2022

BIOLOGICAL MONITORING OF LANDINGS OF COMMERCIALLY IMPORTANT SPECIES

Scientific report on contract N71/15/03/2022 covering the results of 1st and 2nd quarter of 2022

This survey was conducted thanks to the financial support of the European Commission under the REGULATION (EU) 2017/1004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008 (recast)

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.

List of authors:

Associate Professor Maria Yankova, Ph.D.

Associate Professor Violin Raykov, Ph.D.

Associate Professor Petya Ivanova, Ph.D.

Main assistant Nina Djembekova Ph.D

Ph.D student Yordan Raev

Technician Neli Valcheva

Technician Diana Hristova

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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.

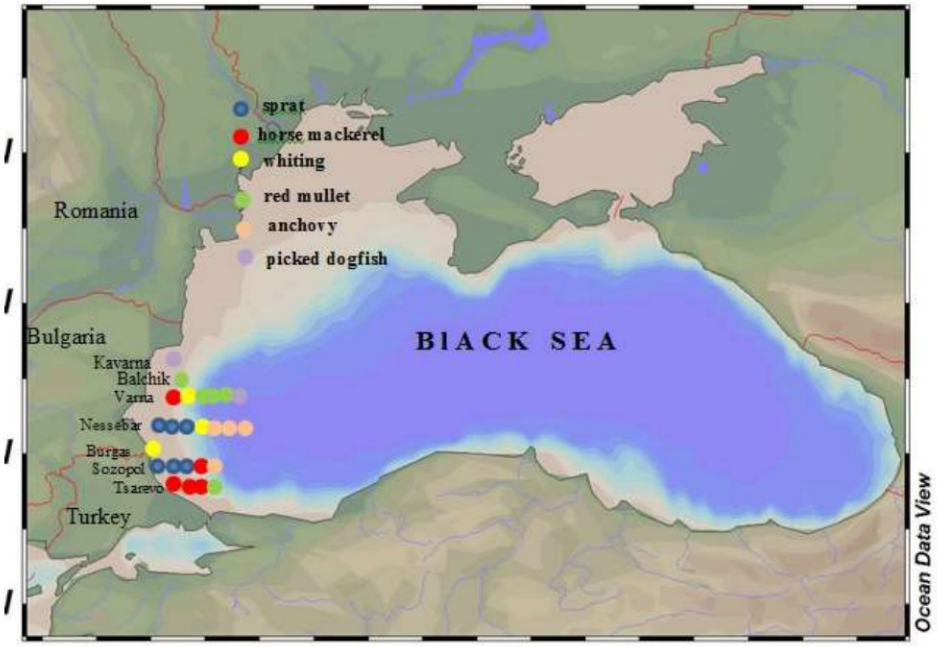

Figure 1 Sampling map of the Bulgarian Black Sea coast.

25 samples are shown on the map, 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);

Biological catch data were collected from **14 vessels**. Fishing vessels used in the biological monitoring study during the period I-VI, 2022:

№	Fishing vessel	External marking
1.	FV 28 1	BS22
2.	FV 40	BS258
3.	FV 26	BS219
4.	FV37	BS255
5.	ISHTAR	NS1182
6.	MEDUZA 3	BS288
7.	CIKLAMA V	AX215
8.	HARASIMOV MLADSHI	VN 422
9.	KORSAR 2	VN 7643
10.	GONDOLA	VN4321
11.	IRINA	VN 440
12.	FV 5	VN 8186
13.	RUSANO	VN4445
14.	VENI	VN 2998

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

I.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze sprat catches, as well as to form a database. The collection of biological samples of sprat catches in I-VI, 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 period I-VI, 2022 were collected **6 samples with 890 specimens.** Information on the size of the catches was also collected.

I.2.2 Sampling period

In I-VI 2022, the biological data on sprat were collected from a total of **6 landings at the ports of Nessebar and Sozopol**. 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 2.1.1.**

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	FV 28 BS221	OTM	100	42.426200, 27.737700	south
2	4.2.2022	Nessebar	sprat	FV40 BS258	OTM	290	42.646200, 27.727300	south
3	4.3.2022	Sozopol	sprat	FV 26 BS219	OTM	552	42.504700, 28.011300	south
4	3.4.2022	Sozopol	sprat	FV37BS255	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

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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 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.

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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.

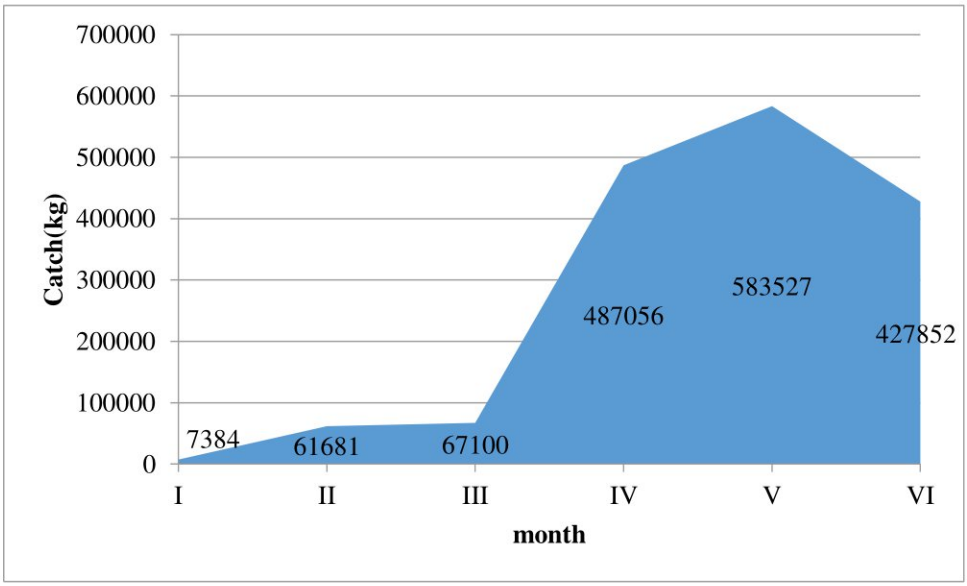

Fig 3.1.1 Official statistics records for sprat landings by month in the first half of 2022.

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 %.

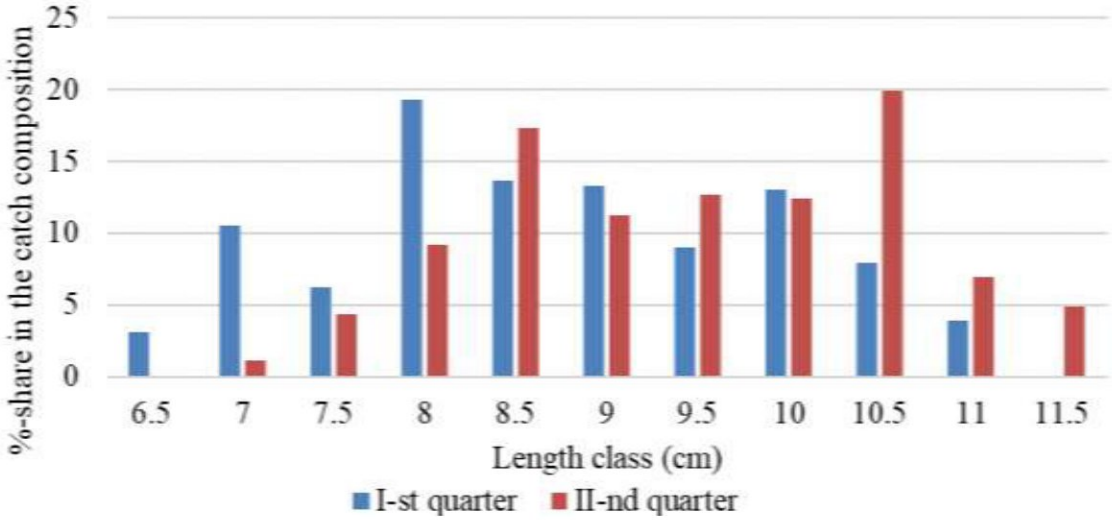

Fig 3.2.1 Size structure and percentage share of length classes in the catch composition in the period January-June 2022.

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 = 890)** 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. 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.

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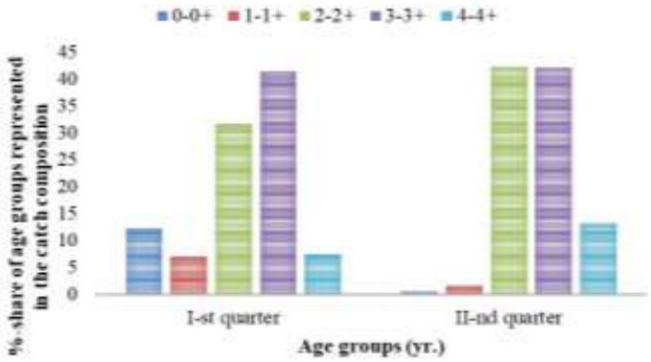

Fig.3.3. 1 Age structure and percentage share of age groups in the catch composition in the period January-June 2022.

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 .

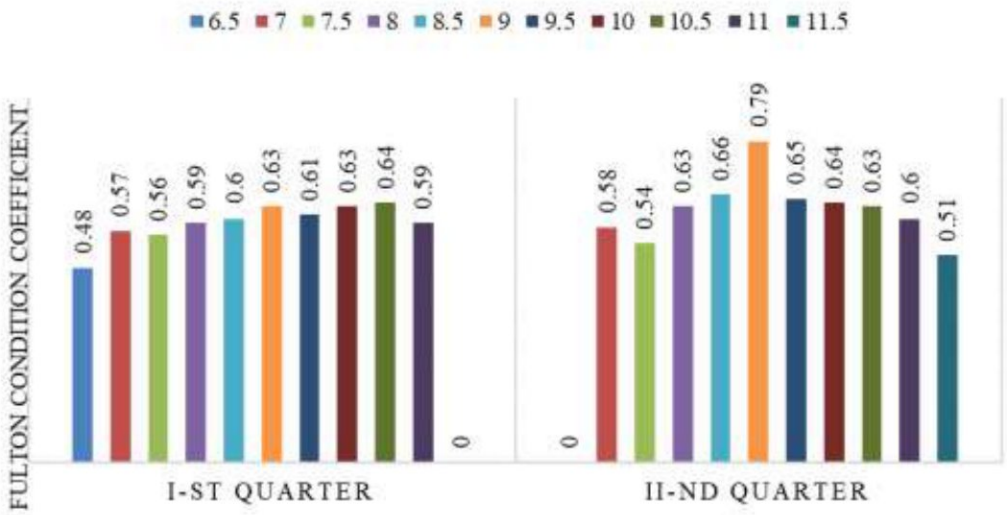

Fig. 3.4.1 Fulton condition coefficient values of sprat by length classes in the period January-June 2022

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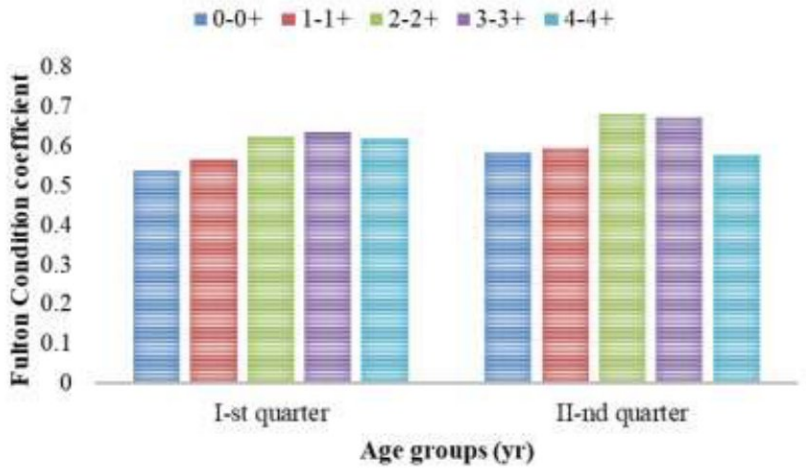

Fig.3.4.2 Fulton condition coefficient values of sprat by age groups in the period January-June 2022.

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.

I.3.5 Weight structure of sprat

Weight was measured of **890 specimens** (period I–VI, 2022). 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.

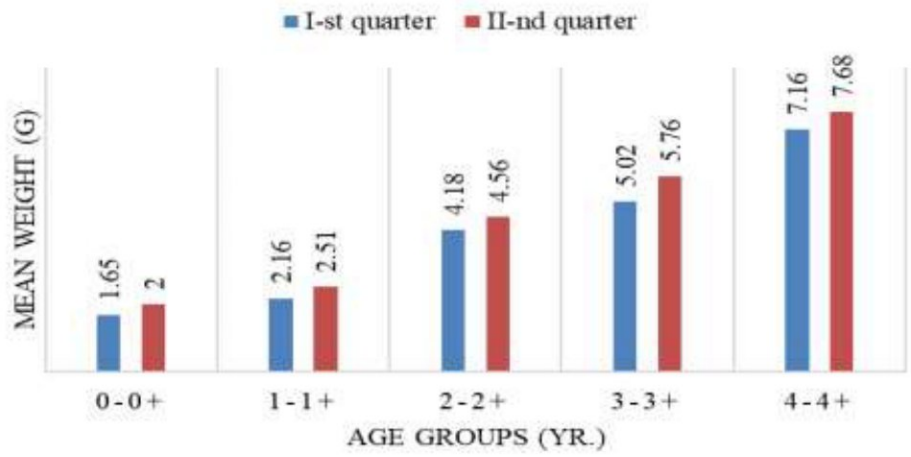

Fig.3.5.1 Distribution of the average weight of Sprat by age groups.

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I.3.6 Size structure of sprat by age group

Size was measured of **890 specimens (I-VI, 2022)**. 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.

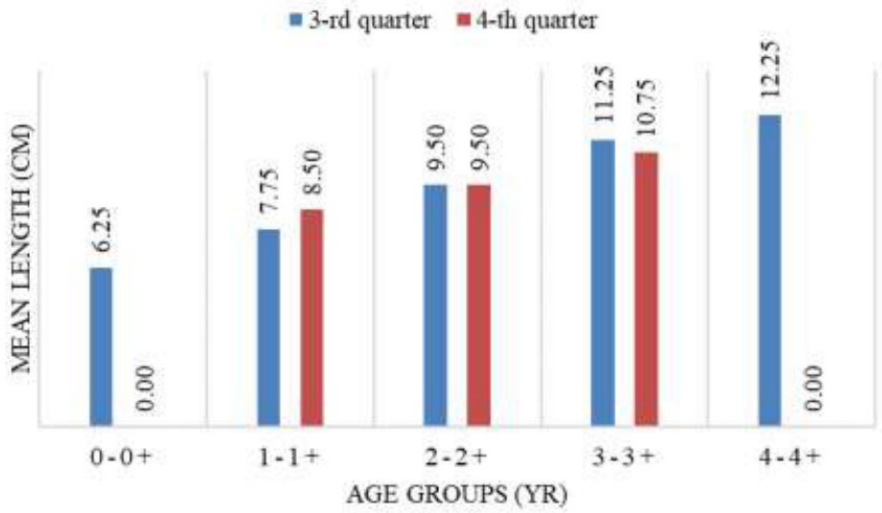

Fig.3.6.1 Mean length by age groups in the period January-June 2022.

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.

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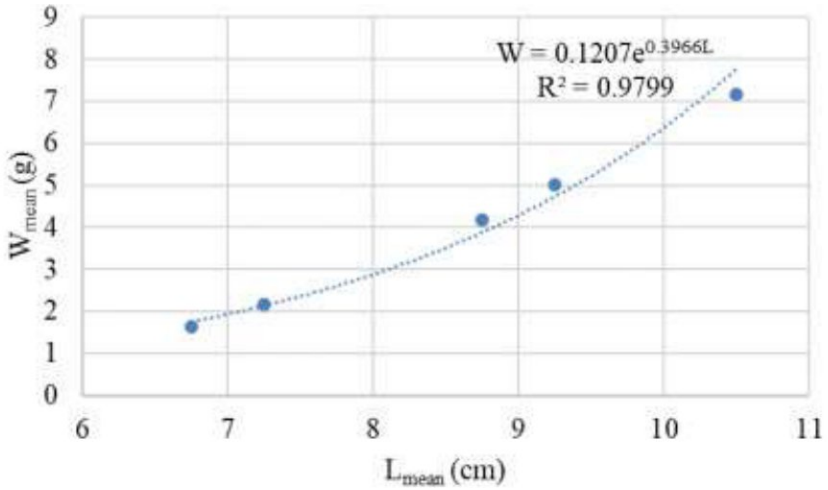

Figure 3.7.1 Length-weight relationship for the 1st quarter of 2022.

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.

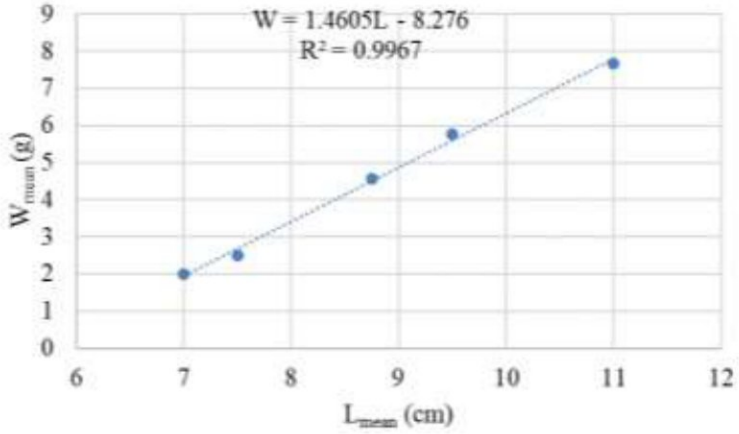

Figure 3.7.2 Length-weight relationship for the 2nd quarter of 2022.

I.3.8 Sex ratio

The sex ratio was determined of **250 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.

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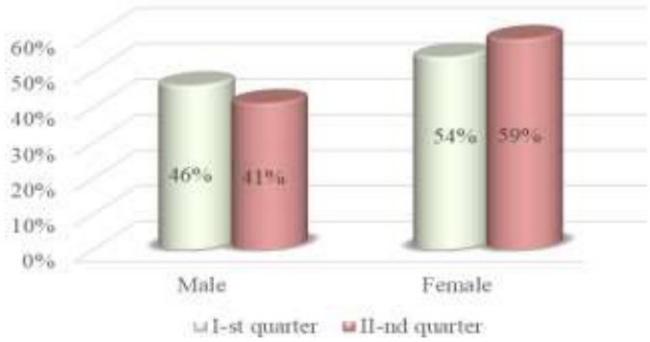

Fig.3. 8.1 Sex-ratio distribution of sprat by quarter in the first half of 2022.

I.3.9 Fertility

Fertility was determined on **250 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.

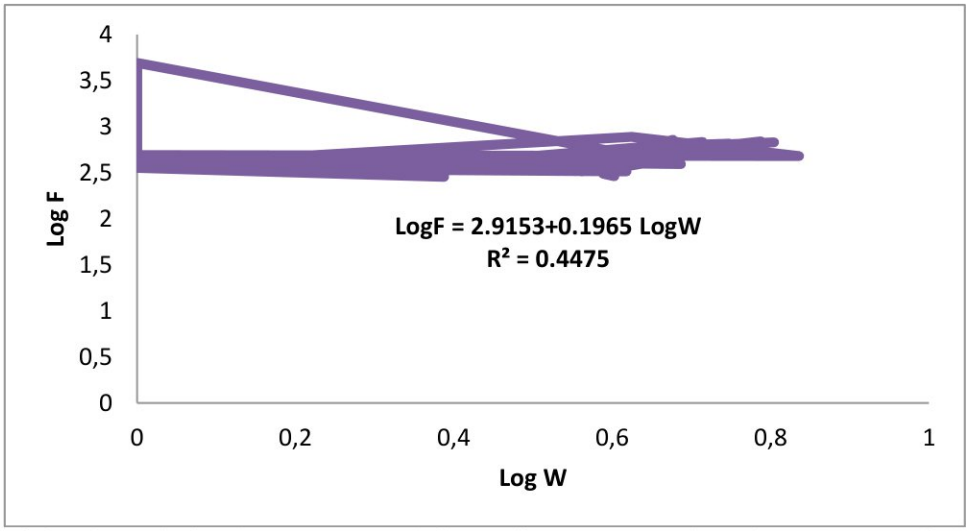

Figure 3.9.1 The relation between Batch fecundity (Log F) plotted vs. Sprat weight (Log W).

