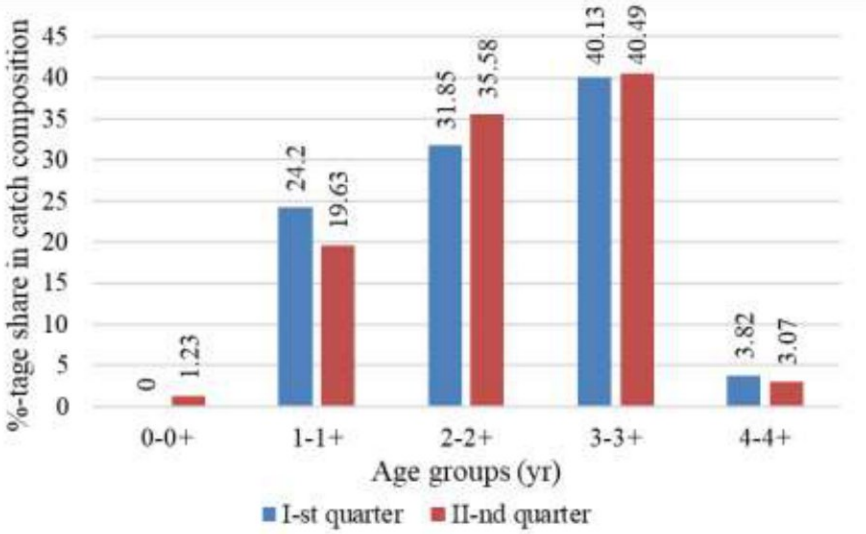
In the 3rd quarter the age distribution showed the presence of age groups from 0+ to 3-3+ years, while in the 4th quarter the age distribution was from 1-1+ to 4-4+ year old individuals in the catches.



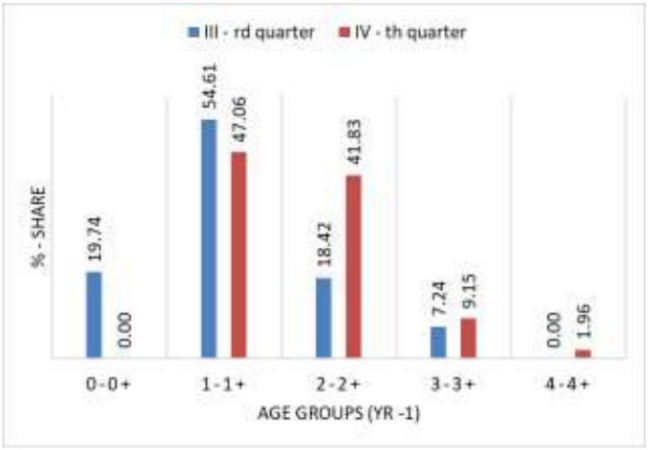


Fig.3.3.1 Age structure and percentage share of age groups in the catch composition.

IV.3.4 Condition factor

Fulton's conditioning factor is evenly distributed for both quarters. The highest values are in the sizes classes of 9 cm, 11 cm and 13.5 cm. The lowest values of the factor are showed in classes 15.5 and 15 are the lowest.

In terms of condition by size group, turbot showed better condition in the 4th quarter.

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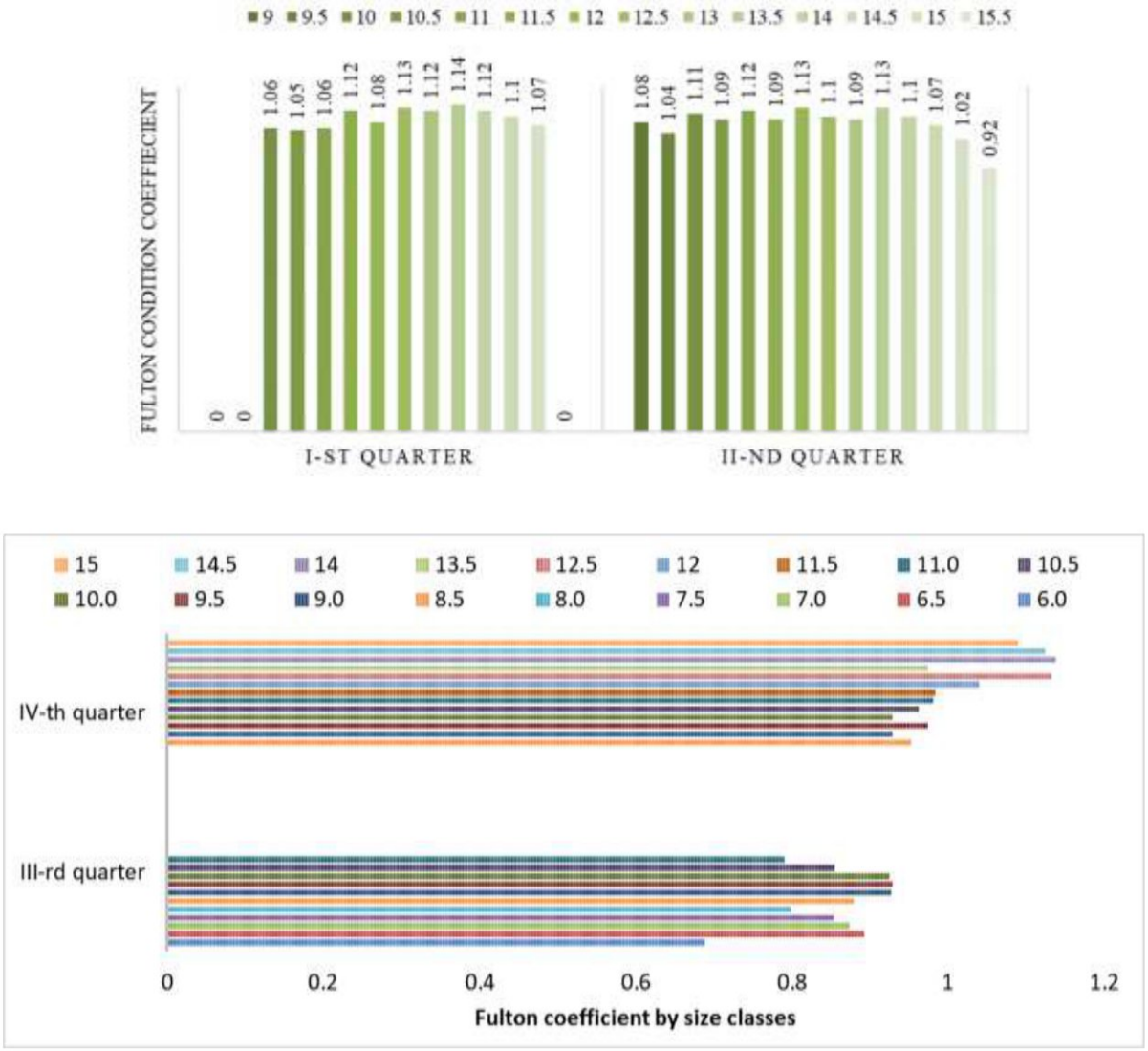

Fig.3.4.1. Fulton condition coefficient values of sprat by length classes.

The conditioning factor has the highest values in the 1-1 and 2-2+ age groups. The lowest value is in age group 4-4+.
The condition factor by age in the 3rd quarter showed similar values, while in the 4th quarter all values were significantly higher, indicating a better physiological condition of the species in the 4th quarter compared to the 3rd quarter.

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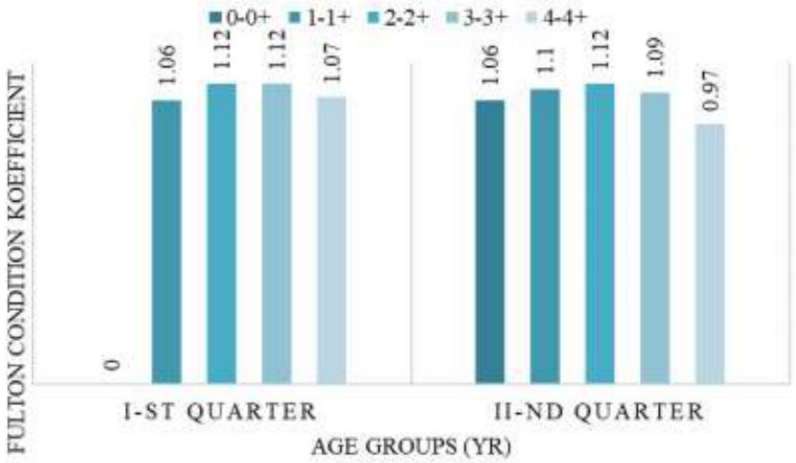

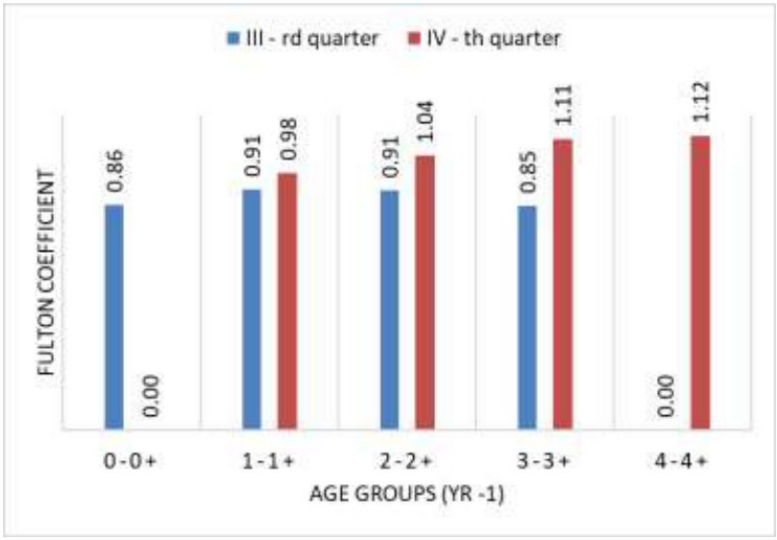

Fig.3.4.2 Fulton condition coefficient values of red mullet by age groups.

IV.3.5 Weight structure

Weight was measured of **608 specimens**. The graph shows that the highest value is the age group 4-4+, and the lowest is 0-0+ for both quarters. The relationship between average weights and age groups is directly proportional.

Average red mullet weights in the 3rd trimester were very low (age 0+: 2.63g; 1-1+: 5.14g; 2-2+: 8.46g; 3-3+: 9.89g). In the 4th quarter, we observed a significant increase in average weights, which ranged from 9.08 to 34.09 g (1-1+ to 4-4+ year-old individuals.

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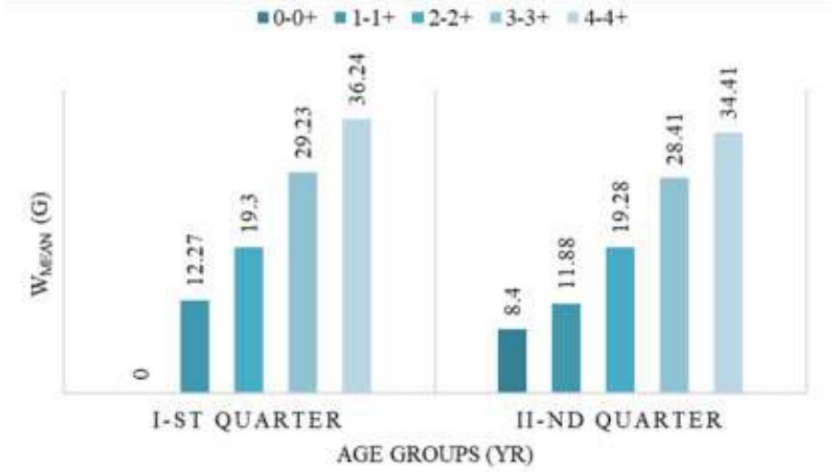

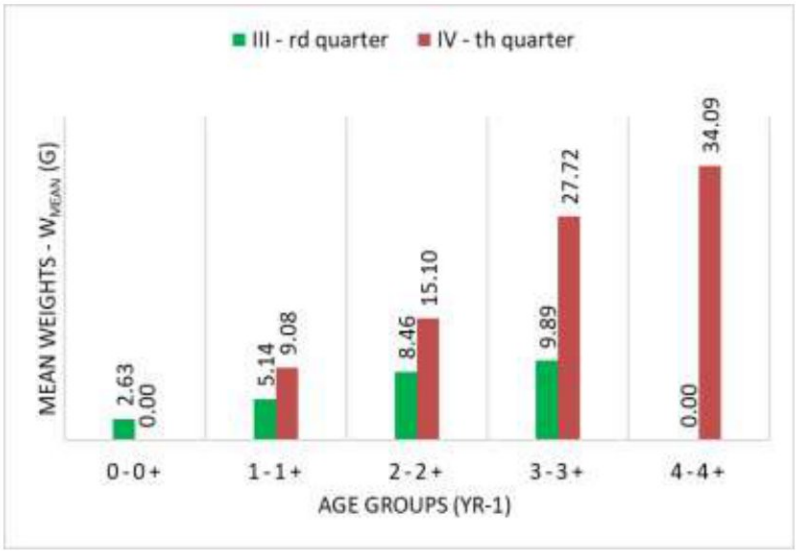

Fig.3.5. 1 Mean weights by age groups.

IV.3.6 Size structure by age group

The fish length was measured of **608 specimens**. As the age increases, the average length of individuals increases too.

The mean lengths in the 3rd trimester were significantly lower than those in the 4th trimester as follows: 6.75 (0+y); 8.25 years (1-1+ years); 9.75 (2-2+ years); 10.50 (3-3+ years). In the following months of the 4th quarter, the average lengths increased as follows: 9.75 (1-1+); 11.31 (2-2+); 13.58(3-3+); 14.50 (4-4+).

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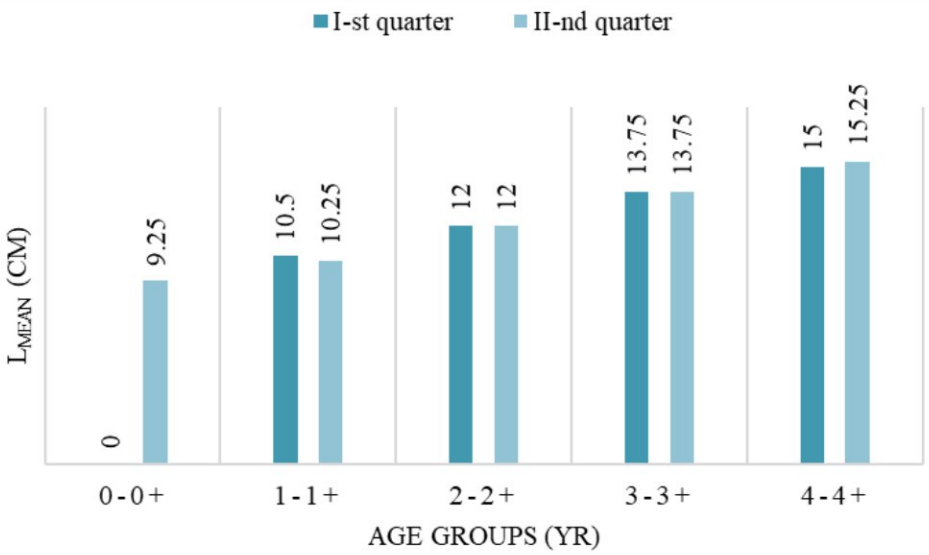

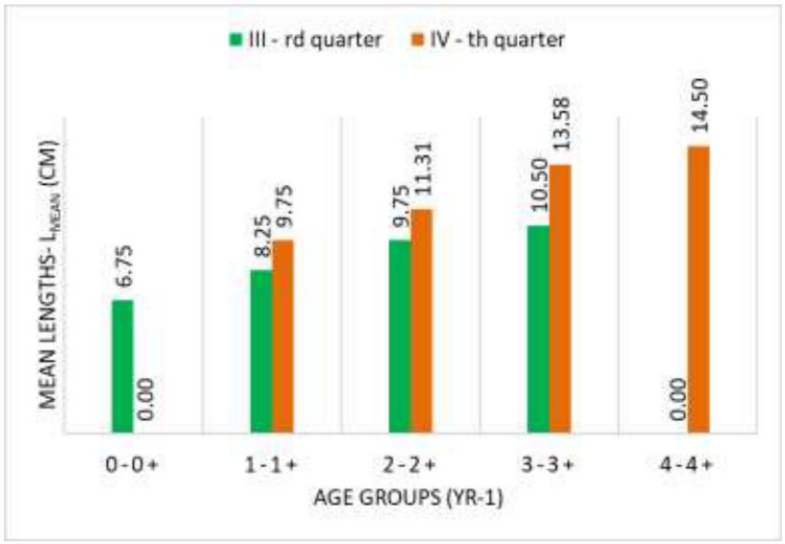

Fig.3.6.1 Mean length by age groups .

IV.3.7 Length- weight relationship

The graph shows a proportional relationship between the length and weight of red mullet **(Фиг. 3.7.1).** The length-weight relationship for the considered periods was very strong, with a degree of determination R^2= 0.99, which indicates a very good relationship between size and weight.

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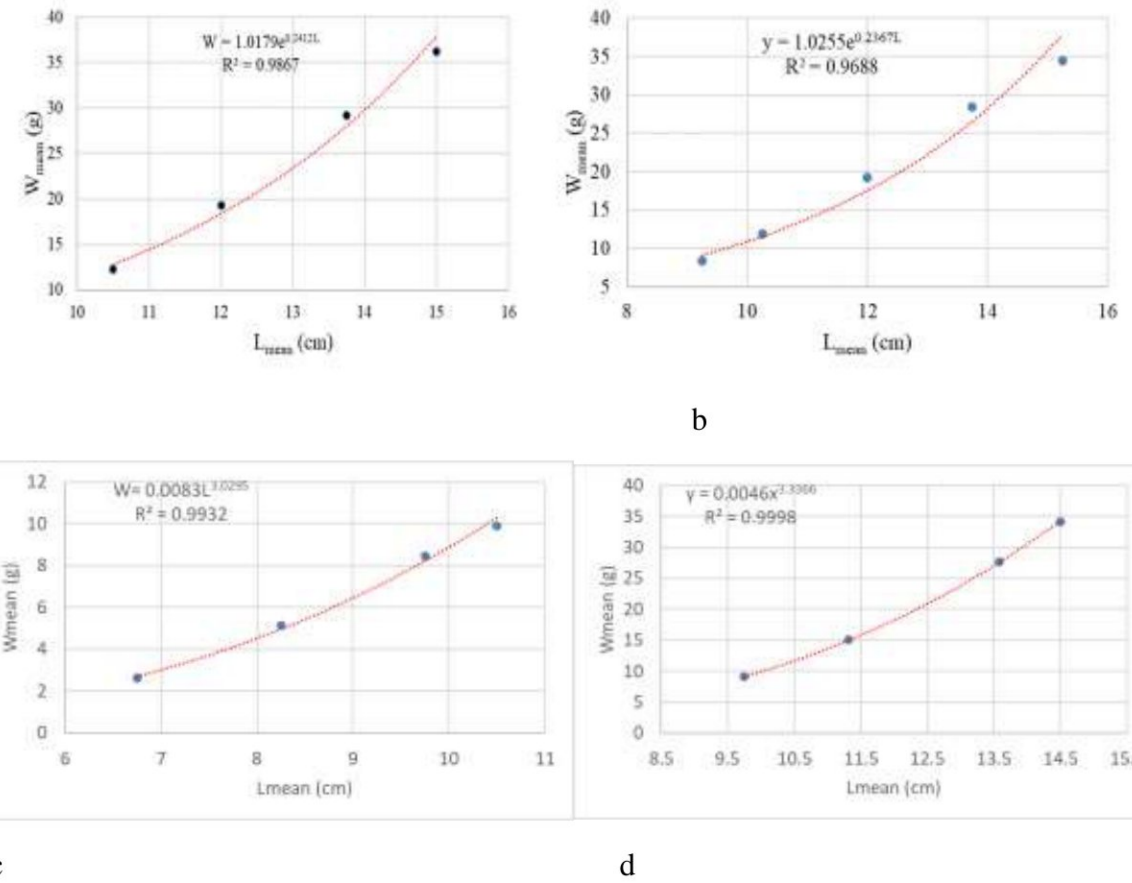

a b

c d

Fig. 3.7.1 Length-weight connection – 1th quarter (a), 2nd quarter (b), 3th quarter (c), 4rd quarter (d) of of 2022.

