BIOLOGICAL MONITORING OF LANDINGS OF COMMERCIALLY IMPORTANT SPECIES 2017-2019

Contract - N 56/29/09/2017
Contract –N 161/28/05/2018

EUROPEAN UNION
EUROPEAN FUND FOR MARITIME AFFAIRS AND FISHERIES

MINISTRY OF AGRICULTURE, FOOD AND FORESTRY

MARITIME AFFAIRS AND FISHERIES PROGRAM

INSTITUTE OF OCEANOLOGY „FRIDTJOF NANSEN“
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https://doi.org/10.7546/IO.BAS.2020.5 **ISBN 978-619-245-078-6**

Project proposal № BG14MFOP001-3.003-0001 "Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2017-2019", funded by the Maritime Affairs and Fisheries Program, co-financed by the European Union through the European Maritime and Fisheries Fund

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

I.1 Objectives

Fish are an important component of aquatic ecosystems through their role as consumers of other organisms and they can have a significant influence on the structure and function of these ecosystems. Because of this, adverse effects on fish can have adverse flow–on effects on other aquatic organisms even if they are not directly affected by those changes in water quality. Monitoring of fish communities can, therefore, provide a useful indicator of the ecological health of natural waters. Fish are sensitive to many changes in water quality and habitat structure caused by human activities and by natural causes. Common adverse anthropogenic effects on fish can result from many factors including: contamination of water by waste metal pollution, pesticides, salinity and organic wastes and nutrients causing either direct effects on fish health or indirect effects on the oxygen climate in the water through eutrophication; and physical habitat changes such as thermal pollution, changes in stream flow regime, stream bed aggradation, de-snagging, and land clearance, especially in riparian zones. Consequently, as well as their intrinsic biodiversity value and the human food value of some species, fish can be useful indicators of the impact of many different human activities on the environmental health of a water body. Multiannual biological monitoring on landings provides the so called “Fishery dependent” information. The Black Sea sprat (*Sprattus sprattus* L.) is a key species in the Black Sea ecosystem.The aim of this study was to collect and to analyze dynamics in length, weight and age distribution as well as to determine the condition of the sprat species using the so-called Fulton’s condition factor. The condition factor is also a useful index for monitoring of feeding intensity, age, and growth rates in fish. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live. Biological information on sprat species collected each month, analyzed and compared to previous periods could be used for estimation of growth parameters. These indicators are very important for the short-lived species. Reliable and informative long-term data are crucial for the assessment of fish stocks, fisheries management and the decision-making process in general.

I.2 Sampling in the period 2017-2019

I.2.1 Geographical area coverage

The samples used for the present analysis were gathered directly from landings at ports of fishing vessels in the Bulgarian region of the Black sea (Fig. 2.1.1).

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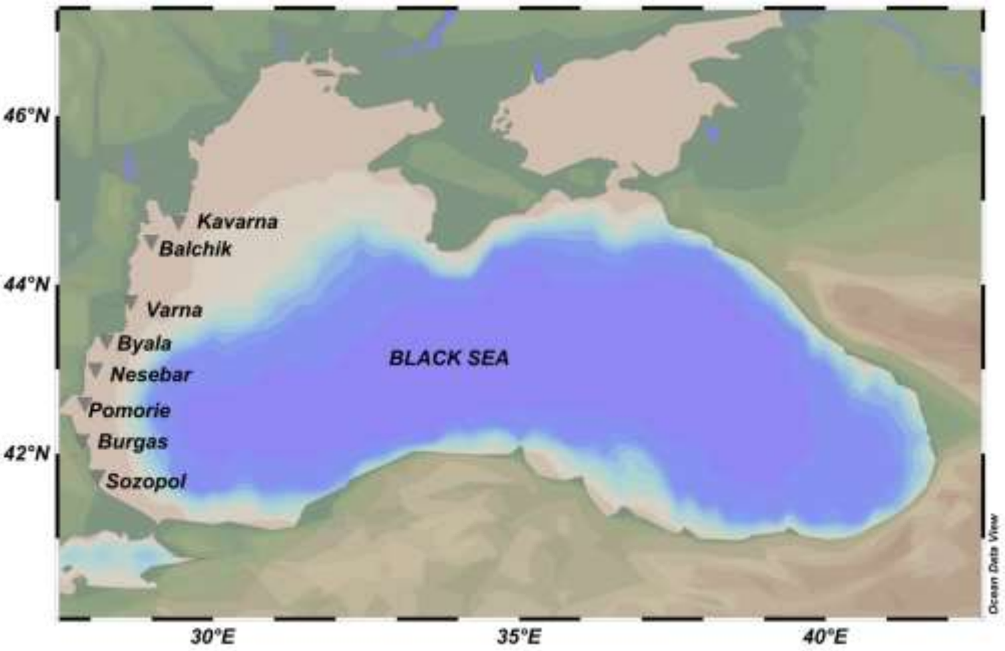

Fig. 2.1.1 Sampling area along the Bulgarian Black sea coast

I.2.2 Samples

In 2017 the fish was caught at depths varying from 40 m to 60 m with the majority caught at 45 m by pelagic trawls. The collected statistical sample in November 2017 presented 2368 specimens.

In 2018 the samples collected in the period March – April for analysis of length, weight and age structure represented 1781 specimens in total.

In 2019 25 samples (5882 specimens) were collected and processed to ensure the analysis of the length, weight and age structure of sprat presented in the commercial catches.

2017		2018		2019	
Date	**Fishing vessel**	**Date**	**Fishing vessel**	**Date**	**Fishing vessel**
		12. 03. 2018	FV 40	22.02.2019	FV ISHTAR HC 1182
		03. 2018	FV Herson	06.03.2019	FV 27 БС290
				07.03.2019	FV Barbun Vn7979
				11.03.2019	FV BL21-33
				21.03.2019	FV KB5636
				21.03.2019	FV KB5465
				22.03.2019	FV БЧ 5156
				01.04.2019	FV TAIS VN393
		02. 04.2018	FV 40	03.04.2019	FV KB 5465

			04.04.2019	FV Sv.Nicola-I"-Nesebar
			10.04.2019	FV Herson БС210
			06.05.2019	FV VN 3261
			14.05.2019	FV VN 3261
			08.06.2019	FV 29 БС 222
			29.07.2019	FV 29БС222
			01.08.2019	FV 41 БС259
			18.08.2019	FV 40 БС258
			07.09.2019	FV 40БС258
			27.09.2019	FV 40БС258
			02.10.2019	FV40 БС258
			29.10.2019	FV 40 БС258
27.11.2017	ELEKTA EOOD		19.11.2019	FV 40 БС258
			29.11.2019	TAIS VN393
			5.12.2019	TAIS VN393
			07.12.2019	TAIS VN393
1 sample with 2368 sp.		**3 samples with 1781 sp.**	**25 samples with 5882 sp.**	

I.2.3 Statistical analysis of data

The samples listed in paragraph I.2.2 were randomly collected in compliance with the requirements for sampling a population of fish species. It is important to be noted that 2017-2019 sprat catches were not abundant compared to previous years due to a current shift of key species (for example bluefish *Pomatomus saltatrix*), as well as the absence of significant agglomerations of the studied species registered within the period of the present research.

The samples were processed under laboratory conditions. Total length (TL, ±0.5 cm precision) was measured using an ichtyometer and total fresh weight was measured using an electronic analytical balance (W, ±1g precision). The study used otoliths to determine age, which was determined from otolith rings. Otoliths were removed and dried in a laboratory and stored in labeled envelopes. Age was determined by microscope Olympus CX 31RTSF-6 and recorded. Thus, the yearly annulus was detected as hyaline and opaque zones, shifting active growing with period of growth stagnation. For ageing estimation 1090 fish were examined. Sections from the other otoliths were judged illegible and were excluded from the study. In order to check the accuracy of the age readings in the present study, an ageing intercalibration exercise was carried out between the authors. Age readings were compared using a signed rank statistical test. A consistent agreement between readers with low average percentage error (APE) values was established.

Determination of individual growth parameters is of crucial importance, especially for key species, not only for the proper analysis of length, weight and age structure but also for the proper stock management – definition of minimal length presented in catches and recommendations for the selectivity of the fishing gears and etc.

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The mathematical expression of von Bertalanffy growth model points out the length (L) as a function of age t: $L(t) = L_{\infty}[1 - exp(-K(t - t_0))]$, where: t is the age of individual, L_{∞} - is the asymptotic length, to which a given biological species increases in length during their lifespan, K – curvature parameter, which reflects the speed of approaching the asymptotic length, t_0 – initial condition parameter (determines the moment, when the length of the studied species is equal to 0).

LWR model is widely applied in analysis of the of marine living resources as it represents the condition of the stocks. LWR analysis results can be implemented to provide weight estimates on the base of length measurements and vice versa, as well as for comparison of growth parameters of one and the same species spread in different geographical areas.
The model assumes that with the increase of the total length the species also increases in weight, which determines the following functional relationship between the two parameters W and L, which is nonlinear:
$W(i) = q * L(i)^b$, where: $W(i)$ is the weight of the studied species, $L(i)$ is length, q is a scale coefficient, and b – is the alometric coefficient, which determines the body form and the type of the growth: isometric or alometric. For most species it was found to be close to 3.00, while q varied in value per different fish species. Fulton coefficient (condition factor): $K = \frac{W}{L^3} * 100$, where: W is the weight of the studied species, L – length, is also of significant interest when the condition of fish species stocks are being studied.

Batch fecundity can vary considerably during the short spawning season, low at the beginning, peaking during high spawning season and declining again towards the end. Annual egg production is the product of the number of batches spawned per year and the average number of eggs spawned per batch. Batch fecundity of sprat was determined using the 'Hydrated Oocyte Method' (Hunter et al., 1985). Oily hydrated females were used. After sampling their body cavity was opened and they were preserved in a buffered formalin solution (Hunter et al., 1985). Three tissue samples of ca. 50 mg were removed from different parts of the ovary and their exact weight determined. Under a binocular, the number of hydrated oocytes in each of the three subsamples was determined. Hydrated oocytes can easily be separated from all other types of oocytes because of their large size, their translucent appearance and their wrinkled surface which is due to formalin preservation. Batch fecundity was estimated based on the average number of hydrated oocytes per unit weight of the three subsamples. Gonadosomatic Index (GSI) was determined monthly. GSI was calculated as: $GSI = \frac{GW}{SW} X\ 100$, where, GW is gonads weight and SW is somatic weight (represents the BW without GW).

I.3 Results

I.3.1 Sprat landings in the period 2017-2019

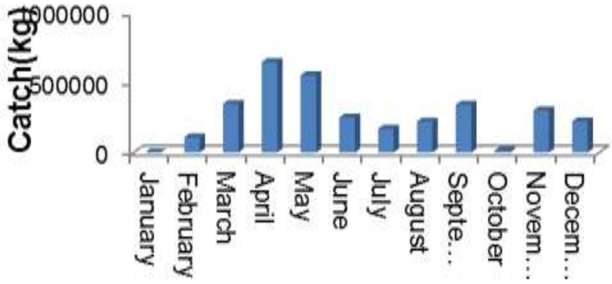

Fig. 3.1.1 Sprat landings in 2017

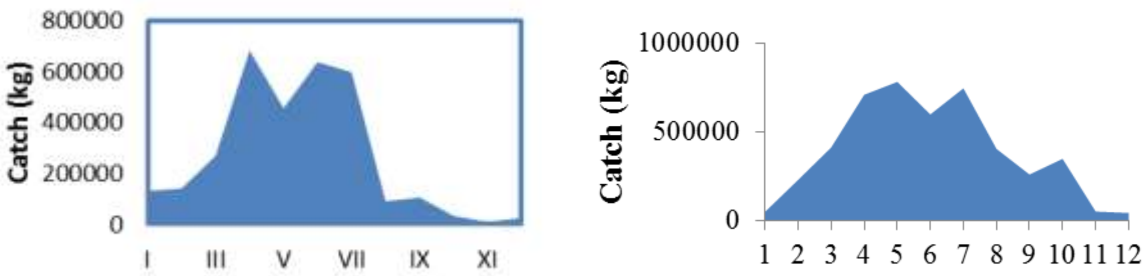

Fig. 3.1.2 Sprat landings in 2018 (left) and 2019 (right)

The official statistics showed that in 2017 the biggest catches and intensity of sprat fishery was registered in the period April - May, and in 2018 and 2019 in the months between April and July.

I.3.2 Length structure of sprat catches in the period 2017-2019

I.3.2.1 Length structure analysis in 2017

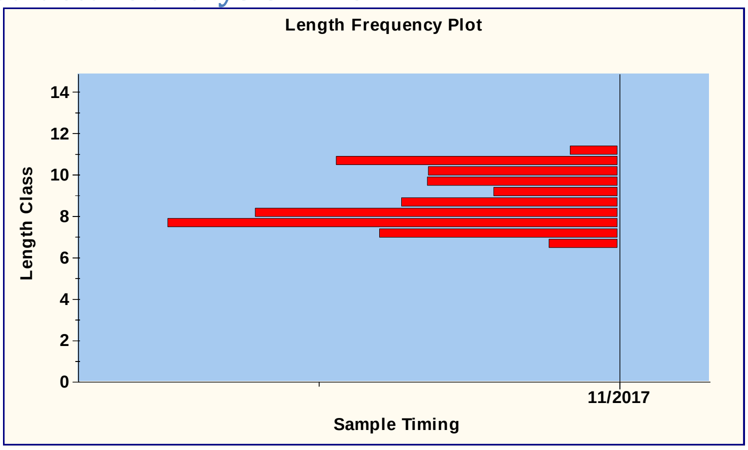

Fig. 3.2.1.1 Length structure of sprat, presented in the catches in November 2017

The length structure of sprat in 2017 is presented in Fig. 3.2.1.1. The total length of the specimens presented in the catches varied within the rage 6.5cm - 11.0 cm, the biggest percentage shares were registered for length classes 7.5 cm, 9.0 cm and 10 cm.