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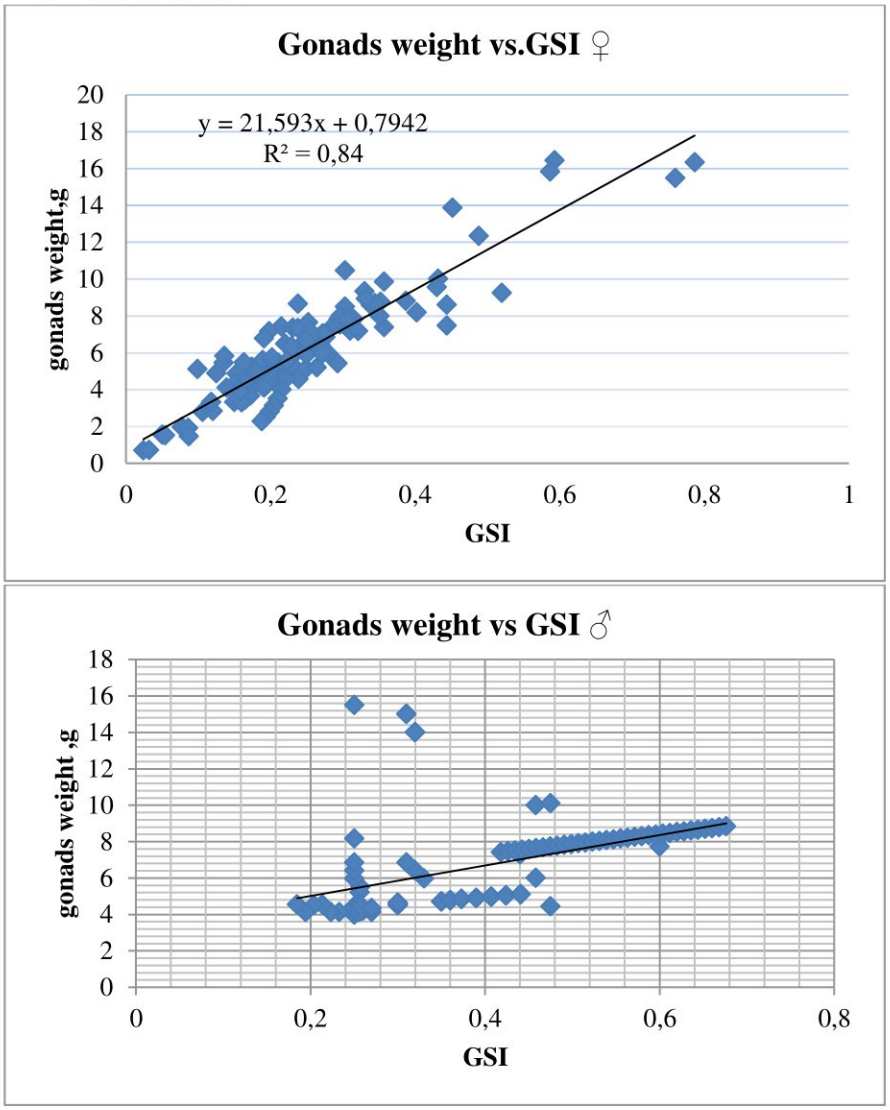

Figure 3.9.2 Relation of GSI and gonads weight (g).

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

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.

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Table 3.9.1 Absolute and relative fecundity of the sprat.

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
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**

I.3.10 Sexual maturity

500 specimens (250♀ and 250♂) 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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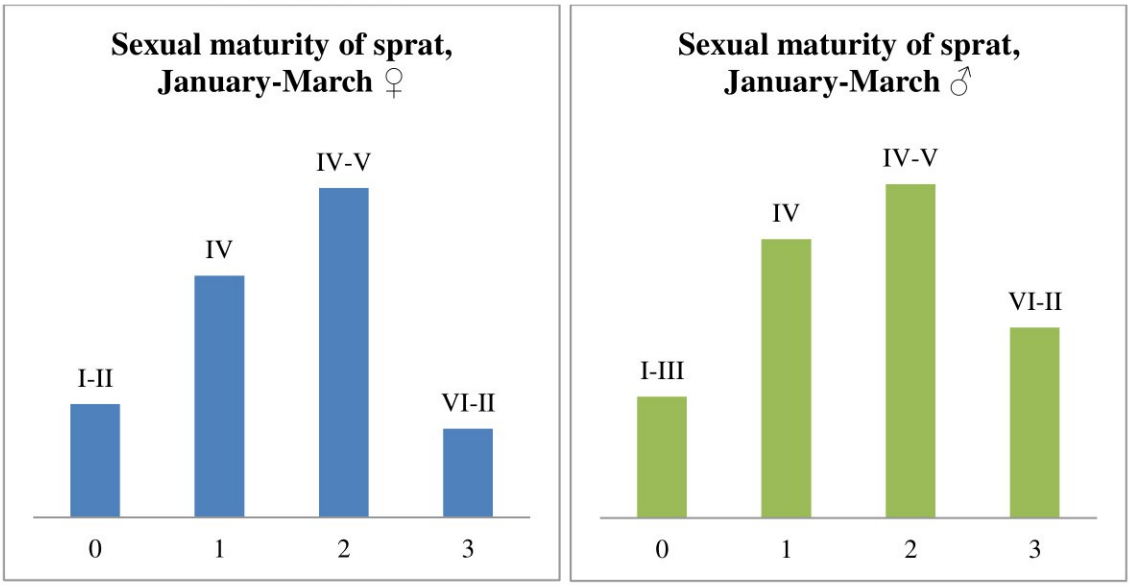

Figure 3.10.1 Sex maturity by age – females ♀ and males ♂.

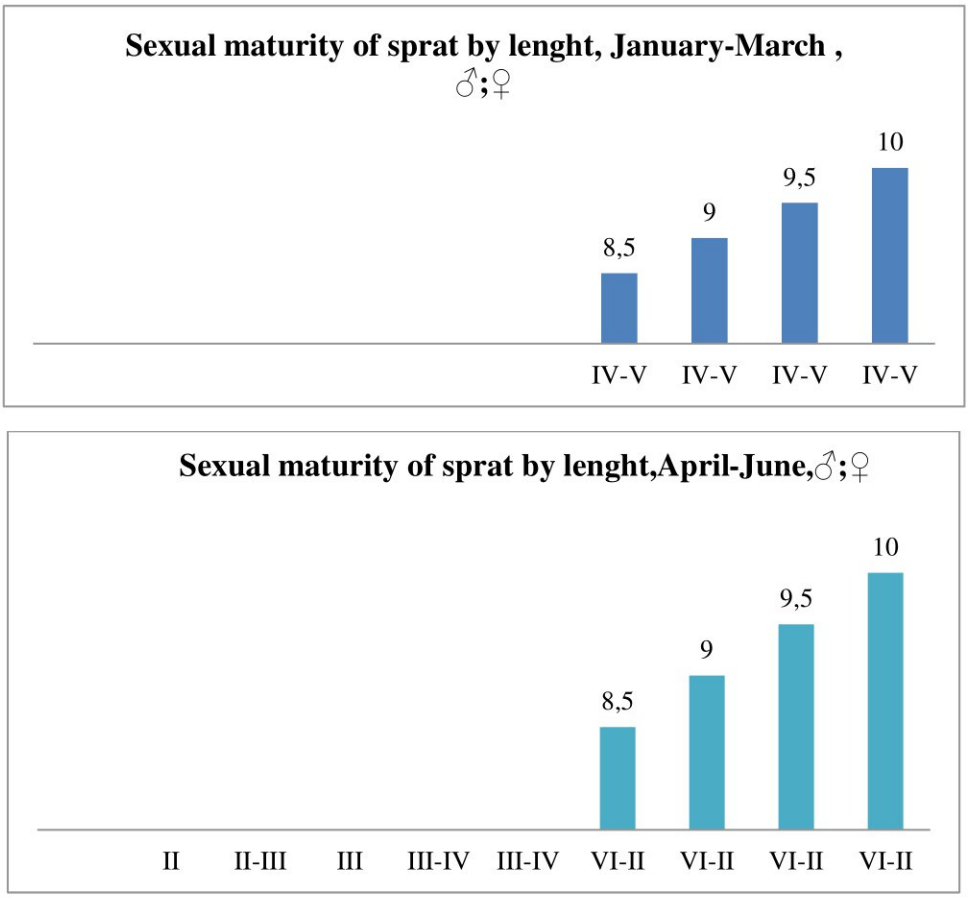

Figure 3.10.2 Sex maturity by length(cm) –females ♀ and males ♂ (Jan-March;April-June).

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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 spra for Ist and IInd quarter.

Length classes (см)	Catch in numbers *10-3			Biomass (kg)		
	I-st quarter	II-nd quarter	Total	I-st quarter	II-nd 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)**		
	I-st quarter	**II-nd quarter**	**Total**	**I-st quarter**	**II-nd quarter**	**Total**
0-0+	10196.05	4417.19	**14613.23**	16807.38	8834.37	**25641.75**
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**

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 the catch and landings. The landings are significantly higher and surpass 600.00 t in May, which is the highest value from all six months. By comparison, the winter season is weaker than the spring by value.
2) 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.

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3) 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 %.

4) 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.

5) 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.

6) 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+.

7) 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. 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.

8) 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.

9) 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.

10) Fecundity was determined on 250 specimens (125 males and 125 females). The relation between glandule weight and GSI and of males of sprat, indicate linear negative trend with good coefficient of determination (R^2 = 0.83). 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.

11) 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.

12) Male individuals from research in first six months, show weak correlation between sex glandula weight and Gonado Somatic Index.

13) The relation between GSI and batch fecundity for sprat in the examined period show no clear pattern.

14) The GSI as a measure of sexual maturity shows that sprat in the period of January-June 2022 was in relatively good maturity (females), which corresponds to the end of active maturation season of the species (Jnuary-March).

15) Mean value of the absolute fecundity was estimated 35529 caviar grains. The average value of the relative fecundity was 3344.

16) Most of the individuals are with IV-V stage of gonads for females and males. The last show maturation stage VI-II at age 3-3+y-1. 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

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indicates high weight growth rates with the increase in length in the first quarter of 2022.

17) 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.

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

II.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze horse mackerel catches, as well as to form a database. The collection of biological samples of horse mackerel catches in I-VI, 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 I-VI 2022, **5 samples with 1004 specimens** were collected and processed. Information on the size of the catches was also collected.

II.2.2 Sampling period

In I-VI 2022, the biological data on sprat were collected from a total of **5 landings at the ports of Varna, Tsarevo and Sozopol**. 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 2.1.1.**

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

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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 catches of Black Sea horse mackerel with OTM were made in the Bulgarian water area of the Black Sea (3024 кg) **Figure 3.1.1.**

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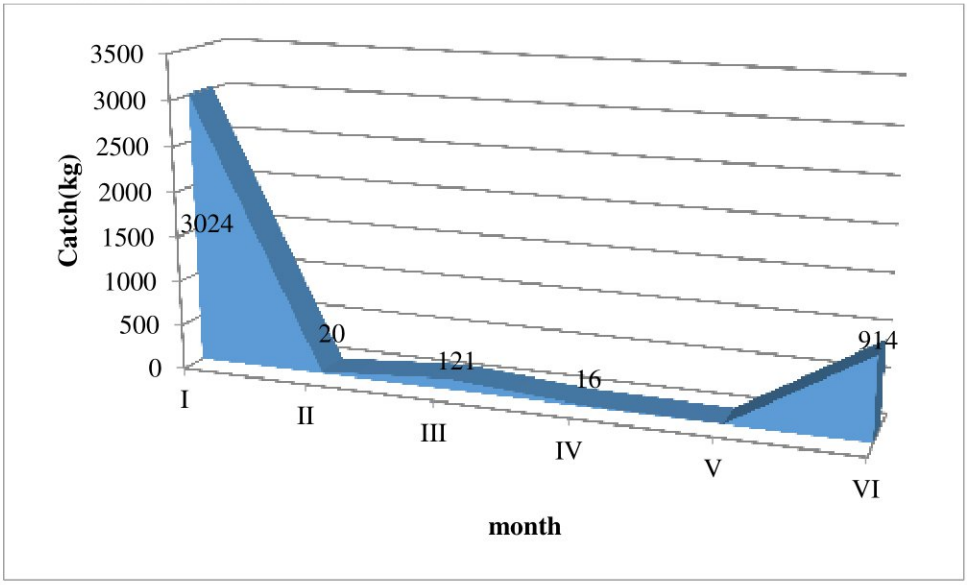
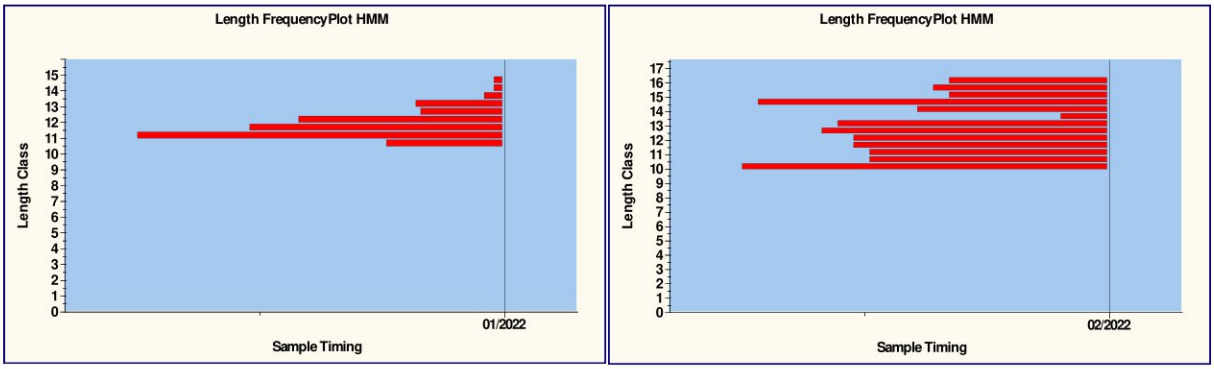


Figure 3.1.1 Landings statistics of horse mackerel.

II.3.2 Length structure of landings

The size composition of the captured horse mackerel individuals 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 I-VI, 2022, 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 an absolute length of 11 cm and 12.5 cm are represented by 13.5% of the total number of specimens caught.



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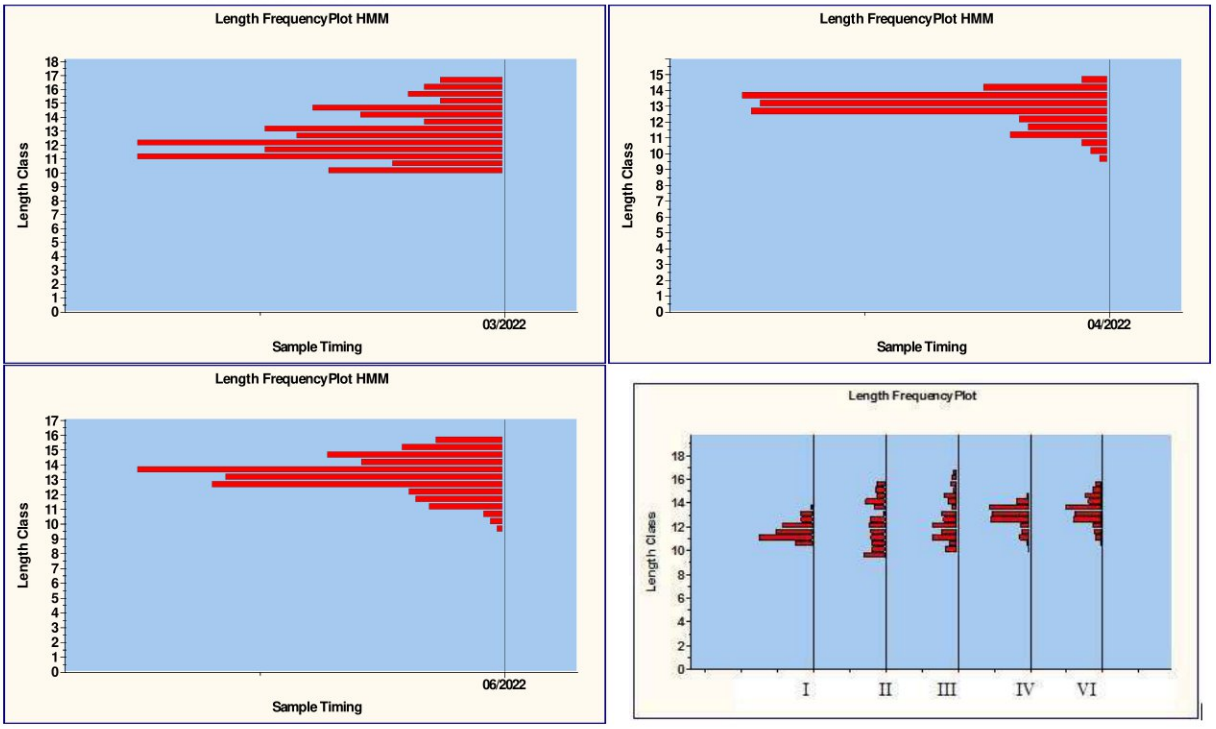

Figure 3.2.1 Histogram of length frequency data of horse mackerel landings I-VI quarter, 2022.

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 = 1004)** 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%.

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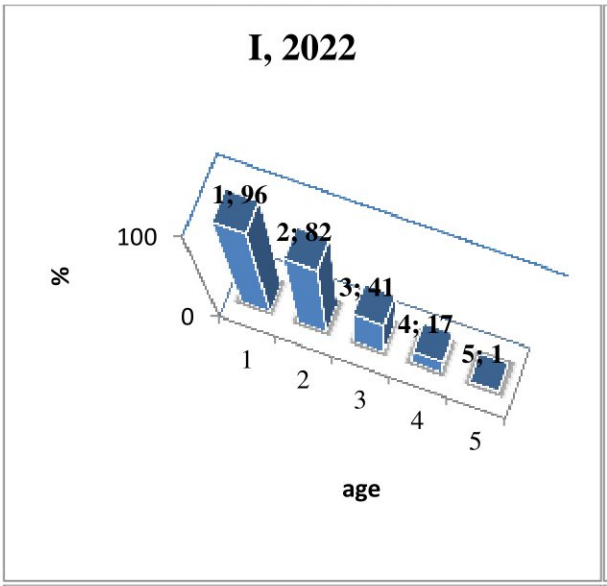

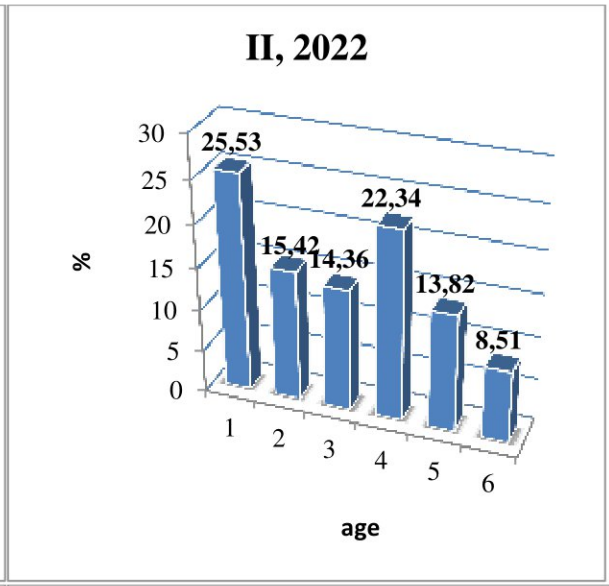

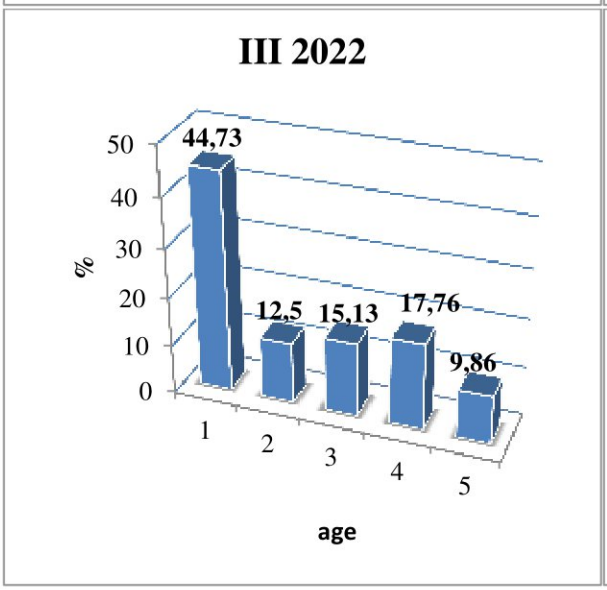

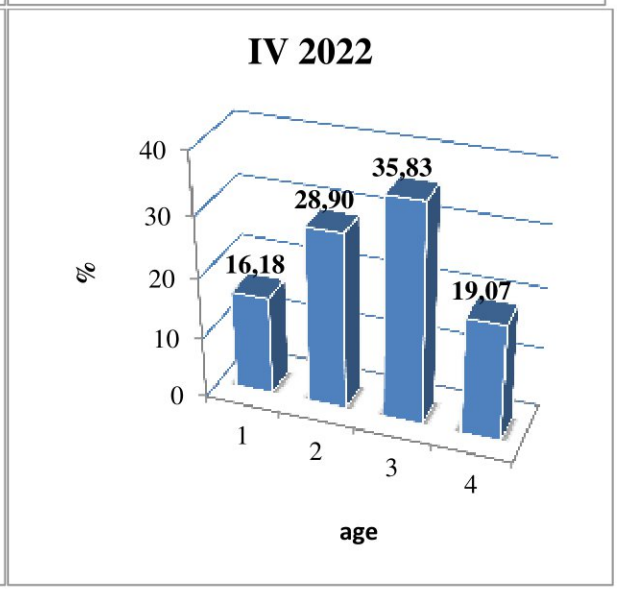

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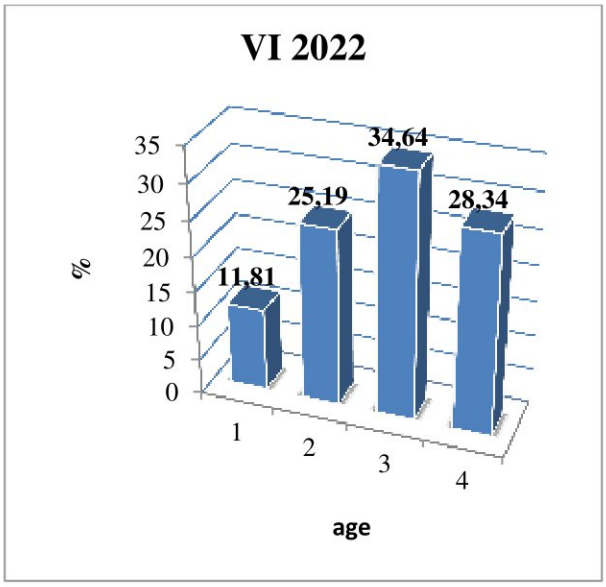

Figure 3.3.1 Age distribution of horse mackerel.

The summary graph for the I-VI 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**).