IV.3.8 Sex ratio

The sex ratio was determined of **300 specimens**. Males (55-60%) predominated in the first and second quarters of 2022. Females were 40-45% in the first and second quarters (**Figure 3.8.1**).

The gender ratio in the 3rd quarter was in favor of female individuals with 63% to 37% in the 4th quarter. Males had similar percentages in both quarters.

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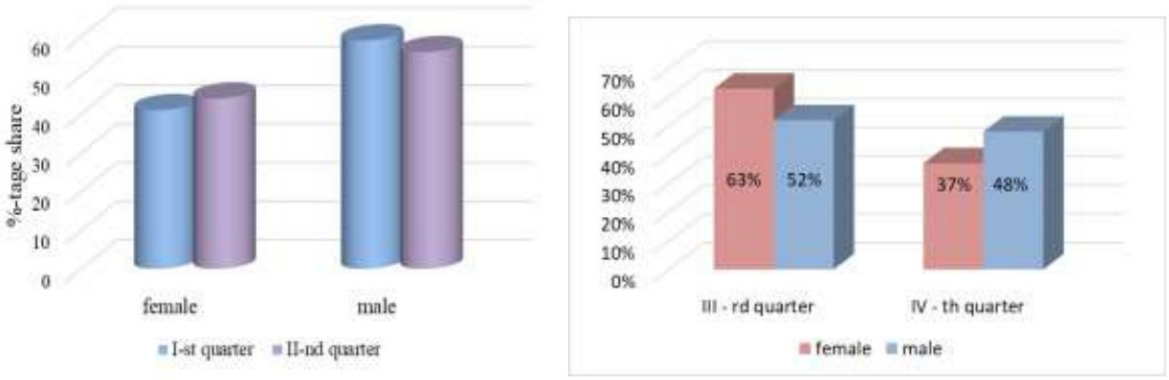
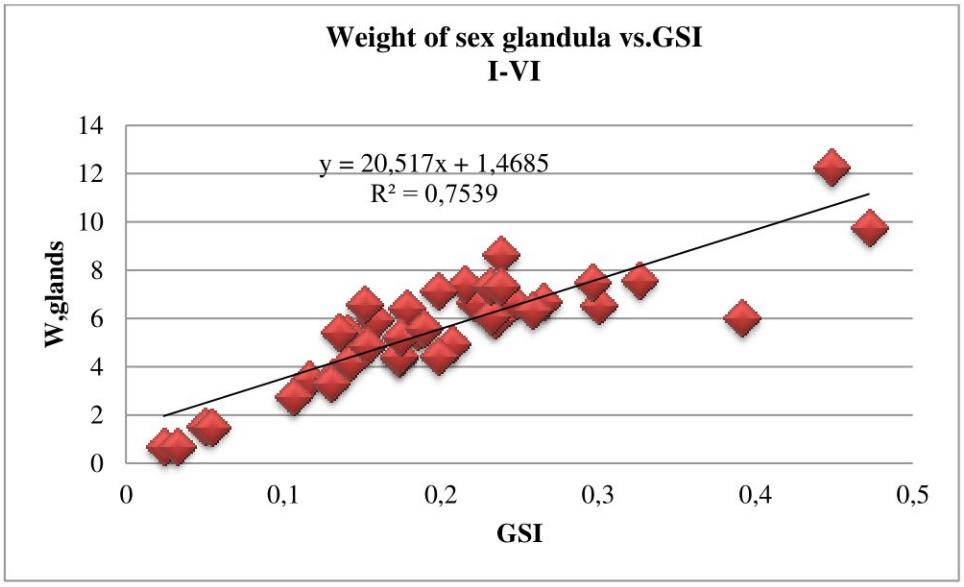


Fig. 3.8.1 Sex-ratio distribution.

IV. 3.9 Fecundity

150 specimens were investigated for batch fecundity of red mullet. The degree of reproduction during the research period indicates a good level of determinicity (r^2 = 0.76), which is directly dependent on the active propagation period of the species.
The reproduction rate during the study period shows a good degree of determinacy (r^2 = 0.92), which is directly related to the active reproduction period of the species.



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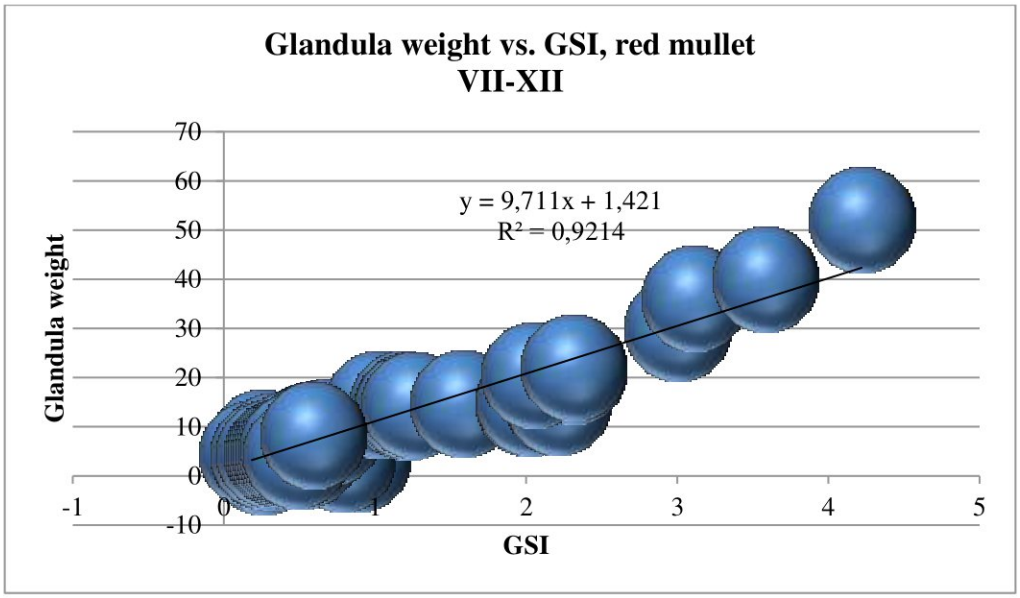
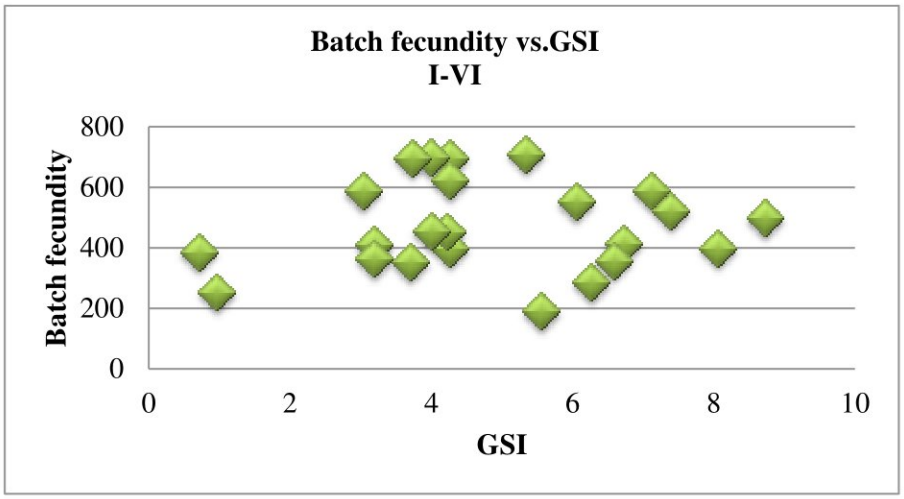


Fig.3.9.1 Dependence of the GSI on the weight of sex glandula of red mullet.



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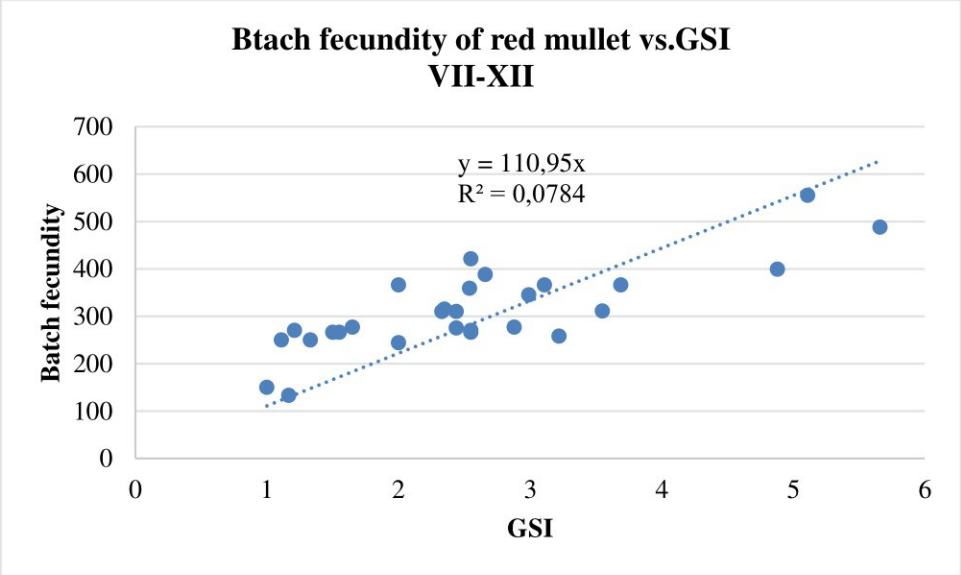

Figure 3. 9.2 Batch fecundity related to GSI of red mullet.

Table 3.9.1 Absolute and relative fertility.

I-VI					
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)♀**
6	1,85111	6,1	na	na	1
6,5	2,332588	6,489	na	na	1
7	2,910257	7,11	na	na	1
7,5	3,665487	7,48	na	na	1
8	4,44189	8,2	na	na	1
8,5	5,6521	8,49	na	na	4
9	6,921444	8,99	7885	877,08565	4
9,5	7,621048	9,45	9256	979,4709	4
10	8,71445	10,11	14500	1434,2235	6
10,5	11,21454	10,52	22036	2094,6768	6
11	14,701	11,33	382451	34147,411	6
11,5	15,2369	11,43	41200	3604,5494	5
12	19,01258	12,22	43690	3634,7754	5
12,5	21,4417	12,51	48215	3863,3814	5
13	29,25666	13,29	50012	3763,1302	5
13,5	33,22145	13,71	52200	3821,3763	5
14	33,65414	14,33	59360	4165,614	5
14,5	34,0125	14,77	65000	4452,0548	5
15	34,5556	15,27	67450	4460,9788	5
15,5	35,21044	15,78	68115	4346,8411	5
16	36,9985	16,17	70145	4337,9716	5

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16,5	41,0211	16,85	70999	4271,9013	5
17	41,22366	17,54	71600	4167,6368	5
17,5	46,1	17,99	72000	4090,9091	5
			average	**average**	∑
			64375,1	**4912,8839**	100

VII-XII					
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)♀**
6	1,85111	6,15		na	
6,5	2,33259	6,432	na	na	1
7	2,91026	6,667	na	na	1
7,5	3,66549	7,345	na	na	1
8	4,44189	7,654	na	na	1
8,5	5,6521	8,112	na	na	4
9	6,92144	8,56	4561	658,966539	4
9,5	7,62105	8,89	8411	1103,65401	4
10	8,71445	9,45	13567	1556,8395	6
10,5	11,2145	9,99	22455	2002,31129	6
11	14,701	10,45	36781	2501,93864	6
11,5	15,2369	11,23	40233	2640,49774	5
12	19,0126	11,69	42112	2214,95452	5
12,5	20,2346	12,34	45667	2256,87683	5
13	22,5651	13,25	52012	2304,97436	5
13,5	27,1125	13,71	53023	1955,66981	5
14	30,3022	14,33	60250	1988,30382	5
14,5	32,6678	14,77	64222	1965,91139	5
15	34,5556	15,02	65931	1907,96861	5
			average	**average**	∑
			39171,2	**1927,60516**	**75**

IV.3.10 Sexual maturity

300 specimens are used for maturity determination. The red mullet is a summer breeding species. The beginning of the active breeding of the species was registered in March-April. In June, we observed mass mature sex products in over 40% of the female subjects surveyed.In Januray-March the predominating stages II-III belonged to males at age 2-2+, and females ata age of 3-3+y^{-1}.

During the 3rd quarter, the senior age groups 3-3+ and 4-4+ years were with degrees of maturity V-VI. Individuals 0+ to 2-2+ were in primary maturation. At age 0+ years: stages I; 1-1+ stages II-III. During the 4th trimester, the glands of females continued mass maturation, with older age groups showing flowing glands, a clear sign of already bred individuals gradually entering dormancy. In males, the trends are similar, as the final maturation of the

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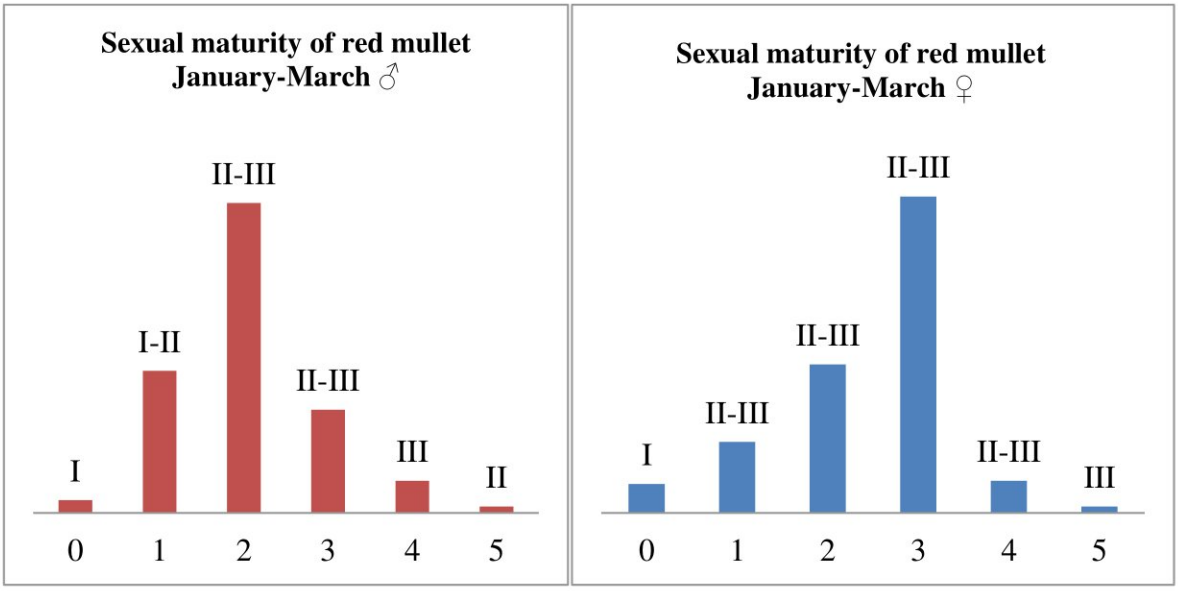
glands in the older groups began already in the third trimester and continued until the end of 2022.



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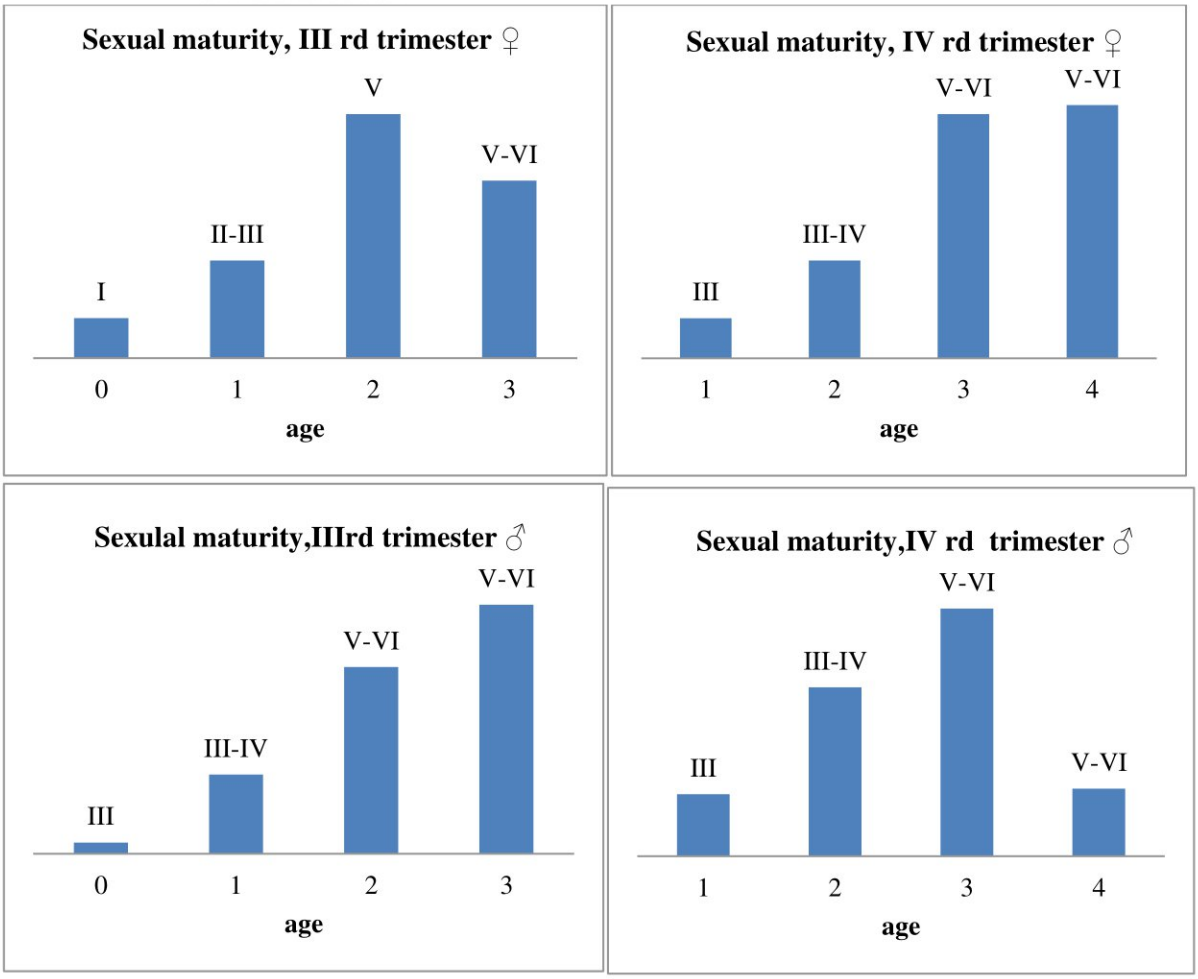

Figure 3.10.1 Sex maturity by age for red mullet.