I.3.2.2 Length structure analysis in 2018

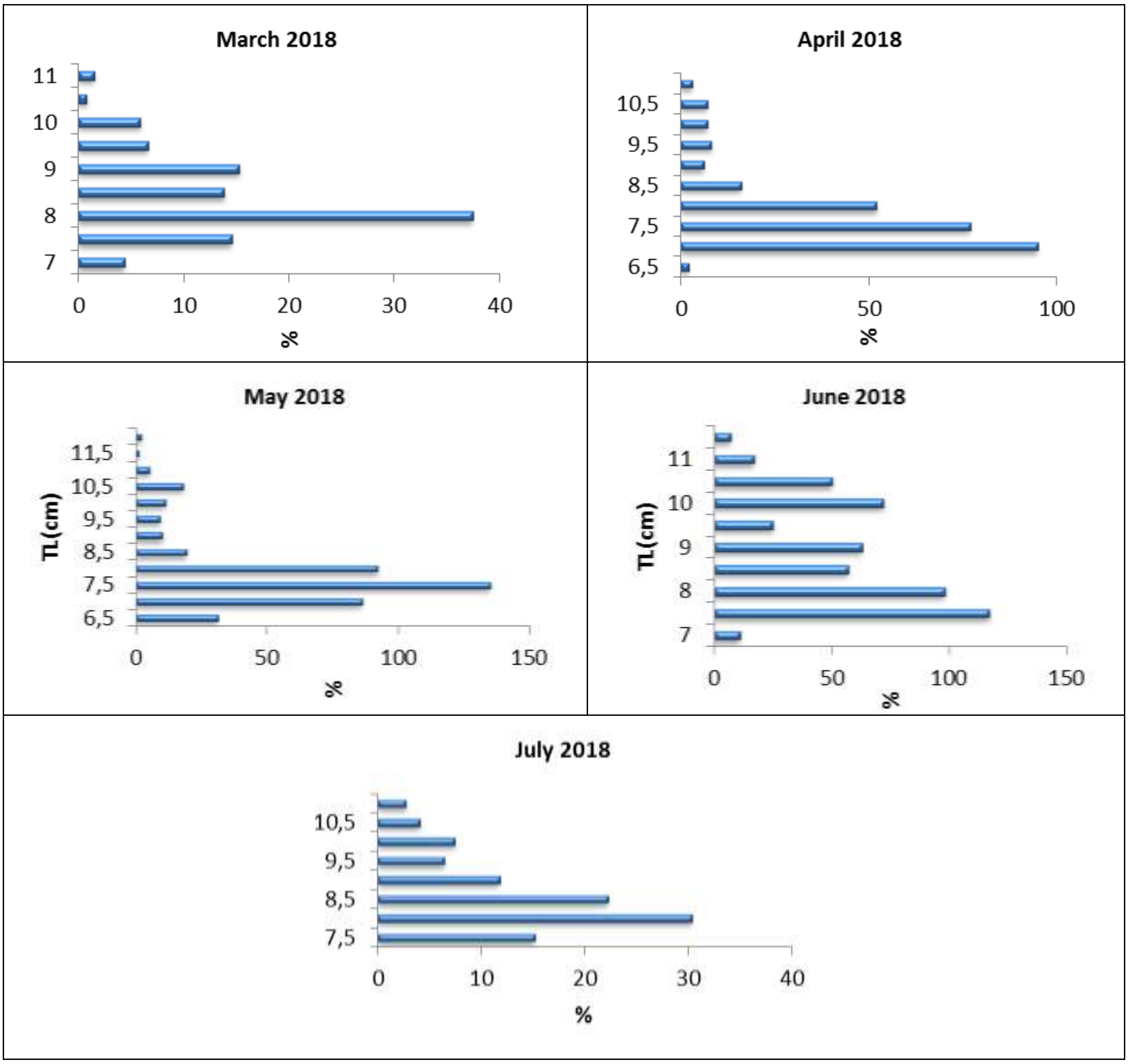

Fig. 3.2.2.1 Length structure of sprat, presented in the catches in the period March-July 2018

In March the total length of the sampled specimens varied in the range 7-11 cm, as with the biggest share in the length structure was presented the length class of 8cm, the smallest share was registered for the length class 10.5cm. In April the total length of the sampled specimens varied in the range 6.5-11cm, the biggest percentage share in the length structure had length classes 7, 7.5 and 8 cm, and the smallest one was registered for the length class 6.5cm. In May the total length of the sampled specimens varied in the range 6.5-12cm, the biggest percentage

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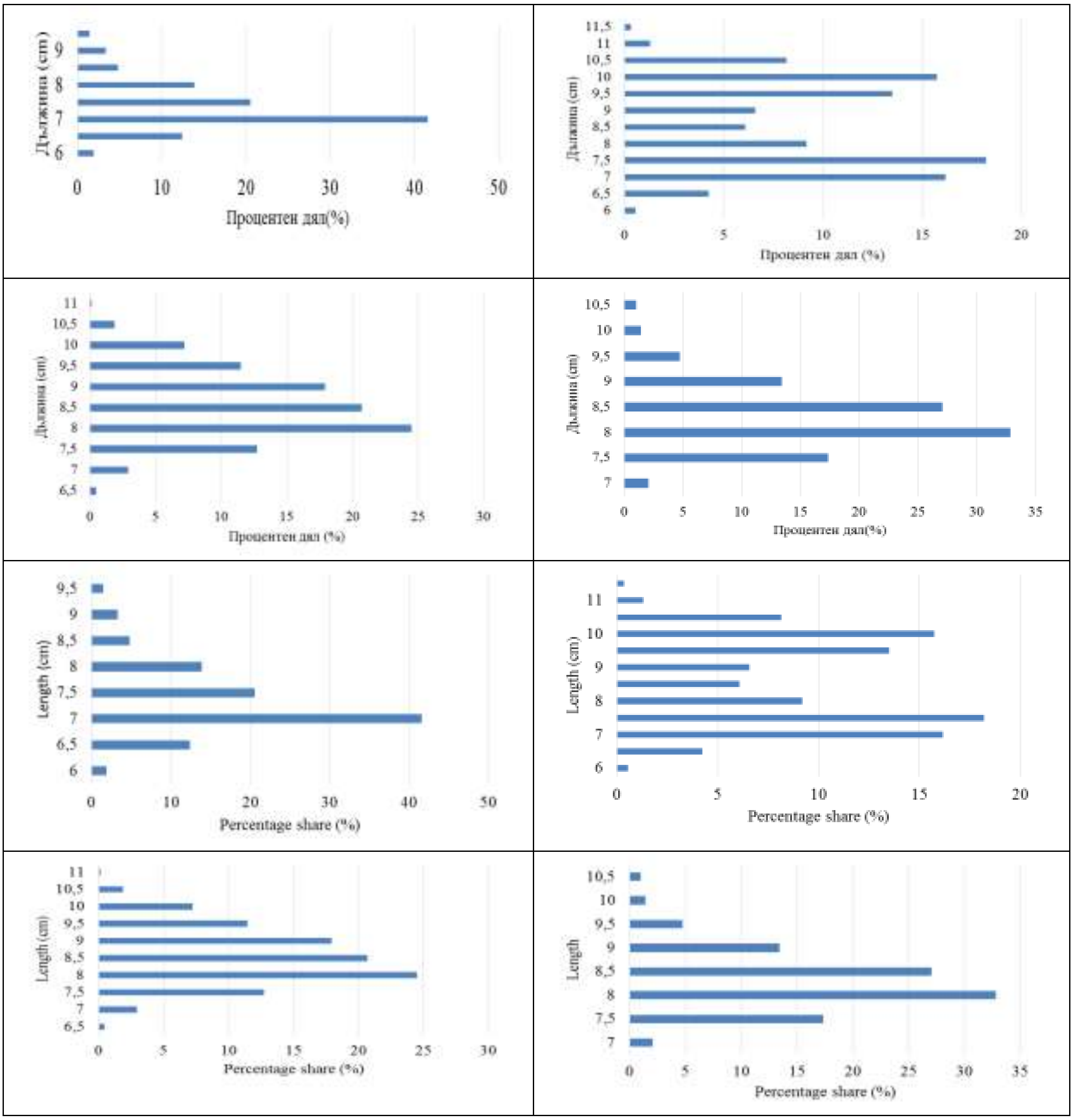
share in the length structure had the length classes 7, 7.5 and 8 cm, and with the smallest percentage shares were registered the length classes 11.5 and 12 cm. In June, the length classes 7.5, 8 and 10 cm were registered with the biggest percentage shares, and the smallest one was registered for the length class 11.5 cm. In July with the biggest shares were the length cclasses 8 cm and 8.5 cm, and with the smallest – 11.5 cm.

I.3.2.3 Length structure analysis in 2019



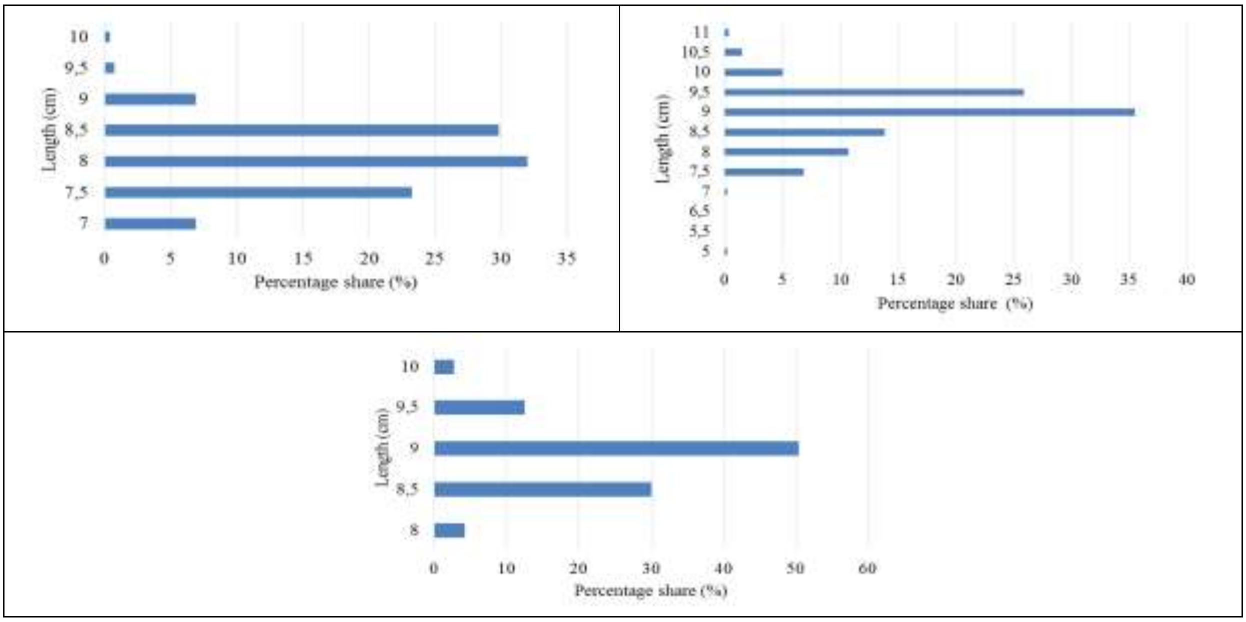


Fig. 3.2.3.1 Length structure of sprat landings, presented in the catches in the period February – December 2019

In February, the total length of sampled specimens varied in the range 6 cm to 9.5 cm, length classes 7, 7.5 and 8 cm were most frequent in the catches, and the less frequent length class was 9.5 cm. In March, the total length of sampled specimens varied in the range 6.5-11 cm, with the biggest percentage share in the catches length structure were presented length classes 7, 7.5, 9.5 and 10 cm, and the smallest percentage share was registered for length class 11.5 cm. In April, the total length of sampled specimens varied in the range 6.5-11cm, most frequent in the catches were length classes 8, 8.5 and 9 cm, the less frequent class was 11cm. In May, most frequent in the catches' length structure were classes 8 cm and 8.5 см, less frequent specimens with total length of 10.5 cm. In June, the biggest percentage shares in the samples were registered for the length classes 7, 8 and 8.5 cm, the smallest share was of the length class 10 cm. In July, the total length of sampled specimens varied in the range 5 - 11 cm, most frequent in length structure of the catches were length classes 9 cm and 9.5 cm, less frequent - 7cm and 11 cm. In August, the total length of sampled specimens varied in the range 8 - 10 cm, most frequent in the length structure of the catches was class 9 cm, less frequent - class 10 cm. In September and October, the most present within the length structure of catches were classes 9, 9.5, 10 and 10.5 cm and less frequent were classes 11cm and 11.5 cm. Most frequent in the samples collected in November were classes 7.5, 8 and 8.5 cm, less frequent - 6 cm and 11 cm, in December most frequent- 7cm and 8 cm and less frequent 11.5cm and 12 cm.

Due to the high amount of the samples collected in 2019, the length structure of the catches represented the natural dynamics and seasonality of growth parameters of the studied species.

In general, for the entire period of the research 2017-2019 most abundant and respectively most frequent in the catches were specimens with length from 7cm to 10cm, those with total length below 7 cm were hardly presented in the catch composition due to the selectivity of the

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fishing gears used. Thus, it can be further assumed that in the exploitation phase the specific total length varied within the range from 7cm to 12cm.
Specimens with total length above 11cm were rare in the catches due to the natural physiology and biology of the studied species.

I.3.3 Age structure analysis of sprat in the period 2017-2019

I.3.3.1 Age structure analysis in 2017

Three ichthyologists determined the age of sprat otoliths, and one of them read all otoliths twice. Specimens (n = 1250) were used for age determination. Indices of precision for age readings within and between readers are presented in Table 3.3.1.1. The test of symmetry (χ^2_{R1vsR2} = 9, DF=7, p=0.1723; χ^2_{R1vsR3} =6.17, DF=3, p=0.1387; χ^2_{R2vsR3} = 7.11, DF=6, P=0.3021) showed that age disagreement was due to simple random error and not to a systematic error between readers.

Table 3.3.1.1 Indices of precision for age readings of sprat, from the Bulgarian Black Sea waters, within and between readers

Index	Index comparison	
	Reader 1	Between readers
APE [%]	2.102	3.069
CV [%]	2.063	4.211
D [%]	1.623	2.34

APE = average percentage error, CV = coefficient of variation, D = index of precision.

In November, the age distribution showed five age classes (0-4). 1-1+, 2-2+ and 3-3+ age groups were presented with almost equal shares in the landings. The oldest specimens in the samples belong to 4+ years old, with a very low share in the landings. The recruitment share was detected to be 11.99%.