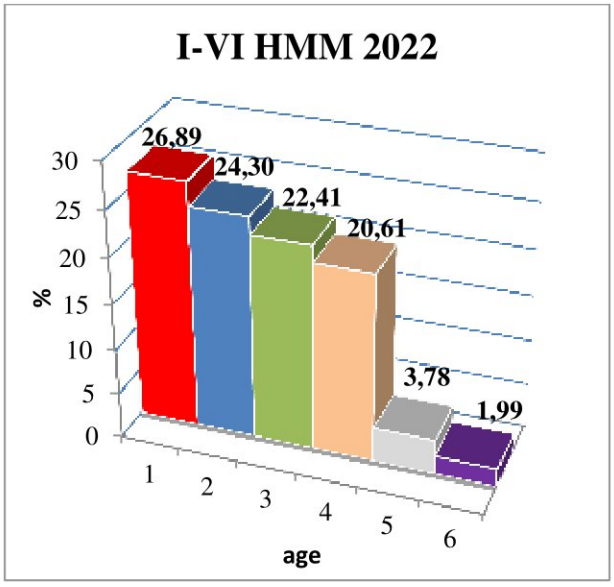

Figure 3.3.2 Age distribution of horse mackerel for I-VI 2022.

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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).

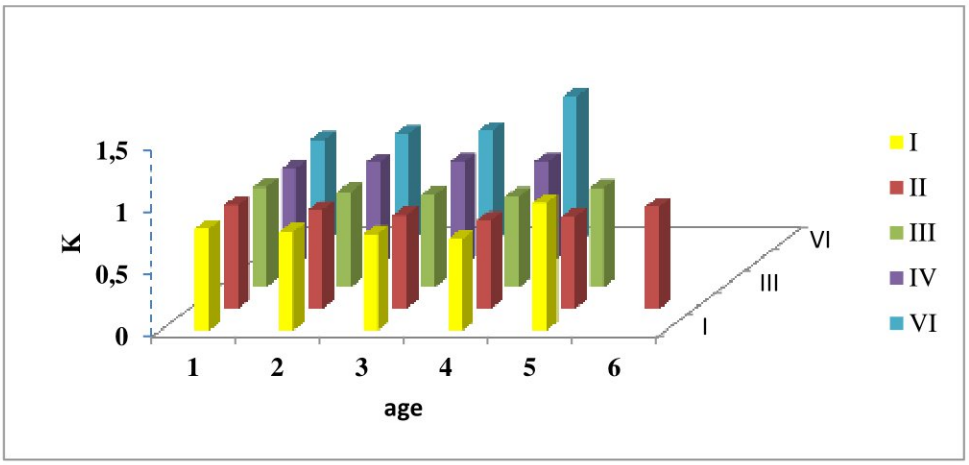

Figure 3.4.1 Condition factor of horse mackerel by age groups.

II.3.5 Weight structure of horse mackerel

The weight was measured on **1004 specimens**. Six-year-old fish showed the highest weight, and one-year-old fish showed the lowest weight.

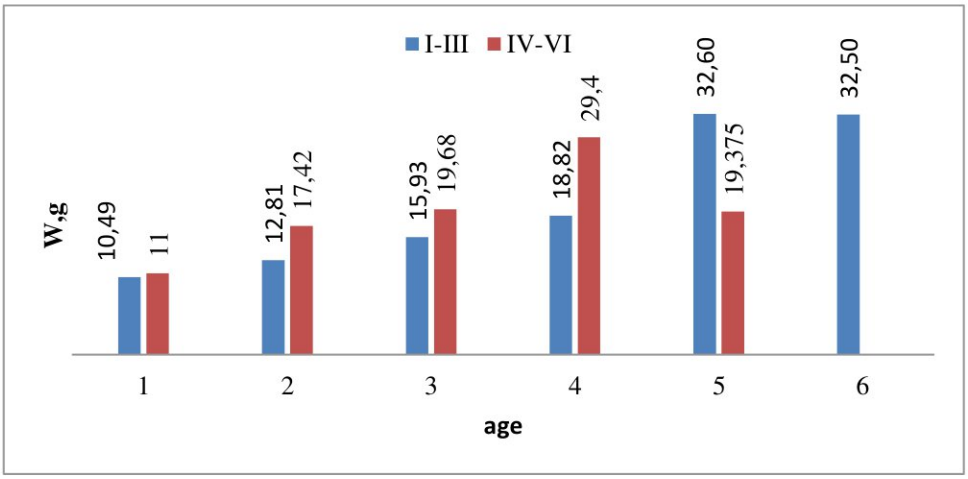

Figure 3.5.1 Average horse mackerel weights by age.

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II.3.6 Size structure of horse mackerel by age group

The fish length was measured of **1004 specimens**. The senior age groups show the highest values in terms of average lengths

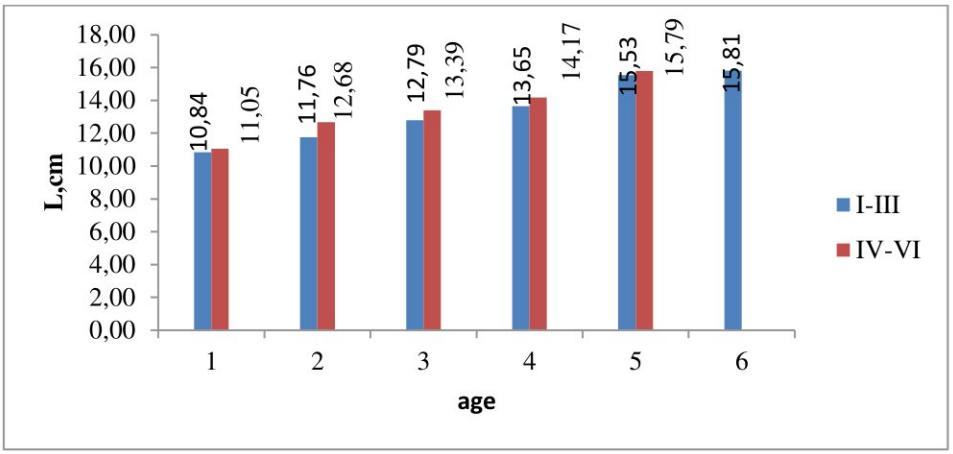

Figure3.6.1 Average horse mackerel lengths by age.

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. 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.**

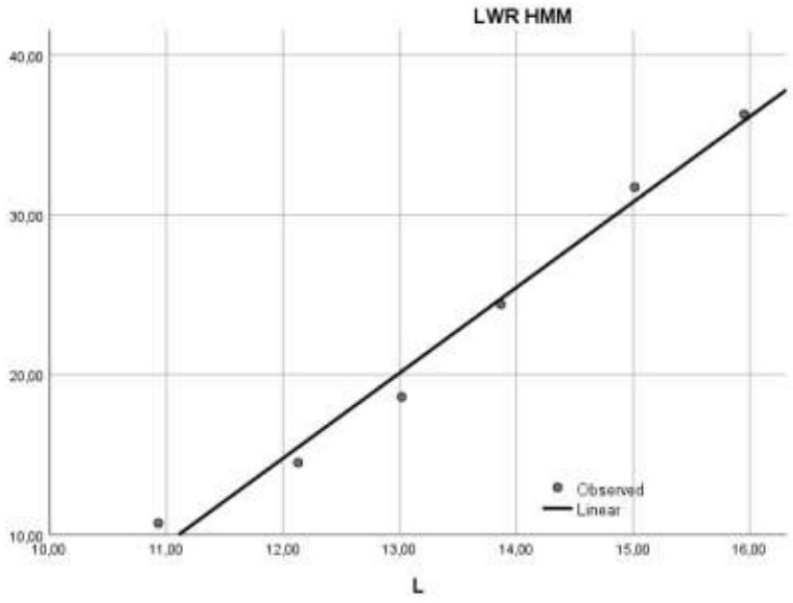

Fig. 3.7.1 Representation of the length-weight model for horse mackerel on a scatter plot.

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Table 3.7.1 Results of modeling the length-weight relationship.

	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*

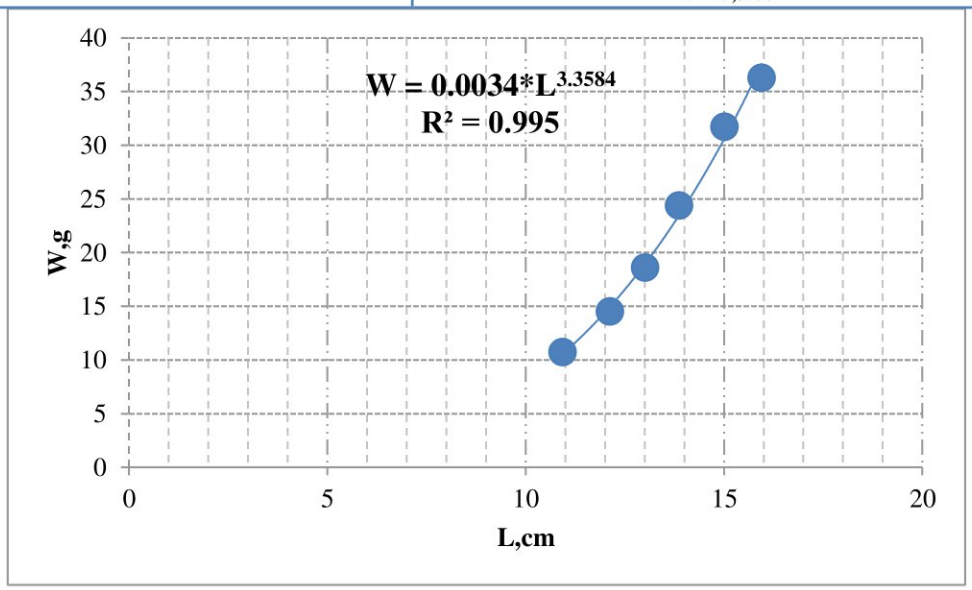

Figure 3.7.2 Length (L) - weight(W) relationship of horse mackerel.

II.3.8 Sex structure

At **250 specimens**, the sex ratio is determined. Females (♀) prevailed by 55%, followed by male (♂) specimens by (45%) **(Figure 3.8.1)**.

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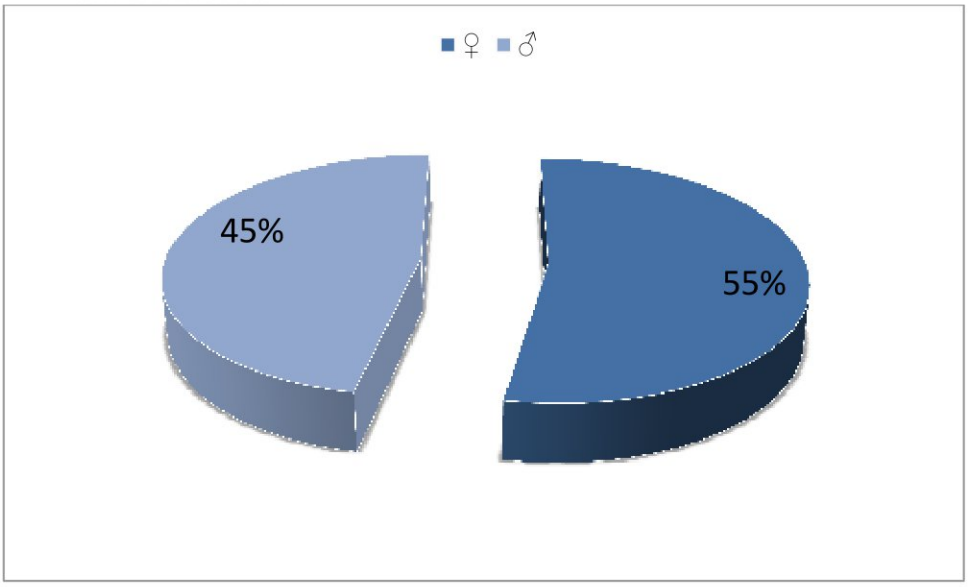

Figure 3.8.1 Sex ratio of horse mackerel (♀:♂).

Average lengths of female ♀ are higher in 2, 3 and 4 year old fish (**Figure 3.8.2**). One-year-old fish show close values during the studied period -L♀=10.931cm L♂=10.989cm.

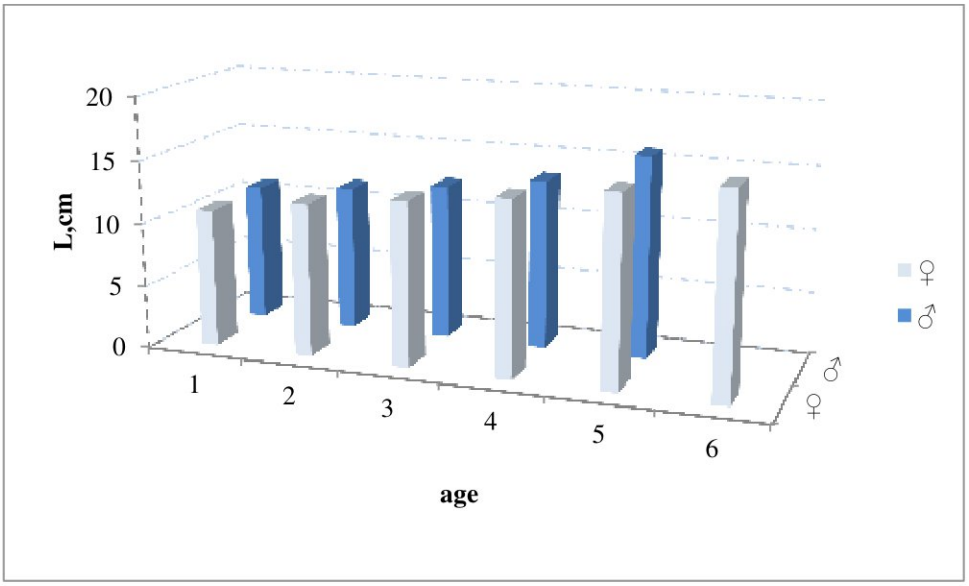

Figure 3.8.2 Sex ratio(♂♀) by size and age of horse mackerel.

II.3.9 Fertility

Fertility was determined on **100 specimens**.

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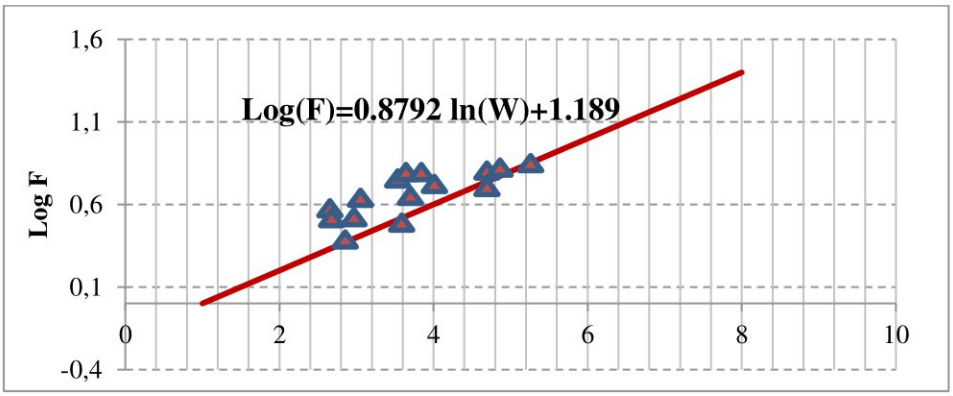

Figure. 3.9.1 Dependence on the weight of the gland of the Gondosoman Index (GSI).

The relationship between the weight and fertility of the mackerel in the I-VI 2022 showed a relatively strong dependence (R^2=0.9943), on the Gonado-somatic index and the weight of the gland (ovary) (**Figure 3.9.2**).

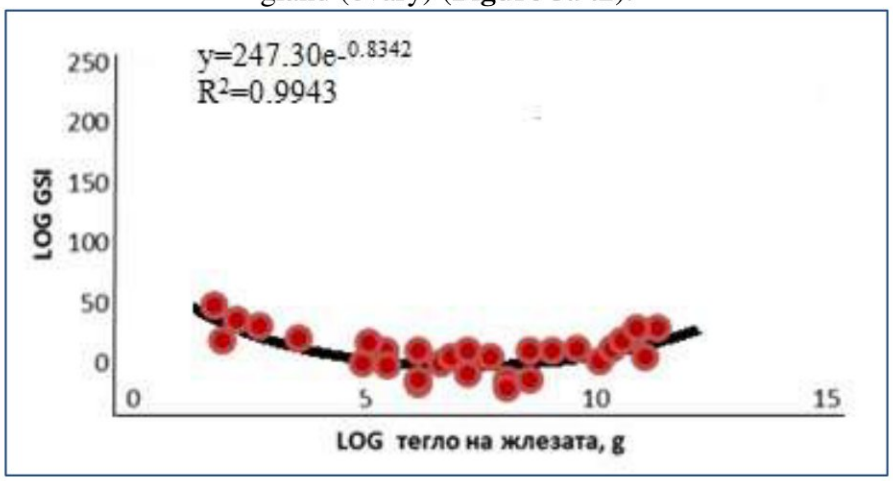

Figure. 3.9.2 Dependence of the ration fertility on the size of horse mackerel.

Absolute fertility fluctuates with average weighted fertility 72471,13 caviar grains. Absolute fertility increases with increasing length, weight and age. The weighted average relative fertility was 4685,0183 **(Table 3.9.1**).

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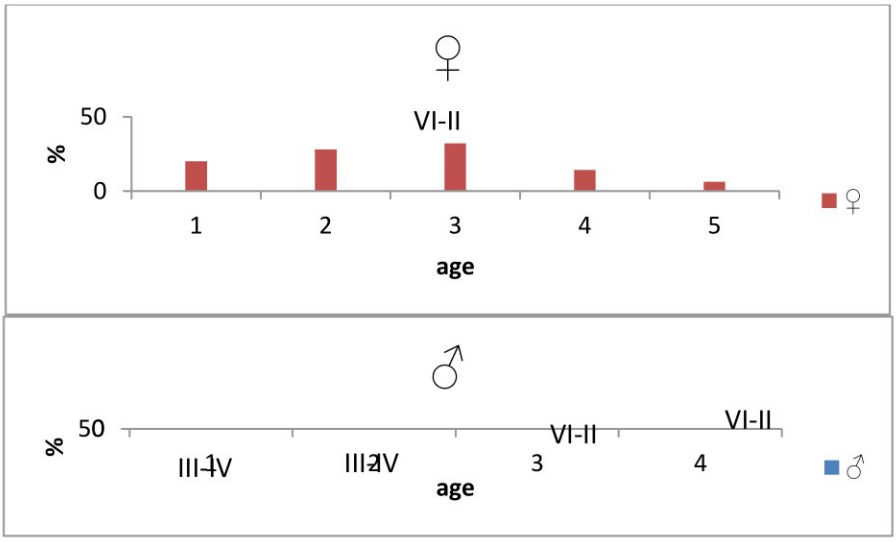
Table 3.9.1 Absolute and relative fertility.

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

II.3.10 Sexual maturity

250 specimens have been assigned sexual maturity. In June, we watched mass mature sex products in over 80% of the female subjects surveyed. Study specimens showed a degree of running gonads (VI-II), with a small percentage of 20% being in grade (III-IV).



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

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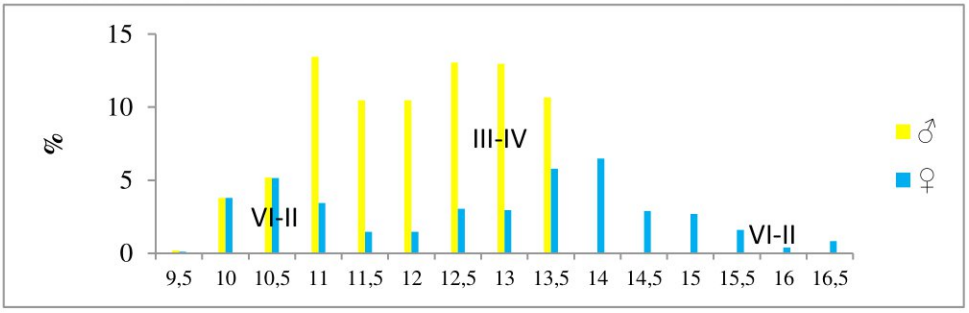

Figute 3.10.2 Sexual maturity by length(cm) of horse mackerel - female ♀ and male ♂.

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 for Ist and IInd quarter.

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**

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).**

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

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**
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**

Horse mackerel biomass is higher in the second quarter (IV-VI) of the study period **(Figure 3.11.1)**.

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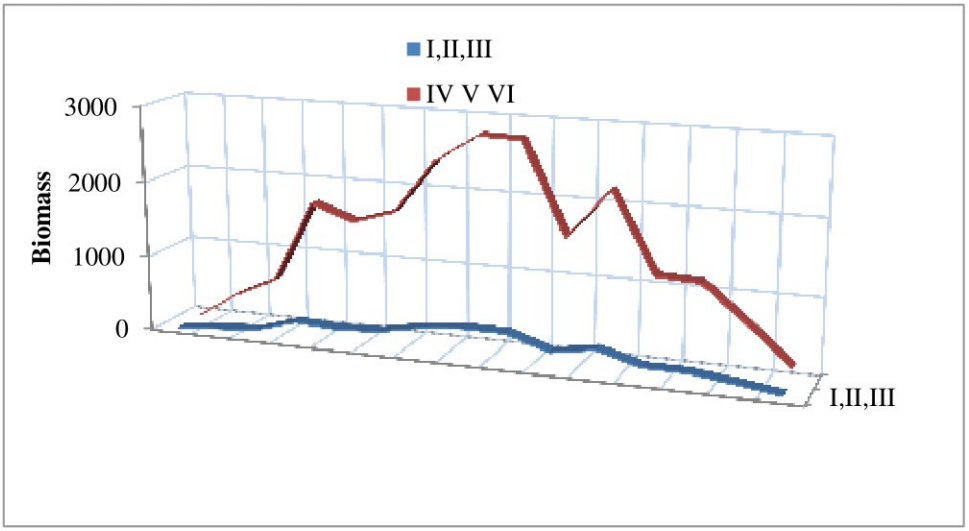

Figure 3.11.1 Biomass dynamics for I-VI 2022.

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 L9.5 to L16.5 cm. From the distribution of fish by size classes for I-VI, 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.
2) The age composition of the studied specimens includes from 1 to 6 year old individuals. The age composition for I-VI 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.
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 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).