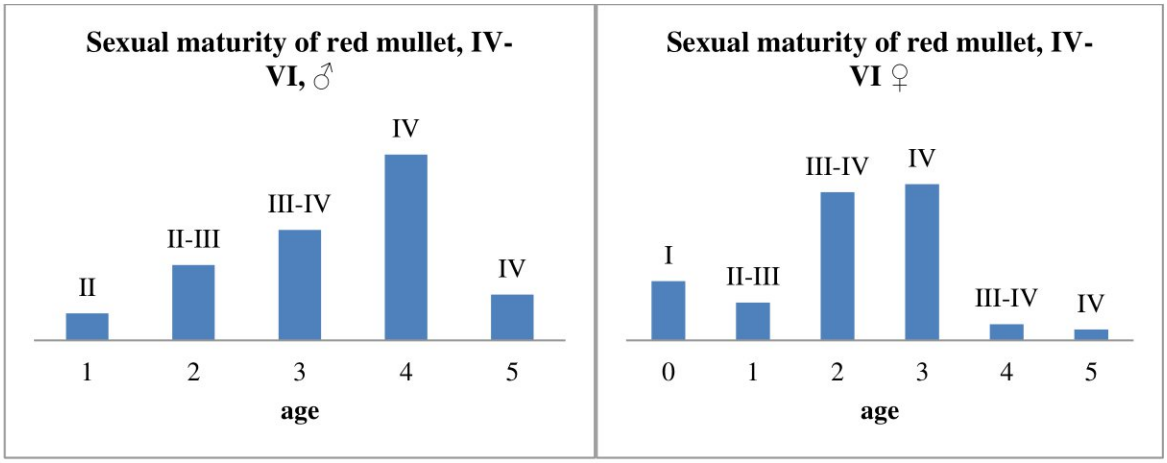

Figure 3.10.2 Sex maturity by age for red mullet.

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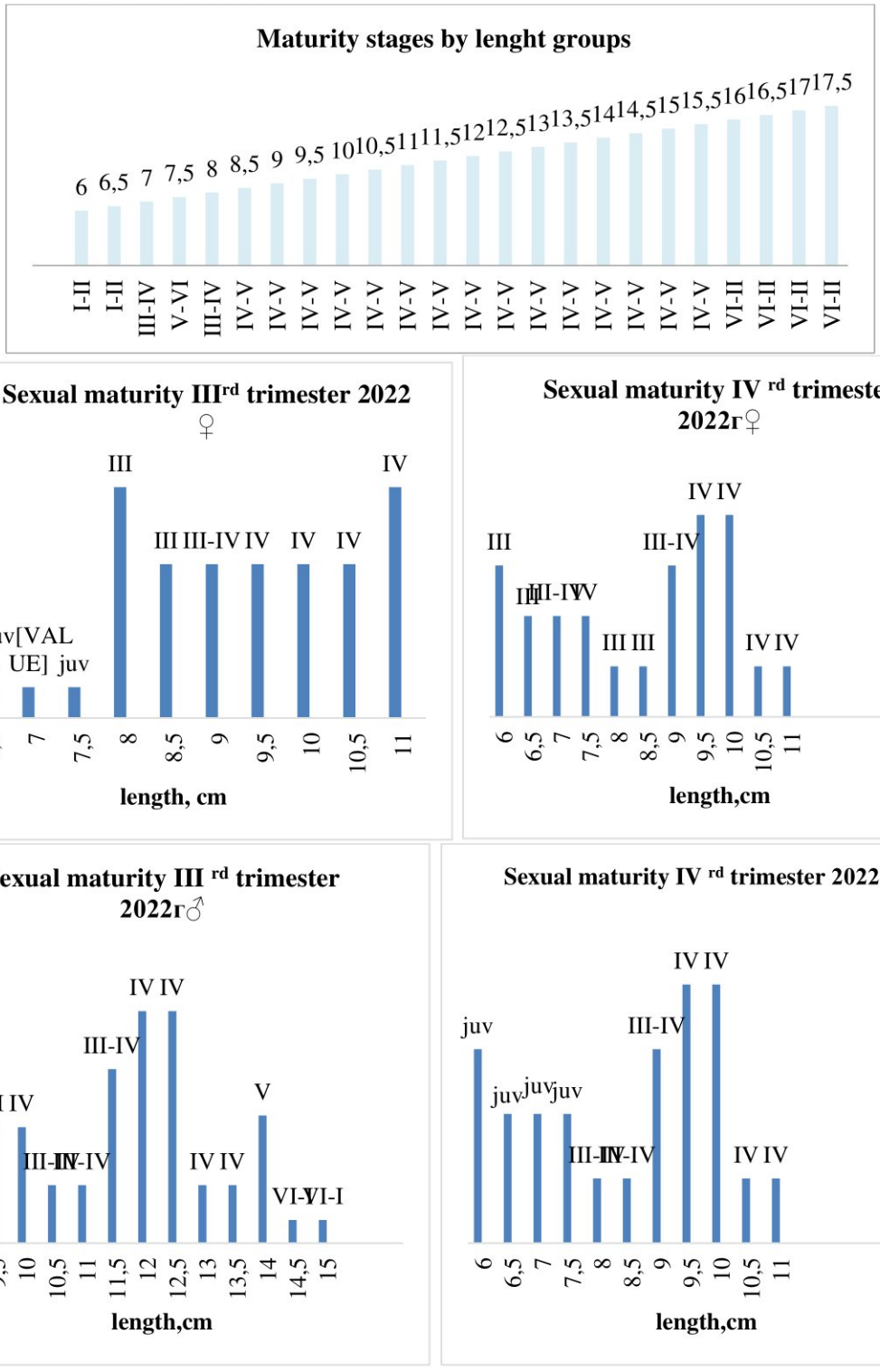

Figure 3.10.3 Sex maturity by length(cm) for red mullet.

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IV.3.11 Catch numbers and biomass by age and length

Monthly catches (in tonnes) together with mean weights of red mullet were used to derive the monthly catch numbers. The share (%) by age groups and catch numbers were used to create catch-at-age matrix for selected months by age groups **(Table 3.11.1)**.

The number in catches increases in size classes. The table shows that for the first quarter in size classes 9 cm, 9.5 cm and 15 cm the value is 0, and in the other classes the values are relatively higher. With the highest value in cash catches are the size classes at 10 cm and 11 cm, with the lowest 12.5 and 15 cm.

During the 1st and 2 nd quarter, biomass is the largest in individuals of 14 cm size class and is smallest at 11.5 cm and 12.5 cm size classes. The number of catches by age group shows that the highest value among catches occupy the groups of 1-1+ and 2-2+ groups.

Biomass by age group is greatest in individuals of 3-3+ and smallest at 4-4+ for the first trimester. For the second age group with the lowest biomass is 0-0+, while the first in this group is missing data.

During the 3rd and 4th quarter, the number in catches increases by size classes. From the table it can be seen that for the 3rd quarter both the numbers and the biomass are lower than the 4th quarter, being mainly immature individuals from size groups starting from 6.00cm (0+ years) to 8.cm (0+ years) to 11 cm (3-3+ years). In the 4th quarter, the contribution of size groups from 8.5 to 15 cm (1- 4 + year olds), with the schwenil forms being completely absent from the catches. Numbers and biomass in the 4th quarter are increasing. Predominance is given to individuals of size class 13 cm and age 3-3+ years.

Table 3.11.1 Catch at lenght $*10^{-3}$ and catch at age (10^{-6}) matrix and biomass (kg) of red mullet.

Length classes (см)	Catch in numbers *10-3			Biomass (kg)		
	I st quarter	II nd quarter	Total	I st quarter	II nd quarter	Total
9	0	0.14205	0.14205	0	1.1350	1.135
9.5	0	0.25250	0.2525	0	2.2699	2.2699
10	35.74511	1.07812	36.82323	384.3057	12.4847	396.7904
10.5	16.68124	0.89579	17.57703	213.5032	11.3497	224.8529
11	27.51141	1.36287	28.87428	405.6561	20.4294	426.0855
11.5	10.06299	1.15605	11.21904	170.8025	19.2945	190.097
12	15.96895	0.86748	16.83643	298.9045	17.0245	315.929
12.5	6.76058	1.00761	7.76819	149.4522	21.5644	171.0166
13	15.59202	0.66456	16.25658	384.3057	15.8896	400.1953
13.5	11.40752	0.93597	12.34349	320.2548	26.1043	346.3591
14	14.54826	0.56502	15.11328	448.3567	17.0245	465.3812
14.5	10.83268	0.41682	11.2495	362.9554	13.6196	376.575
15	5.89202	0.06576	5.95778	213.5032	2.2699	215.7731
15.5	0	0.13236	0.13236	0	4.5399	4.5399
Age groups (yr)	Catch in numbers $*10^{-3}$			Biomass (kg)		
	I st quarter	II nd quarter	Total	I st quarter	II nd quarter	Total

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0-0+	0	0.27023	0.27023	0	2.2699386	2.26993865
1-1+	66.13564	3.05774	69.19338	811.3121019	36.319018	847.631120
2-2+	55.31731	3.41380	58.73111	1067.515924	65.828220	1133.34414
3-3+	46.01462	2.63627	48.65089	1345.070064	74.907975	1419.97803
4-4+	3.53521	0.16492	3.70013	128.1019108	5.6748466	133.776757

Length classes (cm)	**Catch number by lenght *10^{-3}**		**Biomass (kg)**	
	IIIrd trimester	**IVrd trimester**	**IIIrd trimester**	**IVrd trimester**
6	0,15165442	0,096005	0,18753586	0,11872
6.5	0,27297796	0,172809	0,45382585	0,287295
7	0,45496326	0,288015	1,05305797	0,666639
7.5	0,45496326	0,288015	1,21020228	0,766119
8	0,45496326	0,288015	1,40128685	0,887085
8.5	1,06158095	0,672034	5,37061383	3,399868
9	0,7582721	0,480024	3,69581823	2,339639
9.5	0,60661768	0,384019	3,21507372	2,035303
10	0,69761034	0,441622	3,81327155	2,413992
10.5	0,48529415	0,307216	4,3430793	2,749387
11	0,36397061	0,230412	4,03257901	2,552825
11.5	0,15165442	0,096005	2,39583654	1,516685
12	0,60661768	0,384019	11,4165448	7,227246
12.5	0,60661768	0,384019	12,0025375	7,598209
13.5	0,45496326	0,288015	12,8436129	8,130652
14	0,45496326	0,288015	13,4359751	8,505647
14.5	0,39430149	0,249613	12,2430614	7,750473
15	0,30330884	0,19201	10,4762874	6,632016
∑	**8,73529464**	**5,52988**	**103,5902**	**65,5778**
Age groups	**Catch number by age *10^{-3}**		**Biomass (kg)**	
	IIIrd trimester	**IVrd trimester**	**IIIrd trimester**	**IVrd trimester**
0-0+	0,87959564	0,556828	2,52122875	1,596064
1-1+	1,63786774	1,036853	6,84360366	4,332345
2-2+	2,42647073	1,536078	16,7471505	10,60179
3-3+	2,27481631	1,440073	34,0050215	21,52689
4-4+	1,51654421	0,960049	43,4731956	27,52072
∑	**8,73529464**	**5,52988**	**103,5902**	**65,5778**

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IV. 3.12 Conclusions

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

1) The month of January has the lowest value in terms of mullet catches. In the second quarter, landings were significantly higher than the first quarter. In the second half of 2022, red mullet catches were low, with a peak recorded in September (68394.2 kg). In July and December, the catches varied between 8923 and 10313.7 kg.

2) With the highest values are the catches in the size classes of 10 cm and 14 cm, and with the lowest percentage are the size classes 9, 9.5 and 15 and 15.5 cm

3) Smooth rise in red mullet catch values (%) for both quarters, with age group 0-0+ having the lowest possible catch values and 3-3+ having the highest catch percentage. Catch scores are best represented in groups 1-1+, 2-2+ and 3-3+. The highest values are in the size classes 9 cm, 11 cm and 13.5 cm. The lowest factor values are shown in classes 15.5 and 15 are the lowest.

4) The highest value is the age group 4-4+ and the lowest is 0-0+ for both quarters. The relationship between average weights and age groups is directly proportional.

5) The length-weight relationship for the considered periods was very strong, with a degree of determination R^2= 0.98, R^2= 0.96, R^2= 0.99 which shows a very good relationship between size and weight.

6) In the first and second quarter of 2022 male individuals predominate (55-60%). Females are 40-45%, in the first and second trimester. The gender ratio in the 3rd quarter is in favor of female individuals with 63% to 37% in the 4th quarter. Males had similar rates in both the 3rd and 4th trimesters.

7) The condition coefficient has the highest values in the age groups 1-1+ and 2-2+. The lowest value is in the 4-4+ age group.

8)) The relationship between average weights and age groups is directly proportional. The average weights of mullet in the 3rd quarter were very low (at age 0+: 2.63g; 1-1+: 5.14g; 2-2+: 8.46g; 3-3+: 9.89 g). In the 4th quarter, we observed a significant increase in average weights, which ranged from 9.08 to 34.09 g (1-1+ to 4-4+ year-old individuals.

9) With advancing age, the average length of individuals also increases. The mean lengths in the 3rd trimester were significantly lower than those in the 4th trimester as follows: 6.75 (0+y); 8.25 years (1-1+ years); 9.75 (2-2+ years); 10.50 (3-3+ years). In the following months of the 4th quarter, the average lengths increased as follows: 9.75 (1-1+); 11.31 (2-2+); 13.58(3-3+); 14.50 (4-4+).

10) The reproduction rate during the study period shows a good degree of determinacy (r^2 = 0.76), which is directly related to the active reproduction period of the species.

11) The somatic index for red mullet varies within narrow limits, with a pronounced correlation between the gland weight of the measured specimens (r^2 = 0.76). The Gonado-Somatic Index for mullet varies within narrow limits, with a pronounced correlation between the number of spawn grains of the specimens measured (R^2 = 0.93).

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12) The beginning of active reproduction of the species was registered in March-April. In June, we observed mass mature sexual products in over 40% of the women surveyed. In January-March, the predominant instars II-III belonged to males aged 2-2+ and females aged 3-3+y^{-1}.

13) The rate of reproduction during the period of the 3rd and 4th quarter shows a good degree of determinacy (r^2 = 0.92), which is directly dependent on the active period of reproduction of the species.

14) The mean absolute fecundity was estimated at 64375.1 spawn, with the mean relative fecundity being 4912.8839.

15) The number of catches increases in size classes. For the first quarter in the size classes 9 cm, 9.5 cm and 15 cm the value is 0, and in the other classes the values are relatively higher. With the highest value are the size classes 10 cm and 11 cm, with the lowest 12.5 and 15 cm.

16) Biomass was greatest in individuals measuring 14 cm and least in individuals measuring 11.5 cm and 12.5 cm. Biomass by age group is greatest in individuals aged 3-3+ and least in individuals aged 4-4+ for the first trimester.For the second age group with the lowest biomass is 0-0+, while for the first in this group there is no data. The number in catches increases by size classes. For the 3rd trimester, both numbers and biomass were lower than for the 4th trimester, with mainly immature individuals from size groups ranging from 6.00 cm (0+ yr) to 8.0 cm (0+ yr) to 11 cm (3-3+ years old). In the 4th quarter, the contribution of size groups from 8.5 to 15 cm (1- 4 + years old), with juvenile forms completely missing from the catches. Numbers and biomass in the 4th quarter are increasing. Predominance is given to individuals of size class 13 cm and age 3-3+ years.

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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 **2022** 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

The data from this analysis are collected directly from the discharges in the ports from the Bulgarian Black Sea coast. In 2022, **7 samples containing 684 specimens** were collected and processed.

V.2.2 Sampling period

In **2022**, the biological data on species were collected from a total of **7 landings** at the ports of **Varna, Nessebar Sozopol and Tsarevo**. 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 2.2.1.**

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

	Date	Sampling ports	ANE	Fishing vessel	Fishing gear	Catch/kg	Coordinate	Area
1	4.1.2022	Nesebar	anchovy	R/K 40 BS258	OTM	4500	42.655800, 27.730700	south
2	7.2.2022	Sozopol	anchovy	R/K 37BS255	OTM	3348	42.422600, 27.691300	south
3	29.3.2022	Nesebar	anchovy	R/K 40 BS258	OTM	2100	42.646200, 27.727300	south
4	14.4.2022	Nesebar	anchovy	R/K 5 VN 8186	OTM	200	42.659700, 27.731400	south
	V 2022 no recorded catches with OTM							
	VI 2022 no recorded catches with OTM							
5	23.7.2022	Varna	anchovy	Veni VN 2998	OTM	20	43.403900, 28.167800	north

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6	1.9.2022	Varna	anchovy	Lefer VN 03	OTM	10	43.184100, 27.898600	north
7	11.11.2022	Tsarevo	anchovy	Priqtel BS 160	OTM	330	42.170500, 27.858700	south

Photo 4: Laboratory processing of *Engraulis encrasicolus* samples.

V.2.3 Statistical analysis of data

See section statistical analysis of sprat.

V.3 Results

V.3.1 Landings statistics

According to official catch statistics large catches with OTM were taken in February in 1st and 2nd quarter. Catches with OTM in November predominate in 3rd and 4 th quarter. (**Figure 3.1.1**).