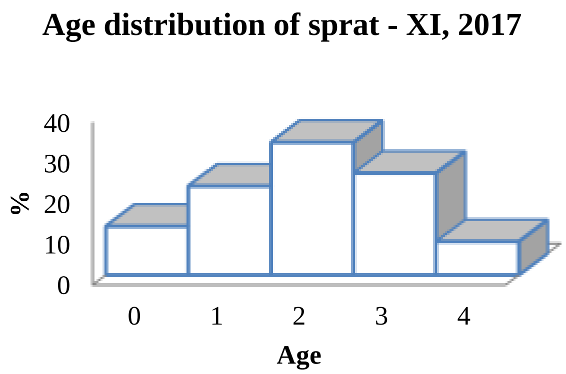


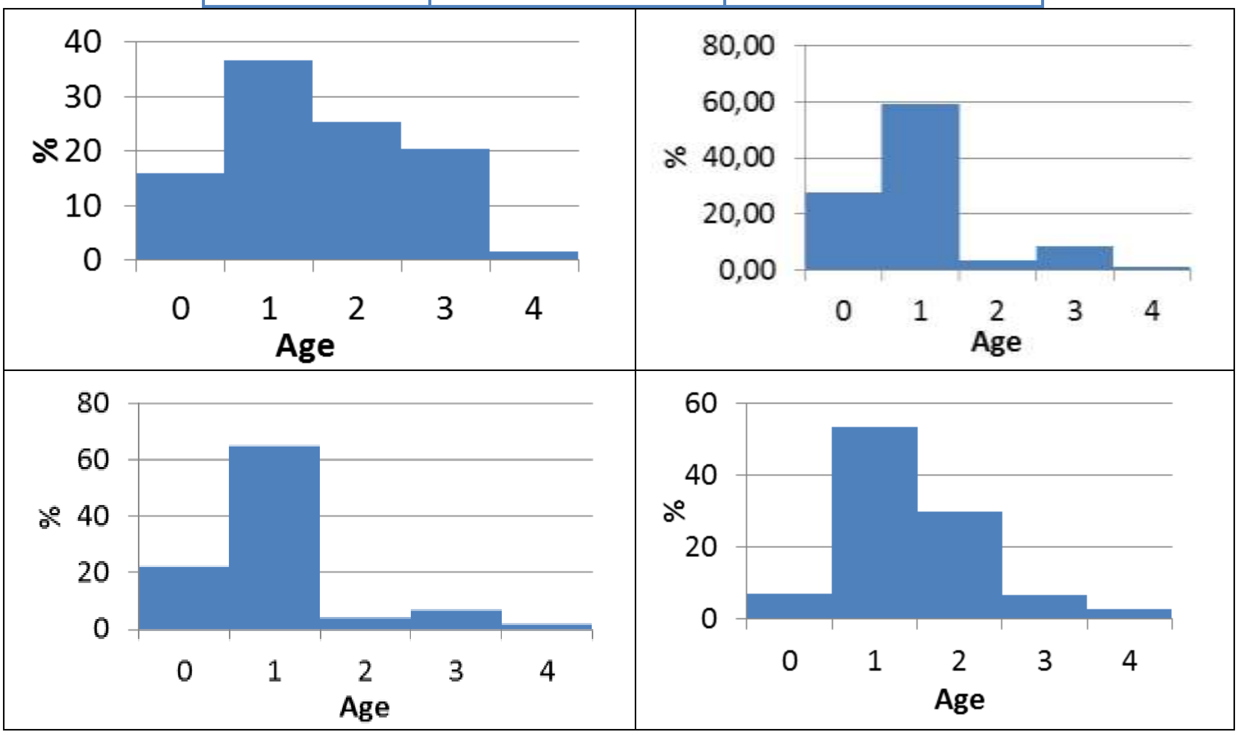
Fig. 3.3.1.2 Age distribution of sprat in November, 2017

I.3.3.2 Age structure analysis in 2018

The same technology as the one described for age reading in 2017 was applied. The test of symmetry ($\chi 2$ R1vsR2 = 7, DF=8, p=0.242; $\chi 2$ R1vsR3 =5.70, DF=2, p=0.3314; $\chi 2$ R2vsR3 = 6.81, DF=5, P=0.2904) showed that age disagreement was due to simple random error and not to a systematic difference between readers.

Table 3.3.2.1 Indices of precision for age readings of sprat, from the Bulgarian Black Sea waters, within and between readers

	Index comparison	
Index	**Reader 1**	**Between readres**
APE [%]	2.213	3.022
CV [%]	1.913	4.189
D [%]	2.113	2.41



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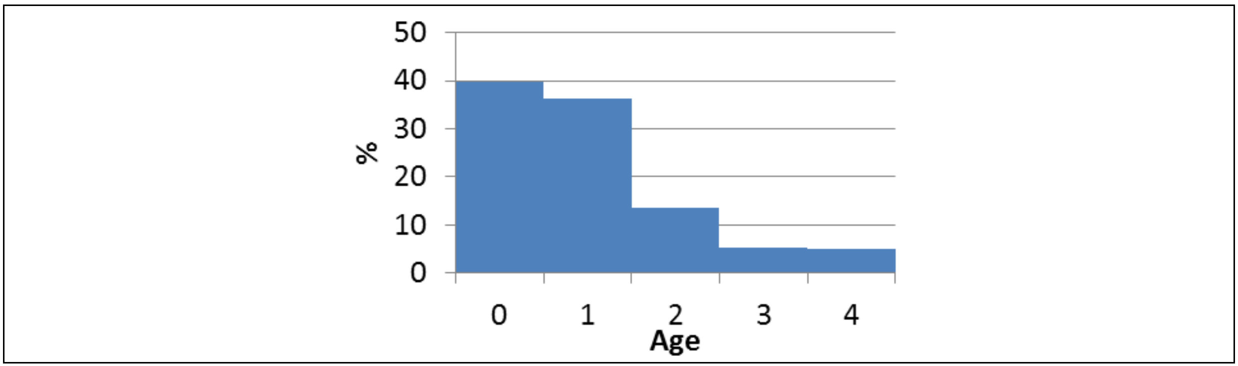


Fig. 3.3.2.1 Age distribution of sprat March – July 2018

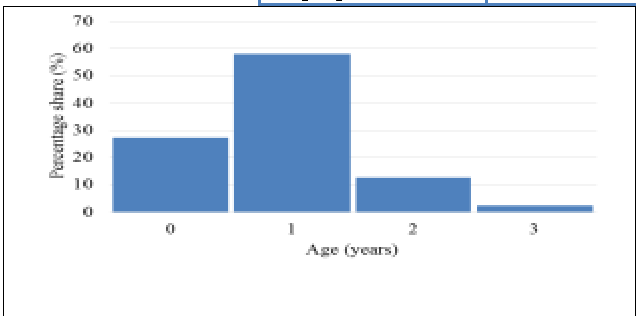
In the majority of the samples collected during the studied period, the highest share was registered for age group 1-1+, with the exception of July samples where age group 0-0+ was most frequent. This is an indication for second annual recruitment of the stock which is considered in compliance with the concept for its seasonal dynamics, recruitment dynamics and sustainable development.

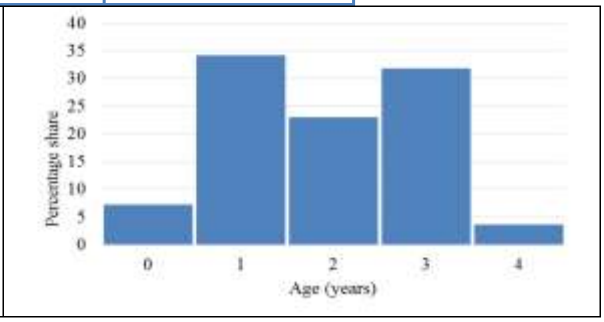
I.3.3.3 Age structure analysis in 2019

The same technology as the one described for age reading in 2017 was applied. Three readers determined the age of sprat otoliths, and one of them read all otoliths twice. Specimens (n = 1250) were used for age determination. Indices of precision for age readings within and between readers are presented in Table 3.3.3.1. The test of symmetry ($\chi 2$ R1vsR2 = 4, DF=, p=0.411; $\chi 2$ R1vsR3 =3.70, DF=4, p=0.2361; $\chi 2$ R2vsR3 = 3.16, DF=4, P=0.2100), showed that age disagreement was due to simple random error and not to a systematic difference between readers.

Table 3.3.3.1 Indices of precision for age readings of sprat from the Bulgarian Black Sea waters, within and between readers

Index	Index comparison	
	Reader 1	Between readers
APE [%]	1.361	3.069
CV [%]	1.421	4.211
D [%]	2.310	2.34





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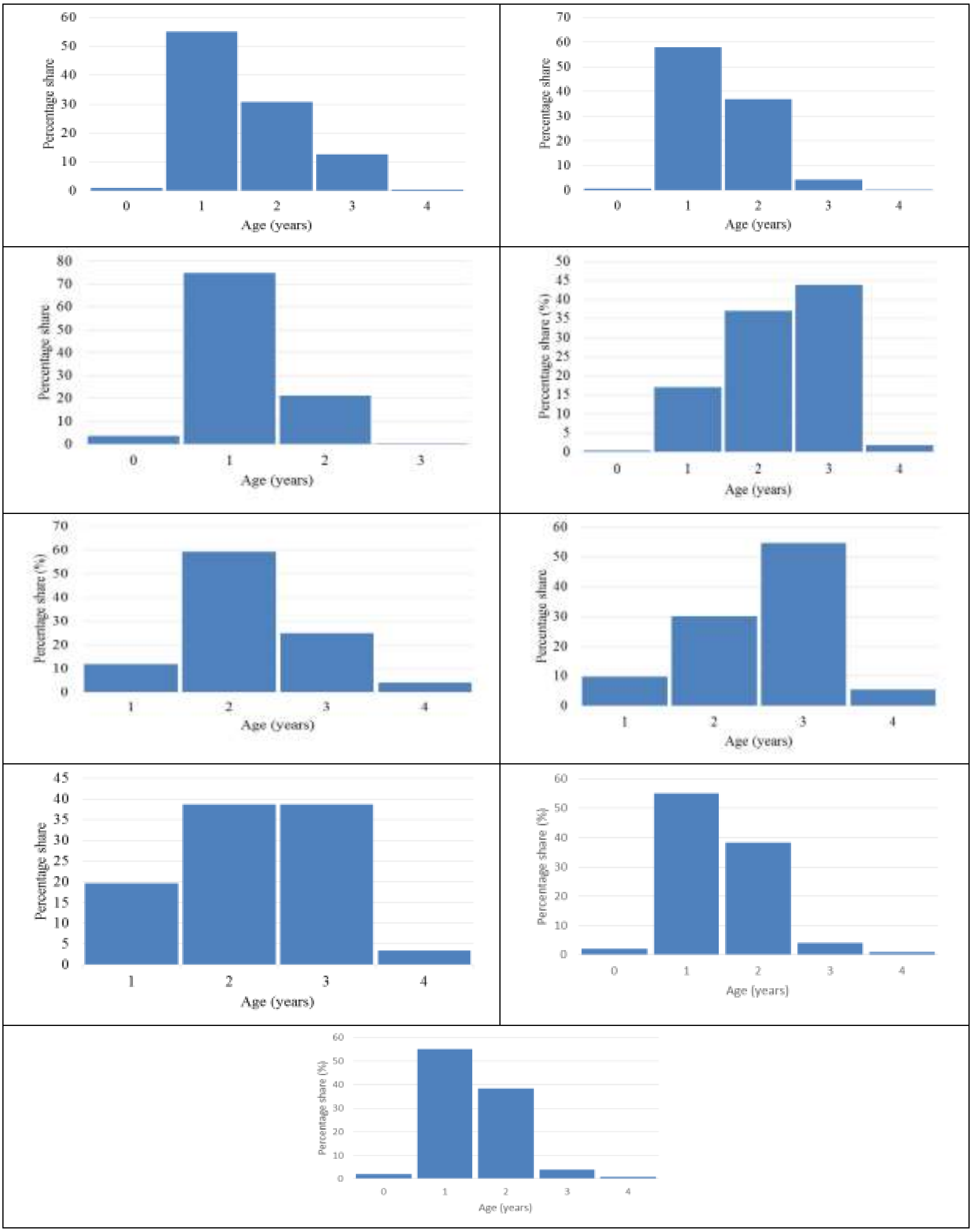

Fig. 3.3.3.1 Age structure of sprat from February to December 2019

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Age structure analysis in February showed that 1-1+age group was presented with 59% of the total number and 0+ age group - with 28% which showed that recruitment in February was high and the spawning processes in late 2018 were increased with comparatively high percentage. Age groups 2-2+ and 3-3+ were represented with 12 % and 2 %, respectively. The oldest age groups were not presented in the catch. In March, the dynamics of age distribution showed decrease in the recruitment (0+), still high share of 1-1+ age group, but significant increase of 2-2+ and especially of 3-3+ age group. 4-4+age olds were discovered in the catch as well. In April 2019, 1-1+age group was presented with 55%, 2-2+ with 30%. The presence of 0+ and 4-4+ age groups was negligible. In May, the age structure observed was almost the same as the one observed in April, and the share of 3-3+even decreased. In June, the prevailing with over 70% share belong to 1-1+ age group. The rest of age groups were presented with a low percentage. 4-4+old individuals were not presented in the catch. In July, the share of 1-1+decreased significantly, 2-2+ years old accounted for 37%, and 3-3+ for 44%. 4-4+ age group was represented with a low share. In August 2019, 2-2+olds showed almost 60% representation in the catch, the rest of the groups were with lower shares. In September, 3-3+ year old individuals were presented with 55%, followed by 2-2+ with 30% share. The rest of the groups were presented with lower shares. In October 2019, 2-2+ and 3-3+ old specimens showed equal share 36%, similar to August and September, no recruitment of 0+ was discovered in the catches. Still, the share of 1-1+ age group was high - about 20%. The oldest groups were represented with a share around 3 % in the catch. In November 2019, a high percentage of 1-1+ and 2-2 + age groups was registered. The appearance of recruitment (0+) made an impression. 3-3+ and 4-4+ year olds were presented with very low percentage share in the catch. The one-year-old numbers raised to 55% in December's catches. The recruitment (0+) increased compared to November, 2-2+ decreased their percentage presence at the expense of 3-4 + individuals.
Due to the high amount of the samples collected in 2019, the age structure of the catches represented the natural dynamics and seasonality of growth parameters of the studied species.

I.3.4 Sprat condition factor analysis 2017-2019

I.3.4.1 Fulton’s condition factor of sprat in 2017

In November 2017, the condition factor of sprat showed an increase in all age groups. The condition factor of age group 0-0+ is usually estimated higher than the rest groups (Fig. 3.4.1.1)