4) The ratio between females(♀) and males (♂) is 55% : 45%.
5) Average lengths of female ♀ are higher in 2, 3 and 4 year old fish. One year fish show close values during the study period of I-VI, 2022.
6) Analysis of the relationship between size (L) and weight (W) of the mackerel shows

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that the increase is allometric. The parameter (n) characterizing the increase showed a value of 3.3584.

7) The relationship between the weight and fertility of the mackerel in the I-VI 2022 showed a relatively strong dependence (R^2=0.9943) 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.Test specimens showed a rate of flowing gonads (VI-II) as a small percentage -20% were in grade (III-IV).

9) The biomass of horse mackerel is higher in the second quarter (IV -VI) of the study period for 2022.

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

III.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze whiting catches, as well as to form a database. The collection of biological samples of whiting catches in I-VI, 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 I-VI 2022, **3 samples with 148 specimens** were collected and processed. Information on the size of the catches was also collected.

III. 2.2 Sampling period

In I-VI 2022, the biological data for the species were collected from a total of 3 landings at the ports of Varna, Nessebar and Burgas. 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	2.4.2022	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

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III. 2.3 Statistical analysis of data

See section statistical analysis of sprat.

III.3 Results

III.3.1 Landings statistics

The whiting catches with OTM ranged from 12 kg in January and 3923 kg in May 2022 (**Figure 3.1.1**).

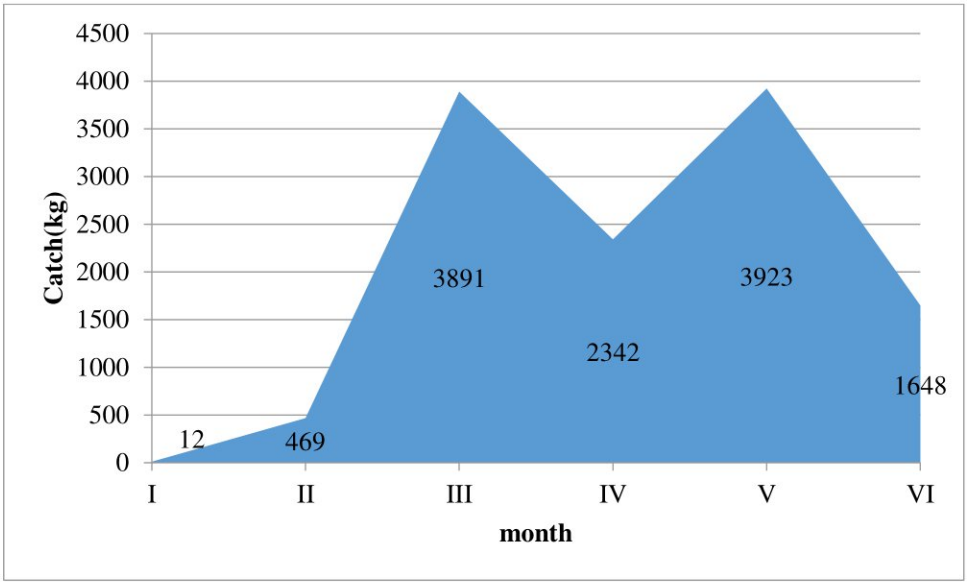
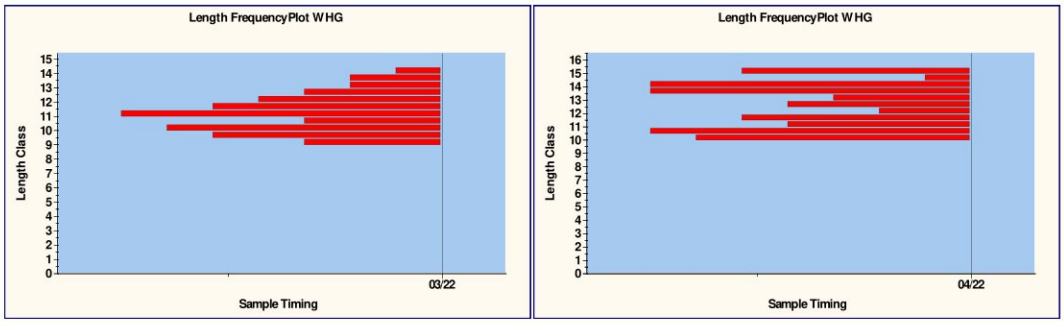


Figure 3.1.1 Landings statistics of whiting.

III.3.2 Length structure of landings

In the catches of the Bulgarian area on the Black Sea in I-VI 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 .



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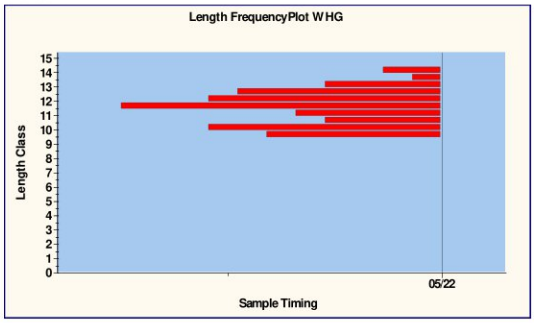

Figure 3.2.1. Histogram of length frequency data of whiting landings in 1th and 2th quarters of 2022.

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.

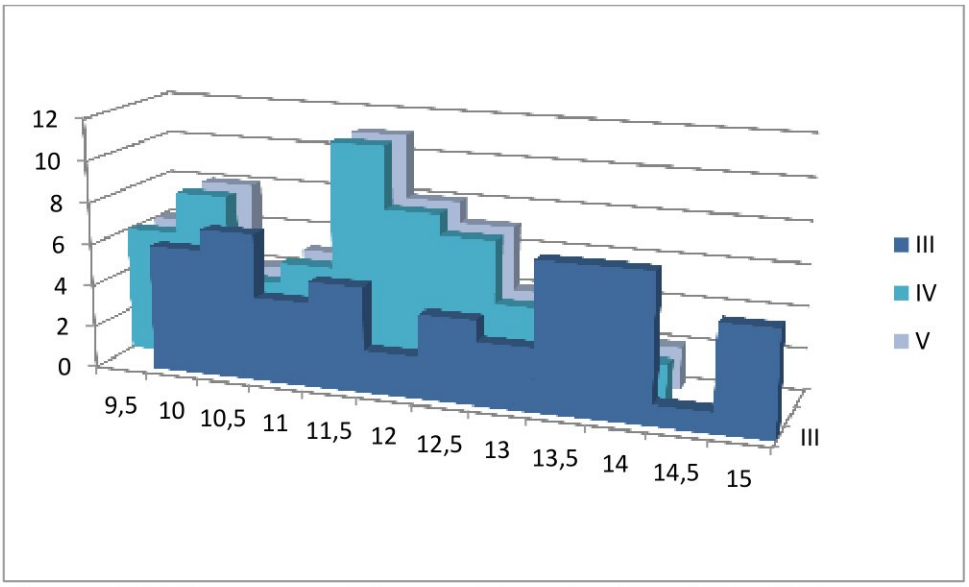

Figure 3.2.2 Frequency of the length from landings in the I-VI quarters of 2022.

III.3.3 Age structure of landings

The three readers determined the age of whiting otoliths, and reader 1 read all otoliths twice. Specimens **(n = 148)** were used for age determination. The age structure of the whiting is represented by 4 age classes, 1,2,3, and 4 years old **(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.

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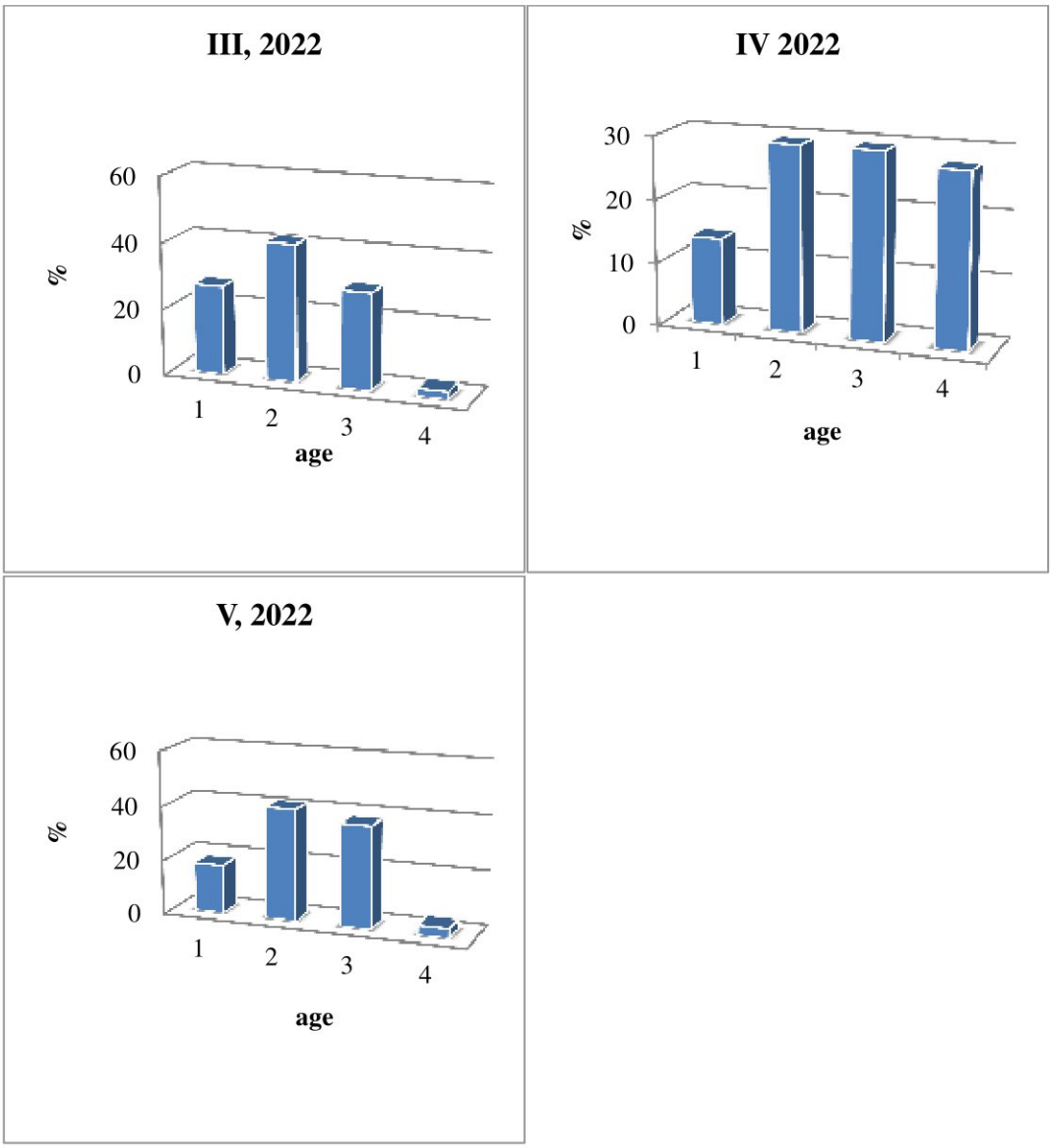

Figure 3.3.1 Age distribution of whiting.

The predominant age was 2-2+ y-1, followed by 32% participation in the catch of 3-3+ y^{-1} age groups.

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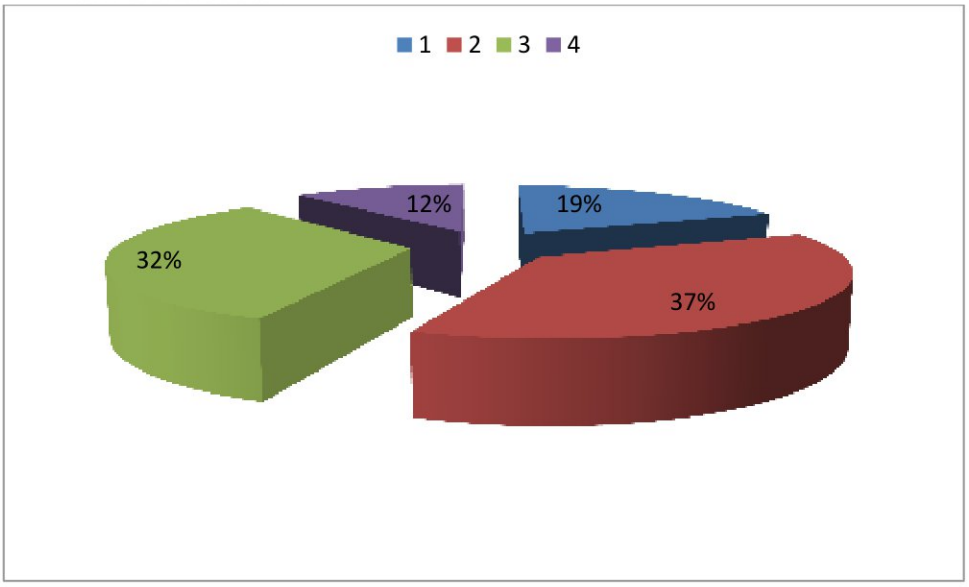

Figure 3.3.2 Age distribution of whiting.

III.3.4 Condition factor

Fulton's factor is relatively evenly distributed both for the first and second quarters **(Fig. 3.4.1).**

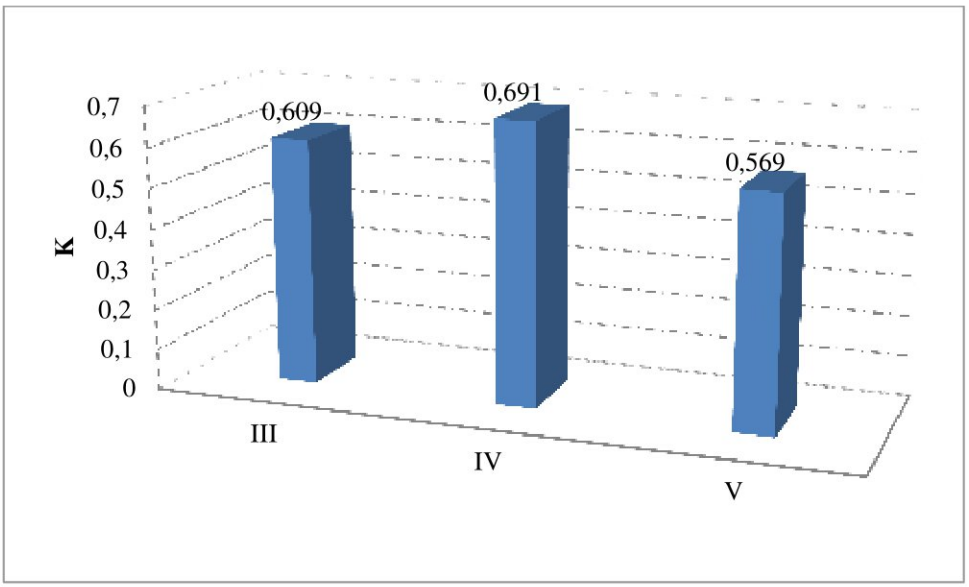

Figure 3.4.1 Mean condition factor of whiting I-VI, 2022.

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III.3.5 Weight structure of whiting

Weight was measured of **148 specimens**. Four-year-old fish showed the highest weight. and the lowest weight was shown by the one-year-olds.

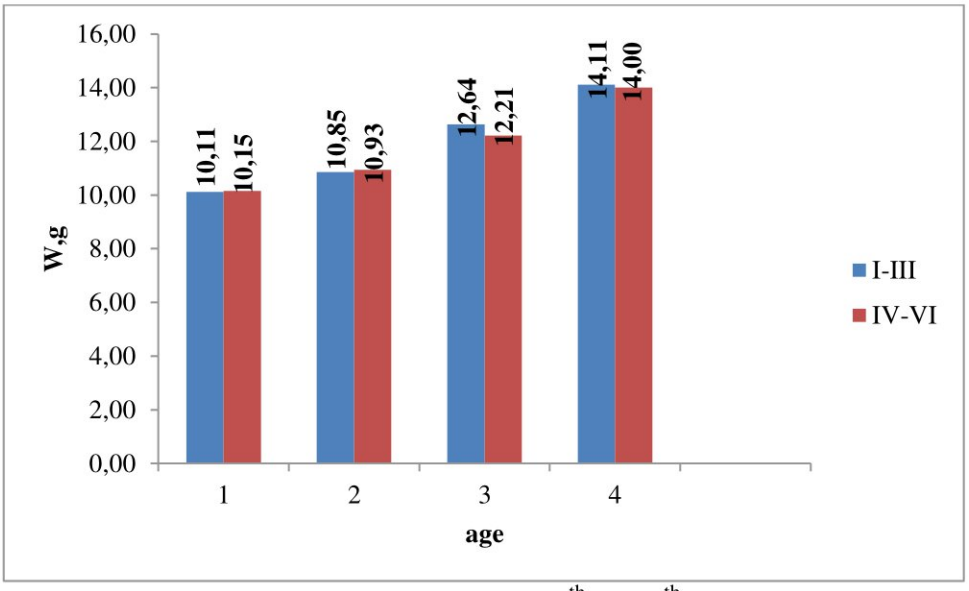

Figure 3.5.1. Weight structure by age group in the 1th and 2th quarters of 2022.

III.3.6 Size structure of whiting by age group

The fish length was measured of **148 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)**.

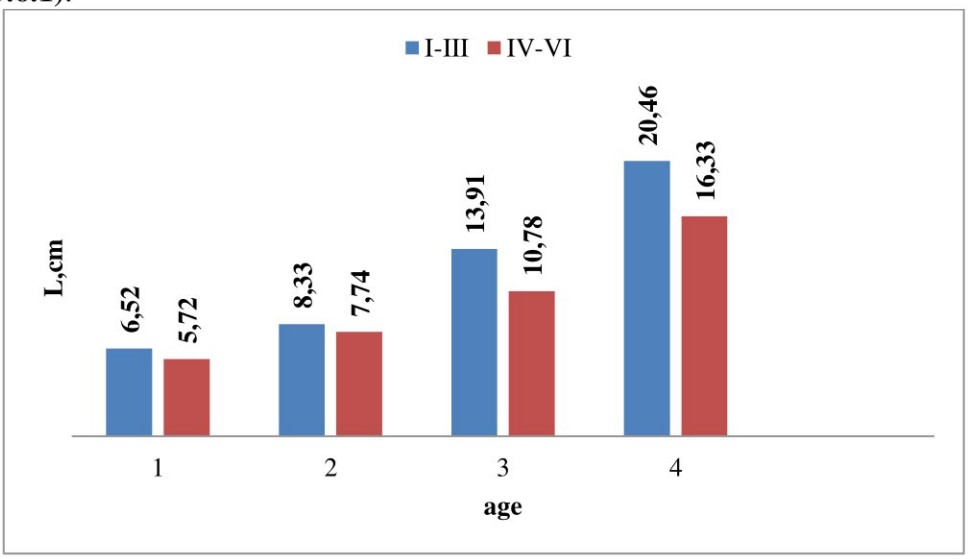

Figure 3.6.1. Length structure by age groups in the 1th and 2th quarters of 2022.

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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. 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.**

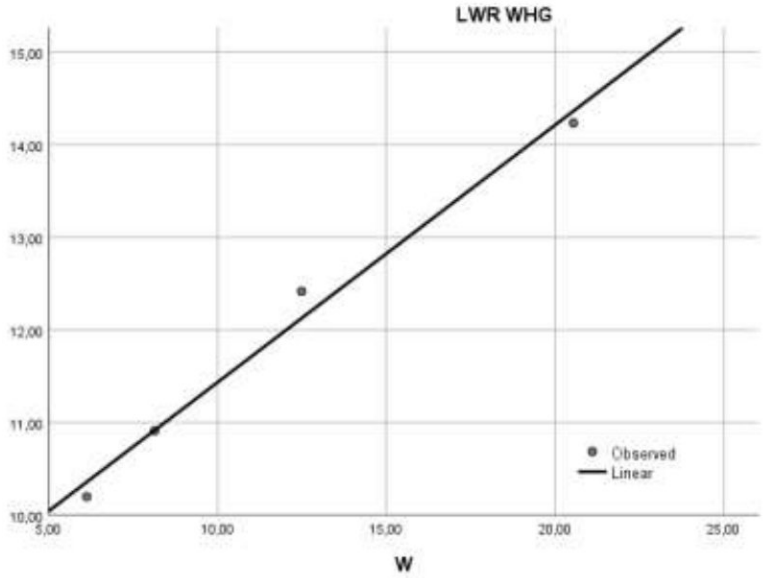

Fig. 3.7.1 Representation of the length-weight model for whiting on a scatter plot.

Table 3.7.1 Length-weight relation parameters.

	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*

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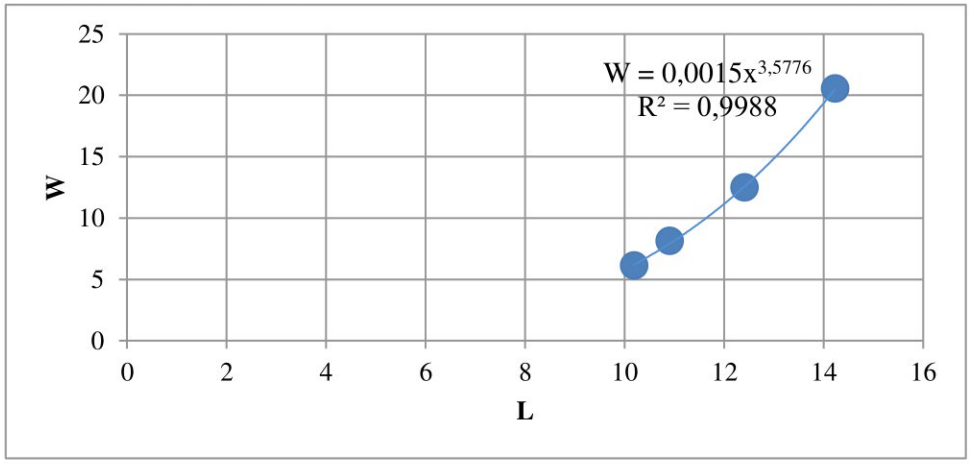

Figure 3.7.2 Length-weight relationship.