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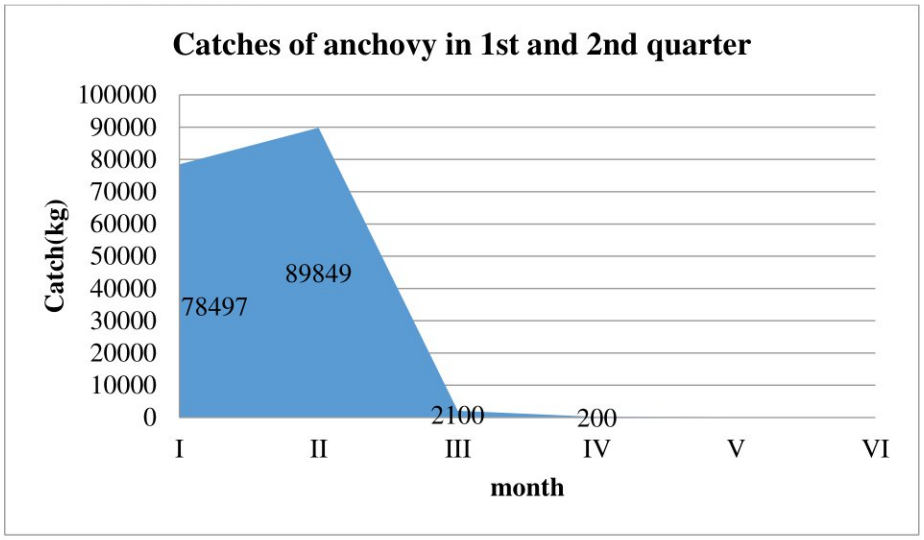

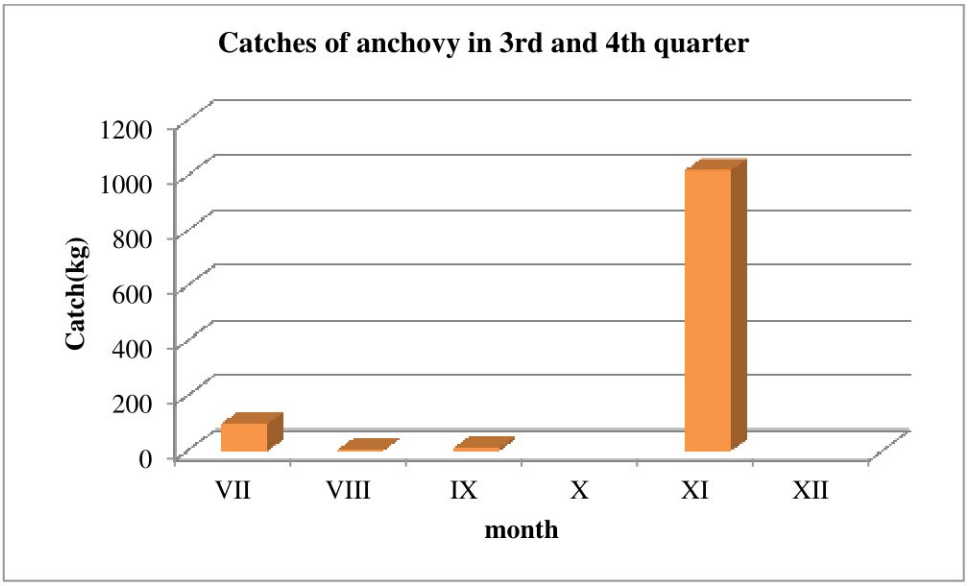

Figure 3.1.1 Landings statistics of anchovy.

V.3.2 Length structure of landings

In the catches of the Bulgarian aquaria of the Black Sea during the research period of I-VI 2022, the size composition is presented by individuals with a body length from 8.5 cm to 13.0 cm.

The graph shows that also in the third and fourth quarters the percentage distribution of catches by size class is uneven. Individuals in the size classes of 9 cm and 11.5 cm have the highest values, and the size classes of 8, 9.0 and 10.5 cm have the lowest percentage value.

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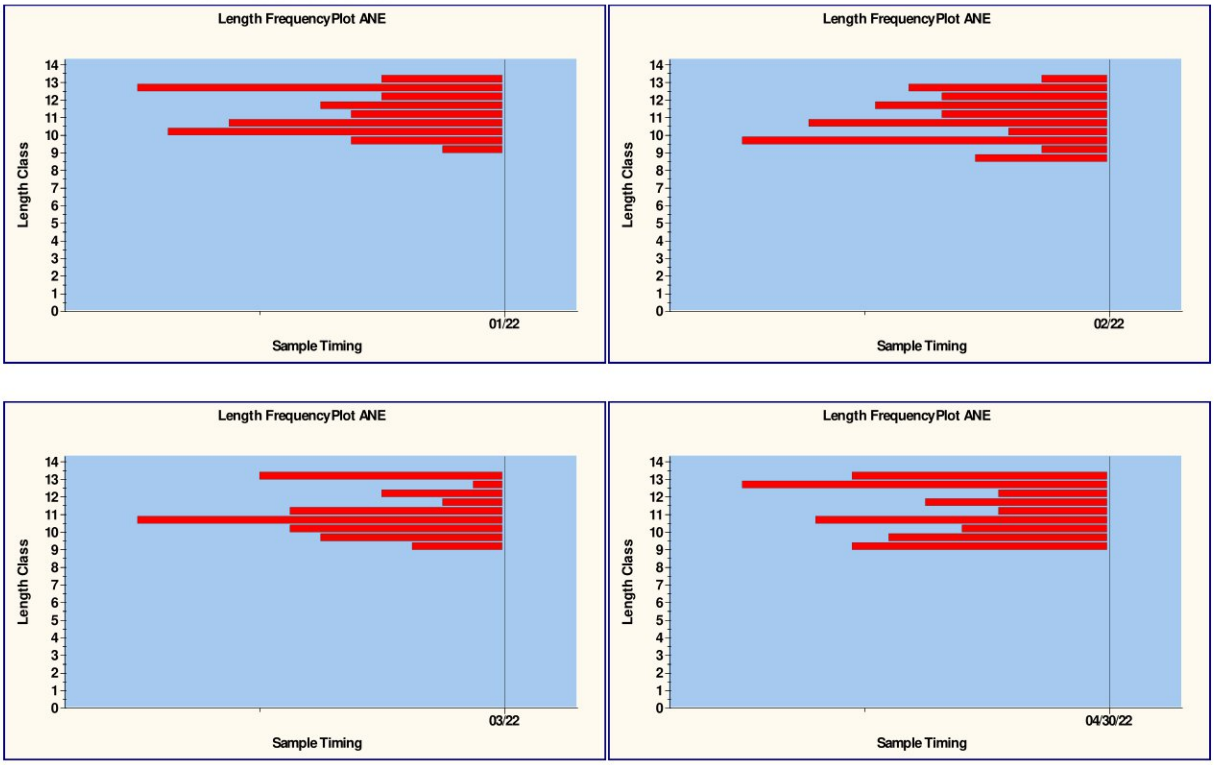

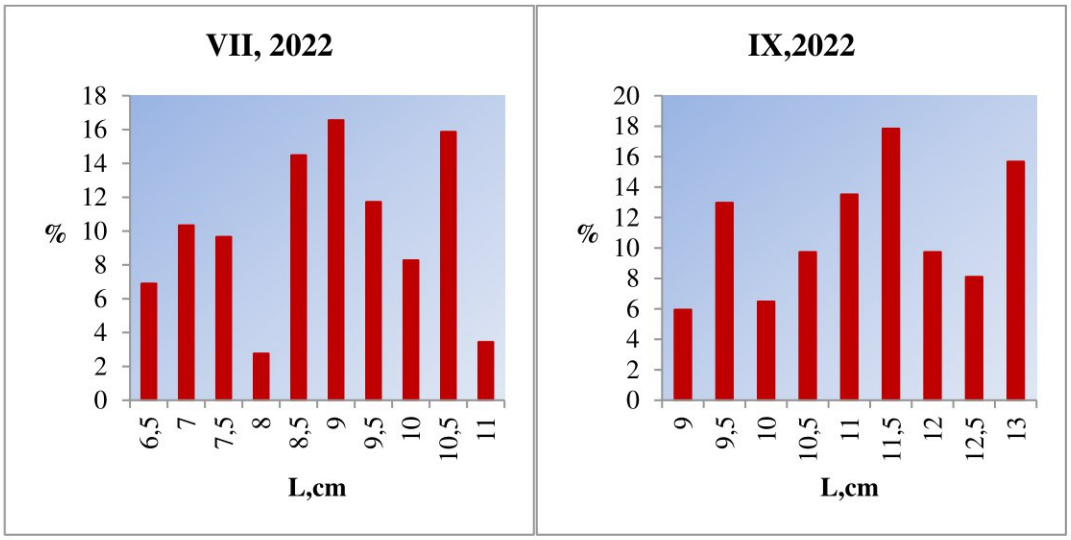

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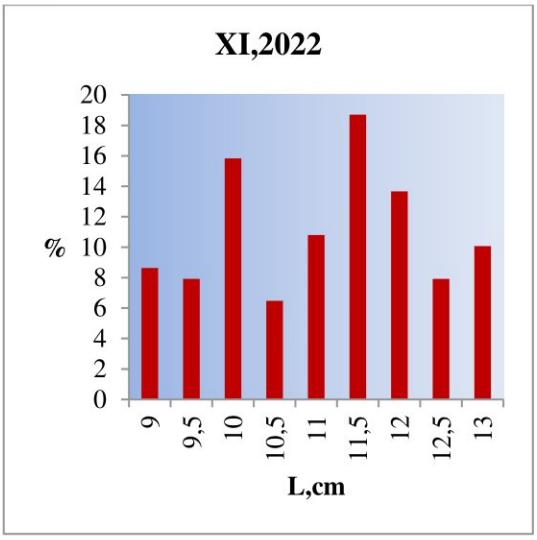
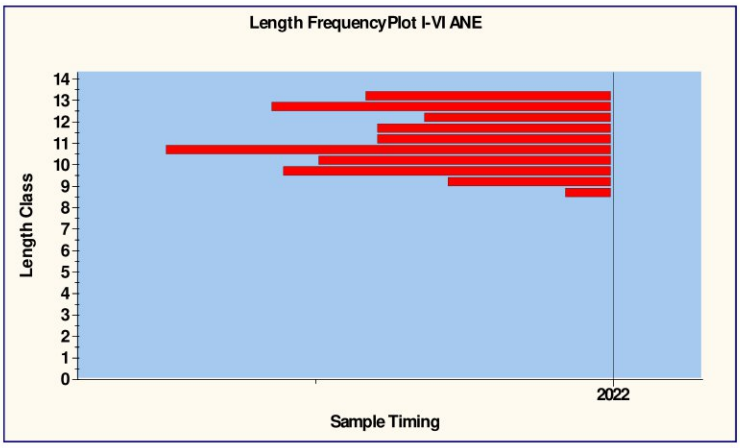


Figure 3.2.1 Frequency of anchovy length from landings.
Note: In May and June, there were no recorded catches of anchovy with OTM

From the distribution of individuals by size groups, it is found that the 10.5 cm group is the most common with 17.67%. Followed by the 12.5 cm and 9.5 cm groups with 13.49 % and 13.02 % respectively.



From the distribution of individuals by size groups in VII-XII, it is established that the 11.5 cm group is the most common with 12.58%. Followed by the 9.5 cm and 10.5 cm groups with 11.09 % and 10.66 % respectively.

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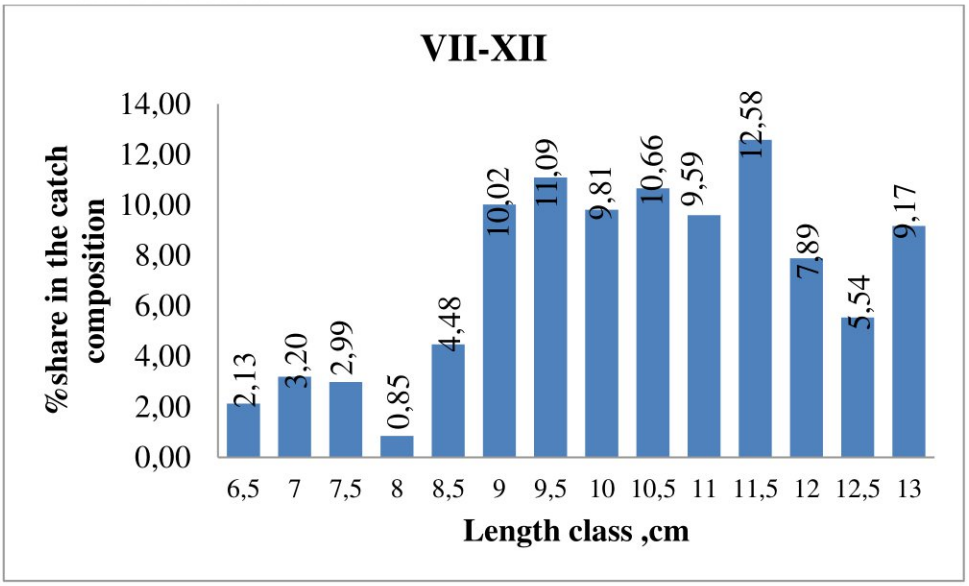

Figure 3.2.2 Frequency of anchovy length from landings.

V.3.3 Age structure of landings

684 fish were used to determine age. In the months of January, February and March, 2022, the share of zero-year specimens is the lowest (10.34% and 12.96% and 6%). In February, two- and three-year-olds show an even distribution in catches. In March, two-year-old fish made up ~34.00% of the catch. In April, the importance of the two-years increased, reaching ~ 45.28%, (**Figure 3.3.1**). In April, 3+ years reduced their share to 20.75%.

The graph shows a smooth rise in catch values for both the third and fourth quarters, with the 4+ age group having the lowest possible catch values and the 2+ and 3+ having the highest percentage performance in catches. Catch results are best represented in the 0+ and 1+ groups in November.

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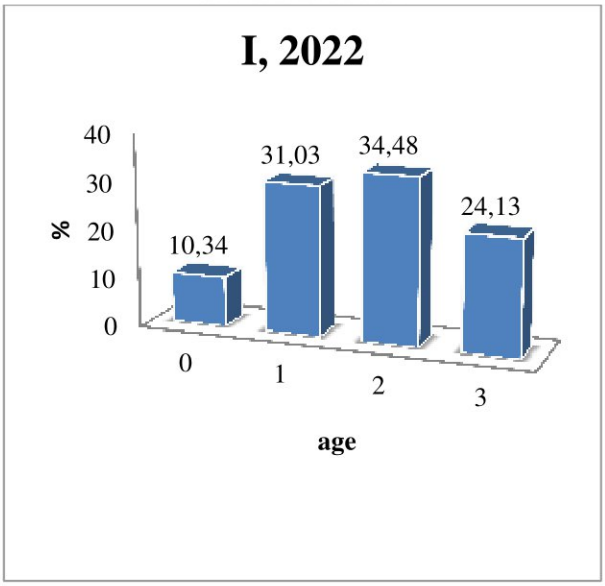