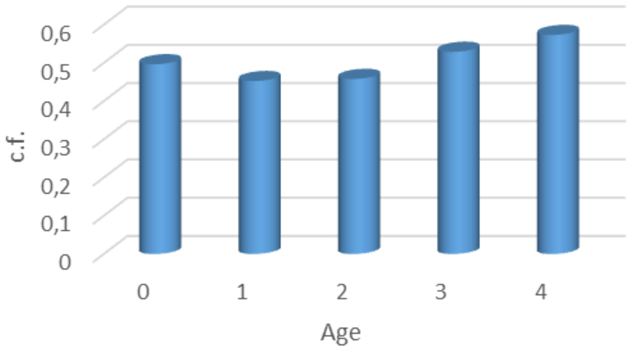


Fig. 3.4.1.1 Condition factor of sprat in November, 2017

I.3.4.2 Fulton's condition factor of sprat in 2018

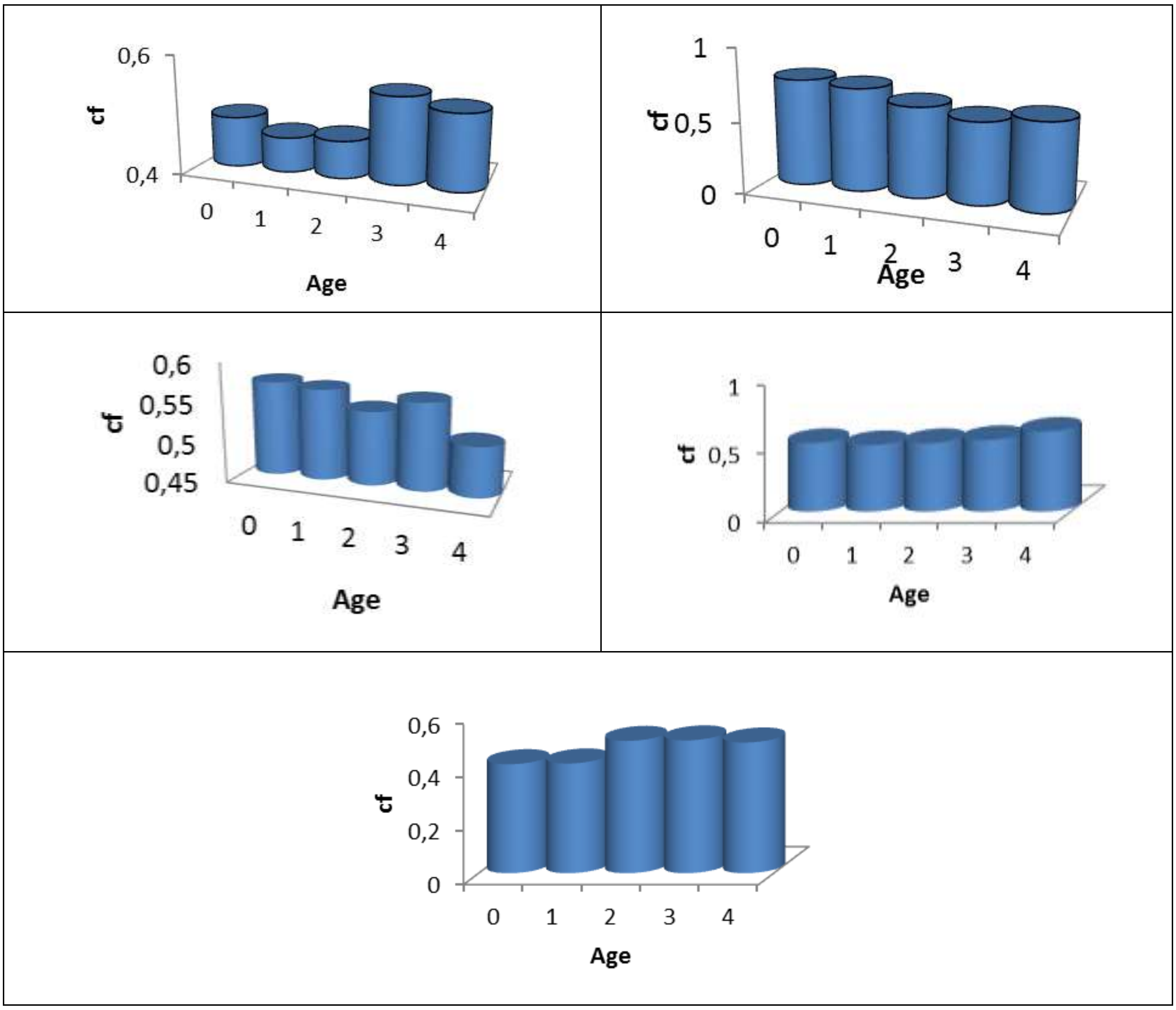
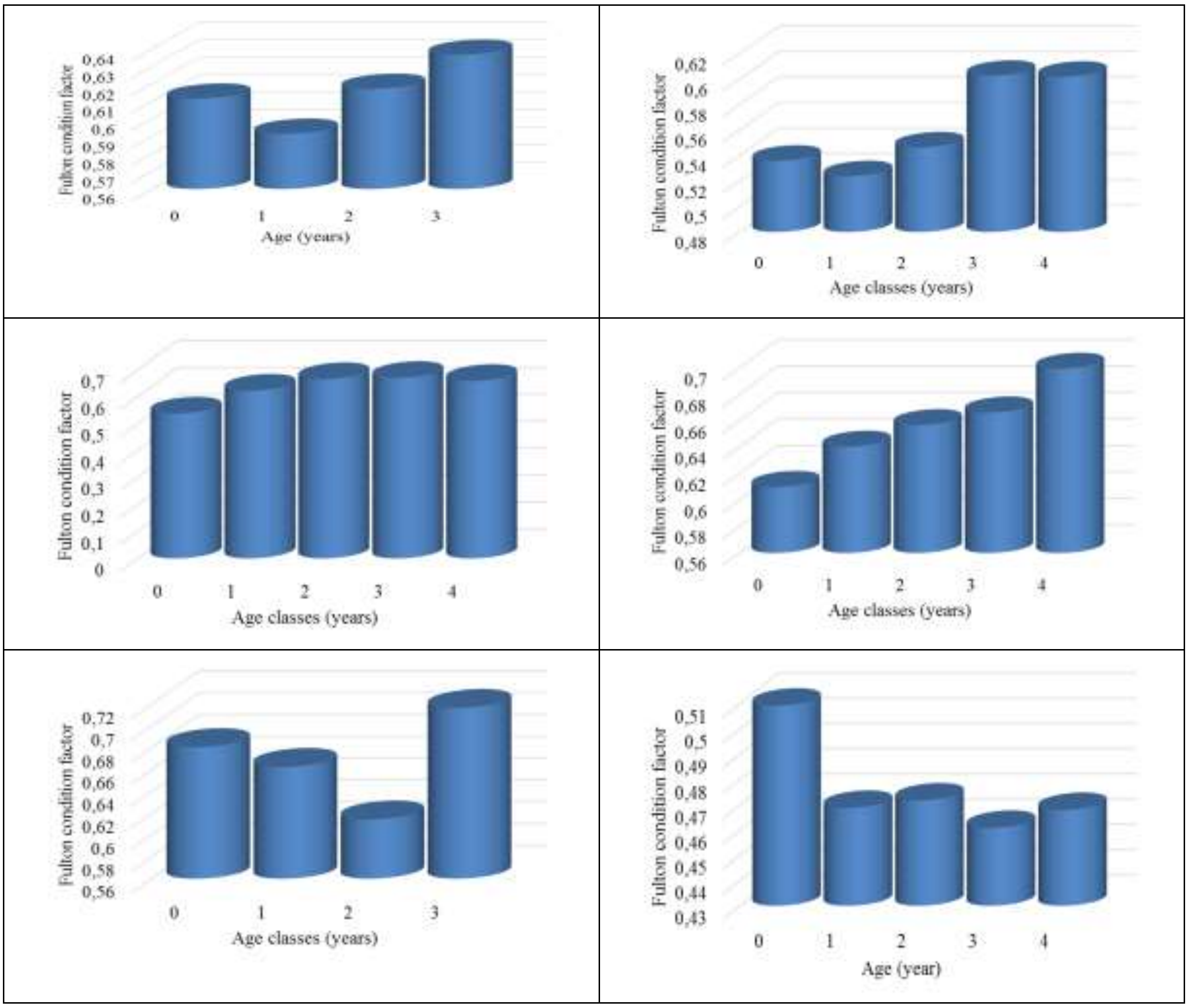


Fig. 3.4.2.1 Condition factor of sprat in the period March - July 2018

Fulton's condition factor variations were observed for the entire period of the research, most likely due to the natural variability of growth parameters as length and weight. From April to June the Fulton's condition factor decreased for all age groups with the exception of 0-0+, which was compensated in July and the condition of age group 0-0+ decreased as a result of the new recruitment to the stock and that specific pattern was expected to reappear in the annual dynamics of sprat growth parameters.

I.3.4.3 Fulton's condition factor of sprat in 2019



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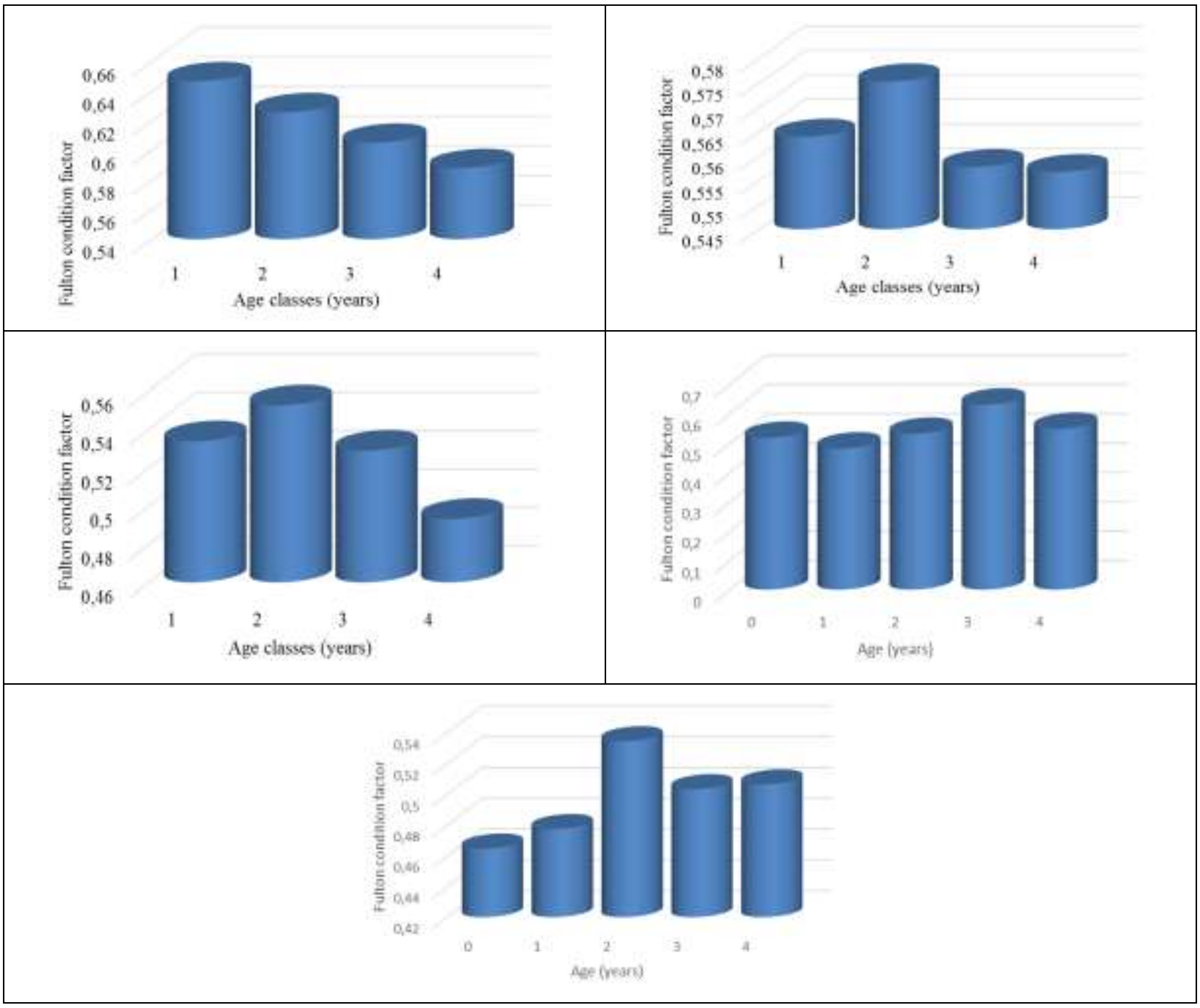

Фиг. 3.4.3.1 Fulton's condition factor in the period February – December 2019

In 2019, Fulton's condition factor of sprat again varied significantly as a result of growth parameters variability and species environment.

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I.3.5 Weight structure of sprat in the period 2018-2019

I.3.5.1 Weight structure of sprat in 2018

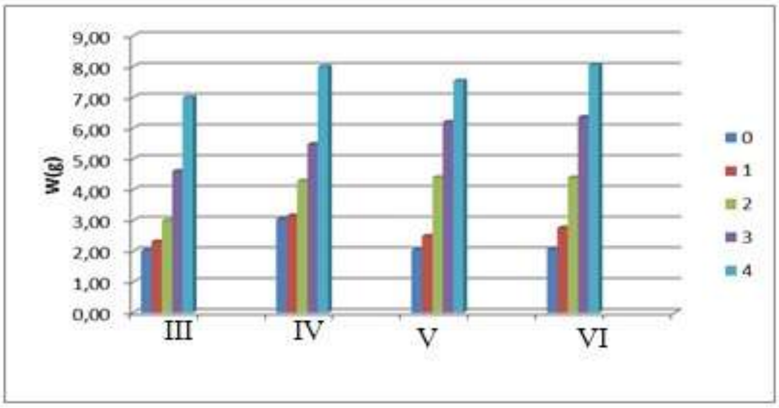
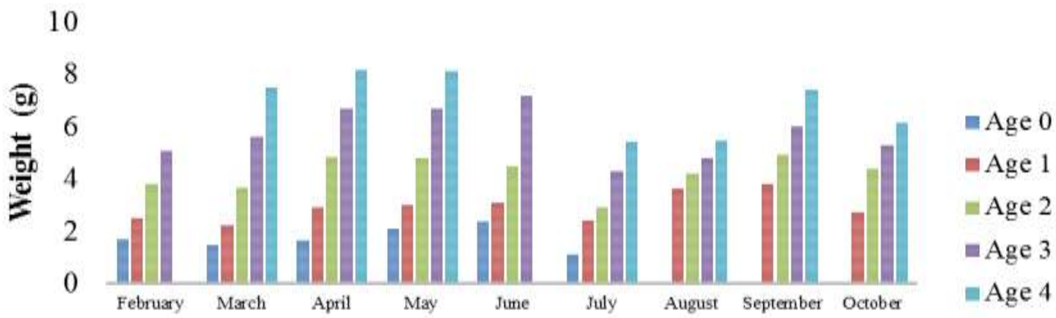


Fig. 3.5.1.1 Weight structure of sprat by age groups in 2018

It is evident that the mean weight of age groups 0-0+ and 1-1+ tended to increase in April, however later in May and June it went down to the levels registered in March. Age group 2-2+ showed an increase in the mean weight with 1g from March to April and remained the same in May and June. Age group 3-3+ showed a sustainable increase in the mean weight for the entire period of the research and the mean weight of age group 4-4+ varied in a short range between 7g and 8g.

I.3.5.1 Weight structure of sprat in 2019



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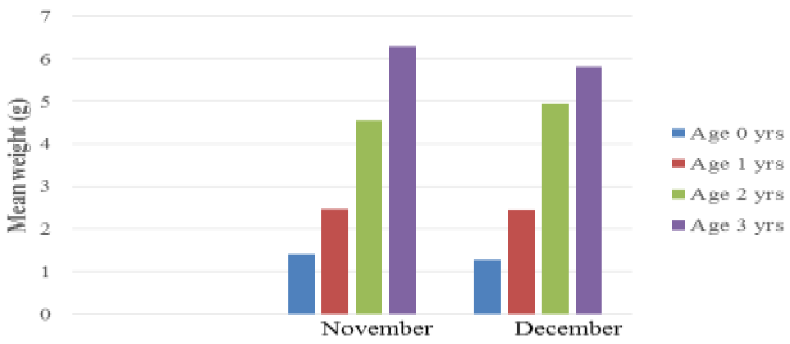

Fig. 3.5.1.1 Weight structure of sprat by age groups in 2019

As 2019 research covered longer period, the analysis of weight structure on almost annual basis showed the natural variability and seasonality of sprat weight. In the period September – February, a decrease in the mean weights by age groups was observed and in the period March – June, respectively, an increase of the mean weights of sprat by age groups.

I.3.6 Length structure of sprat by age groups in the period 2018-2019

Table 3.6.1 Length structure of sprat by age groups in 2018

age	March	April	May	June	July
		Length, cm			
0	7,47	7,45	7,04	7,45	7,99
1	7,95	7,91	7,63	8,19	8,33
2	8,57	8,83	9,30	9,89	9,56
3	9,43	9,91	10,34	10,66	10,03
4	11,05	11,22	11,35	11,16	10,76

Table 3.6.2 Age structure of sprat by age groups in 2019

Age	February	March	April	May	June	July	August	September	October	November	December
						Length (cm)					
0	6.5	6.5	6.75	7	6	n/a	7	n/a		6.5	6.5
1	7.5	7.5	7.75	7.75	8	8.25	7.75	8.75	8.25	8	8
2	8.5	8.75	9	9	8.5	8.75	9	9.5	9.5	9.5	9.75
3	9.25	9.75	10	10	9.75	9.25	10	10.25	10.5	10	10.5
4	n/a	10.75	10.75	10.5	10.5	9.75	n/a	11	11	11	11.5

The data given in Tables 3.6.1 and 3.6.2 show a slight tendency for decrease of the total length of sprat by age groups. This observation cannot be applied as a solid base for specific

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conclusions about the stock as a whole, since parameters such as length and weight are strongly dependent on the environment and food availability.