III.3.8 Sex ratio

The sex ratio was determined of **100** specimens. Sex of the determined specimens, 54% was female and 46% was male **(Figure 3.8.1)**.

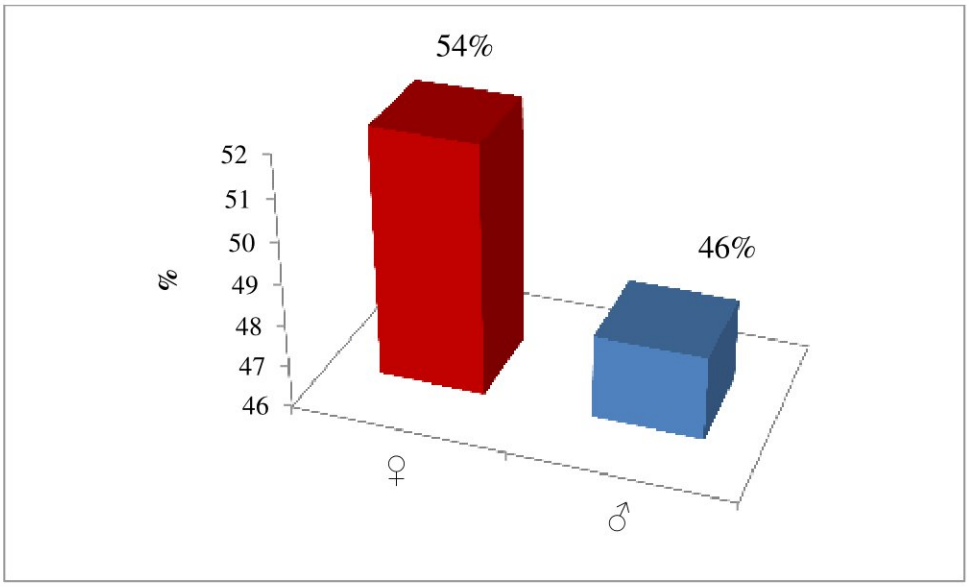

Figure 3.8.1 Sex ratio of whiting (*Merlangius merlangus*) caught in the Bulgarian Black Sea waters.

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 **(Figure 3.8.2)**.

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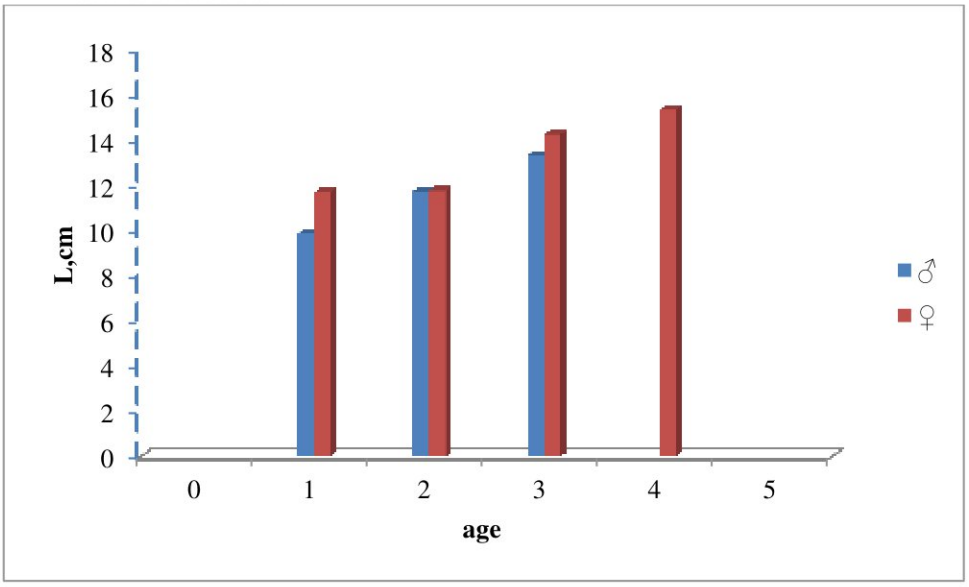

Figure 3.8.2 Sex ratio by size and age of whiting.

III.3.9 Fertility

Fertility was determined on **100 specimens**. Gonado somatic index is highly dependent on the on the sexual glands weights (R^2= 0.8770), which is correlated with the high maturation of females in the late spring and summer spawning processes of whiting **(Figure 3.9.1)**.

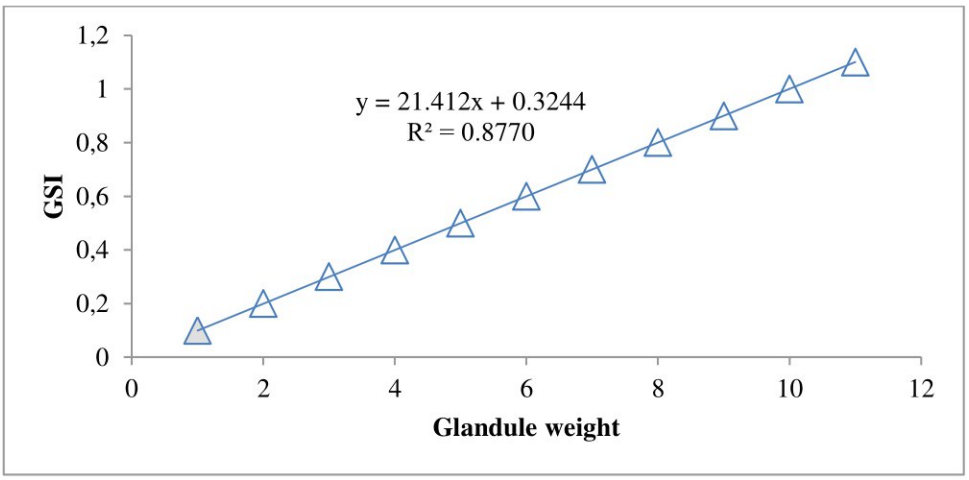

Figure 3.9.1 Glandule weight (g) vs.GSI for whiting.

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

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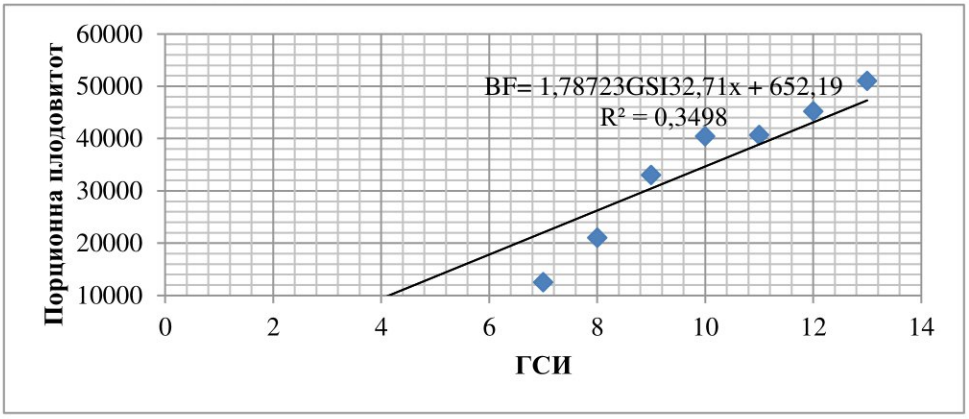

Figure 3.9.2 Batch fecundity vs. GSI for whiting.

Absolute fertility increases with increasing length, weight and age. The weighted average relative fertility is 1609,348 (**Table 3.9.1**).

Table 3.9.1 Absolute and relative fertility.

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
			средно	средно	100
			22031,08	1609,348	

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III.3.10 Sexual maturity

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

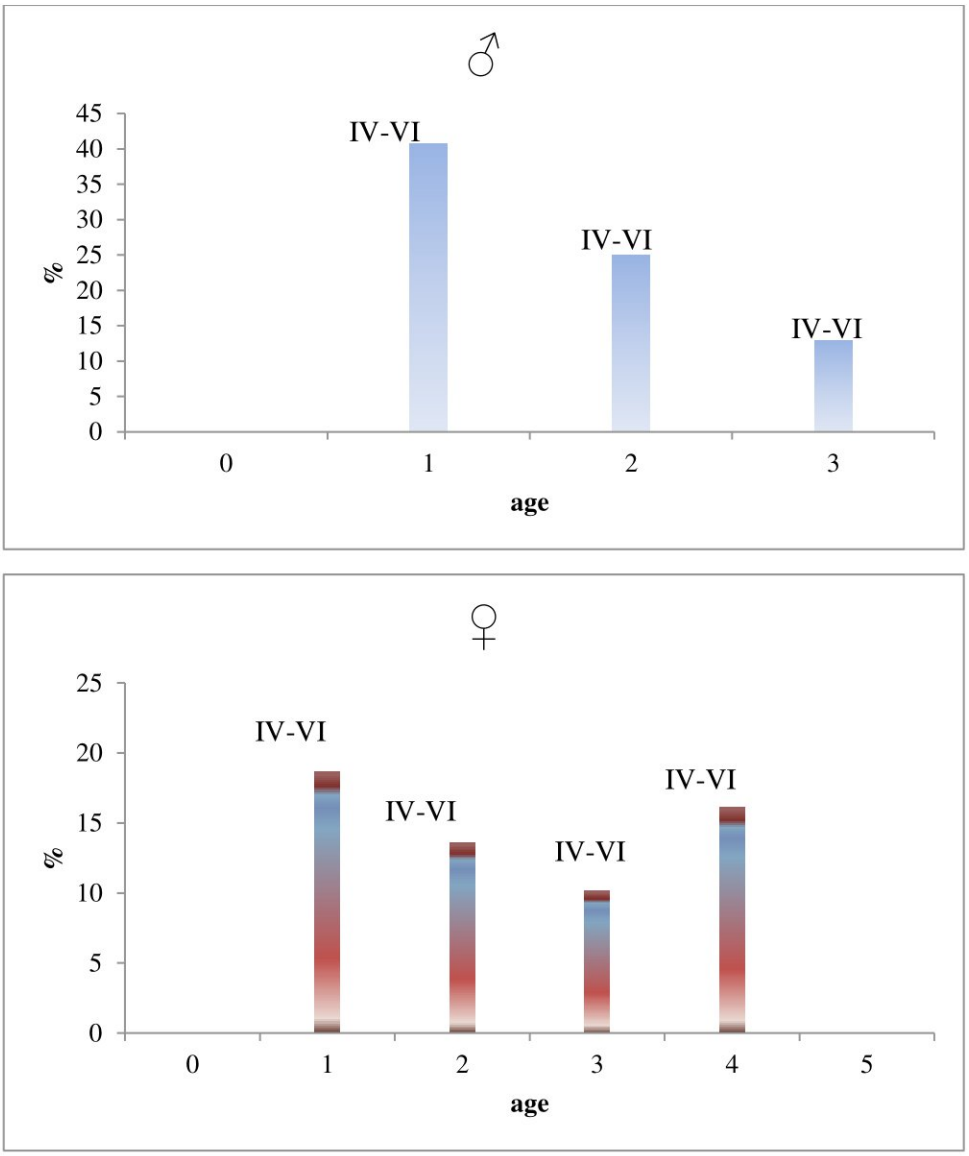

Figure 3.10.1 Sexual maturity by age of whiting - female♀ and male ♂.

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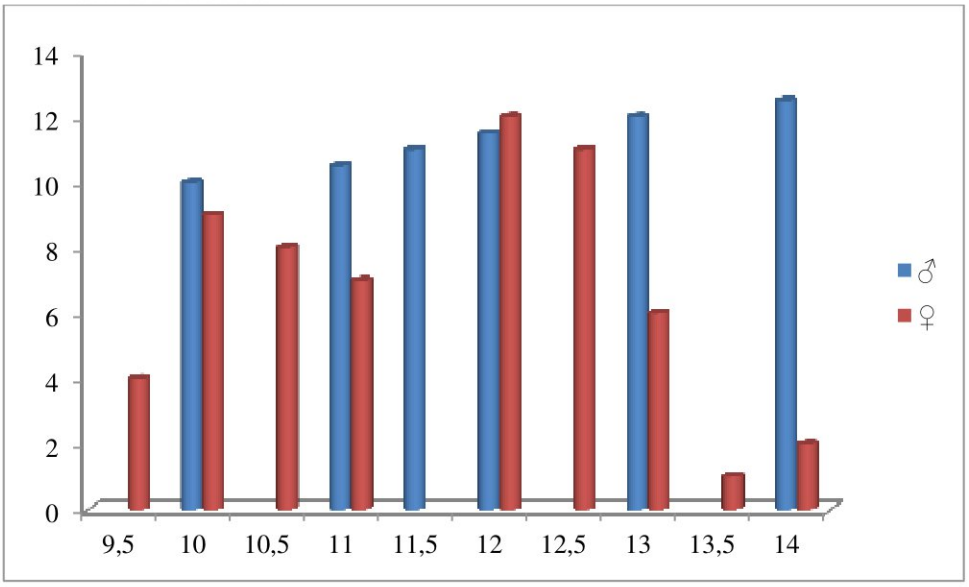

Figure 3.10.2 Sexual maturity along the length (cm) of whiting - female ♀ and male ♂.

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 for Ist and IInd quarter.

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**

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 for Ist and IInd quarter.

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
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**

The biomass was higher in the second quarter (IV-VI) of the study period (**Figure 3.11.1).**

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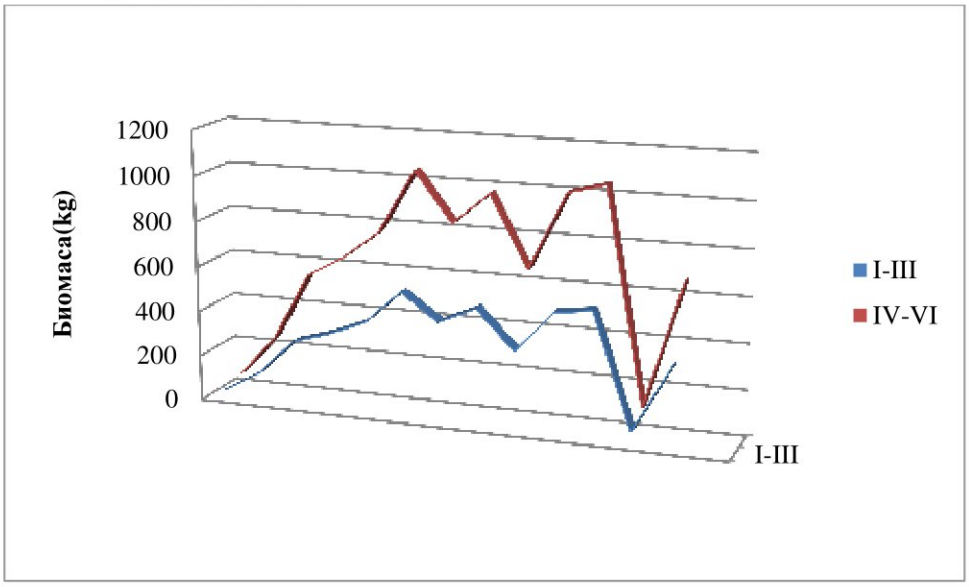

Figure 3.11.1 Biomass dynamics.

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 15.0 cm. In the landings during the studied period, the size group 10.5 cm predominates with a total of 13.52%.
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.
3) Analysis of the condition shows close values of the parameter in the individual months.
4) The relationship between the size (L) and the weight (W) of the specimens examined is described by the equation: $W = 0.0015*L^{3.5776}$
5) Female (♀) specimens prevailed by 54%, followed by males (♂) by (46%).
6) The average lengths in females by age group are higher, with the exception of two-year-old specimens where close values are observed.
7) Gonado- somatic index is highly dependent on the weight of the gonads ($R^2 = 0.8770$), 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.
9) The biomass of the whiting is higher in the second quarter (IV-VI) of the study period.

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

IV.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze red mullet catches, as well as to form a database. The collection of biological samples of red mullet catches in I-VI, 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 I-VI 2022, **5 samples of red mullet containing 320 specimens** were collected. Information on the size of the catches was also collected

IV.2.2 Sampling period

In I-VI 2022, the biological data on species were collected from a total of 5 landings at the ports of Varna, Tsarevo and Balchik. Information on the size of the catches was also collected. Ports and ships from which monitoring was carried out to collect biological data from landings are presented in **Table 2.1.1**.

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

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Table 9.1 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	26.2.2022	Varna	Red mullet	KORSAR 2 VN 7643	OTM	2	43.366200, 28.386800		north
2	26.3.2022	Balchik	Red mullet	KORSAR 2 VN 7643	OTM	70	43.410400, 28.349600		north
3	4.4.2022	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

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.

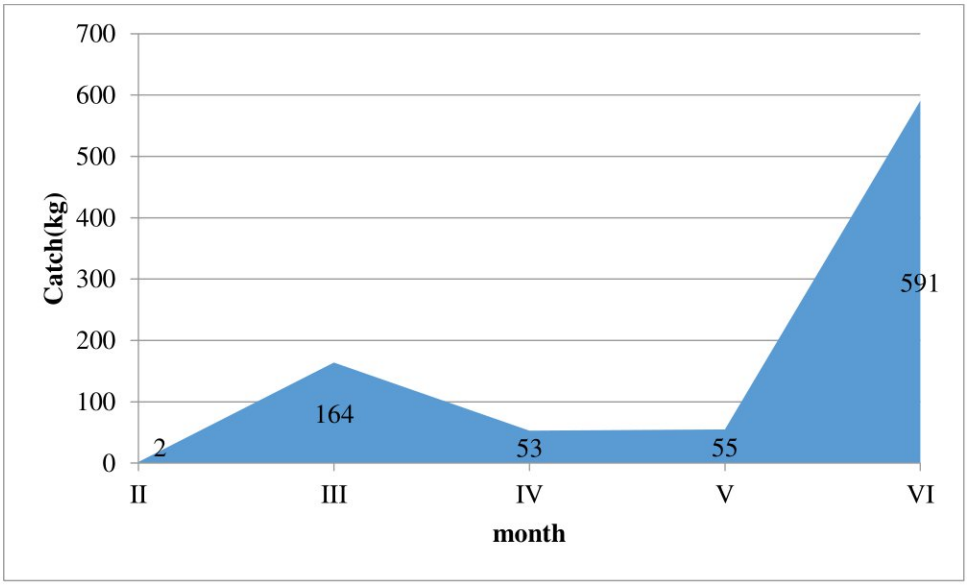

Fig.3.1.1 Official statistics records for red mullet landings by month in the first half of 2022.

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IV.3.2 Length structure of landings

The graph shows that in both quarters the percentage distribution of catches by size 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.

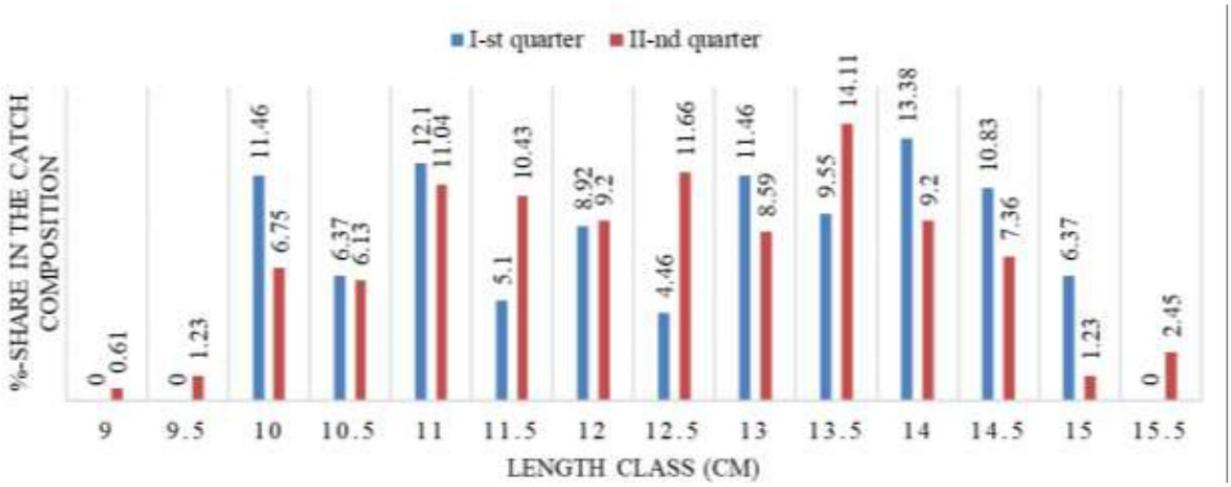

Fig.3.2.1 Size structure and percentage share of length classes in the catch composition in the period January-June 2022.

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 = 320)** 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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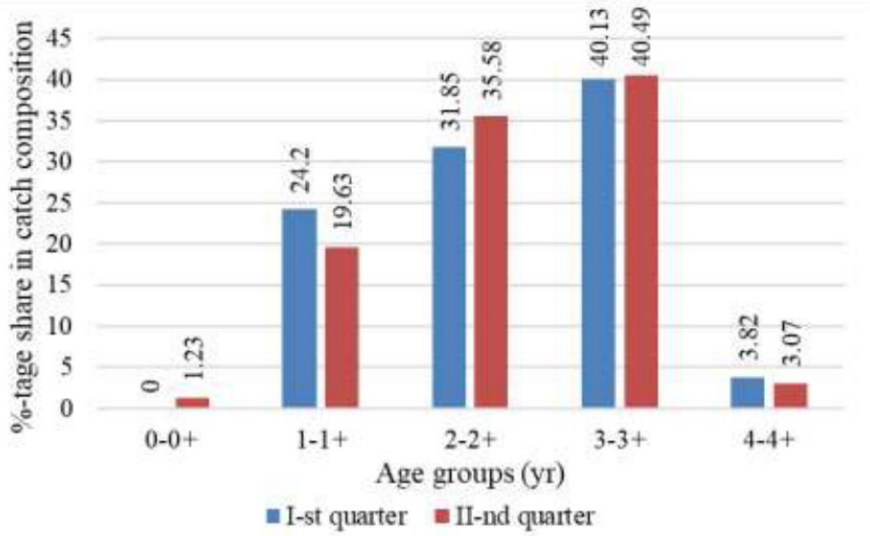

Fig.3.3.1 Age structure and percentage share of age groups in the catch composition in the period January-June 2022.