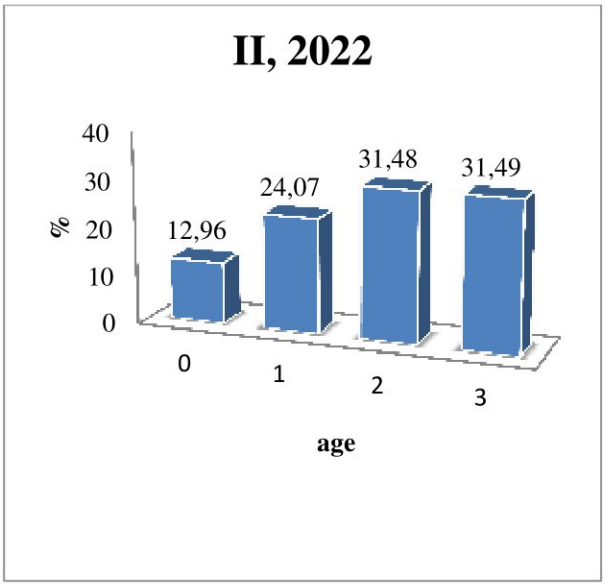

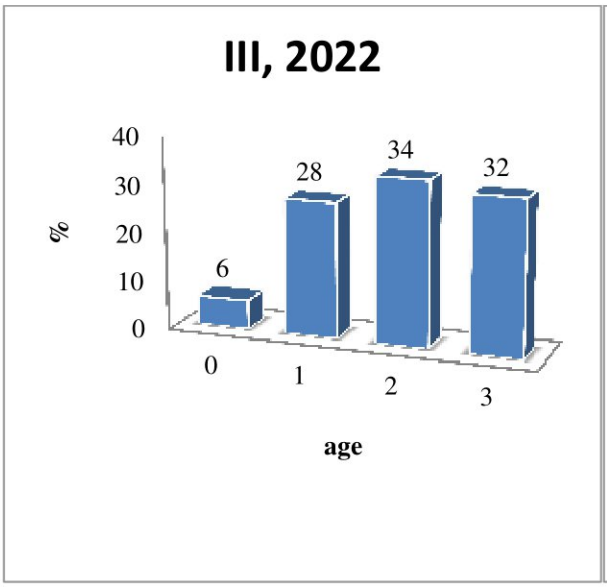

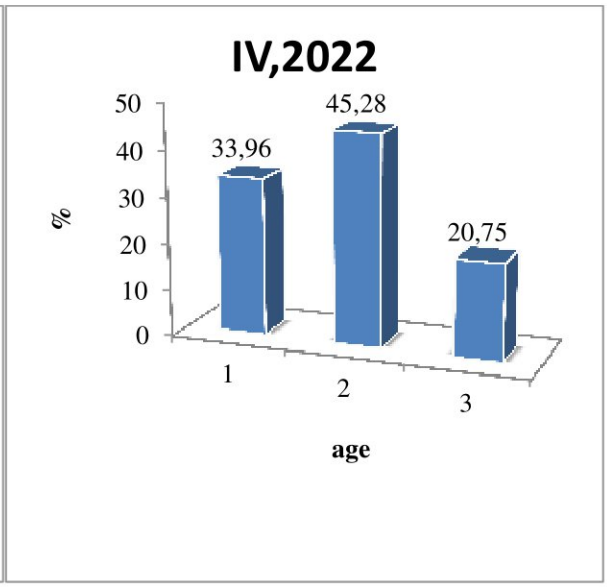

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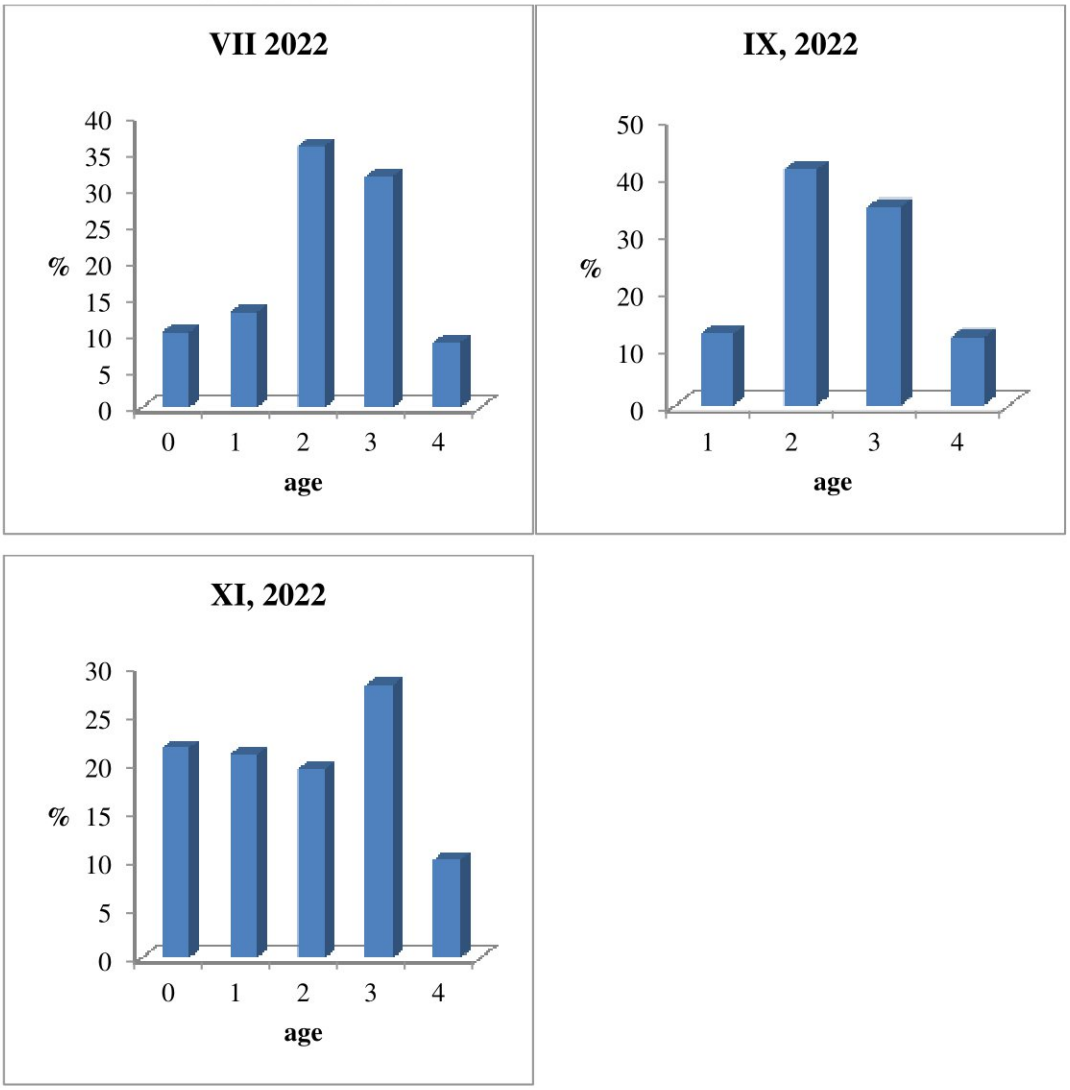

Figure 3.3.1 Age distribution of anchovy (%).

The age composition of the studied specimens includes from 0 to 3-year-old individuals (in 1st and 2 nd quarter), with two (36.28%) year-old fish predominating and from 0 to 4-year-olds (in 3 rd and 4 th quarter). During the studied period, a lower participation of zero-year-olds was observed (7.44% and 10%) (**Figure 3.3.2).**

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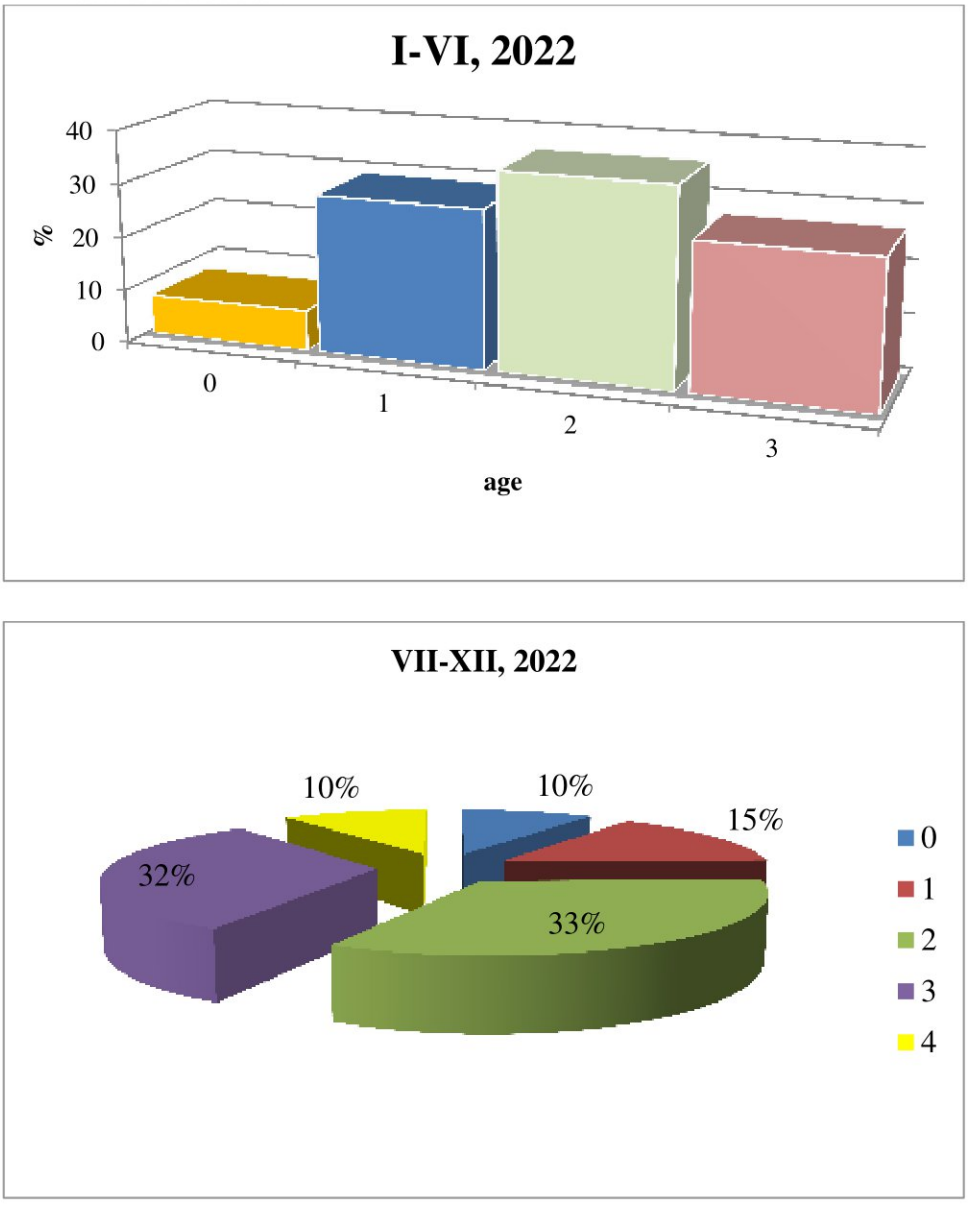

Figure 3.3.2 Age distribution of anchovy in I-VI and VII-XII, 2022.

V.3.4 Condition factor

For the one-year condition indicator, it showed the highest values and decreases in the remaining months. The condition factor of the anchovy from the studied period shows relatively low values due to the absence or small percentage of the largest and oldest groups in the catch.

In the third and fourth quarters, the condition factor was highest in the 1-1 and 2-2+ age groups in November. It has the lowest value in the age group 0+.

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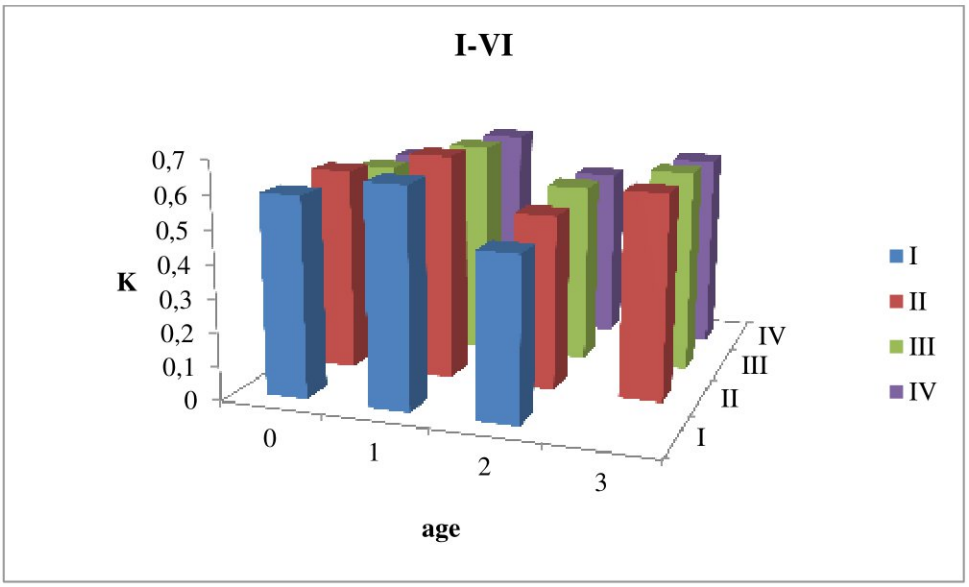

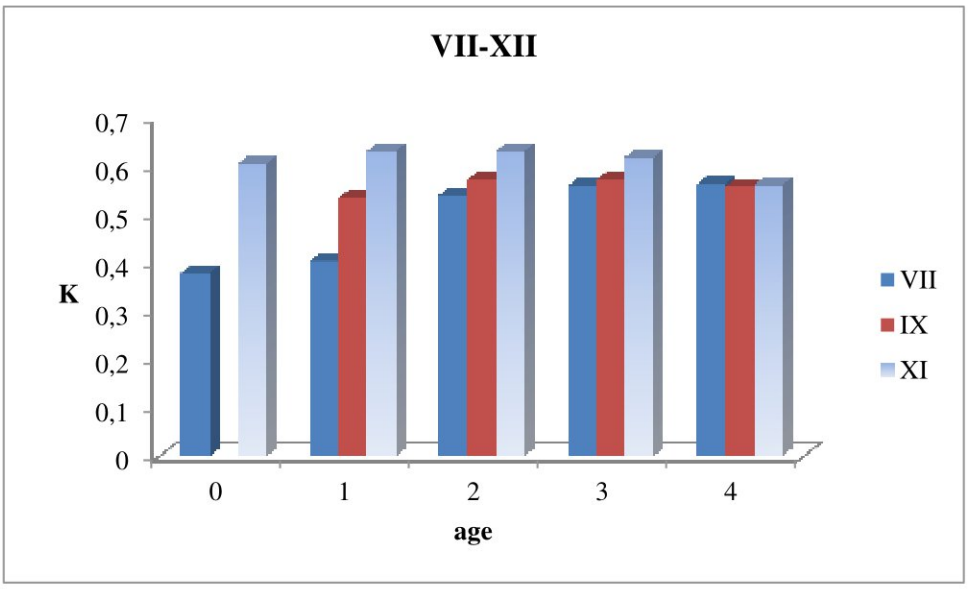

Figure 3.4.1 Average anchovy conditioning values by age.

V.3.5 Weight structure

The weight was measured at **684 specimens**. The weight structure analysis shows that the average weights by age group vary by range. Average anchovy weights in the first quarter were significantly lower than those in the second quarter due to the presence of zero-year fish in the first three months.

In the third and fourth quarters, the graph shows that the highest value is the age group 4-4+ and the lowest is 0-0+ for both quarters. The relationship between average weights and age groups is directly proportional.

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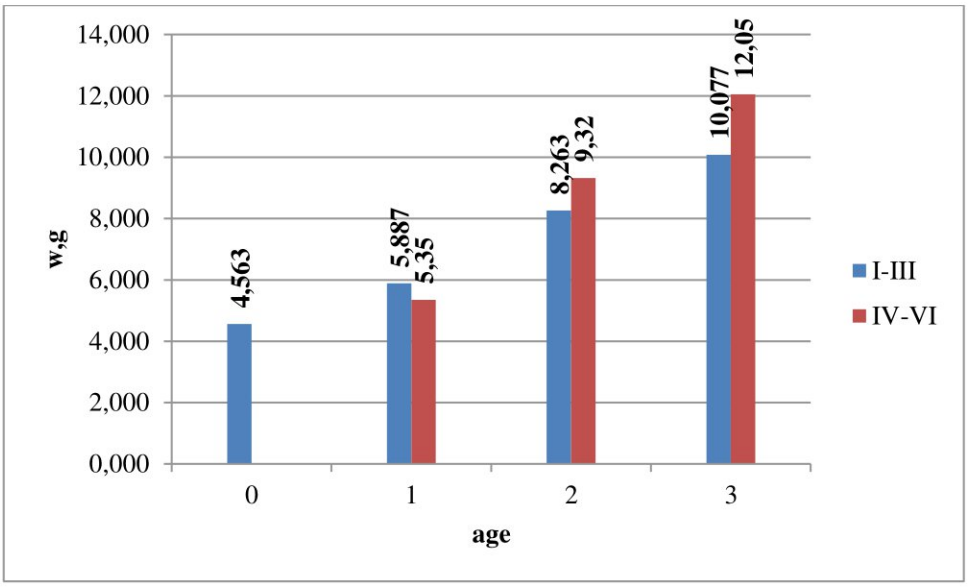

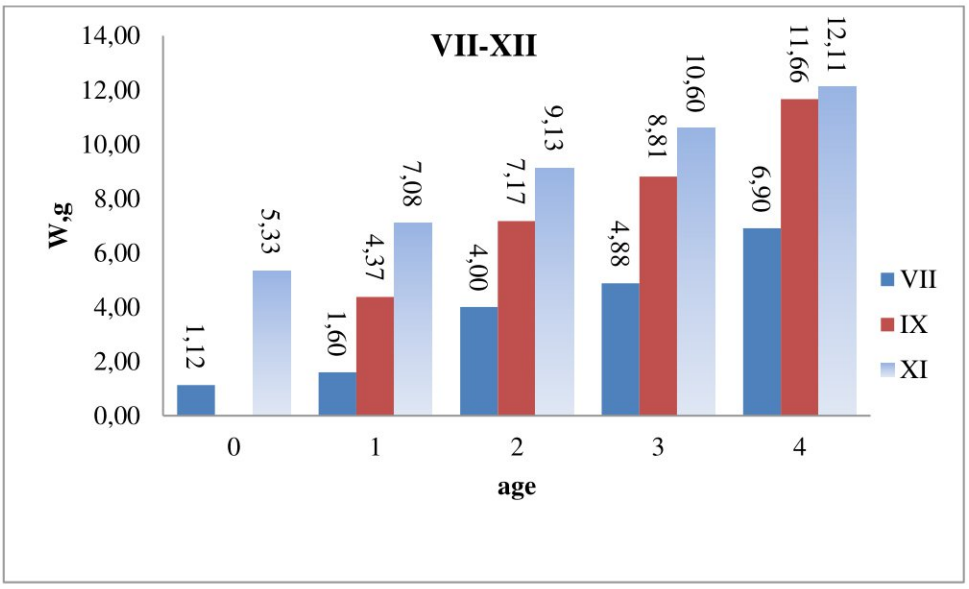

Figure 3.5.1 Average anchovy weights.

V.3.6 Size structure by age group

The length of the fish was measured at **684 specimens**. As the age increases, the linear dimensions increase steadily. Average lengths show similar values in all size groups. In the third and fourth quarter, average lengths by age group increase with age.

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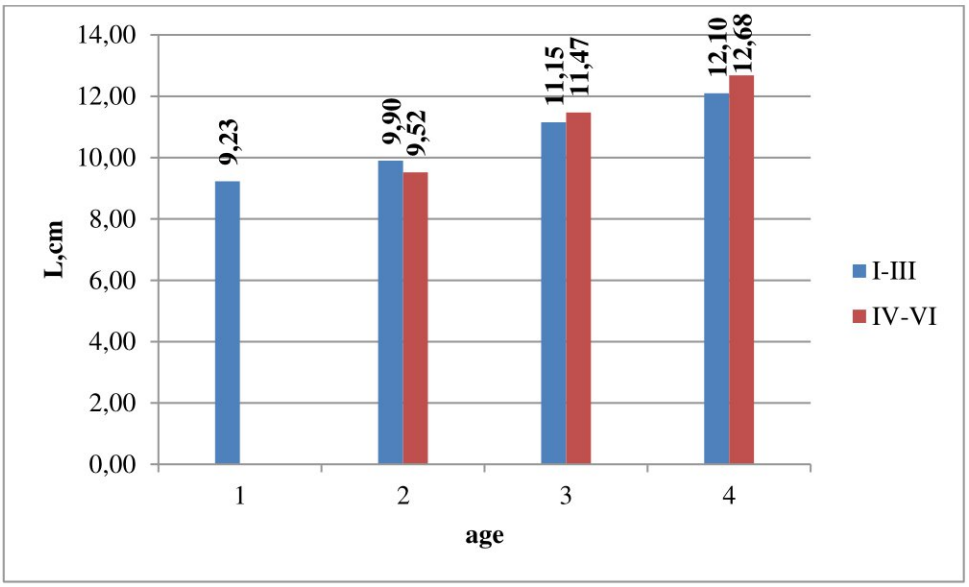

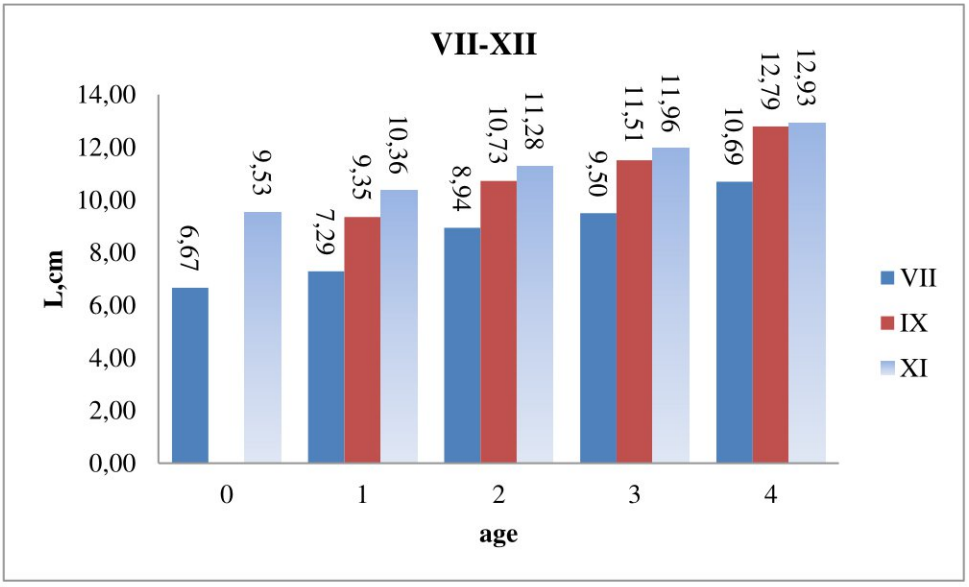

Figure 3.6.1 Average anchovy lenght.