I.3.7 Length-weight relationship of sprat in the period 2018-2019

I.3.7.1 LWR of sprat in 2018

LWR of sprat in 2018 is well described by: $W = 0.084*L^{2.8085}$

I.3.7.1 LWR of sprat in 2019

LWR model of the sampled specimens in the period February-October 2019 can be described as: $W = 0.0048*L^{2.89}$

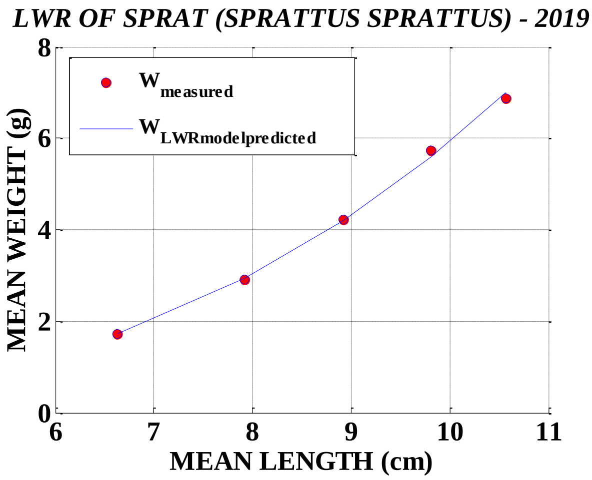

Fig. 3.7.1.1 LWR model of sprat in the period February-October 2019

LWR of the sampled specimens in November and December 2019 can be described as: $W = 0.0031 * L^{3.2410}$.

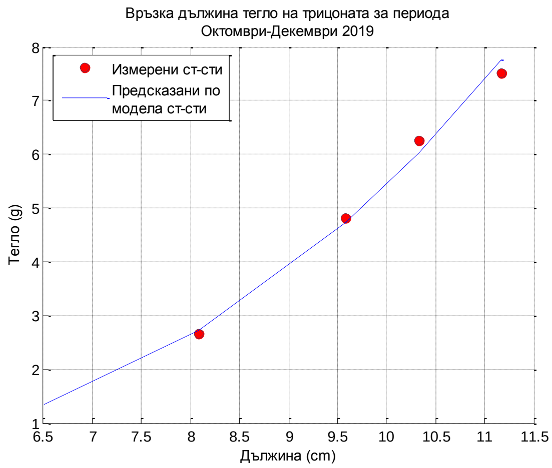

Fig. 3.7.1.2 LWR model of sprat in the period November-December 2019

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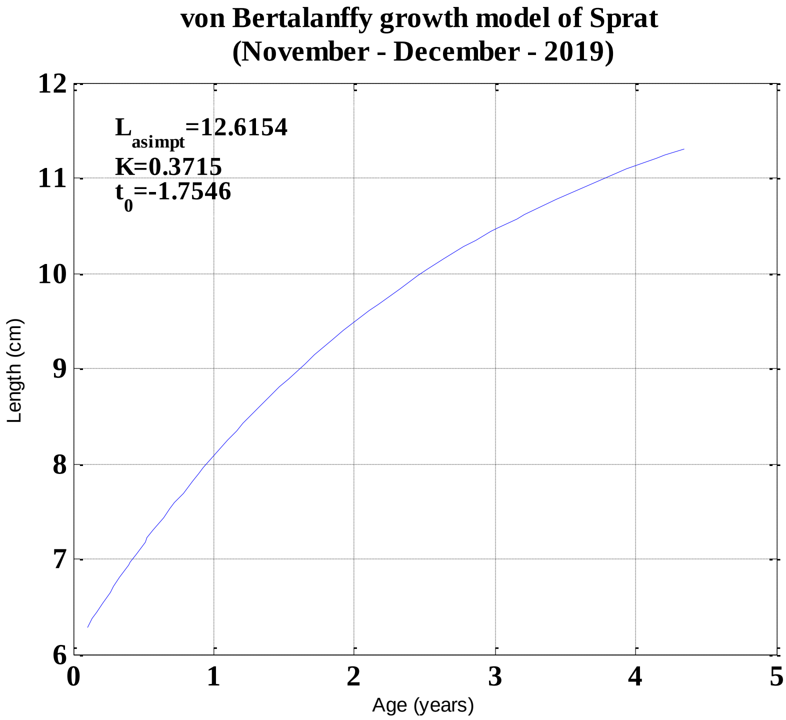
<u>Von Bertalanffy growth model parameters:</u>

$L_{asimpt} = 12.6154$, $K = 0.3715$, $t_0 = -1.7546$. Model statistics - $R = 0.9573$; $F - statistics = 21.9446$ - Gulland and Holt method $R = 0.9981$; $F - statistics = 788.9312$ – von Bertalanffy method for estimations of t_0.



I.3.8 Sex ratio of sprat in the period 2017-2019

I.3.8.1 Sex structure of sprat in 2017

Female specimens (♀) were represented with 58%, and male specimens (♂) - with 42%.

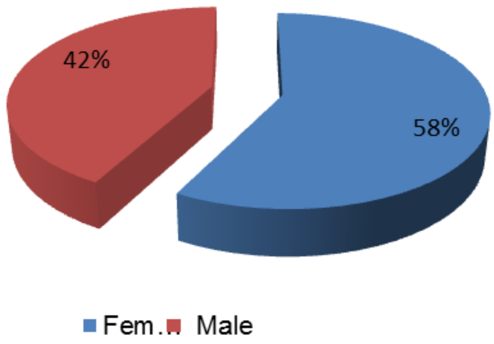


Fig. 3.8.1.1 Sex ratio of sprat in 2017

I.3.8.2 Sex structure of sprat in 2018

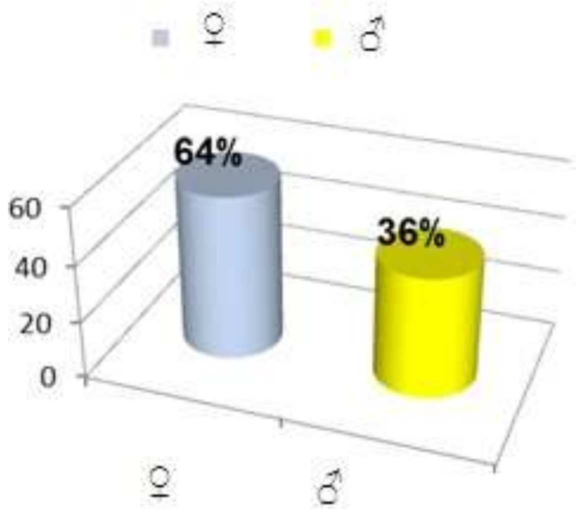


Fig. 3.8.2.1 Sex ratio of sprat in 2018

I.3.8.3 Sex structure of sprat in 2019

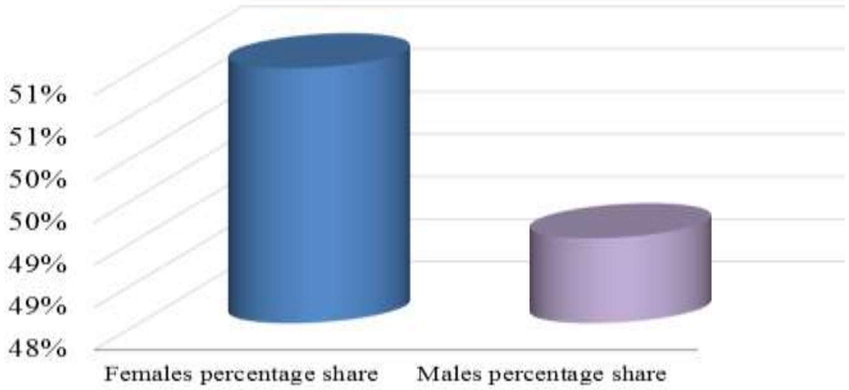


Fig. 3.8.3.1 Sex ratio of sprat in 2019

250 specimens were analyzed for determination of sex structure of sprat in 2019. The female specimens were presented with 51%, and the male specimens (♂) with (49%) (Fig. 3.8.3.1).

I.3.9 Fertility of sprat in the period 2018-2019

I.3.9.1 Fertility of sprat in 2018

Batch fecundity correlated with length (cm) positively with determination (R^2 = 0.4751).

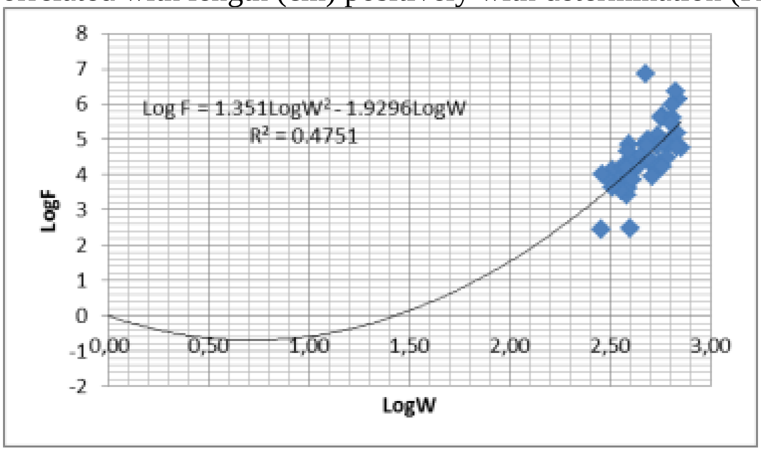


Fig. 3.9.1.1 Relation of LOG F and LOG L

Batch fecundity correlates with individual weight (g) positively with good determination (R^2 = 0.4751).

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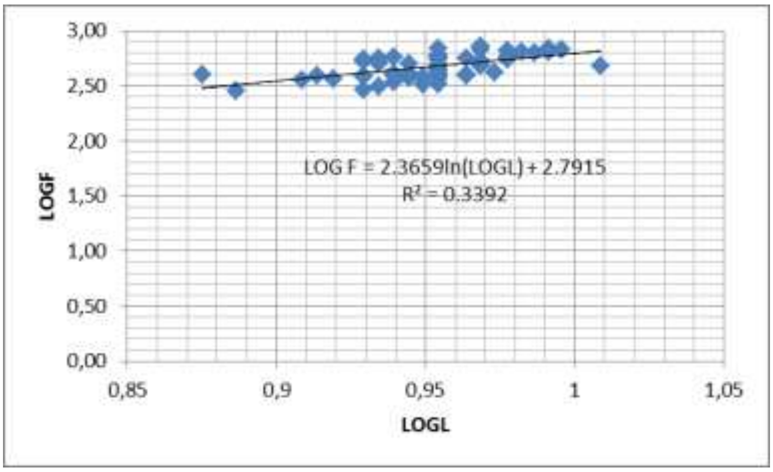

Fig. 3.9.1.2 Relation of LOG F and LOG W

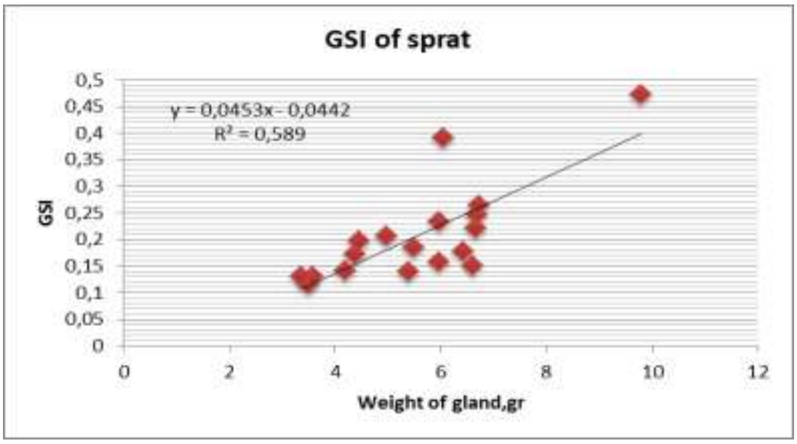

Fig. 3.9.1.3 Relation of GSI and gonads weight (g)

Very strong relation between GSI and weight of sprat (R^2 = 0.589) wae established. This fact clearly spoke that sprat was in active maturation .

I.3.9.2 Fertility of sprat in 2019

Fertility was determined on 500 specimens. The relation between body weight (g) and glandule weight of males of sprat indicated linear negative trend with good coefficient of determination (R^2 =0.43).

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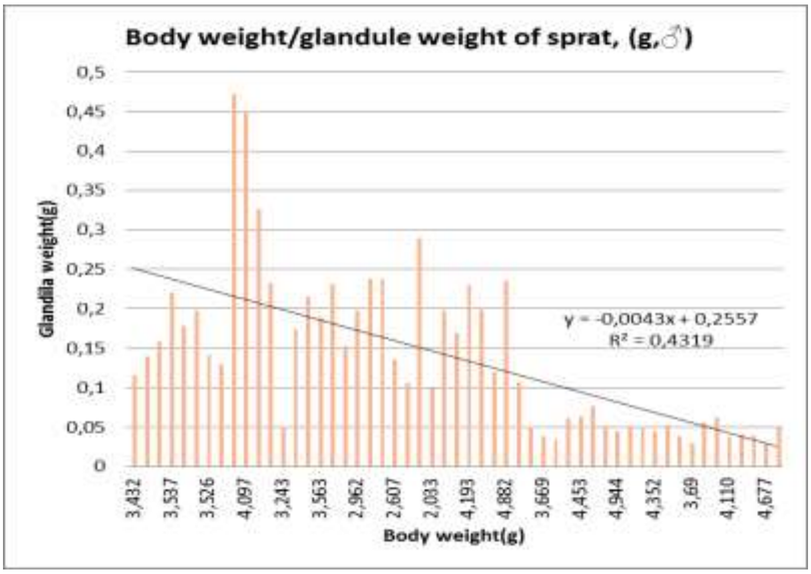

Fig. 3.9.2.1 Body weight/glandule weight of sprat ♂

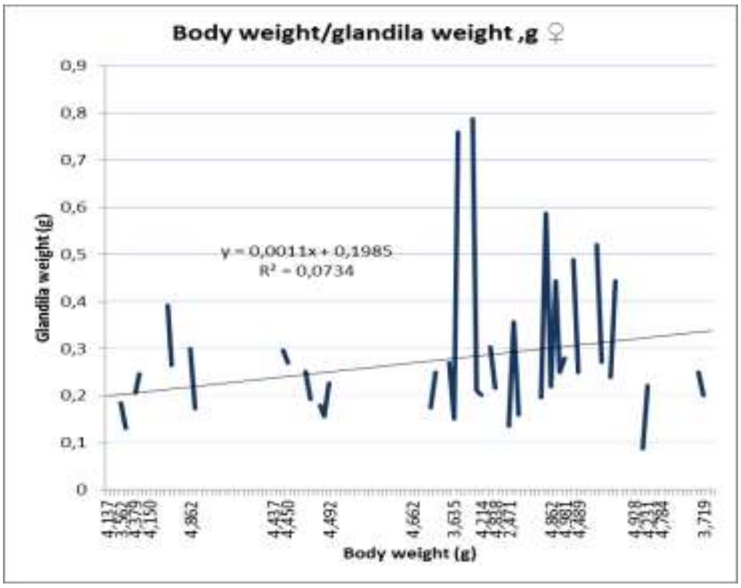

Fig. 3.9.2.2 Body weight/glandule weight of sprat ♀

There was a very weak linear relationship between individual weight and gland weight of the female individuals (June, 2019), which was a clear indication for the low contribution of female sex products as a ratio from the total sprat body weight. The individuals were not in active reproduction and the glands were in the developmental stages II-III, I-II, in many cases there were also non-sexually mature individuals.