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.

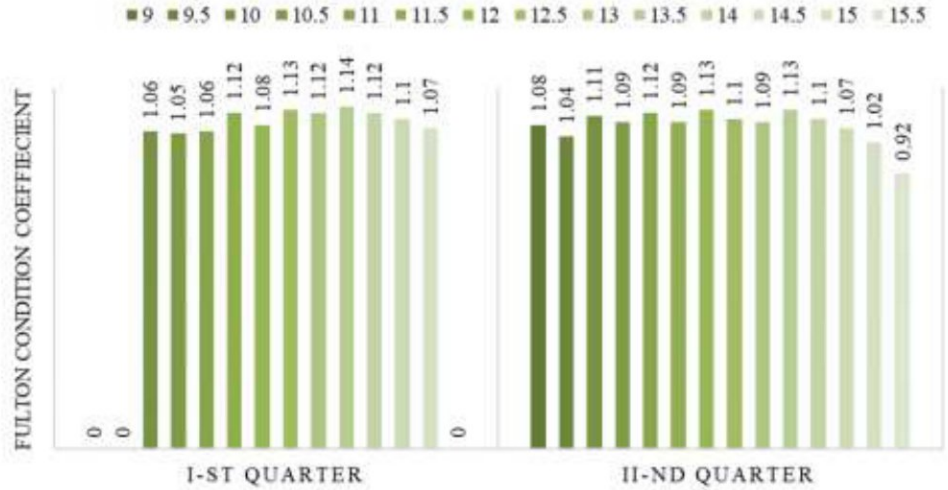

Fig.3.4.1. Fulton condition coefficient values of sprat by length classes in the period January-June 2022.

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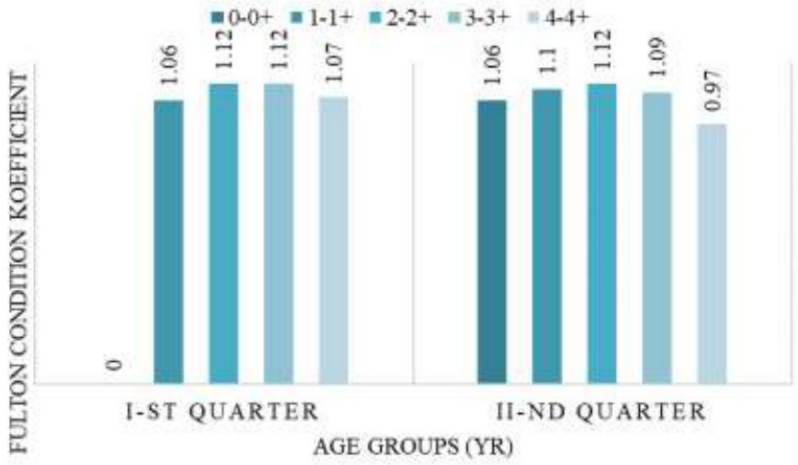

Fig.3.4.2 Fulton condition coefficient values of red mullet by age groups in the period January-June 2022.

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+.

IV.3.5 Weight structure

Weight was measured of **320 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.

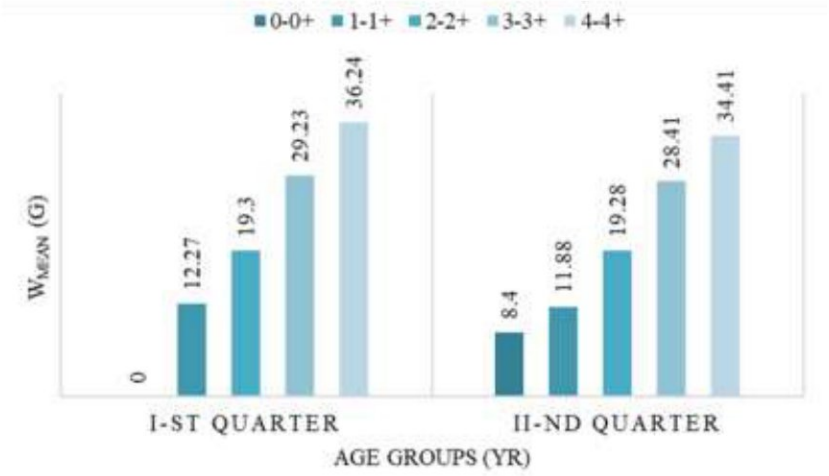

Fig.3.5. 1 Mean weights by age groups in the period January-June 2022.

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IV.3.6 Size structure by age group

The fish length was measured of **320 specimens**. As the age increases, the average length of individuals increases too.

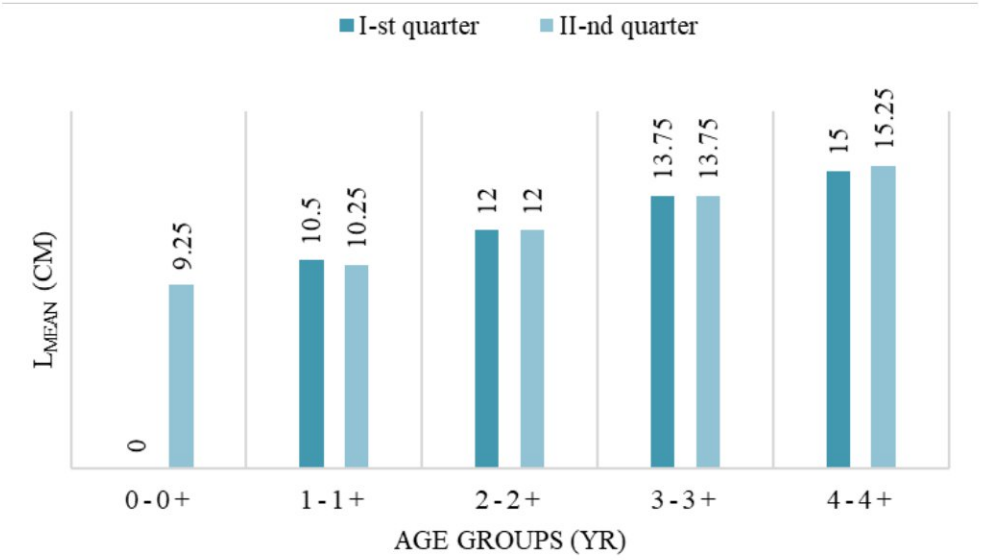

Fig.3.6.1 Mean length by age groups in the period January-June 2022.

IV.3.7 Length- weight relationship

The graph shows a proportional relationship between the length and weight of red mullet **(Фиг. 3.7.1).**

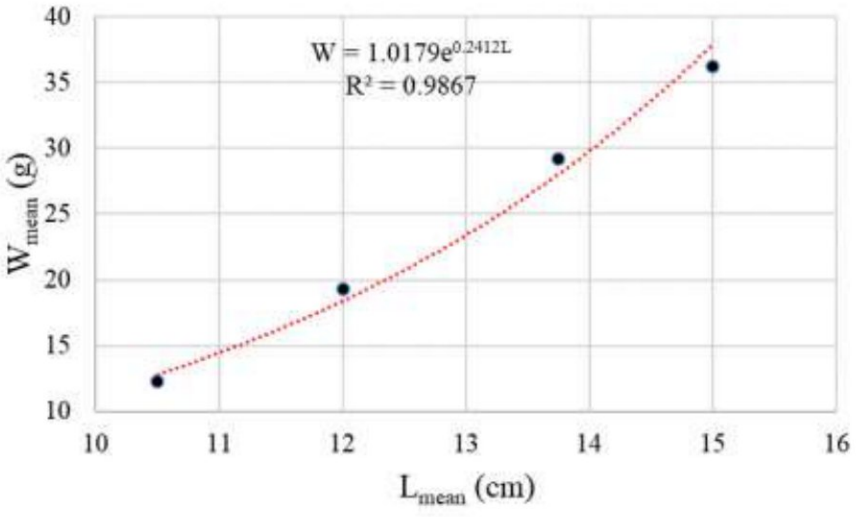

Fig. 3.7.1 Length-weight connection – 1th quarter of 2022.

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The graph shows a proportional relationship between red mullet length and weight (**Fig. 3.7.2**).

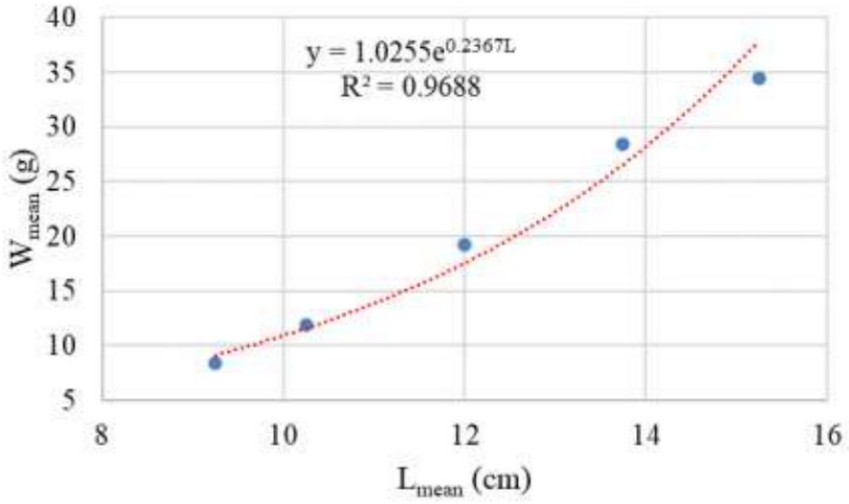

Fig. 3.7.2 Length-weight connection – 2 nd quarter of 2022.

IV.3.8 Sex ratio

The sex ratio was determined of **100 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**)

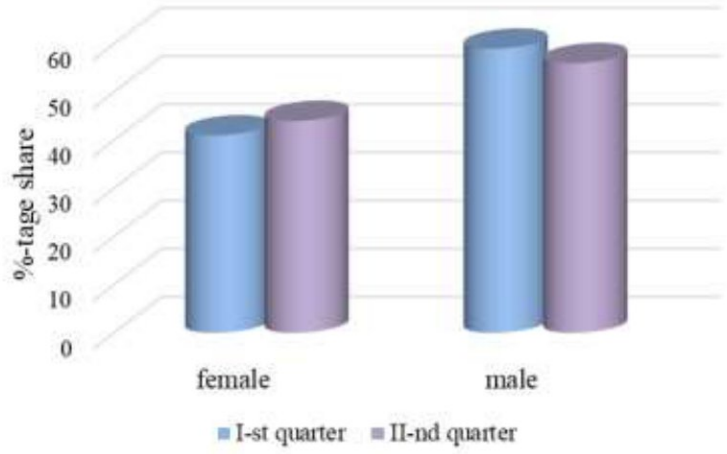

Fig. 3.8.1 Sex-ratio distribution by quarter in the first half of 2022.

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IV. 3.9 Fecundity

100 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.

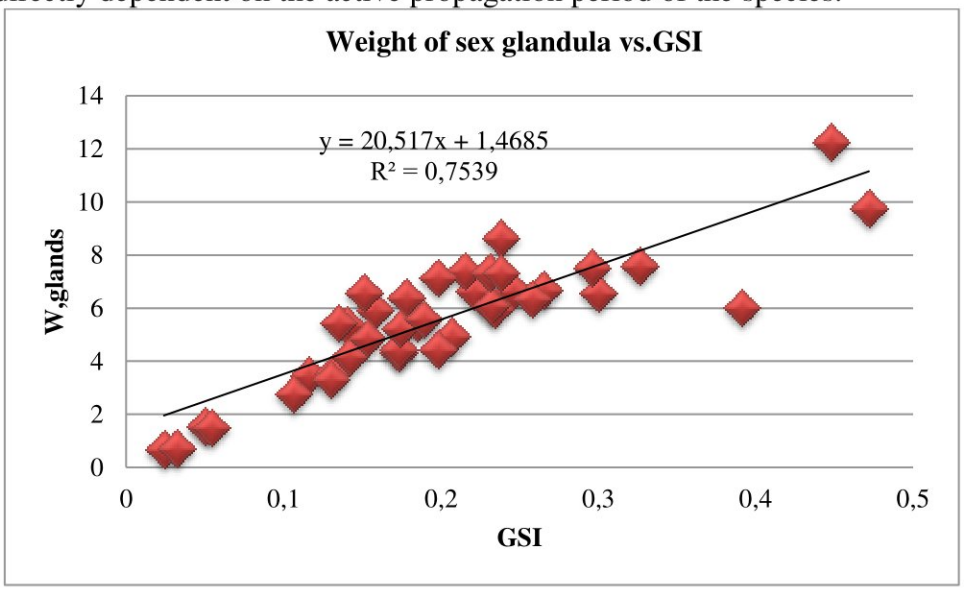

Fig.3.9.1 Dependence of the GSI on the weight of sex glandula of red mullet.

The Goado somatic index for red mullet varies in narrow bounds, with pronounced correlation between the glandula weight of the measured specimens (r^2 = 0.76), **Fig.3.9.1**.

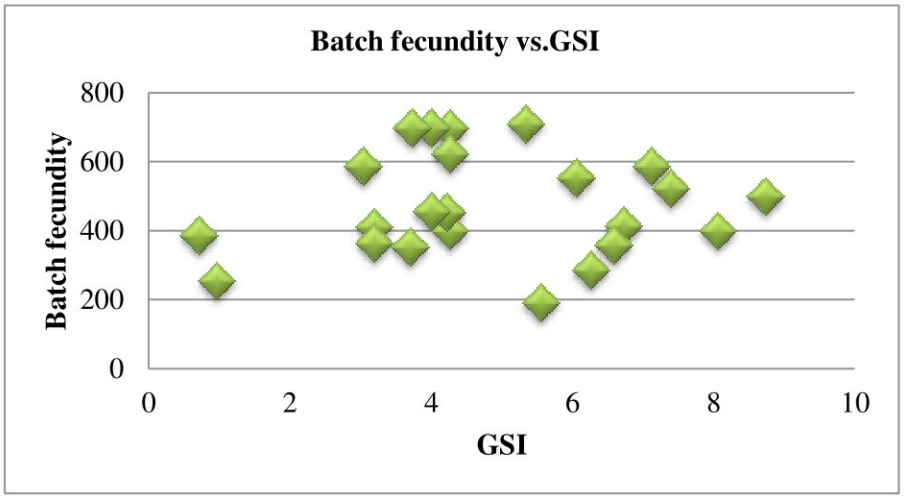

Figure 3. 9.2 Batch fecundity related to GSI of red mullet.

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Table 3.9.1 Absolute and relative fertility.

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
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

IV.3.10 Sexual maturity

250 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}.

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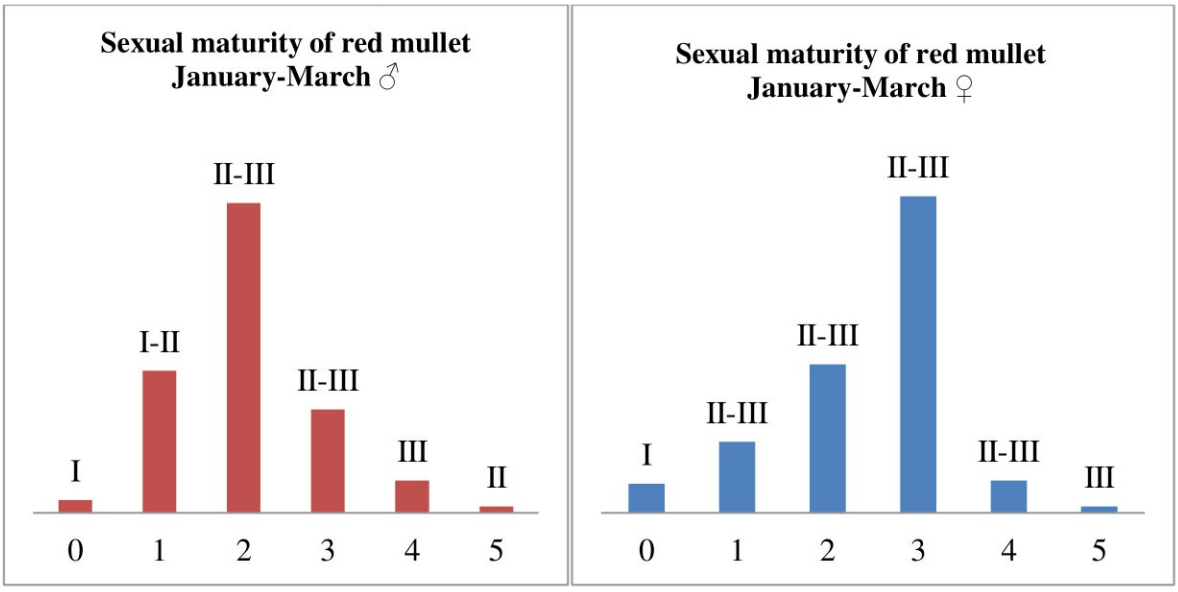

Figure 3.10.1 Sex maturity by age for red mullet January-March, 2022.

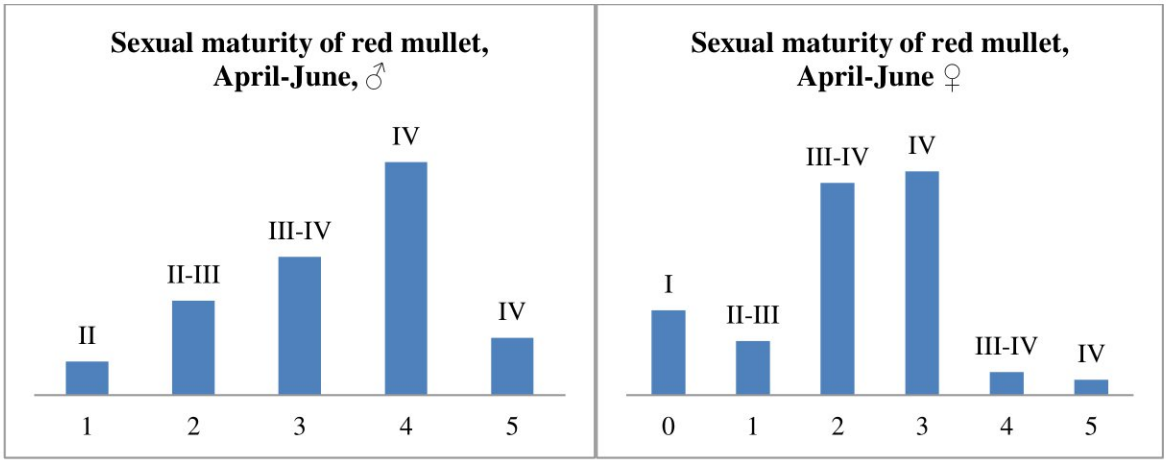

Figure 3.10.2 Sex maturity by age for red mullet, April-June 2022.

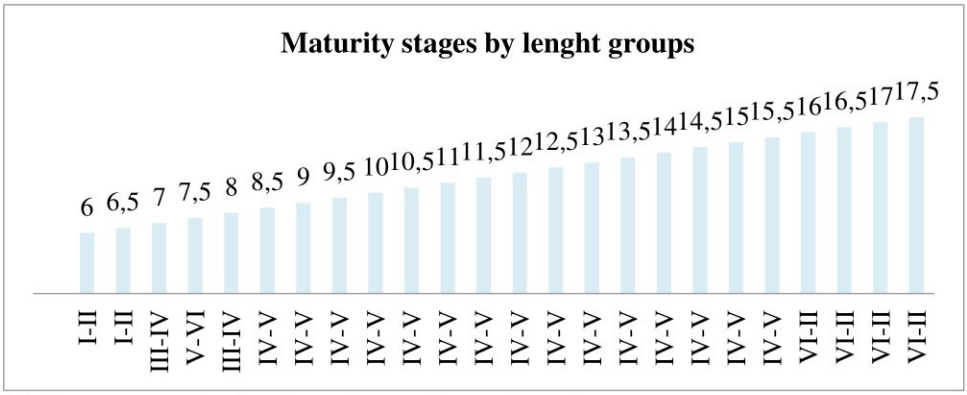

Figure 3.10.3 Sex maturity by length(cm) for red mullet.

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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. 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.

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

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
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

IV. 3.12 Conclusions

1. The month of January has the lowest value. In the second quarter landings are significantly higher than the first quarter.
2. 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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3. 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+. 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.
4. The condition factor has the highest values in the 1-1 and 2-2+ age groups. The lowest value is in age group 4-4+.
5. The relationship between average weights and age groups is directly proportional.
6. As the age increases, the average length of individuals increases too.
7. 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.
8. The Goado somatic index for red mullet varies in narrow bounds, with pronounced correlation between the glandula weight of the measured specimens ($r^2 = 0.76$),
9. 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 $3\text{-}3+y^{-1}$.
10. The average absolute fecundity was assessed as 64375,1 caviar grains, as the average relative fecundity was 4912,8839.
11. The variability was in limits of 0.10 - 0.22 and could be estimated as low. This means that the random sampling of red mullet in months of interest was conducted according to the variation statistics and correctly reflected the general population at this time of the year.
12. 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.
13. Biomass is the largest in individuals of 14 cm size class and is smallest at 11.5 cm and 12.5 cm size classes.
14. The number of catches by age group shows that the highest value among catches occupy the groups of 1-1+ and 2-2+ groups.
15. 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.

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

V.1 Objectives

The purpose of biological monitoring is to collect data that will be used to analyze anchovy catches, as well as to form a database. The collection of biological samples of anchovy catches in I-VI, 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 I-VI 2022, **4 samples containing 215 specimens** were collected and processed.