V.3.7 Length- weight relationship

It follows from the analysis that the growth in the anchovy is allometric ($n \neq 3$), i.e. is not the same in terms of linear and weight growth. The results of the modeling of the length-weight relationship are presented in **Table 3.7.1**, and the graphical presentation of the model in **Fig. 3.7.1.**

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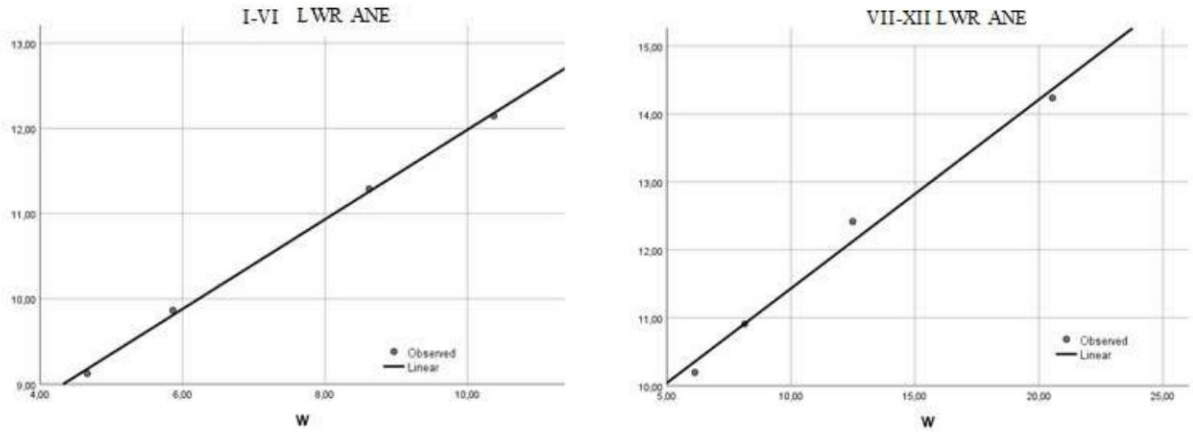

Fig. 3.7.1 Representation of the length-weight model for anchovy on a scatter plot.

Table 3.7.1 Results of modeling the length-weight relationship.

I-VI	**ANE**
	LWR model
Parameter estimates a and b	*a=0.0095;* *b=2.8071*
LWR model	$W = 0.0095*L^{2.8071}$
Statistical significance (α=0.05)	*R=0,992* R^2*=0,999*

VII-XII	**ANE**
Parameter estimates a and b	*LWR model* *a=0.0029;* *b=3.3052*
LWR model	$W = 0.0029*L^{3.3052}$
Statistical significance (α=0.05)	*R=0,992* R^2*=0,9959*

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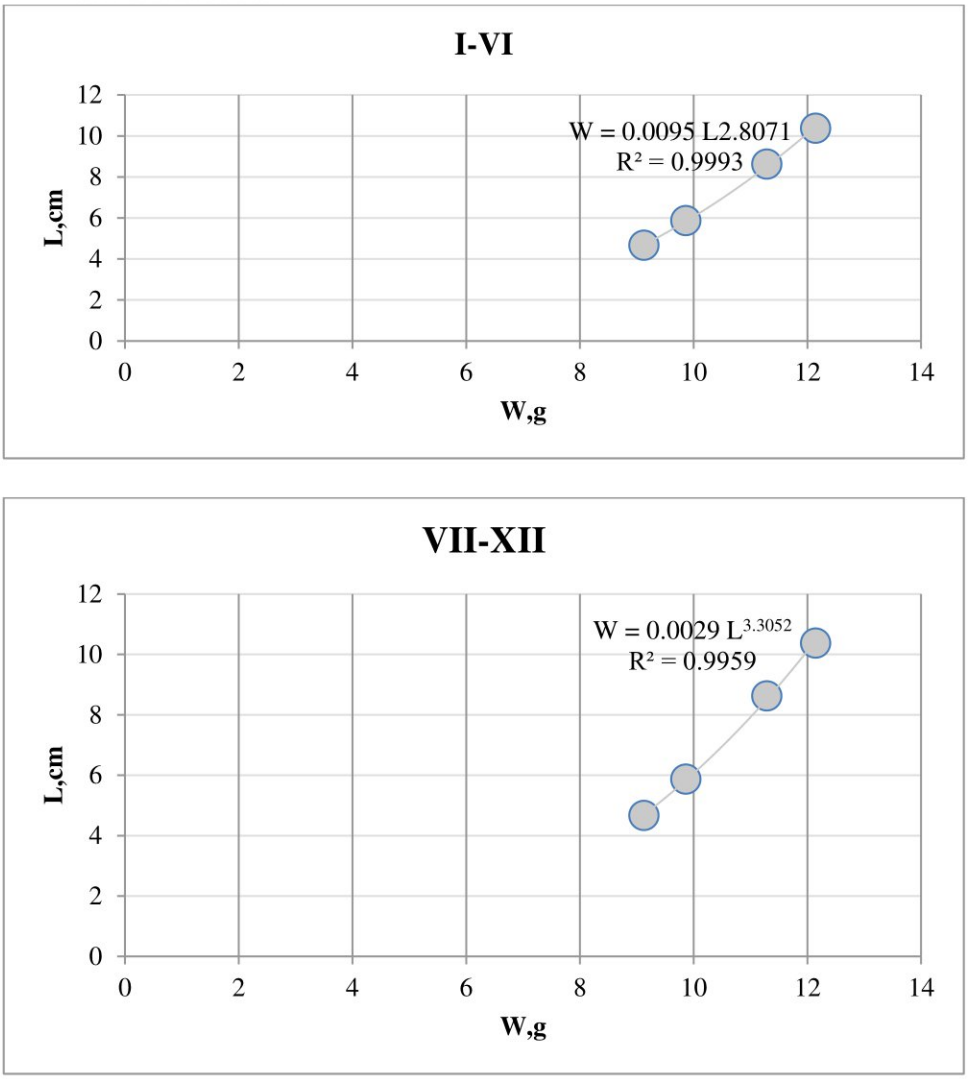

Figure 3.7.2 Linear regression of the ratio size (L)-weight(W) of the anchovy.

V.3.8 Sex ratio

The sex ratio was determined 300 **specimens**. Sex of the determined specimens, 33% was male (♂)) and 67% was female (♀) **(Figure 3.8.1).** In the third and fourth quarters of 2022, female individuals predominate (58%).

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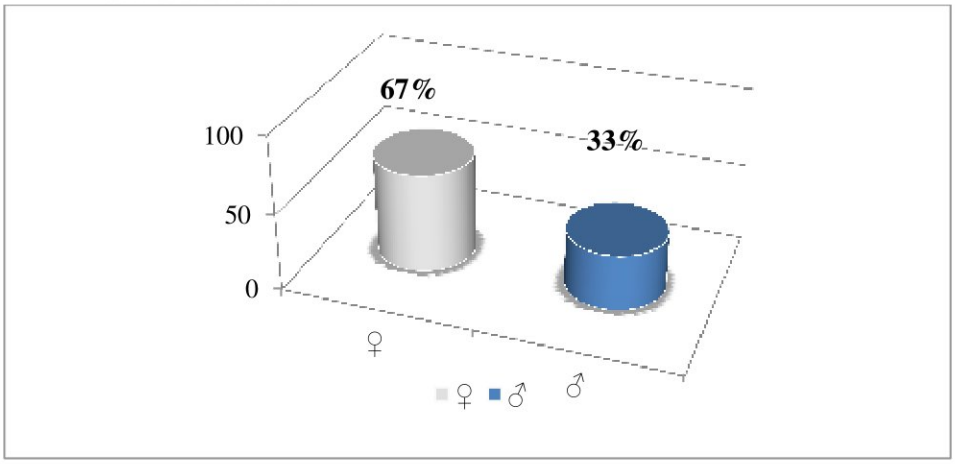

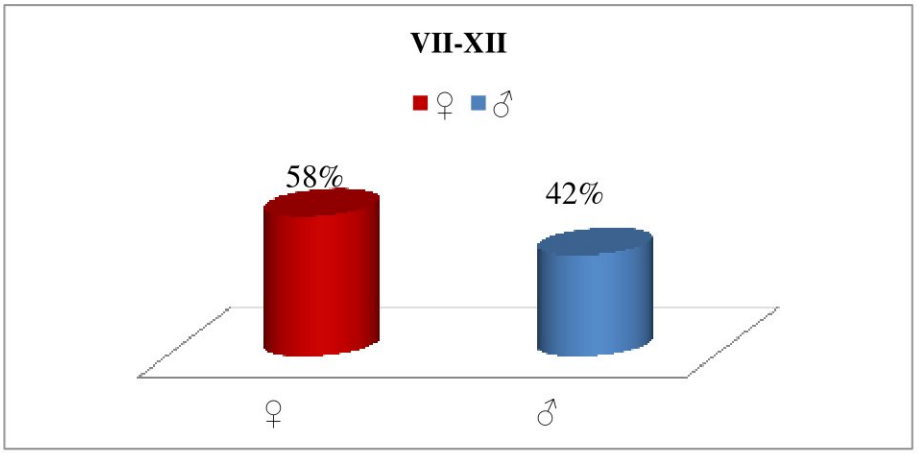

Figure 3.8.1 Sex ratio of anchovy.

The average lengths in females♀ have higher values, but in three-year-olds close values are observed.

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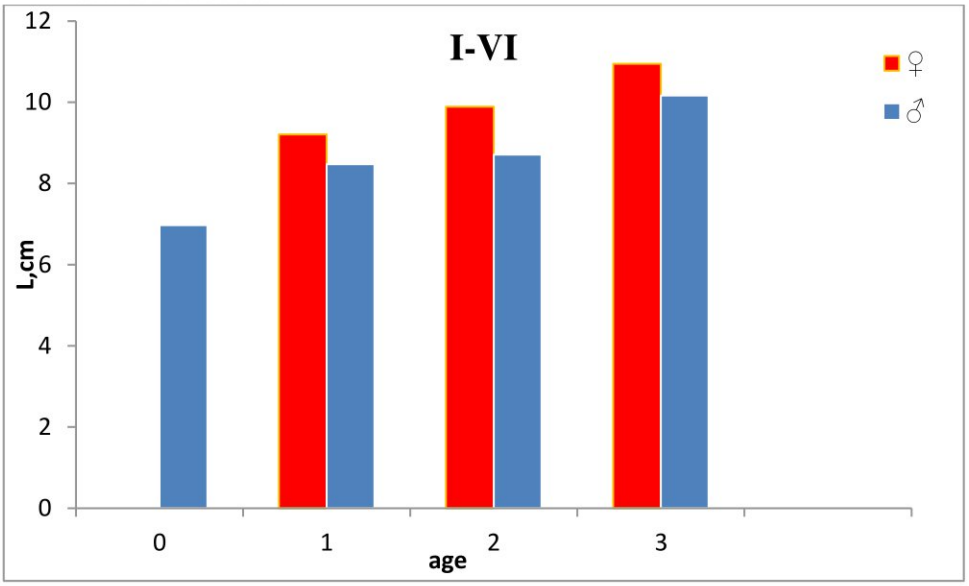

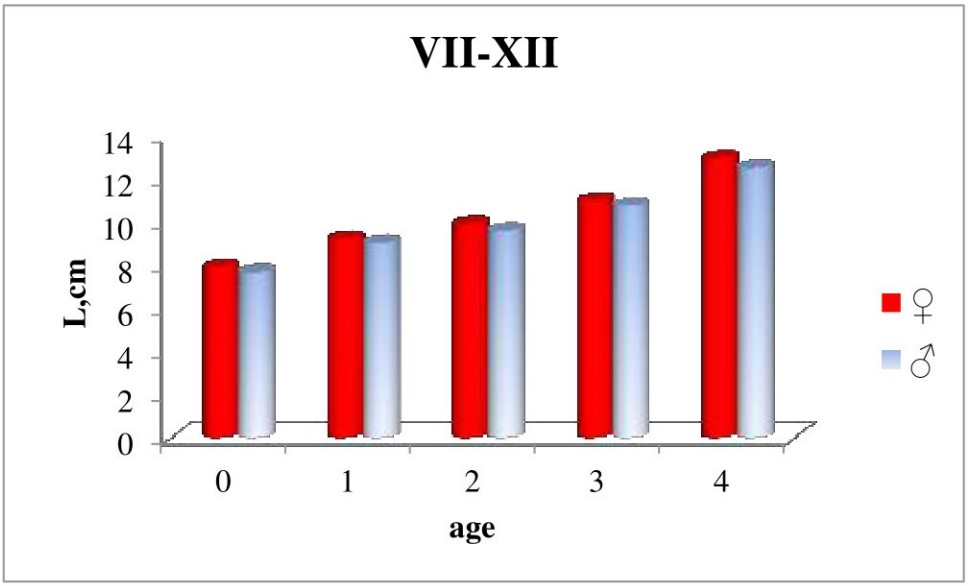

Figure 3.8.2 Sex ratio by size and age of anchovy.

V.3.9 Fertility

Fertility was determined on **150 specimens**. The gonado-somatic index is highly dependent on the weight of the gonads (R^2 = 0.9901; R^2=0.8250), which is associated with the high maturation rate of females and the breeding process of the anchovy **(Figure. 3.9.1**).

The somatic index for the anchovy varies within narrow limits, with a pronounced correlation between the weight of the gland of the measured specimens (R^2 = 0.8250), **Fig. 3.9.1.**

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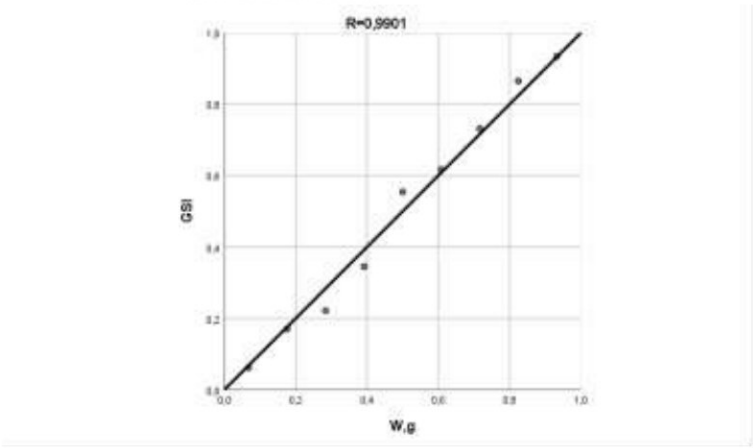

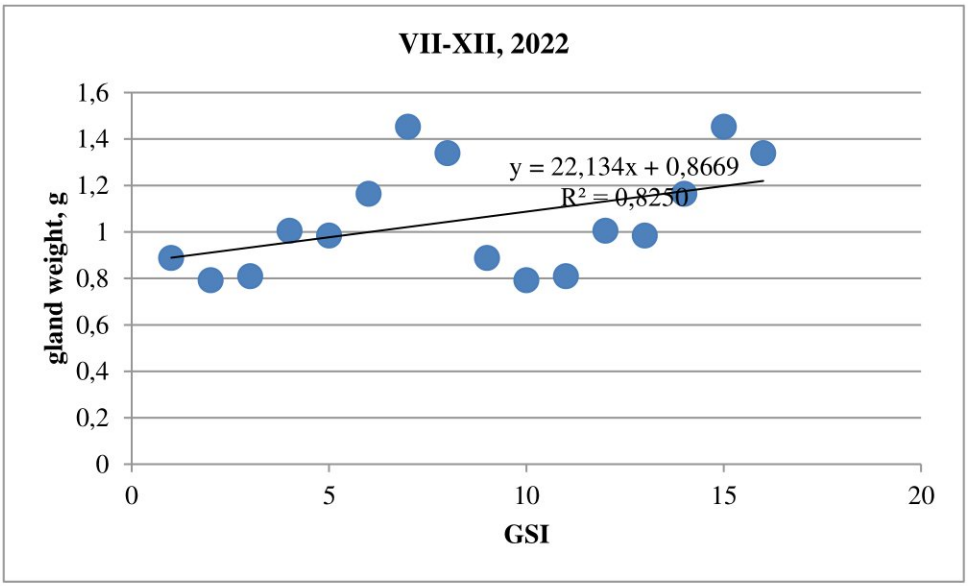

Figure. 3.9.1 Dependence of the weight of the gland on the gonadosomatic index (GSI).

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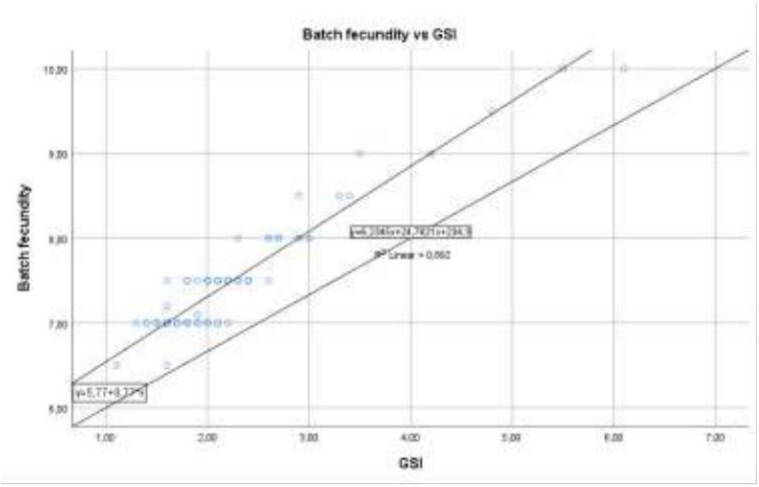

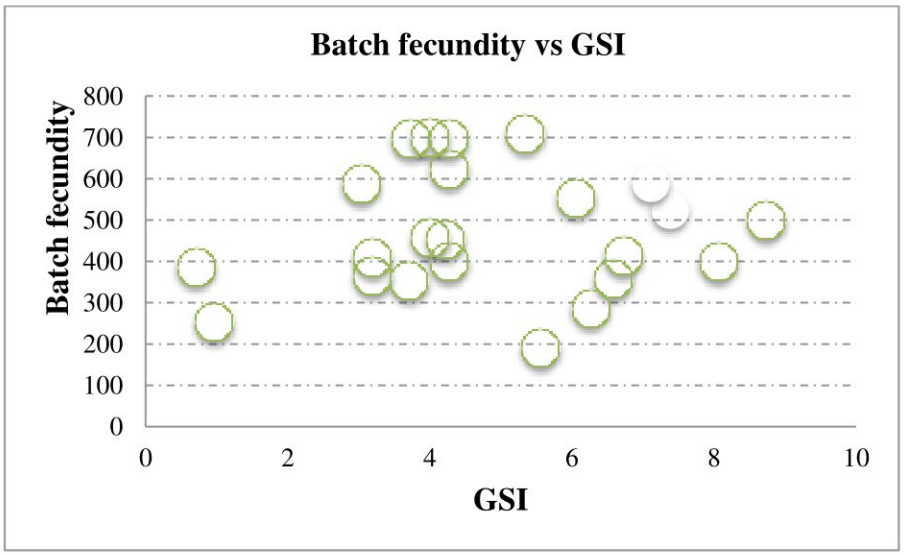

Figure 3.9.2 Batch fecundity vs. GSI for anchovy.