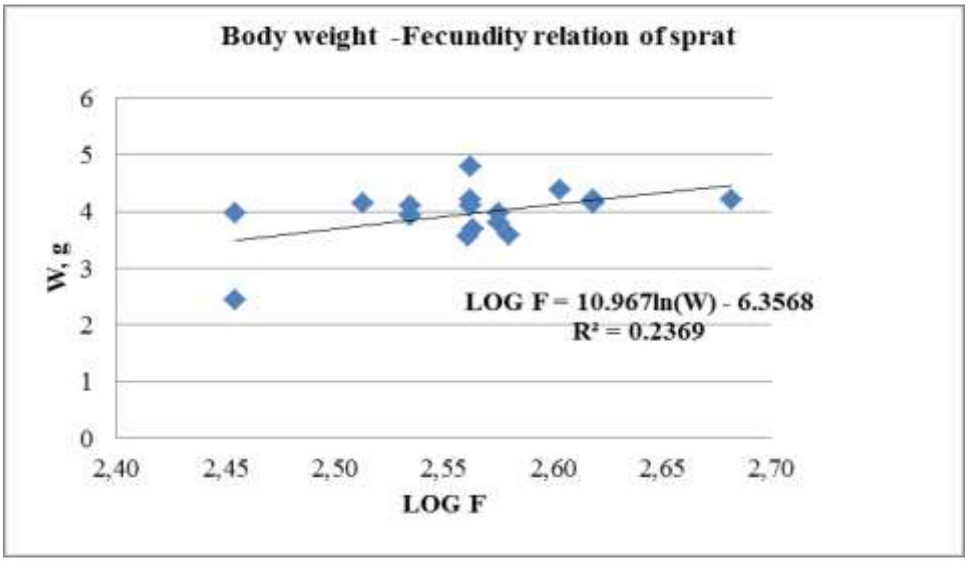

Fig. 3.9.2.3 Body weight-fecundity relation of sprat

The association of somatic weight with the fecundity of sprat in June 2019 was low deterministic (R^2 = 0.24), which was explained by the lack of mass spawning of sprat during the spring and summer seasons.

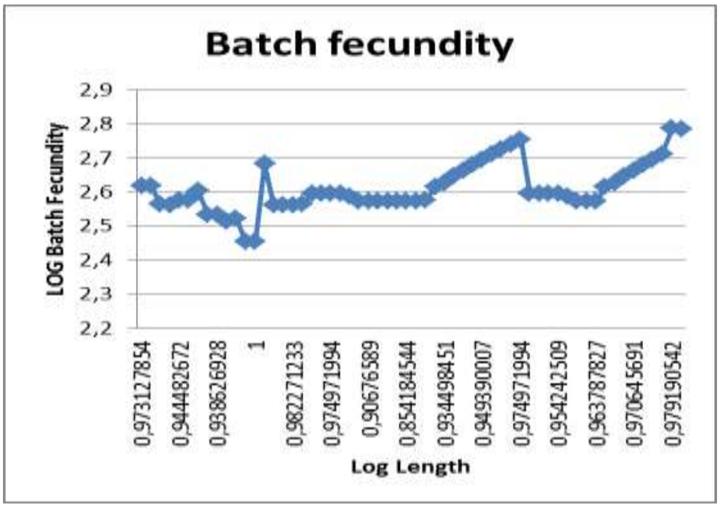

Fig. 3.9.2.4 Batch fecundity of sprat in October-December, 2019

The batch fecundity, in most of the cases, showed values above 2.5 (Log fecundity), corresponding to the Log individual weights (g) from 0.85 to 1.

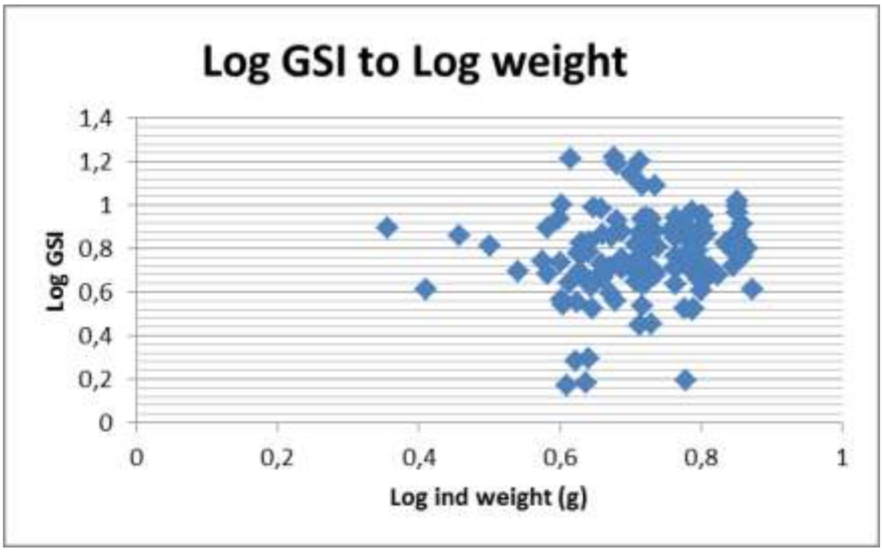

Fig. 3.9.2.5 Gonadosomatic index vs individual weights of sprat

GSI as a measure of sexual maturity showed that sprat in the period Octobre-December 2019 was in relatively good maturity (females), which corresponded to the active maturation season of the species.

I.3.10 Sexual Maturity

1000 specimens were used for sexual maturity determination. Most of the individuals were in III - IV stage of gonads.

I.3.11 Catch numbers and biomass of sprat by age and length in the period 2017-2019

I.3.11.1 Analysis of the abundance and biomass of sprat by age and length in 2017

Monthly catches (in tons) 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.

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Table 3.11.1.1 Catch-at-age (10^{-3}) matrix and biomass (kg) of sprat by months

Catch-at-age	
(10^{-3})	
Age groups	**November**
0	10748.596
1	19642.680
2	29331.555
3	22519.065
4	7380.198
∑	89622.094
Biomass (kg)	
Age groups	**November**
0	19052540.471
1	38231614.583
2	82932884.849
3	112380647.320

Monthly catches (in tons) together with mean weights of sprat 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 3.11.1.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of sprat by months

Catch-at-length (millions)	
Length group (cm)	**November**
6.5	67.601
7.0	231.266
7.5	435.848
8.0	351.347
8.5	209.919
9.0	120.970
9.5	185.013
10.0	184.124
10.5	273.072
11.0	47.143
∑	2106.302
Biomass (kg)	

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Length group (cm)	November
6.5	0.995
7.0	4.053
7.5	8.377
8.0	7.437
8.5	4.659
9.0	4.839
9.5	8.696
10.0	10.390
10.5	18.179
11.0	3.536
∑	71.16

I.3.11.2 Analysis of the abundance and biomass of sprat by age and length in 2018

Monthly catches (in tons) 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 3.11.2.1 Catch-at-age (10^{-3}) matrix and biomass (kg) of sprat by months

Catch-at-age (10^{-3})					
Age groups	**March**	**April**	**May**	**June**	**July**
0	14528.38008	55806.40413	36.39010924	12.37333333	82.28474
1	33349.23609	118955.7562	104.9119107	95.20592593	75.31146
2	23113.33195	6608.653121	6.968318791	53.27407407	27.89313
3	18490.66556	16888.7802	11.22673583	11.68592593	11.15725
4	1320.761826	2202.884374	2.709901752	5.155555556	10.45992
Biomass (kg)					
Age groups	**March**	**April**	**May**	**June**	**July**
0	29440053.58	169493005.9	74157.43811	25650.45333	172536.5
1	76946282.26	375555843.9	262115.6487	262976.1898	182622
2	69209184.72	28329093.05	30667.35984	233947.3421	122176.3
3	85093146.66	92601916.12	69592.81092	74360.49847	56052.41
4	9245332.779	17623074.99	20424.14238	41529.51634	64258.81
∑	269934000	68357705	456957.4	638464	597646

Monthly catches (in tons) together with mean weights of sprat 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 3.11.2.2).

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Table 3.11.2.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of sprat by months

Catch-at-length (millions)					
Length group (cm)	**March**	**April**	**May**	**June**	**July**
6.5		1,51	18,9271		
7.0	0.022949	71.50	52.50743	8.992089	
7.5	0.076498	57.95	82.42445	95.64313	33.13253
8.0	0.196981	39.13	56.17074	80.11134	66.26505
8.5	0.072673	12.04	11.60048	46.59537	48.59437
9.0	0.080322	4.52	6.105515	51.50014	25.76974
9.5	0.034424	6.02	5.494964	20.43657	13.98929
10.0	0.030599	5.27	6.716067	58.85731	16.19812
10.5	0.003825	5.27	10.98993	40.87313	8.83534
11.0	0.00765	2.26	3.052758	13.89686	5.890227
11.5			0.610552	5.722238	
12.0			1,221103		
Biomass (kg)	**March**	**April**	**May**	**June**	**July**
Length group (cm)					
6.5		0.03	0.252071	0.169051	
7.0	0.000428	1.47	1.173988	1.912045	
7.5	0.001494	2.08	2.050298	1.999187	0.61868
8.0	0.004689	1.56	1.426039	1.284234	1.259752
8.5	0.001758	0.49	0.35473	1.814767	1.281357
9.0	0.003181	0.19	0.231643	0.904114	0.826242
9.5	0.001711	0.30	0.264125	3.178049	0.637387
10.0	0.001589	0.29	0.376466	2.334837	0.807746
10.5	0.000249	0.33	0.713124	1.167745	0.041596
11.0	0.000535	0.18	0.211007	0.421157	0.39759
11.5			0.04341		
12.0			0.109899		

I.3.11.3 Analysis of the abundance and biomass of sprat by age and length in 2019

Table 3.11.3.1 Catch at age (10^{-3}) matrix and biomass (kg) of sprat by months

Age groups	**Catch-at-Age *10^{-3} (in thousands)**							
	February	**March**	**April**	**May**	**June**	**July**	**August**	**September**
0	5001.91	8783.20	13448.56	17015.22	12766.92	17303.05	9284.91	6043.47
1	32599.35	57243.52	87649.42	110894.71	83206.95	112770.62	60513.34	39387.61
2	16297.36	28617.69	43818.48	55439.47	41597.56	56377.30	30252.37	19691.01
3	8604.66	15109.53	23135.22	29270.86	21962.62	29766.01	15972.60	10396.43
4	608.61	1068.69	1636.35	2070.32	1553.41	2105.34	1129.74	735.34
			Biomass (kg)					
Age								

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groups	February	March	April	May	June	July	August	September
0	8.45	14.84	22.73	28.76	21.58	29.24	15.69	10.21
1	85.52	150.17	229.93	290.91	218.28	295.84	158.75	103.33
2	66.98	117.62	180.09	227.86	170.97	231.71	124.34	80.93
3	48.79	85.67	131.18	165.97	124.53	168.77	90.56	58.95
4	4.25	7.46	11.42	14.45	10.84	14.70	7.89	5.13

Table 3.11.3.2 Catch at length (10^{-3}) matrix and biomass (kg) of sprat by months

Length groups (cm)	Catch-at-length *10^{-3} (in thousands)							
	February	**March**	**April**	**May**	**June**	**July**	**August**	**September**
5	71.52	125.58	192.28	243.28	182.54	247.40	132.75	86.41
6	424.65	745.68	1141.76	1444.56	1083.89	1468.99	788.27	513.08
6.5	2639.00	4634.01	7095.44	8977.21	6735.81	9129.07	4898.71	3188.53
7	8549.60	15012.84	22987.18	29083.55	21822.08	29575.53	15870.40	10329.90
7.5	11635.34	20431.32	31283.78	39580.47	29698.17	40250.02	21598.38	14058.20
8	11527.43	20241.84	30993.64	39213.39	29422.75	39876.73	21398.08	13927.82
8.5	9683.18	17003.38	26035.02	32939.71	24715.45	33496.92	17974.63	11699.54
9	8689.91	15259.23	23364.44	29560.86	22180.22	30060.92	16130.85	10499.44
9.5	5339.00	9375.13	14354.89	18161.92	13627.32	18469.15	9910.65	6450.76
10	3075.83	5401.07	8269.94	10463.19	7850.78	10640.19	5709.58	3716.32
10.5	1235.82	2170.06	3322.73	4203.95	3154.32	4275.06	2294.02	1493.16
11	196.13	344.40	527.33	667.18	500.60	678.46	364.07	236.97
11.5	44.48	78.10	119.59	151.31	113.53	153.87	82.57	53.74
			Biomass (kg)					
Length groups (cm)	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**
5	0.04	0.08	0.12	0.15	0.11	0.15	0.08	0.05
6	0.51	0.90	1.38	1.75	1.31	1.78	0.96	0.62
6.5	4.03	7.08	10.84	13.72	10.30	13.95	7.49	4.87
7	16.78	29.46	45.11	57.07	42.82	58.04	31.14	20.27
7.5	28.23	49.58	75.91	96.05	72.07	97.67	52.41	34.11
8	34.63	60.81	93.10	117.80	88.39	119.79	64.28	41.84
8.5	35.49	62.31	95.41	120.72	90.58	122.76	65.87	42.88
9	38.49	67.59	103.49	130.93	98.24	133.15	71.45	46.50
9.5	26.60	46.72	71.53	90.50	67.90	92.03	49.38	32.14
10	18.75	32.93	50.42	63.79	47.86	64.87	34.81	22.66
10.5	8.58	15.07	23.07	29.19	21.90	29.69	15.93	10.37
11	1.46	2.56	3.92	4.96	3.72	5.05	2.71	1.76
11.5	0.39	0.68	1.04	1.31	0.99	1.34	0.72	0.47