V.2.2 Sampling period

In I-VI 2022, the biological data on species were collected from a total of 4 landings at the ports of Nessebar and Sozopol. 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 2.1.1.**

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		FV 40 BS258	OTM	4500	42.655800, 27.730700	south
2	7.2.2022	Sozopol		FV 37BS255	OTM	3348	42.422600, 27.691300	south
3	29.3.2022	Nesebar		FV 40 BS258	OTM	2100	42.646200, 27.727300	south
4	15.4.2022	Nesebar		FV 40 BS258	OTM	200	42.659700, 27.731400	south
	V 2022	no recorded catches with OTM						
	VI 2022	no recorded catches with OTM						

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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 **(Figure 3.1.1)**.

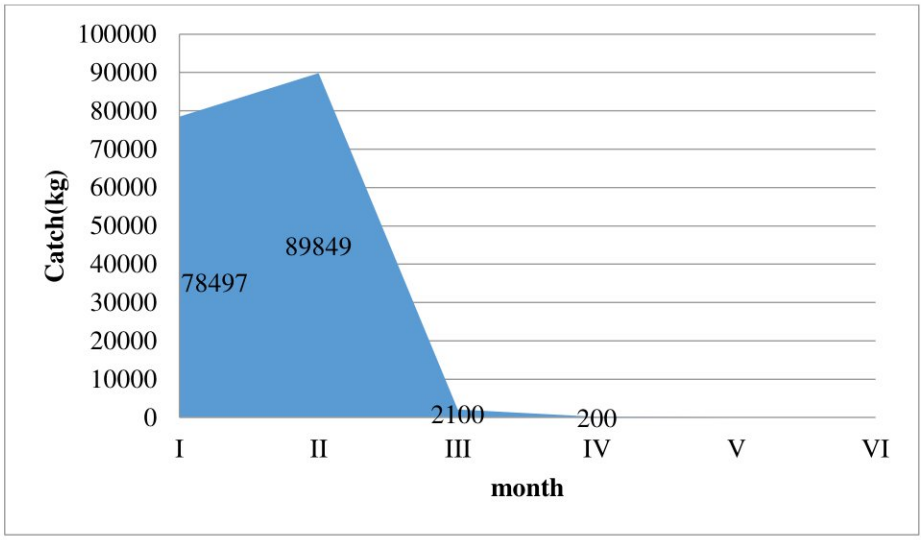

Figure 3.1.1 Landings statistics of anchovy.

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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.

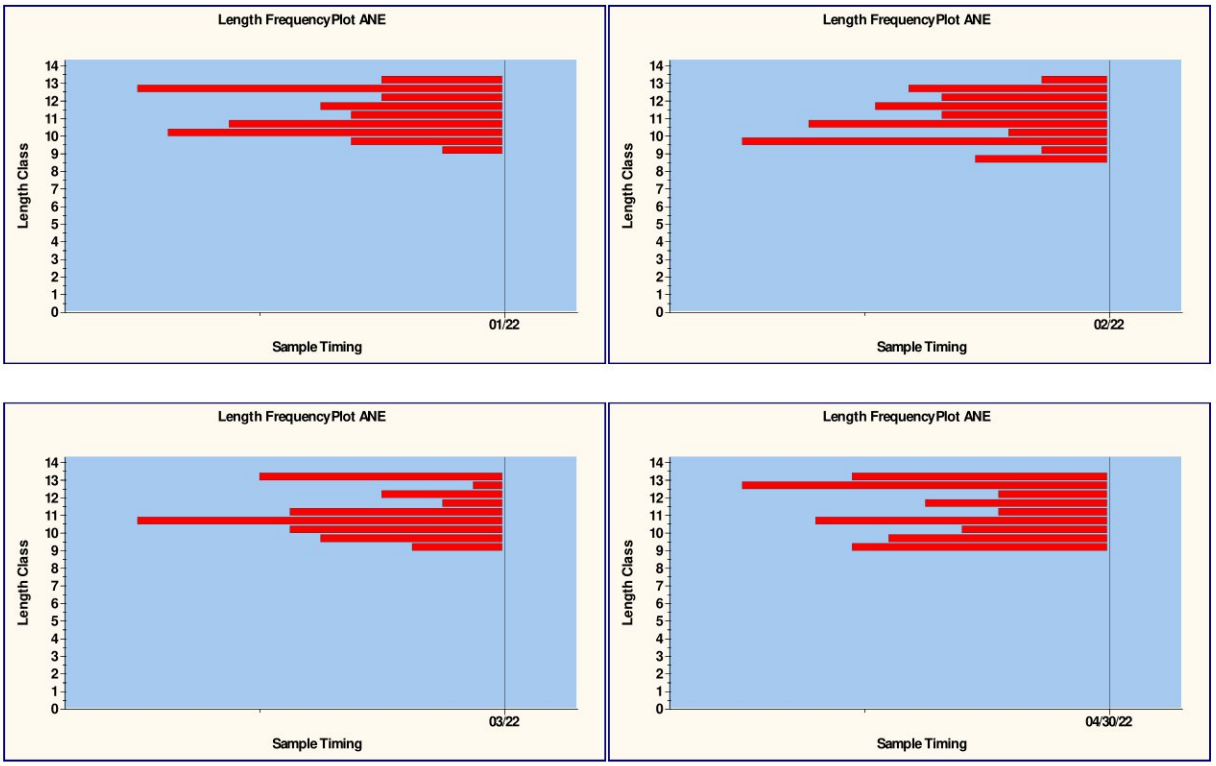

Figure 3.2.1 Frequency of anchovy length from landings.
Note: In May and June, there were no recorded catches of anchovy with OTM

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.

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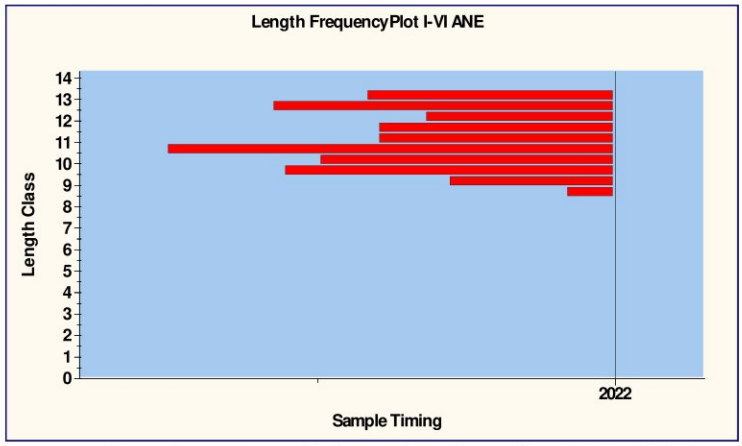
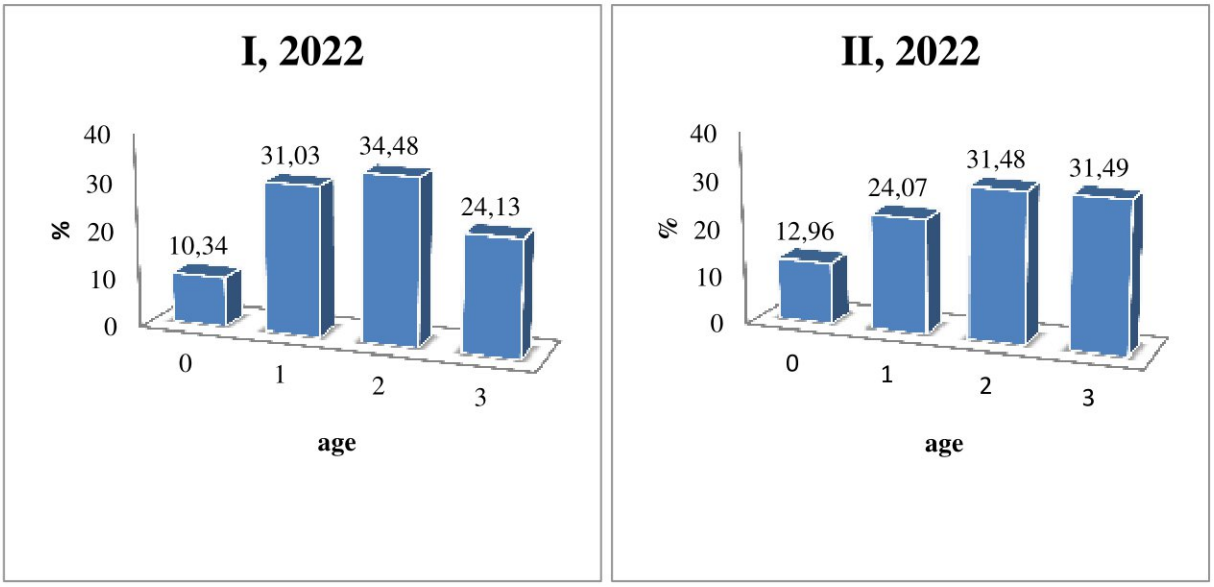


Figure 3.2.2 Frequency of anchovy length from landings for I-VI, 2022.

V.3.3 Age structure of landings

215 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%.



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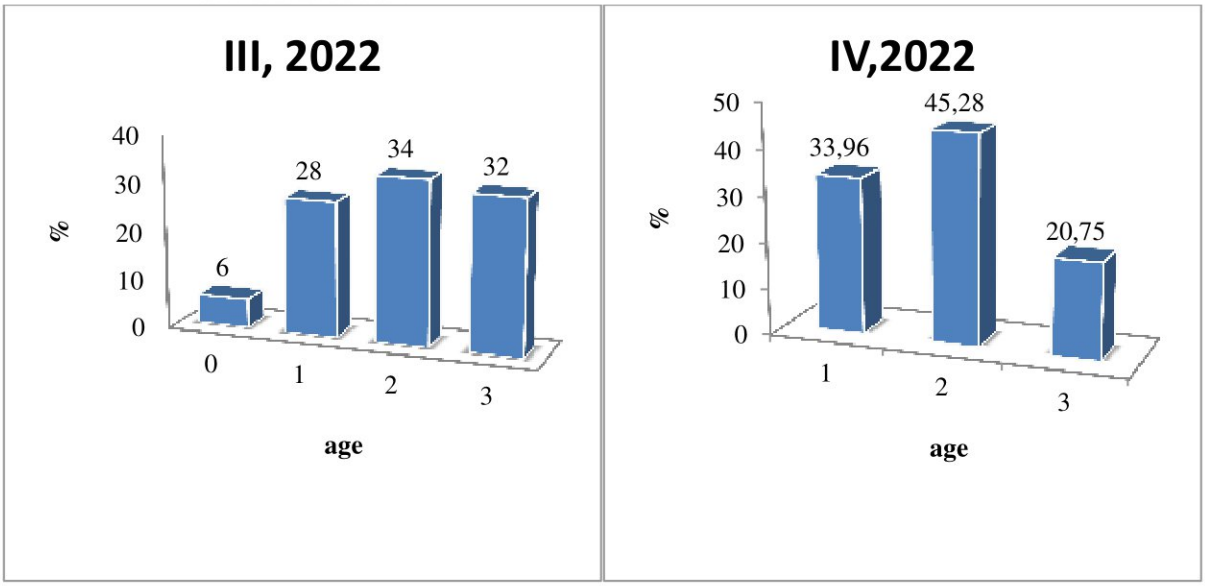

Figure 3.3.1 Age distribution of anchovy (%).

The age composition of the examined specimens includes from 0 to 3 year-old individuals, with two (36.28%) year-old fish predominating. During the research period, a lower participation of zero-year-olds was observed (7.44%) (**Figure 3.3.2**).

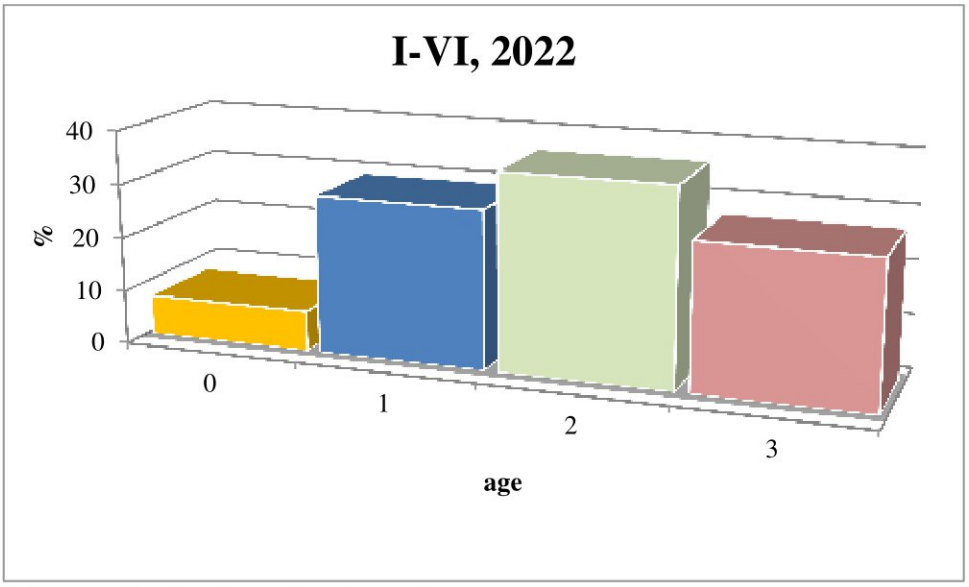

Figure 3.3.2 Age distribution of anchovy in 2022.

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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.

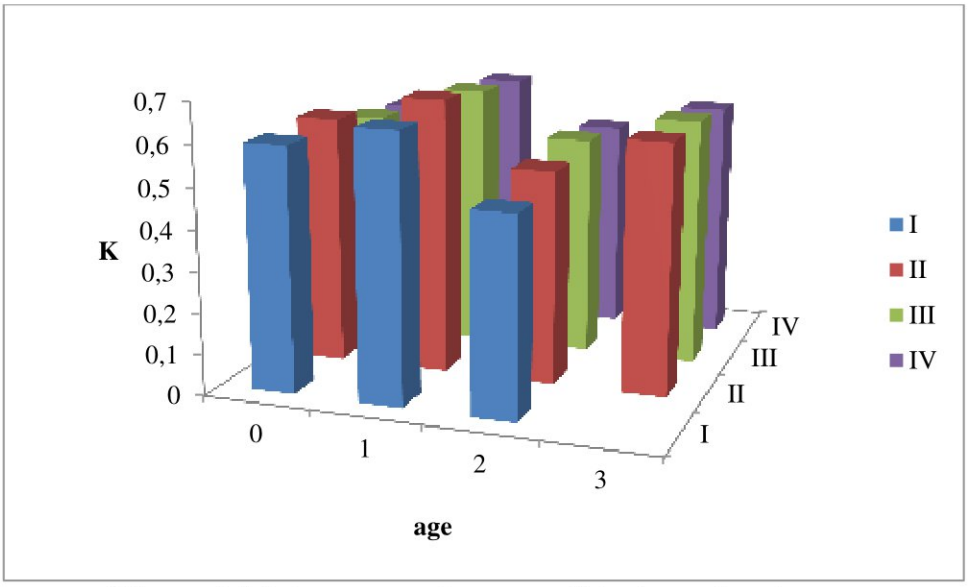

Figure 3.4.1 Average anchovy conditioning values by age.

V.3.5 Weight structure

The weight was measured at **215 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.

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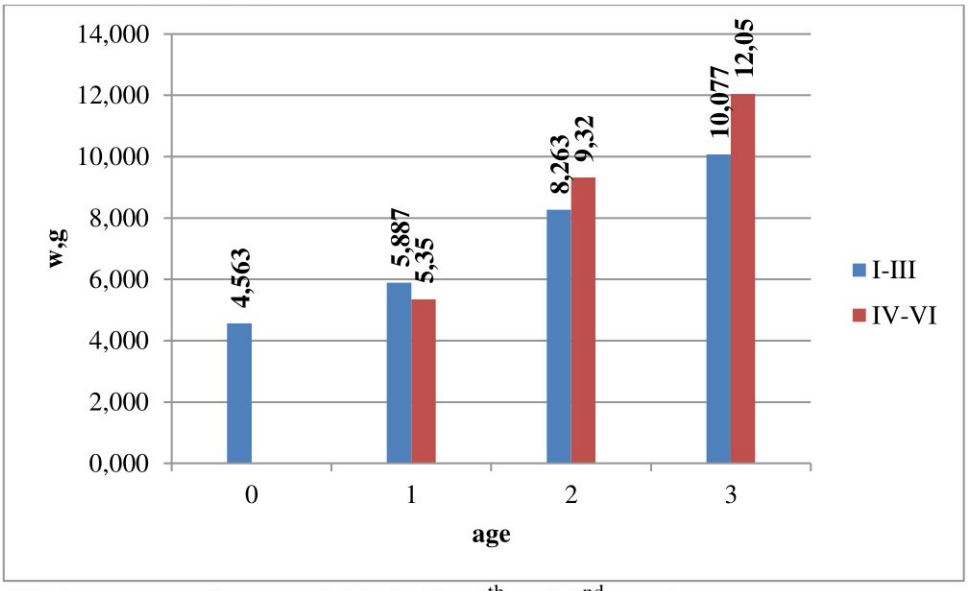

Figure 3.5.1 Average anchovy weights in the 1th and 2nd quarters.

V.3.6 Size structure by age group

The length of the fish was measured at **215 specimens**. As the age increases, the linear dimensions increase steadily. Average lengths show similar values in all size groups.

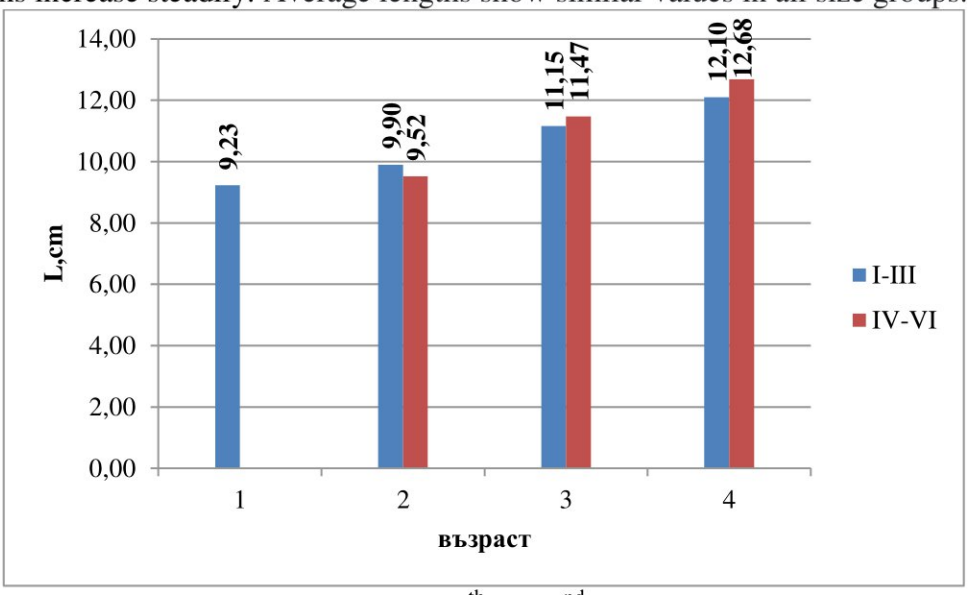

Figure 3.6.1 Average anchovy lenght in the 1th and 2nd quarters.

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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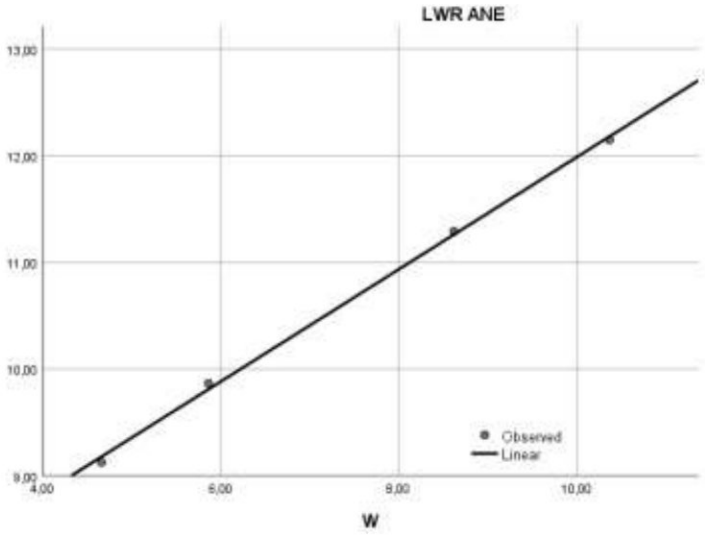

Fig. 3.7.1 Representation of the length-weight model for anchovy on a scatter plot.

Table 3.7.1 Results of modeling the length-weight relationship.

	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*

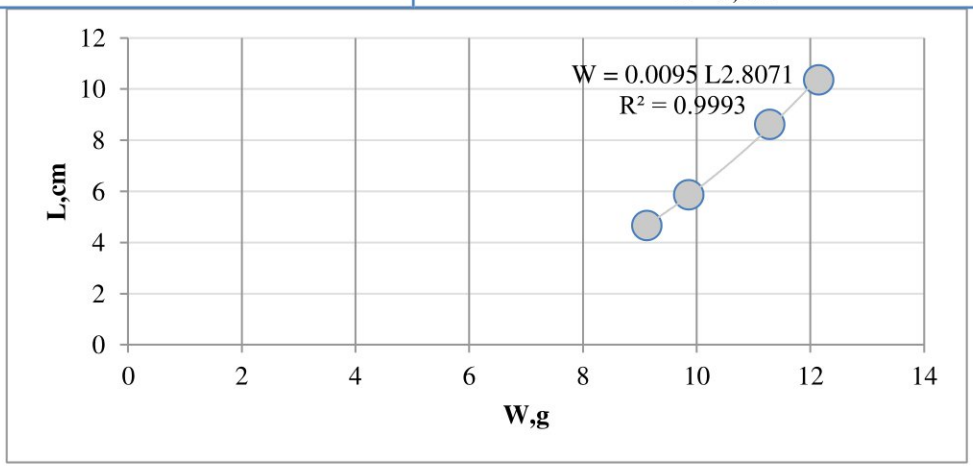

Figure 3.7.2 Linear regression of the ratio size (L)-weight(W) of the anchovy.