Absolute fertility increases with increasing length, weight and age. The weighted average relative fertility is 903,9640 (**Table 3.9.1**).

Table 3.9.1 Absolute and relative fertility.

I-VI					
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)♀**

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8,5	3,97	8,89	3450	869,0176322	10
9	4,125714286	9,34	3650	884,6952909	10
9,5	5,275	9,47	4600	872,0379147	10
10	5,8732	10,44	6201	1055,812845	10
10,5	7,125315789	10,54	7300	1024,515996	10
11	7,922946429	11,21	8300	1047,59007	10
11,5	9,004423077	11,43	14000	1554,791449	10
12	9,90885	12,41	14250	1438,108358	10
12,5	11,23586207	12,43	13420	1194,389885	10
13	12,17380952	13,44	16,45	1351,26149	5
13,5	13,05981	13,71	16,9	1294,046391	5
			average	**average**	∑
			6836,759	**903,9640679**	100

The mean absolute fecundity was estimated at 7918 caviar grains. The average relative fertility is 1054.

VII-XII					
Size class	**Average body weight (W, g)**	**Medium size**	**Absolute fertility F, caviar grains)**	**Relative fertility**	**Number (n)♀**
8,5	4,11	9,02	3650	888,0778	12
9	4,86	9,44	3850	792,1810	7
9,5	5,81	9,55	4705	809,8106	8
10	6,21	10,81	6244	1005,4750	4
10,5	7,52	10,94	7402	984,3085	6
11	7,22	11,56	8405	1164,1274	3
11,5	10,02	11,93	14560	1453,0938	4
12	10,85	12,49	14530	1339,1705	6
			average	**average**	∑
			7918,25	**1054,5306**	50

V.3.10 Sexual maturity

265 specimens have been assigned sexual maturity. All specimens studied showed a rate of running gonads **(V-III).**

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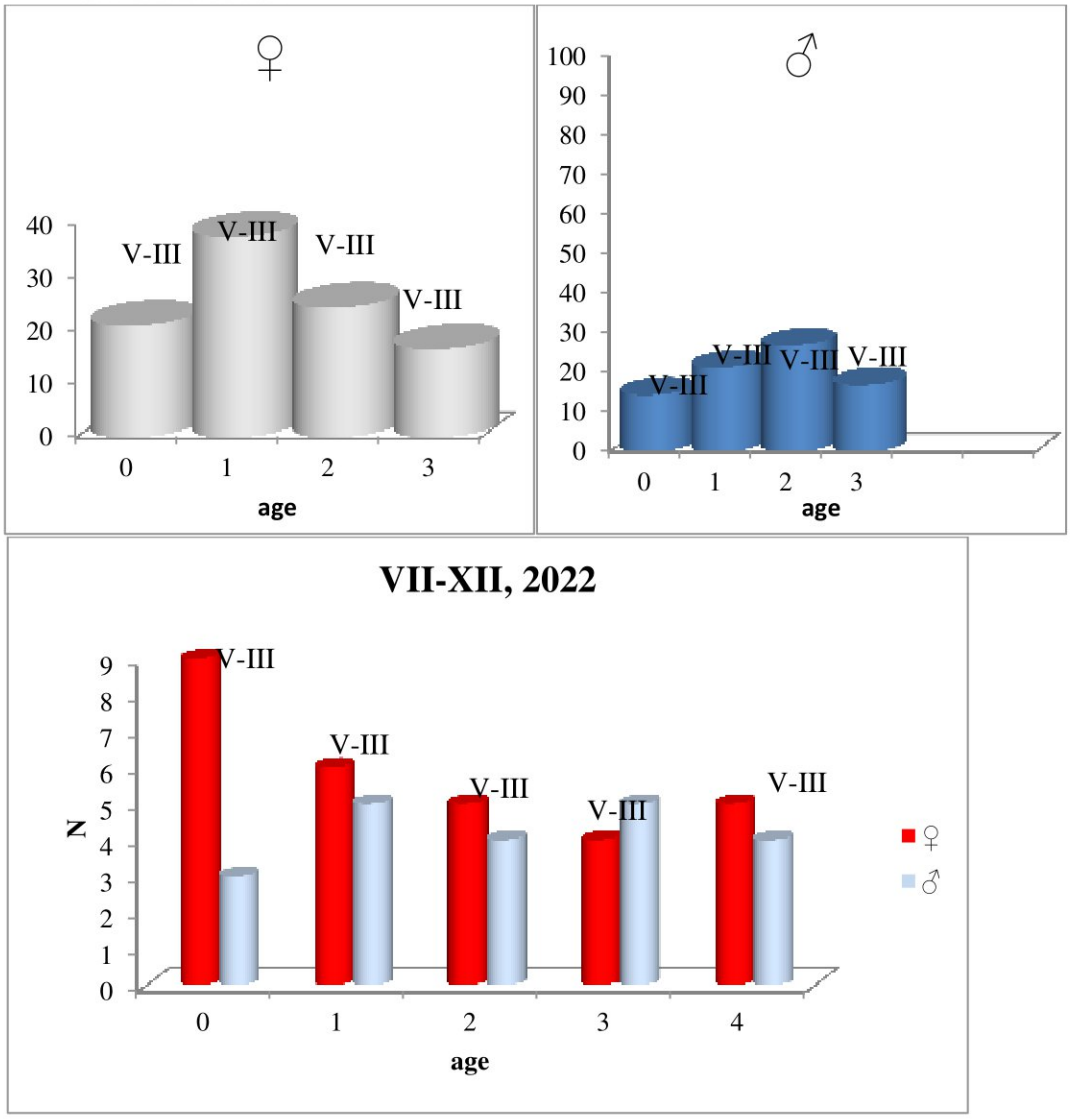

Figure 3.10.1 Sexual maturity by age of anchovies-female ♀ and male ♂.

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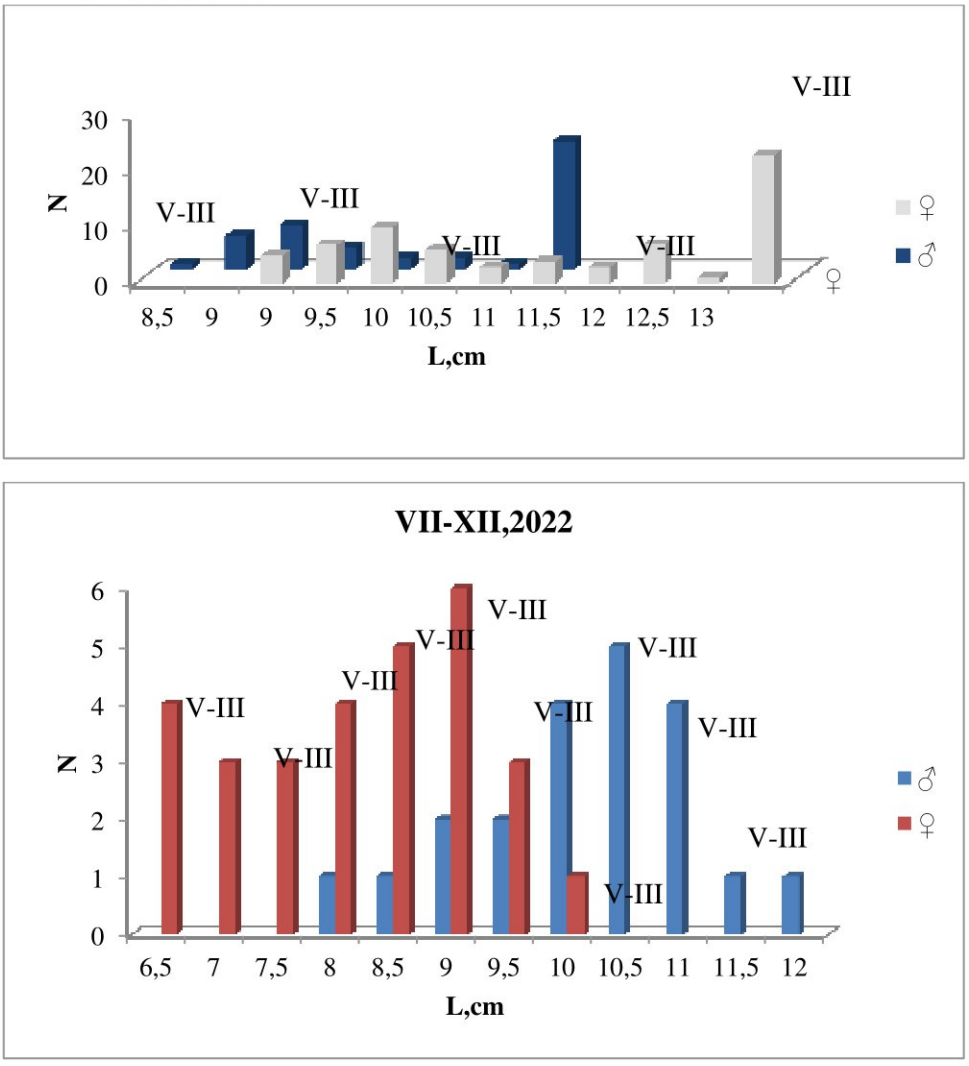

Figure 3.10.2 Sexual maturity by length(cm) of anchovies-female ♀ and male ♂.

V.3.11 Catch numbers and biomass by age and length

Monthly catches (in tonnes) together with mean weights of anchovy were used to derive the monthly catch numbers. The share (%) by age groups and catch numbers were used to create catch-at-age matrix for selected months by age groups **(Table 3.11.1).**

Table 3.11.1 Catch at age-(10^{-6}) matrix and biomass (kg) of anchovy.

Catch-at-Age *10^{-3} (in thousands)		
Age groups	**Ist quarter**	**IInd quarter**
0	1,662741034	0,11133134
1	6,547042822	0,438367151

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2	8,105862542	0,542740283
3	6,027436249	0,403576108
∑	**22,34308265**	**1,496014881**
Biomass (kg)		
Age groups	**Ist quarter**	**IInd quarter**
0	7750,748564	518,9630892
1	38385,5621	2570,163349
2	69857,07998	4677,386413
3	62492,60936	4184,287148
∑	**178486**	**11950,8**

Catch-at-Age *10^{-3} (in thousands)		
Age groups	**IIIrd quarter**	**IVth quarter**
0	0,001523	0,013751
1	0,002404	0,021696
2	0,005247	0,047364
3	0,005044	0,04553
4	0,001659	0,014973
∑	**0,015877**	**0,143313**
Biomass (kg)		
Age groups	**IIIrd quarter**	**IVth quarter**
0	0,005288	0,047736
1	0,010674	0,09635
2	0,034975	0,315701
3	0,043302	0,390868
4	0,018761	0,169346
∑	**0,113**	**1,02**

Monthly catches (in tonnes) together with mean weights of anchovy were used to derive the monthly catch numbers. The share (%) by length groups and catch numbers were used to create catch at length matrix for selected months by age groups **(Table 3.11.2)**.

Table 3.11.2 Catch at length (10^{-6}) matrix and biomass (kg) of anchovy.

Catch at length *10^{-3}		
Length group (cm)	**Ist quarter**	**IInd quarter**
8.5	0,415685259	0,027832835
9.0	1,454898405	0,097414923
9.5	2,90979681	0,194829845

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10.0	2,598032866	0,173955219
10.5	3,949009956	0,264411933
11.0	2,078426293	0,139164175
11.5	2,078426293	0,139164175
12.0	1,662741034	0,11133134
12.5	3,013718125	0,201788054
13.0	2,182347607	0,146122384
∑	**22,34308265**	**1,496014881**
Biomass (kg)		
Length group (cm)	**Ist quarter**	**IInd quarter**
8.5	1650,27	110,4964
9.0	6002,495	401,9061
9,5	15349,18	1027,727
10	15258,77	1021,674
10,5	28137,94	1884,019
11	16467,26	1102,59
11,5	18715,03	1253,093
12	16475,85	1103,166
12,5	33861,72	2267,263
13,0	26567,48	1778,866
∑	**178486**	**11950,8**

Catch at length *10^{-3}		
Length group (cm)	**IIIrd quarter**	**IVth quarter**
6,5	0,000339	0,003056
7	0,000508	0,004584
7,5	0,000474	0,004278
8	0,000135	0,001222
8.5	0,000711	0,006417
9.0	0,001591	0,014362
9.5	0,00176	0,01589
10.0	0,001557	0,014056
10.5	0,001693	0,015279
11.0	0,001523	0,013751
11.5	0,001997	0,018029
12.0	0,001253	0,011306
12.5	0,00088	0,007945
13.0	0,001456	0,01314
∑	**0,015877**	**0,143313**
Biomass (kg)		
Length group (cm)	**IIIrd quarter**	**IVth quarter**
6,5	0,000359	0,003239

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7	0,000675	0,006096
7,5	0,000882	0,007957
8	0,000328	0,002958
8.5	0,002211	0,019957
9.0	0,006081	0,05489
9,5	0,007861	0,07096
10	0,008308	0,074994
10,5	0,010966	0,098984
11	0,012679	0,114452
11,5	0,019216	0,173458
12	0,013771	0,124307
12,5	0,010877	0,098183
13,0	0,018785	0,169565
∑	0,113	**1,02**

In the 1st quarter the anchovy biomass is the highest.

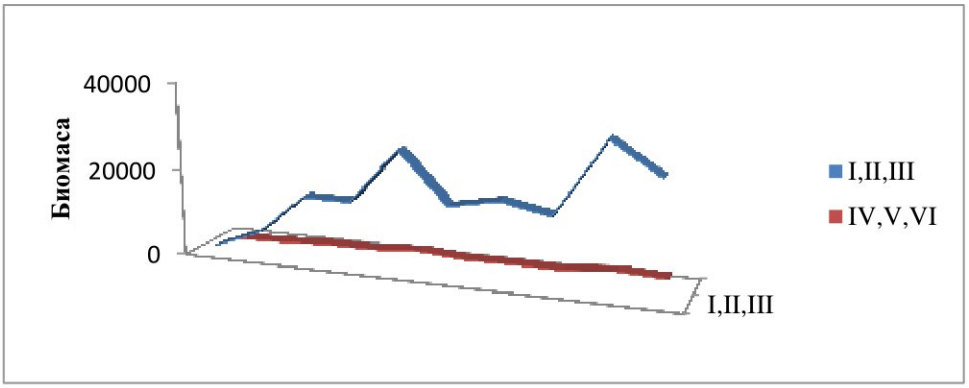

Figure 3.11.1 Biomass dynamics for I-VI 2022.

V.3.12 Conclusions

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

1) The age composition of the studied specimens includes from 0 to 4 year-old individuals, with the predominance of two-year-old fish . During the research period, a lower participation of zero-year-olds was observed.
2) It follows from the analysis that the growth of anchovies during the studied period is allometric.
3) The condition data shows that it is higher for the 1year old fish
4) Females (♀) predominate during the studied period.
5) The size structure shows that the average values for length by age group in female ♀ have higher values.
6) The dynamics of the gonadosomatic index during preparation and molting shows a characteristic rapid maturation of the sexual products. All examined specimens

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showed degree of gonad discharge (V- III) grade. In June, we observe mass mature sexual products in 100% of the female individuals examined.

7) January to March biomass of anchovy is higher, then decreases.

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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

A total of **8 samples** with **100 specimens** were collected and measured (length and weight) distribution and sex were determined. Ports and ships from which monitoring was carried out to collect biological data from picked dogfish landings are presented in **Table 2.2.1.**

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

	Date	Harbour	Species code DGS	Fishing vessel	Fishing gear	Catch	Coordinates	Area
1	17.03.202	Kavarna	**DGS**	RUSANO VN 4445	LLS	52	43.622900, 28.864700	north
2	14.4.2022	Varna	**DGS**	AMBAR VN4496	LLS	20	42.437000, 28.129100	north
3	26.7.2022	Varna	**DGS**	VN 7822	LLD	35	43.434800, 28.473900	north
4	15.8.2022	Nessebar	**DGS**	VN8112	LLS	48	43.430100, 28.521700	south
5	20.8.2022	Kavarna	**DGS**	Hishnik KV6262	LLS	53	43.425100, 28.560900	north
6	21.10.2022	Shabla	**DGS**	KV 6245	LLS	109	43.412300, 28.541800	north
7	3.12.2022	Varna	**DGS**	Bumerang BN8250	LLS	70	43.401700, 28.530800	north
8	24.12.2022	Kavarna	**DGS**	Libra VN 8311	LLD	32	43.393000, 29.020700	north

VI.3. Landings statistics of spiny dogfish

Landings (with LLS) are low throughout the all year. In March has the highest value – 1447 kg. They range from 101.5 to 388.4 kg. Catches with LLD are significantly higher: 200 kg (September)-2619 kg (October).