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Table 3.11.3.3 Catch (10^{-3}) and biomass (kg) by size and age of sprat (October-December, 2019)

	catch-at-length in numbers * 10-3			Biomass (kg)		
Length (cm)	***October***	***November***	***December***	***October***	***November***	***December***
6.5	7329.89224	1058.713831	882.9344028	9990.643123	1443.026952	1203.43959
7	16246.1986	2346.56589	1956.96296	29971.92937	4329.080855	3610.31877
7.5	17900.3107	2585.482288	2156.211805	35772.94796	5166.967472	4309.09015
8	17121.1807	2472.946425	2062.360395	49308.65799	7122.036245	5939.55669
8.5	11726.0681	1693.687997	1412.483106	38673.45725	5585.910781	4658.47584
9	9172.81418	1324.901503	1104.926641	35772.94796	5166.967472	4309.09015
9.5	8836.58309	1276.337008	1064.425363	44152.19703	6377.248141	5318.42658
10	8390.77711	1211.945755	1010.725061	48664.10037	7028.937732	5861.91543
10.5	4253.28169	614.3348367	512.3361444	29649.65056	4282.531599	3571.49814
11	2345.5978	338.7930885	282.5428974	17403.05576	2513.659851	2096.31413
11.5	522.295667	75.43925996	62.9139962	4511.903346	651.6895911	543.488848
12	334.916706	48.37464693	40.34295081	2900.509294	418.9433086	349.385688
	catch-at-age in numbers * 10-3			**Biomass (kg)**		
Age (years)	***October***	***November***	***December***	***October***	***November***	***December***
0+	26244.1631	3790.65033	3161.284463	34677.2	5008.7	4177.1
1	38024.4201	5492.165251	4580.294981	98483.248	14224.708	11862.964
2	24812.1345	3583.811207	2988.787069	115128.304	16628.884	13867.972
3	11168.1804	1613.10789	1345.281804	69354.4	10017.4	8354.2
4	3931.01862	567.7878543	473.5174089	29128.848	4207.308	3508.764

I.3.12 Coefficient of variation of length

Table 3.12.1. Coefficient of variation of length

	February	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Coefficient of variation (CV)	na	CV =0.18	CV =0.18	na	na	na	na	CV =0.11	CV =0.14	CV =0.15	CV =0.14
1 sample		CV =0.22	CV =0.22					CV =0.21	CV =0.22	CV =0.20	CV =0.23
2 sample		CV =0.20	CV =0.16								

I.3.13 Conclusions and recommendations

Sprat is a fast growing species with highly cycling nature of its recruitment and parental stock biomass dependent on the anthropogenic impacts different from fishing, as well as of fishing press and dynamics in the environmental factors. Therefore, the continuity of the study of the dynamics of population parameters is of great importance. In the studied months the observed length, weight and age structure were stable. The condition factor was expected to rise due to the beginning of the spawning period and gonad maturation in the next months. Linearly and by weight, the sprat grew well, as in October-December the condition was high, which was associated with the active ripening of sex products. The majority of samples studied were with developed gonads, the stages of sexually maturation showed readiness for the porational disposal of sexual products during the active breeding season of the species. It prevails 1-1 + age, with the senior age groups presented with a small percentage in the catches. New indicators as lipid content, otoliths chemistry should be introduced when biological characteristics are studied.

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

II.1 Objectives

Horse mackerel (*Trachurus mediterraneus*) is of significant importance to the commercial fishing sector of Bulgara. Information on the age of individual fish species significantly enhances the quality of studies on population characteristics such as growth, recruitment, mortality, and reproduction, and it is often a prerequisite for more detailed studies on life history strategies and stock assessment. Multiannual biological monitoring on the landings provides the so called “Fishery dependent” information. The aim of this study was to collect and analyze the dynamics in length and weight, as well as to determinate the condition of horse mackerel species. The condition factor is also a useful index for monitoring of feeding intensity, age, and growth rates in fish. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live. Biological information on a given species collected each month, analyzed and compared to previous periods could be used for estimation of growth parameters. These indicators are very important for the species. The purpose was to define the age of horse mackerel, as one of the important indicators for the assessment of fishing reserves. Reliable and informative long-term data are crucial for the assessment of fish stocks, fisheries management and the decision-making process in general.

II.2 Sampling

II.2.1 Geographic area coverage

Data of the present analysis were collected from landing ports on the Bulgarian Black Sea coast. Information about the size of the catches was also collected.

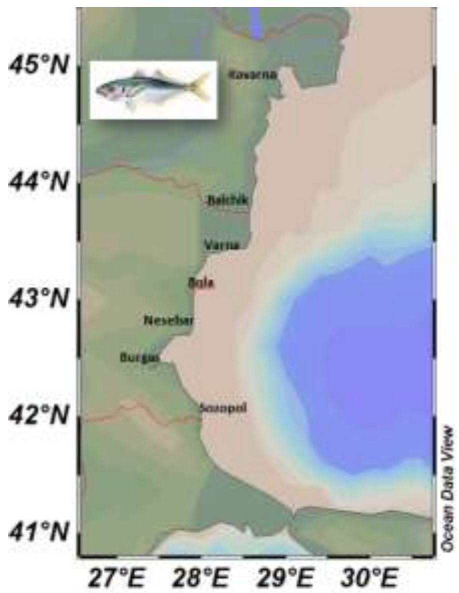

Fig. 2.1.1 Map of the ports for sampling of horse mackerel during the period 2017-2019

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In 2017, 5 samples were collected, containing 1734 specimens.
In 2018, 19 samples were collected, containing 2674 specimens.
In 2019, 11 samples were collected, containing 1500 specimens.

II.2.1.2 Sampling period

2017		**2018**		**2019**	
Date	Vessel	Date	Trap net/ Vessel	Date	Trap net/ Vessel
		25.06.2018	Trap net Ikantalaka		
		25.06.2018	Trap net Balaklava		
		25.06.2018	Trap net Zelenka		
		26.06.2018	Trap net Chervena zvezda		
		26.06.2018	Trap net Karamana	07.06.2019	Danchovoto Georgi
				9.07. 2019	Libra VN
				18.08. 2019	ISHTAR
		13.09.2018	Libra		
		14.09.2018	Korsai		
		22.09.2018	Libra		
		27.09.2018	Trap net Korucheshme	17.09. 2019	Niko
		28.09.2018	Trap net Akopirq	27.09. 2019	Danchovoto Georgi
16.10.2017	Lavrak	10.10.2018	M27 G9		
19.10.2017	KB 6262	12.10.2018	Irina		
		15.10.2018	FV 40		
		17.10.2018	FV40		
		18.10.2018	FV 21-33	7.10. 2019	Danchovoto Georgi
		23.10.2018	Tesi	20.10. 2019	Barbun
6.11.2017	KB 6262	7.11.2018	FV 40	8.11. 2019	FV 29
9.11.2017	KB 6296			27.11.2019	FV 40
8.12.2017	Haithabu	4.12.2018	Kaliakra	7.12.2019	Niko
		4.12.2018	Tais	11.12.2019	Danchovoto Georgi
5 samples with 1734 species		**19 samples with 2674 species**		**11 samples with 1500 species**	

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II.2.1.3 Statistical analysis of data

Refer to the methodology used for sprat stock analysis.

II.3 Results

II. 3.1 Catch statistics in the period 2017-2019

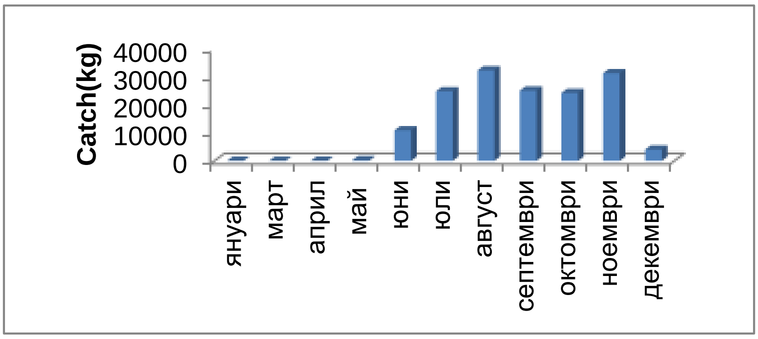


Fig. 3.1.1 Landing statistics in 2017

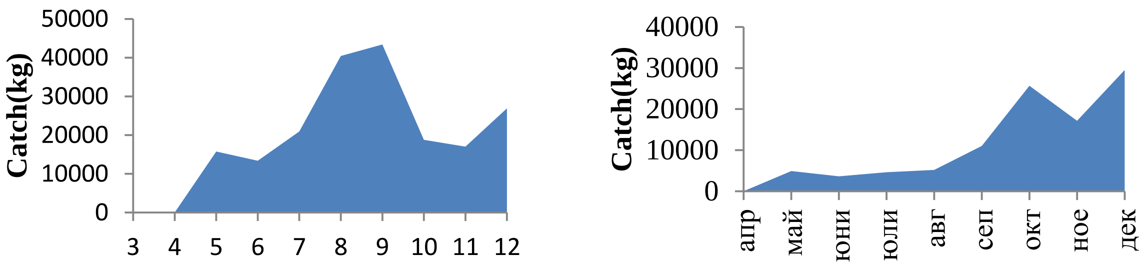


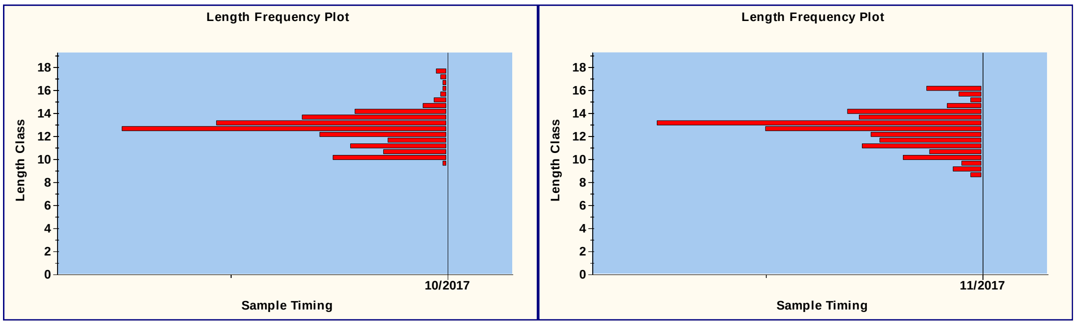
Fig. 3.1.2 Landings statistics in 2018 (left) and 2019 (right)

The statistics collected and the graphical interpretations show that in 2017 the highest quantity and intensity of the catches was registered in August, in 2018 in the period August-September and in 2019 - in December.

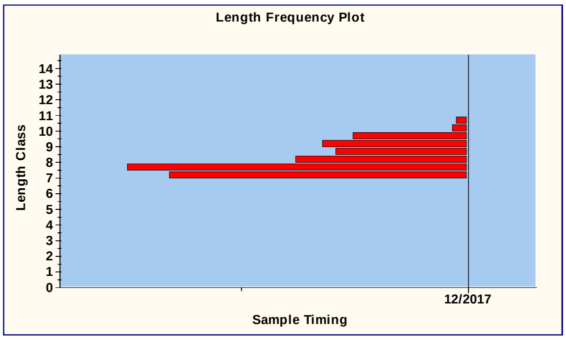
II.3.2 Size structure in the period 2017-2019

II.3.2.1 Size structure analysis for 2017

Dimensional characteristics of horse mackerel are shown on Fig. 3.2.1. The catches from the Bulgarian Black Sea waters during the period October-November 2017 and the size of the composition are represented by individuals with a body length from 9.5 cm to 16.0 cm.



(a) (b)

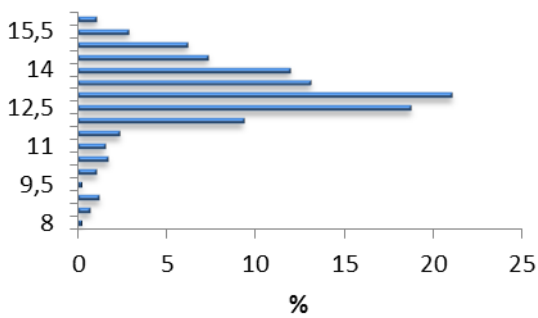


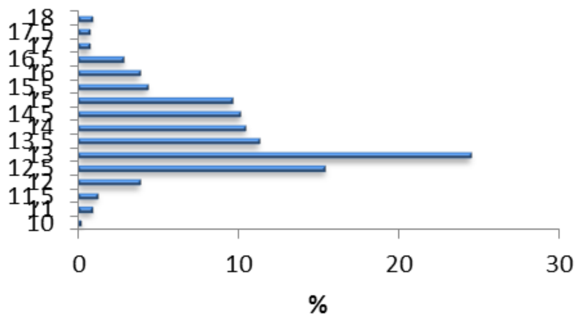
(c)

Fig. 3.2.1 Frequency of horse mackerel length from landings in October (a), November (b), December (c), 2017

II.3.2.2 Size structure analysis for 2018

In the catches from the Bulgarian Black Sea waters in 2018, the size composition is represented by individuals with a body length from 7.0 cm to 18.0 cm.





(a) (b)

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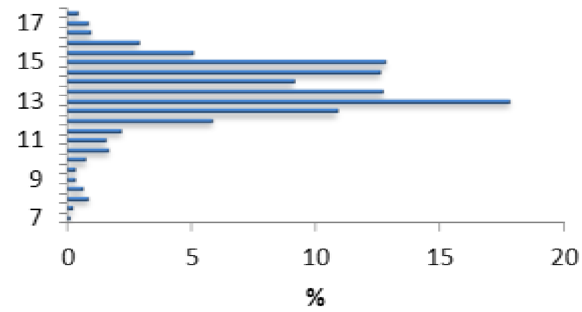
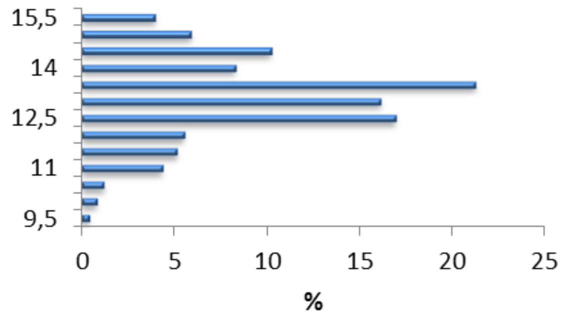
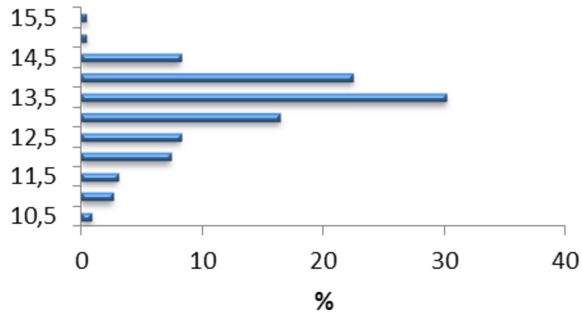


(c)



(d)

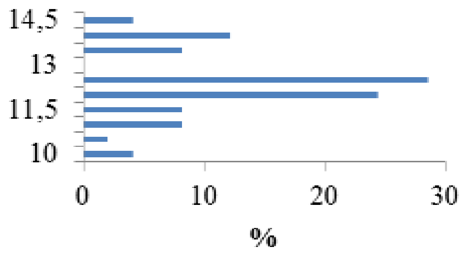


(e)

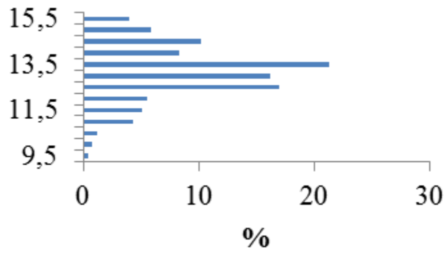
Fig. 3.2.2 Frequency of horse mackerel length on landings in June (a), September (b), October (c), November (d) December (e), 2018

II.3.2.3 Size structure analysis for 2019

The catches from the Bulgarian Black Sea waters in 2019 were dominated by a single-modal structure. In June and August the maximum was 12.5 cm and in July, September and December - 13.0 cm. In November, the proportion of 9-10 cm increased, which was mainly due to the new 0+ species.