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V.3.8 Sex ratio

The sex ratio was determined of **215 specimens**. Sex of the determined specimens, 33% was male (♂)) and 67% was female (♀) **(Figure 3.8.1).**

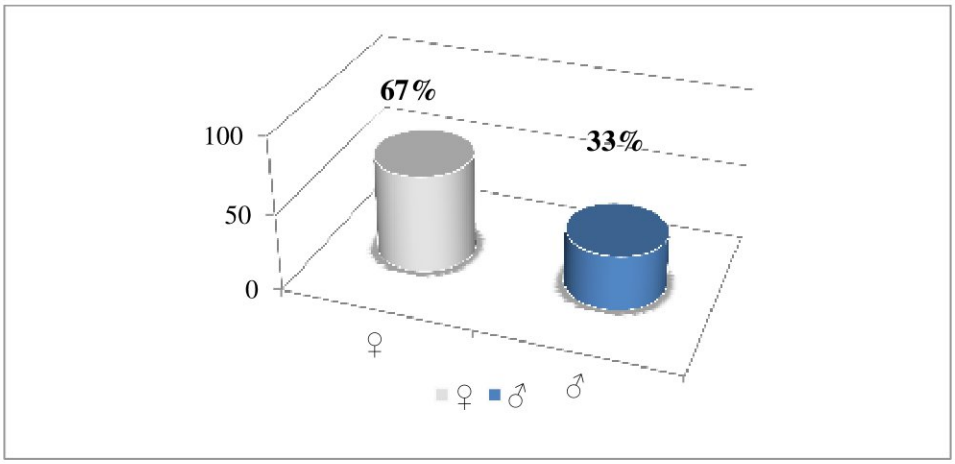

Figure 3.8.1 Sex ratio of anchovy.

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

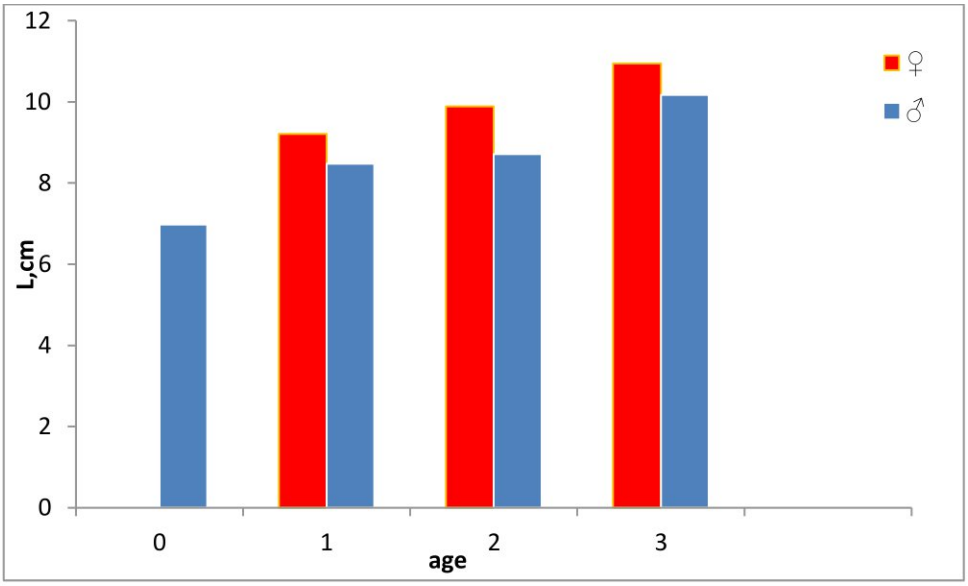

Figure 3.8.2 Sex ratio by size and age of anchovy.

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V.3.9 Fertility

Fertility was determined on **100 specimens**. The gonado-somatic index is highly dependent on the weight of the gonads (R^2 = 0.9901), which is associated with the high maturation rate of females in late spring and summer and the breeding process of the anchovy **(Figure. 3.9.1**).

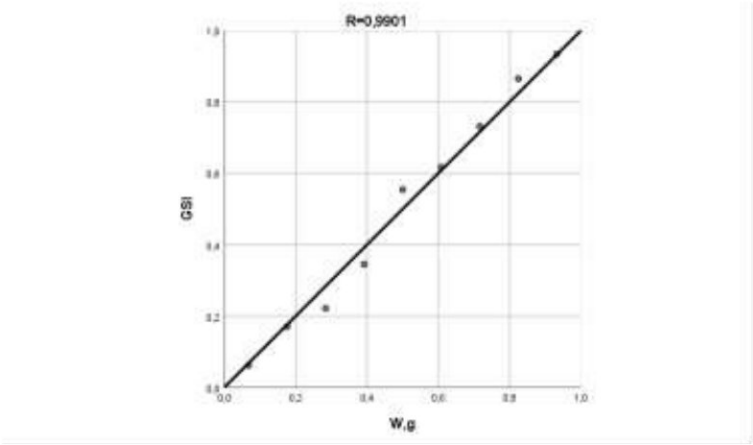

Figure. 3.9.1 Dependence of the weight of the gland on the gonadosomatic index (GSI).

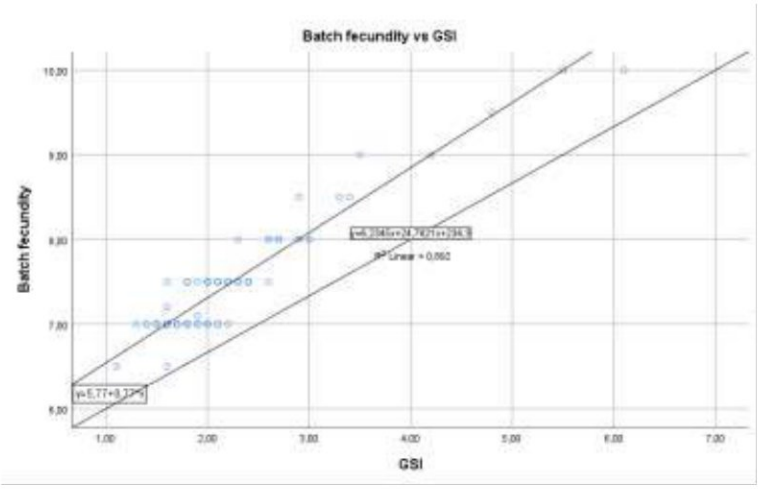

Figure 3.9.2 Batch fecundity vs. GSI for anchovy.

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

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Table 3.9.1 Absolute and relative fertility.

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

V.3.10 Sexual maturity

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

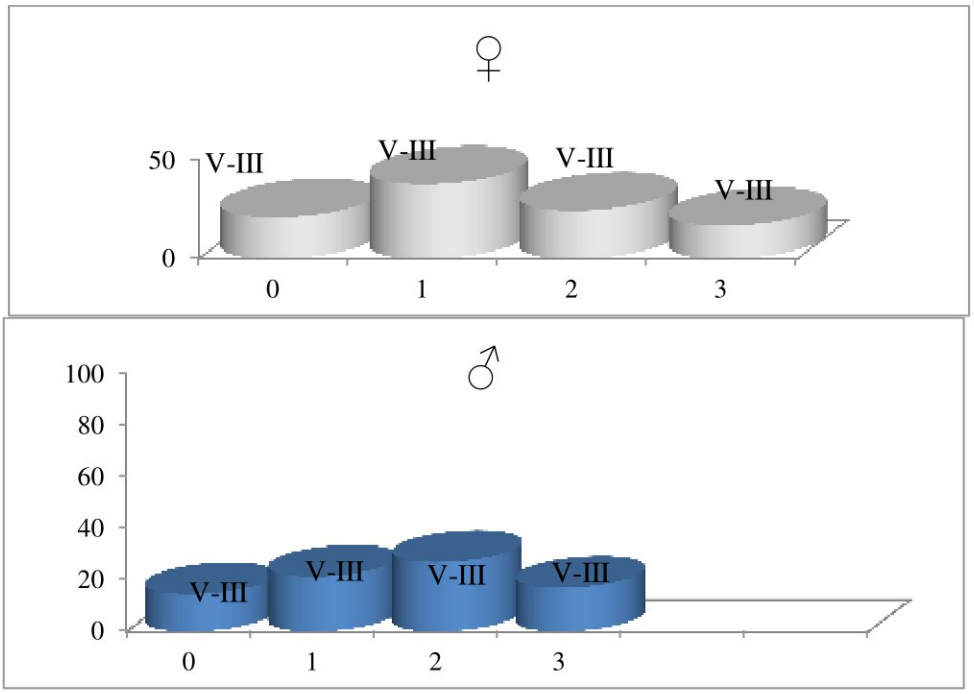

Figure 3.10.1 Sexual maturity by age of anchovies-female ♀ and male ♂.

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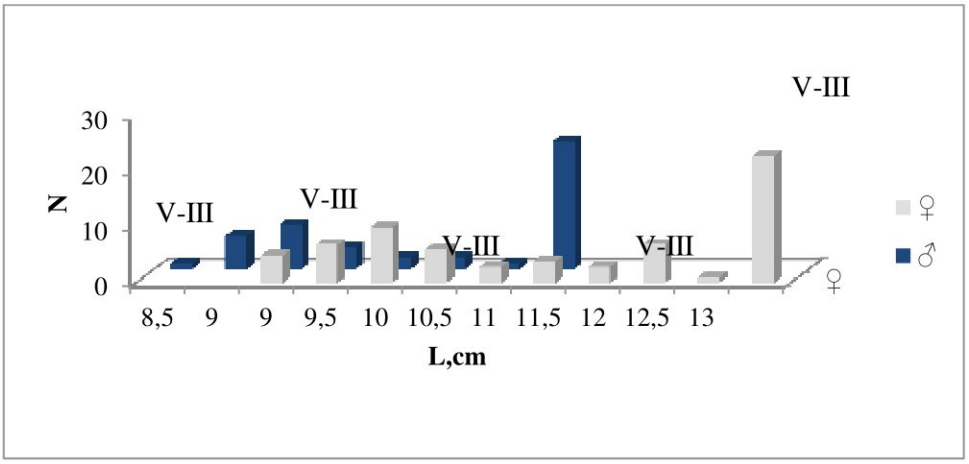

Figure 3.10.2 Sexual maturity by length(cm) of anchovies-female ♀ and male ♂.

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 for Ist and IInd quarter.

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

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)**.

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

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
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**

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

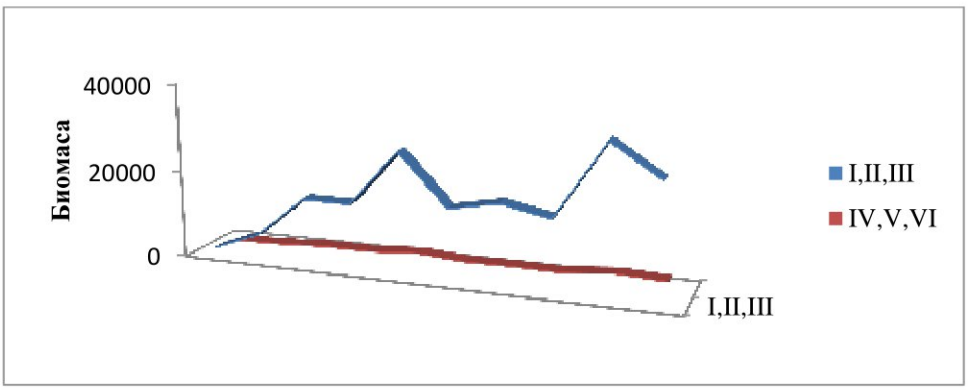

Figure 3.11.1 Biomass dynamics for I-VI 2022.

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V.3.12 Conclusions

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

1) The age composition of the studied specimens includes from 0 to 3 year-old individuals, with the predominance of two-year-old fish (36.28%). During the research period, a lower participation of zero-year-olds was observed (7.44%).
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 (♀) prevailed by 67%, followed by male (♂) specimens by (33%) .
5) The size structure shows that the average values for length by age group in female ♀ have higher values, but in three-year-olds close values are observed.
6) The dynamics of the gonadosomatic index during preparation and molting shows a characteristic rapid maturation of the sexual products. All examined specimens 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 **32 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	13.4.2022	Varna	**DGS**	AMBAR VN4496	LLS	20	42.437000, 28.129100	north
2	24.03.2022	Kavarna	**DGS**	RUSANO VN 4445	LLS	52	43.622900, 28.864700	north

VI.3. Landings statistics of spiny dogfish

Landings (with LLS) are low throughout the half-year. In March has the highest value - 1447 kg.

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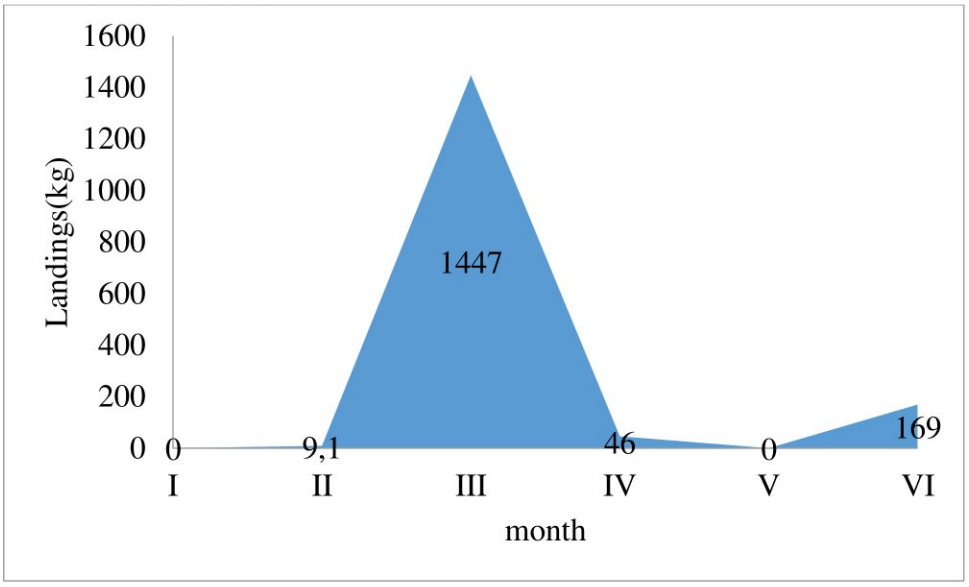

Fig. 3.1 Official statistics records for spiny dogfish landings by month in the first half of 2022.

VI.4Results

VI.4.1 Size and weight structure

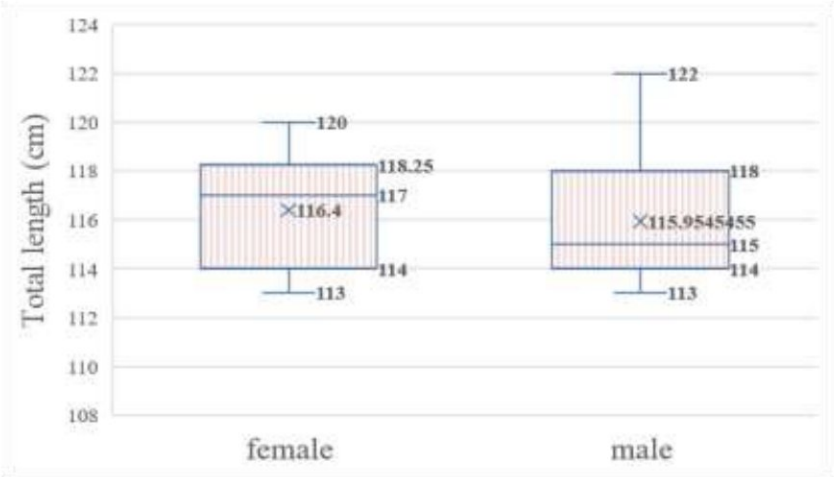

Fig. 4.1.1 Box-plot – the distribution of total length (TL) of the sampled female and male specimens (minimum, maximum, mean and median values shown) in the period January-June 2022.

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. The average values do not differ significantly between the two sexes.

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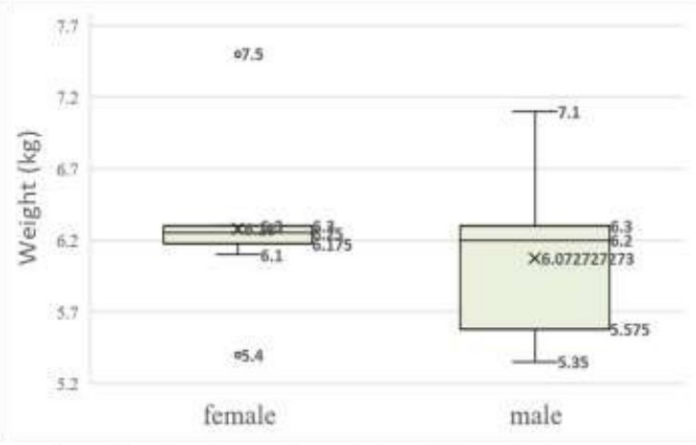

Fig.4.1.2 Box-plot – the distribution of weight (W) of the sampled female and male specimens (minimum, maximum, mean and median values shown) in the period January-June 2022

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).

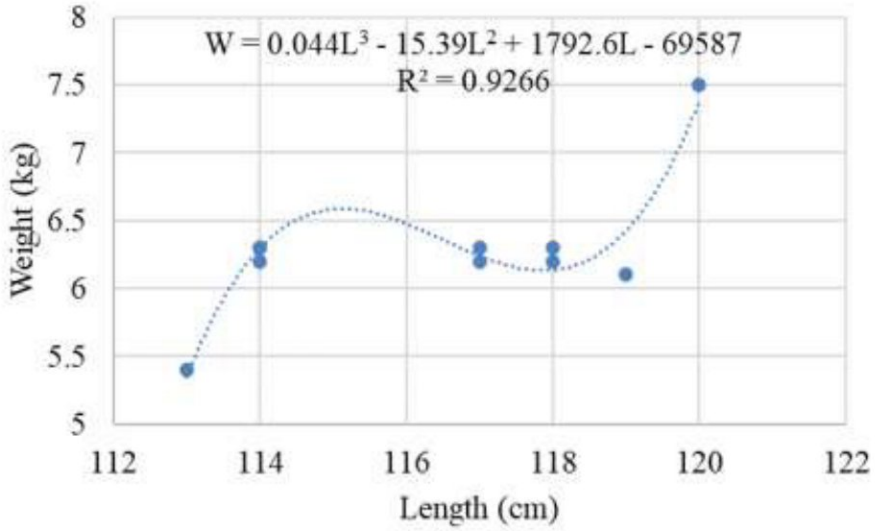

Fig. 4.1.3 Length-weight relationship (LWR) of female specimens in the period January-June 2022.

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=0.3629), 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. Naturally, at least 30 measurements are needed to derive a statistically significant mathematical description of

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regression relationships such as the length-weight relationship, and therefore a replication of the analysis with the total number of samples at the end of the year could deliver more realistic results.

VI.4.2 Sex ratio and Fecundity

At 32 specimens were used for maturity determined (I- VI). All 10 females ♀ were (actively spawning M3b). Males were estimated as follows: 8♂ were M2 (developing) and 14♂ were (spawning capable) M3a.

Males predominate over females by twice as much for the entire half of the year.

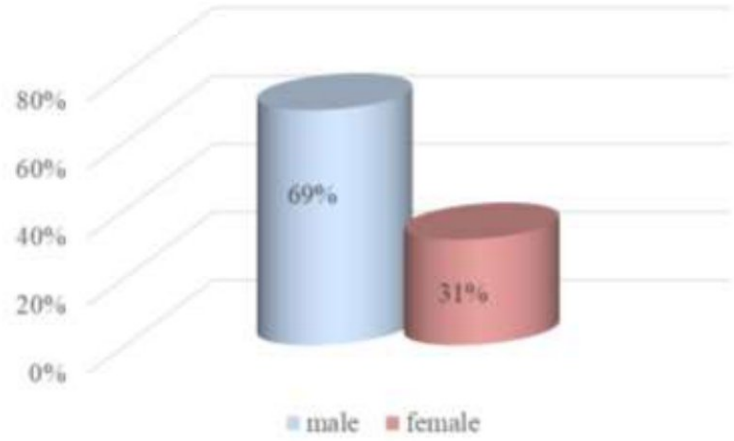

Fig. 4.2.1 Sex ratio of the sampled spiny dogfish specimens in the period January-June 2022.

VI. 5 Conclusions

1. Landings are low throughout the half-year, except for the period from February to April. March has the highest value - over 6000 kg.
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.
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).
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.
5. Naturally, at least 30 measurements are needed to derive a statistically significant mathematical description of regression relationships such as the length-weight relationship, and therefore a replication of the analysis with the total number of samples at the end of the year could deliver more realistic results.
6. Males predominate over females by twice as much for the entire half of the year.

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VII. Anex

Sprattus sprattus		
	Number of specimens from the study	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	890	1250
weight	890	1250
age	890	1250
sex ratio	250	250
fecundity	250	500
sexual maturity	500	1000

Trachurus mediterraneus ponticus		
	Number of specimens from the study	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	1004	1500
weight	1004	1500
age	1004	500
sex ratio	250	250
fecundity	100	100
sexual maturity	250	250
Merlangius merlangus euxinus		
	Number of specimens from the study	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	148	250
weight	148	250
age	148	250

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sex ratio	100	100
fecundity	100	100
sexual maturity	100	100
Mullus barbatus		
	Number of specimens from the study	**Number of specimens Contract 71/15/03/2022, EAFA /IO-BAS**
length	320	500
weight	320	500
age	320	500
sex ratio	250	250
fecundity	100	100
sexual maturity	250	250
Engraulis encrasicolus		
	Number of specimens from the study	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	215	500
weight	215	500
age	215	500
sex ratio	215	250
fecundity	100	100
sexual maturity	215	250
Squalus acanthias		
	Number of specimens from the study	**Number of specimens Contract 71/15/03/2022, EAFA/IO-BAS**
length	32	100
weight	32	100
sex ratio ♀♂	32	50

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