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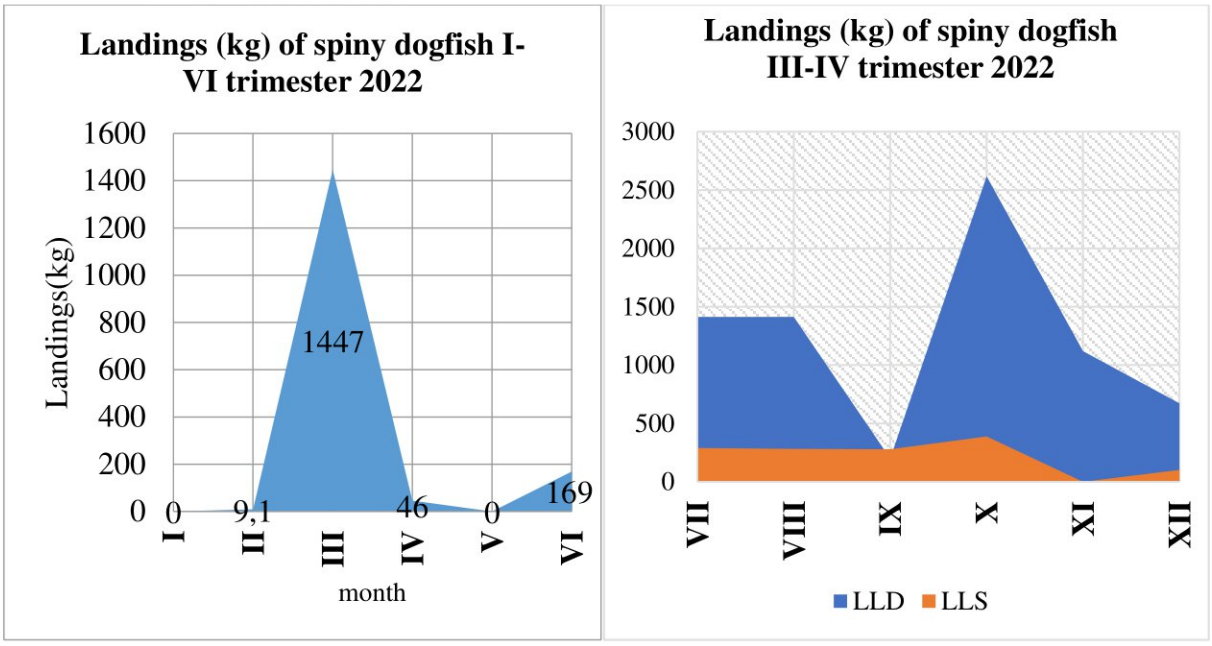

Fig. 3.1 Official statistics records for spiny dogfish landings by month.

VI.4Results

VI.4.1 Size and weight structure

The graph shows the variations in the total lengths of male and female shark individuals in the period January-June 2022. Females vary from 113 to 120 cm, and males from 113 to 122 cm TL.

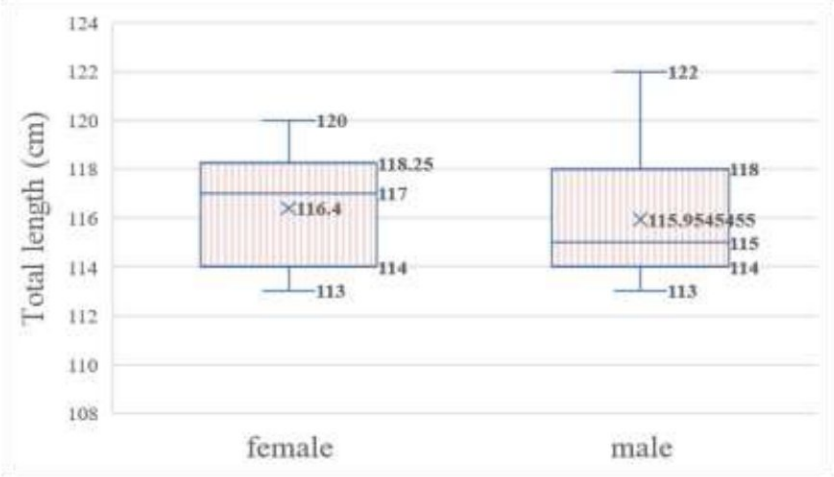

Fig. 4.1.1 Box-plot – the distribution of total length (TL) of the sampled female and male specimens (minimum, maximum, mean and median values shown) in the period January-June 2022.

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Females ranged from 109 to 122.2 cm TL and males from 113 to 120 cm. The standard length for males varied from 90 to 104.9 cm and for females from 90 to 101 cm.

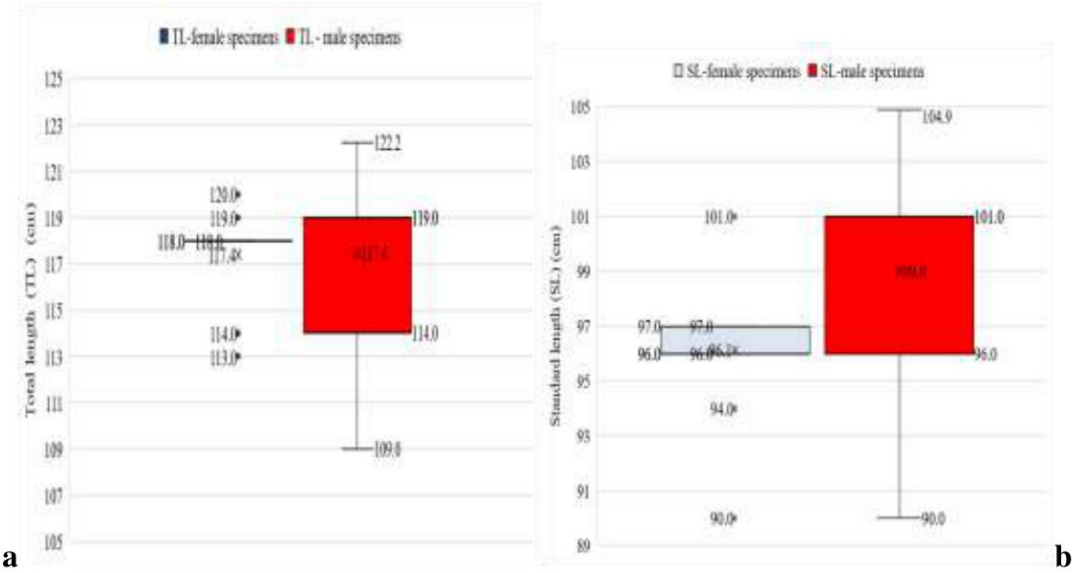

Fig. 4.1.2 Box-plot – the distribution of total length (TL, SL) of the sampled female and male specimens (minimum, maximum, mean and median values shown) in the period July-December 2022.

For females, the variation in weight was within the limits of 5.4-7.5 kg, and for males 5.35-7.1 kg. Average values vary within wider limits for males (5.35-6.3 kg) (fig. 4.1.3).

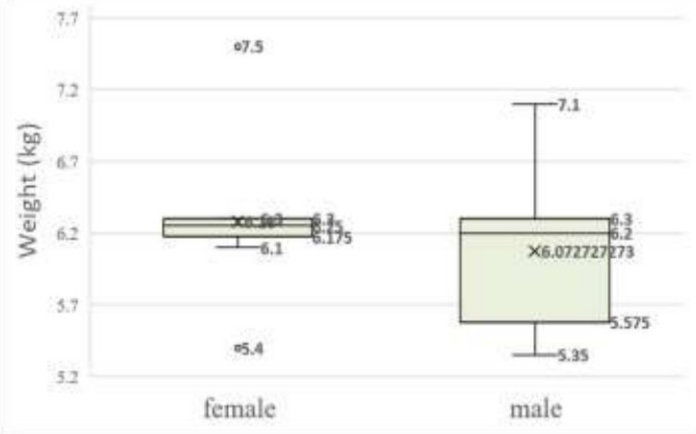

Fig.4.1.3 Box-plot – the distribution of weight (W) of the sampled female and male specimens (minimum, maximum, mean and median values shown) in the period January-June 2022.

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For females, the weight variation is within the limits of 5.3-7.30 kg, and for males 5.40-6.92 kg. Average values vary within wider limits for female individuals (5.30-7.3 kg) (fig. 4.1.4.).

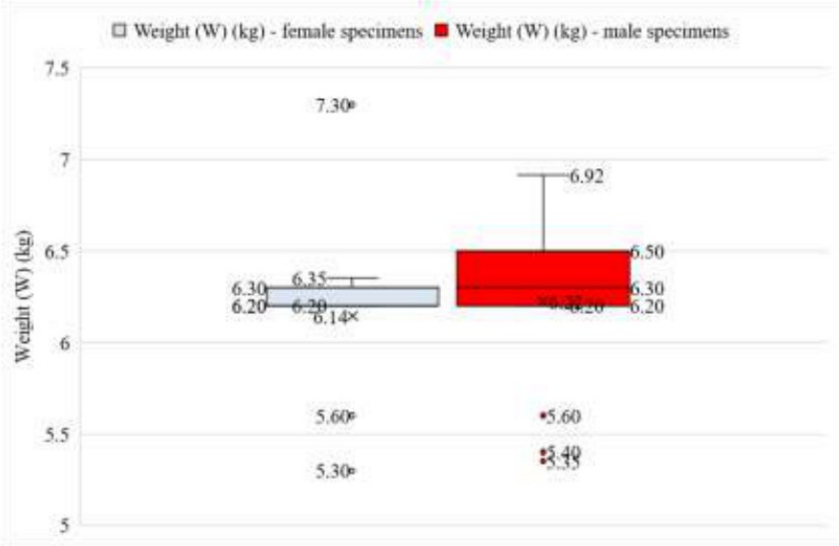

Fig.4.1.4 Box-plot – the distribution of weight (W) of the sampled female and male specimens (minimum, maximum, mean and median values shown) in the period July-December 2022.

The LWR of the male specimens is best described, but with an unsatisfactory accuracy of the approximation with a polynomial of the 5th order (R^2=0.9266), which speaks of a significant variability of the weight of the male specimens, probably as a result of specific dynamics of the processes of the environment and/or changes in biotic interactions.

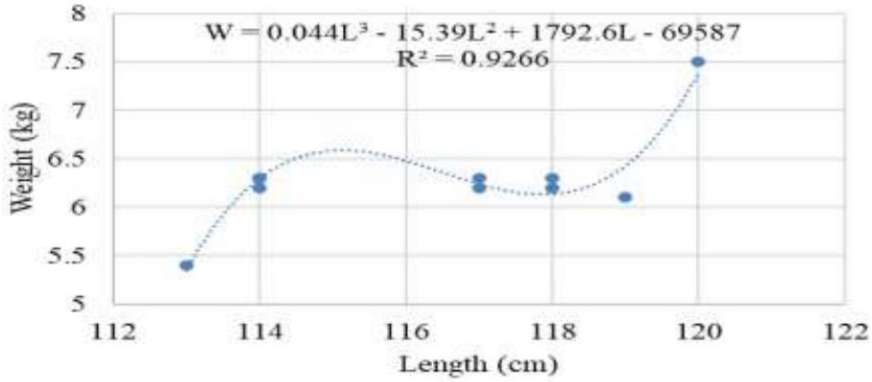

Fig. 4.1.5 Length-weight relationship (LWR) of female specimens in the period January-June 2022.

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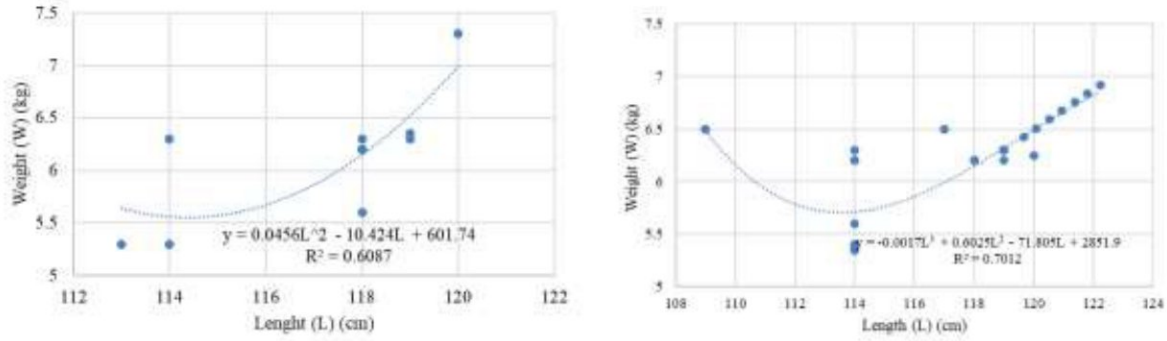
The length-weight relationship of female and male specimens is best described, with satisfactory accuracy of the approximation with a 5th-order polynomial (R^2=0.61 - female and R2 = 0.70 - male), which indicates a low variability of the weight of the male and female specimens, possibly as a result of specific dynamics of environmental processes and/or changes in biotic interactions.



a **b**

Fig. 4.1.6 Length-weight relationship (LWR) of a) female and b) male specimens in the period July-December 2022.

VI.4.2 Sex ratio and Fecundity

At 52 specimens were used for maturity determined . All 15 females ♀ were (actively spawning M3b). Males were estimated as follows: 23♂ were M2 (developing) and 14♂ were (spawning capable) M3a. Males predominate over females.

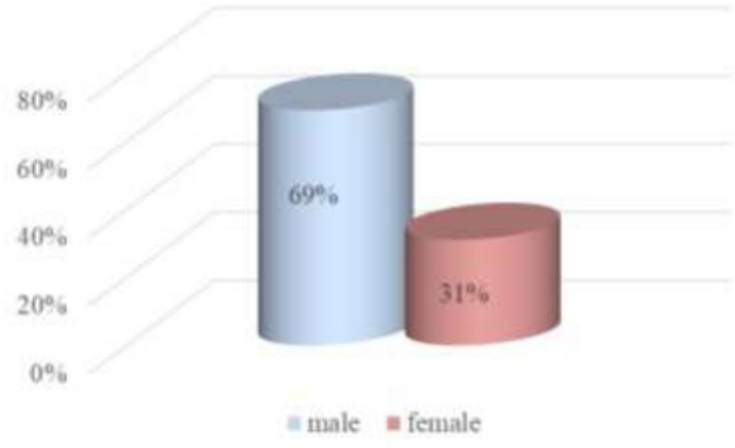


Fig. 4.2.1 Sex ratio of the sampled spiny dogfish specimens in the period January-June 2022.

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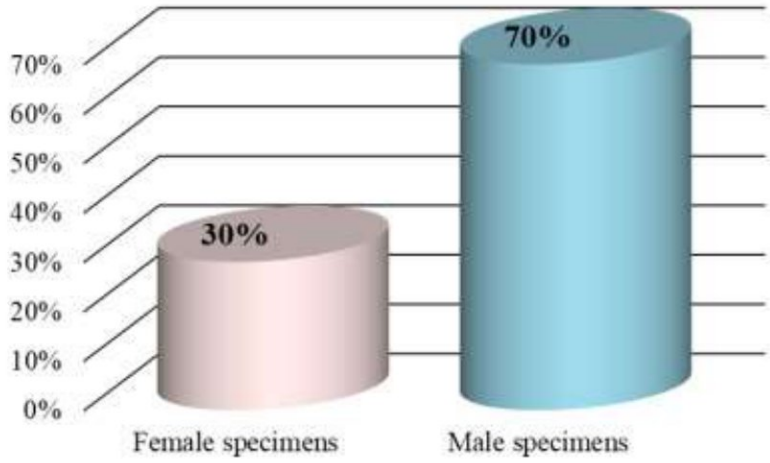

Fig. 4.2.2 Sex ratio of the sampled spiny dogfish specimens in the period July-December 2022.

VI. 5 Conclusions

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

1. Landings (LLS catches) are low throughout the all year. March has the highest value - over 6000 kg. They range from 101.5 to 388.4 kg. Catches with LLD are significantly higher: 200 kg (September)-2619 kg (October).

2. Females vary from 113 to 120 cm, and males from 113 to 122 cm TL. The average values do not differ significantly between the two sexes. Females ranged from 109 to 122.2 cm TL and males from 113 to 120 cm. Mean values did not differ significantly between the two sexes. The standard length for males varied from 90 to 104.9 cm and for females from 90 to 101 cm.
3. For females, the variation in weight was within the limits of 5.4-7.5 kg, and for males 5.35-7.1 kg. Average values vary within wider limits for males (5.35-6.3 kg). For females, the weight variation is within the limits of 5.3-7.30 kg, and for males 5.40-6.92 kg. Average values vary within wider limits for female individuals (5.30-7.3 kg).
4. The LWR of the male specimens is best described, but with an unsatisfactory accuracy of the approximation with a polynomial of the 5th order (R^2=0.3629), which speaks of a significant variability of the weight of the male specimens, probably as a result of specific dynamics of the processes of the environment and/or changes in biotic interactions. The LWR of the male specimens is best described, but with an unsatisfactory accuracy of the approximation with a polynomial of the 5th order (R^2=0.61, female R^2 = 0.70 - male), which indicates a low variability of the weight of the male and female specimens, possibly as a result of specific dynamics of environmental processes and/or changes in biotic interactions.

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5. All 15 females ♀ were (actively spawning M3b). Males were estimated as follows: 23♂ were M2 (developing) and 14♂ were (spawning capable) M3a. Males predominate over females for the entire year.

VII. Anex

Sprattus sprattus				
	Number of specimens from the study I-VI	**Number of specimens from the study VII-XII**	**Number of specimens from the studyI-VI/ VII-XII**	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	890	360	1250	1250
weight	890	360	1250	1250
age	890	360	1250	1250
sex ratio ♀♂	250	100	350	250
fecundity	250	250	500	500
sexual maturity	500	100	600	500
Trachurus mediterraneus ponticus				
	Number of specimens from the study I-VI	**Number of specimens from the study VII-XII**	**Number of specimens from the studyI-VI/ VII-XII**	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	1004	660	1664	1500
weight	1004	660	1664	1500
age	1004	660	1664	500
sex ratio ♀♂	250	50	300	250
fecundity	100	50	150	100
sexual maturity	250	50	300	250
Merlangius merlangus euxinus				
	Number of specimens from the study I-VI	**Number of specimens from the study VII-XII**	**Number of specimens from the studyI-VI/ VII-XII**	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	148	225	373	250
weight	148	225	373	250

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age	148	225	373	250
sex ratio ♀♂	100	50	150	100
fecundity	100	50	150	100
sexual maturity	100	50	150	100
Mullus barbatus				
	Number of specimens from the study I-VI	**Number of specimens from the study VII-XII**	**Number of specimens from the studyI-VI/ VII-XII**	**Number of specimens Contract 71/15/03/2022, EAFA /IO-BAS**
length	320	285	608	500
weight	320	285	608	500
age	320	285	608	500
sex ratio ♀♂	250	50	300	250
fecundity	100	50	150	100
sexual maturity	250	50	300	250
Engraulis encrasicolus				
	Number of specimens from the study I-VI	**Number of specimens from the study VII-XII**	**Number of specimens from the studyI-VI/ VII-XII**	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	215	469	684	500
weight	215	469	684	500
age	215	469	684	500
sex ratio ♀♂	215	50	300	250
fecundity	100	50	150	100
sexual maturity	215	50	265	250
Squalus acanthias				
	Number of specimens from the study I-VI	**Number of specimens from the study VII-XII**	**Number of specimens from the studyI-VI/ VII-XII**	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	32	68	100	100
weight	32	68	100	100
sex ratio ♀♂	32	20	52	50

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