(a)



(b)

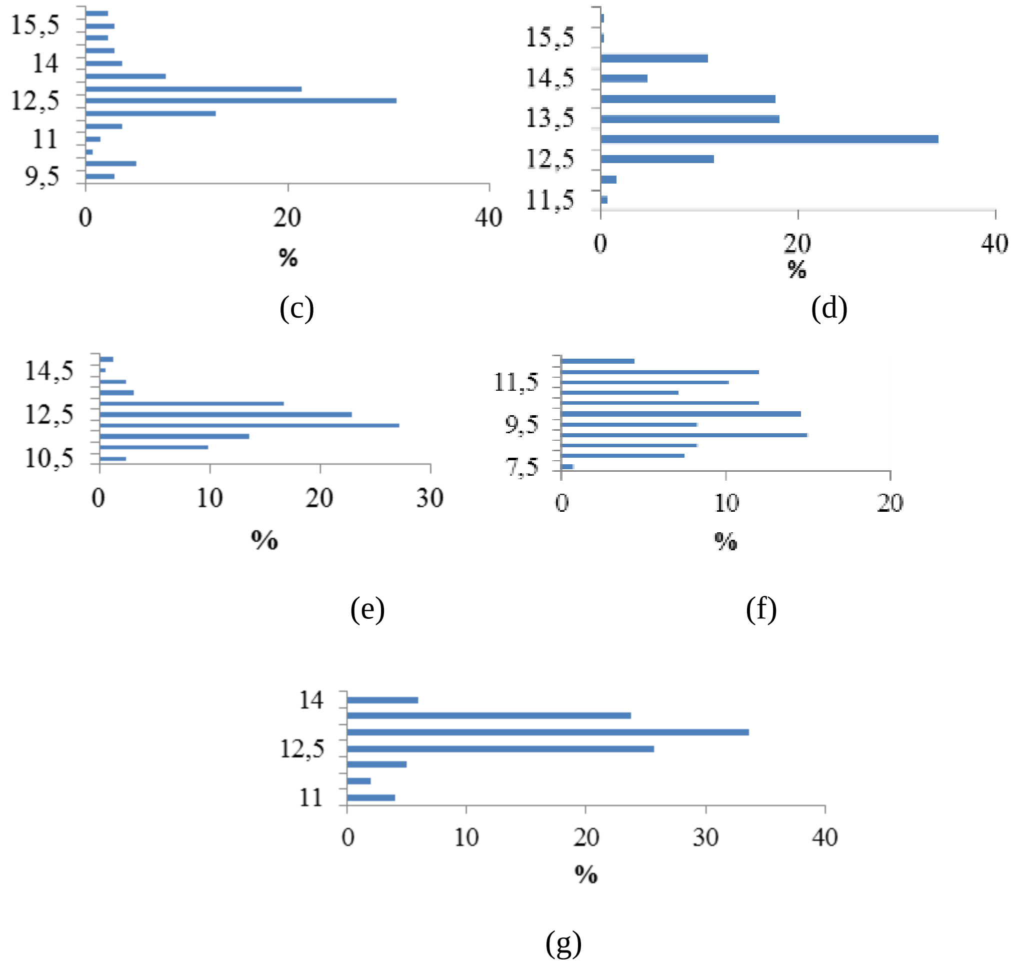


Fig. 3.2.3.1 Frequency of horse mackerel length from landing in June (a), July (b), August (c), September (d), October (f), November (f), December (g), 2019

II.3.1 Age structure of landings

The age structure of horse mackerel during the period 2017-2019 was characterized by 7 age classes. The most indicative of the biological state of the species was the age composition during the spring season (May-June), which most closely reflected the real qualitative composition of the catches of the species in the Bulgarian Black Sea waters. A larger share had the three-year-olds (age 3) in June 2019 - 46.94% and to some extent in 2018 - 22.22%. The four-year-olds were well represented during the said period with a percentage varying between 18.37% (June, 2019) and 39.30% (June, 2018). In June 2019, it should be noted that the 5th and 6th age group were missing. From data on the average age of the species, there was a decrease in the participation of young age groups (annuals) ranging between 2.32% (June, 2018) and 6.12% (June, 2019). On Fig. 3.1.1 is presented the range of variation of the percentage composition in the different age classes in June.

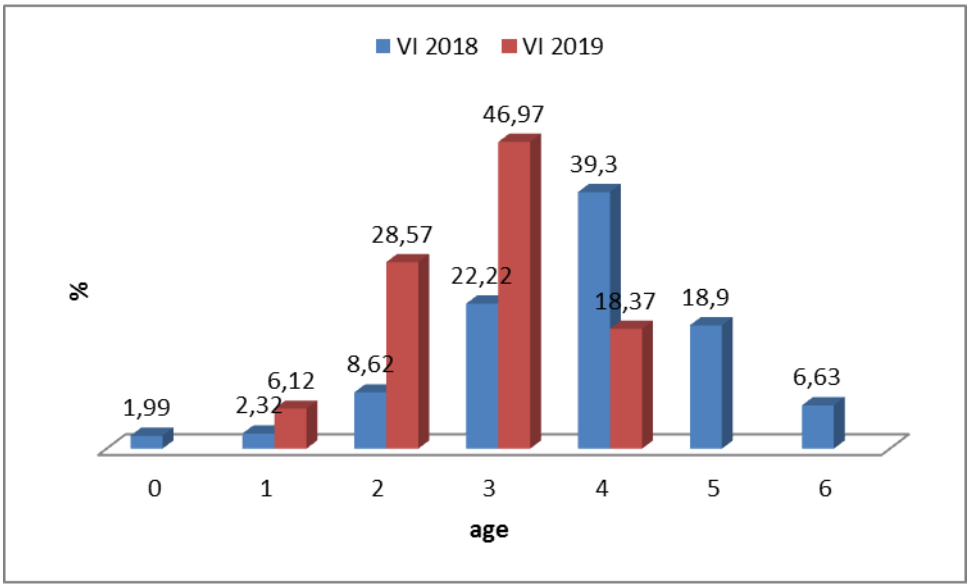


Fig. 3.1.1 Variation of the percentage participation of horse mackerel by age groups in June 2018, 2019
Note: For June, 2017 no comparative analysis data were available.

In a multiannual plan, that age distribution remained below normal for the species due to the low participation of senior age groups (5-6 years old). In July 2019, the expected participation of the one-year old increased (13.39%) and the proportion of senior ages (3-4 years old) showed significant participation. During the month of July there was a significant participation of second age groups (Fig. 3.1.2).

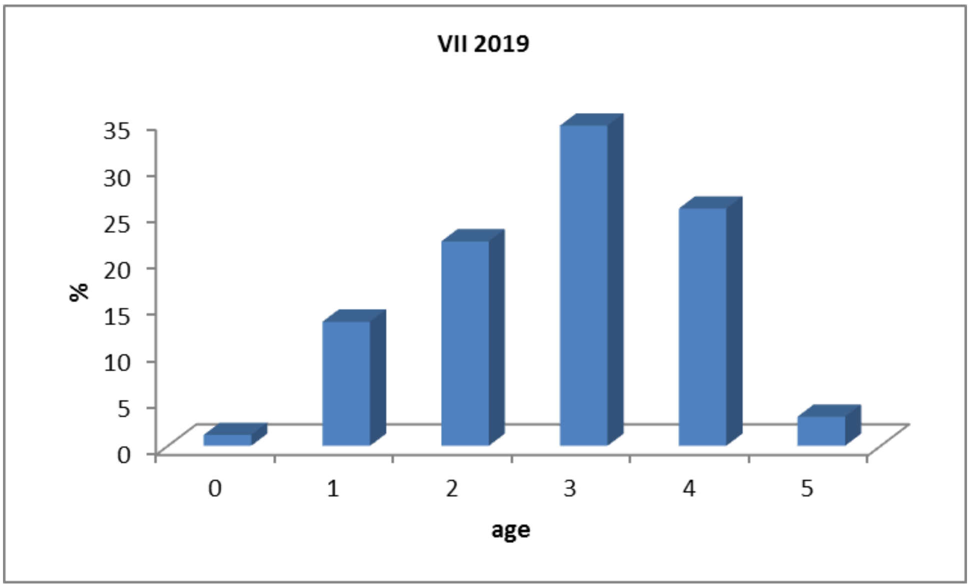


Fig. 3.1.2 Variation in the percentage participation of horse mackerel by age groups in July 2019
Note: For July 2017 and 2018 there were no comparative analysis data available.

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In the autumn season of the accounting period 2017-2019, four year olds had a significant share in the catches, reaching 54.29% (September, 2018) and 36.83% (September, 2019).

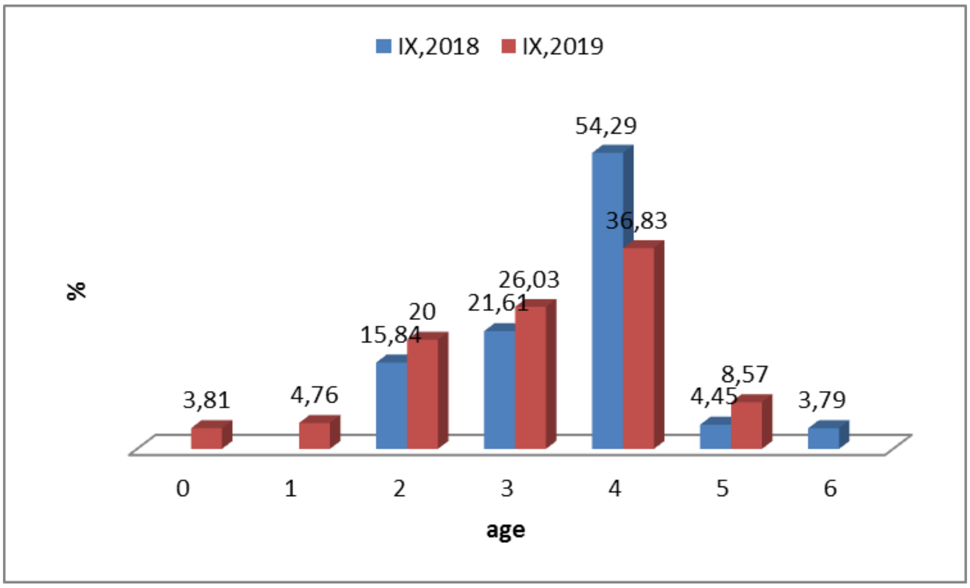

Fig. 3.1.3 Variation in the percentage participation of horse mackerel by age groups in September 2018-2019
Note: For September, 2017 no comparative analysis data were available.

II.3.4 Condition factor

During the spring migration along our coast in June, the values of K = 0.804-0.828 (Fig. 3.4.1). The values of Fulton's condition factor of horse mackerel in June showde high values for all age groups.

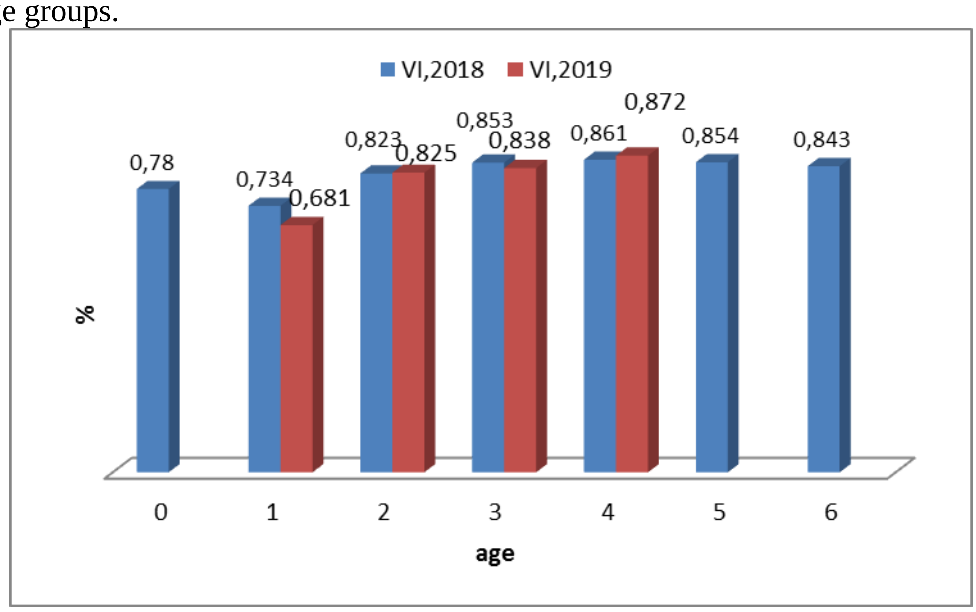

Fig. 3.4.1 Condition factor by age groups in June 2018 and 2019
Note: For June, 2017 no comparative analysis data were available.

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High values of K were also observed in the next month July when the species in parallel with reproduction were actively nourished.

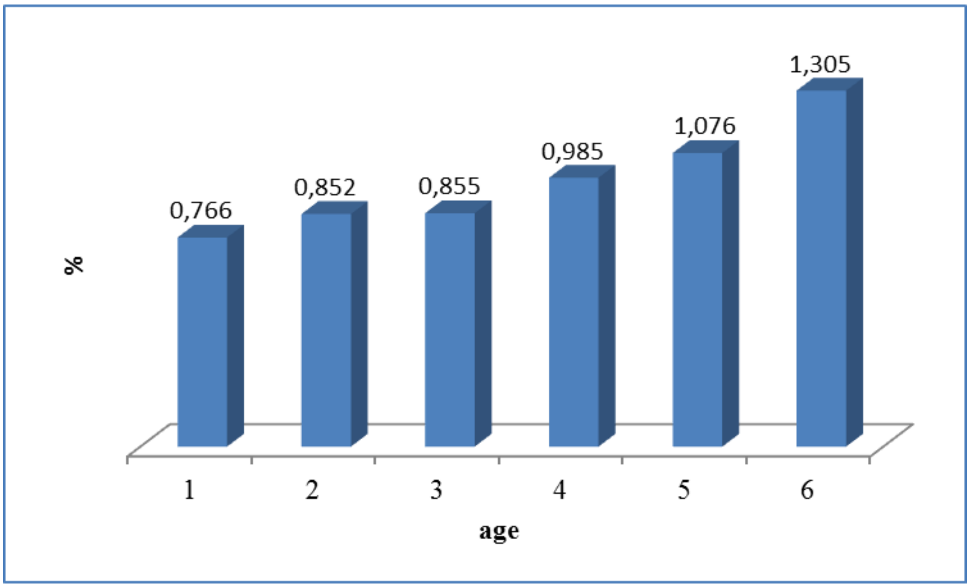

Fig. 3.4.2 Condition factor by age groups in July 2019
Note: For July, 2017 and 2018 no comparative analysis data were available.

The autumn months are usually characterized by a significant increase in the Fulton's condition factor. For those reasons, the autumn condition factor reached 0.954 (September, 2019). In September of the reporting period, the condition factor was relatively high compared to the previous months.

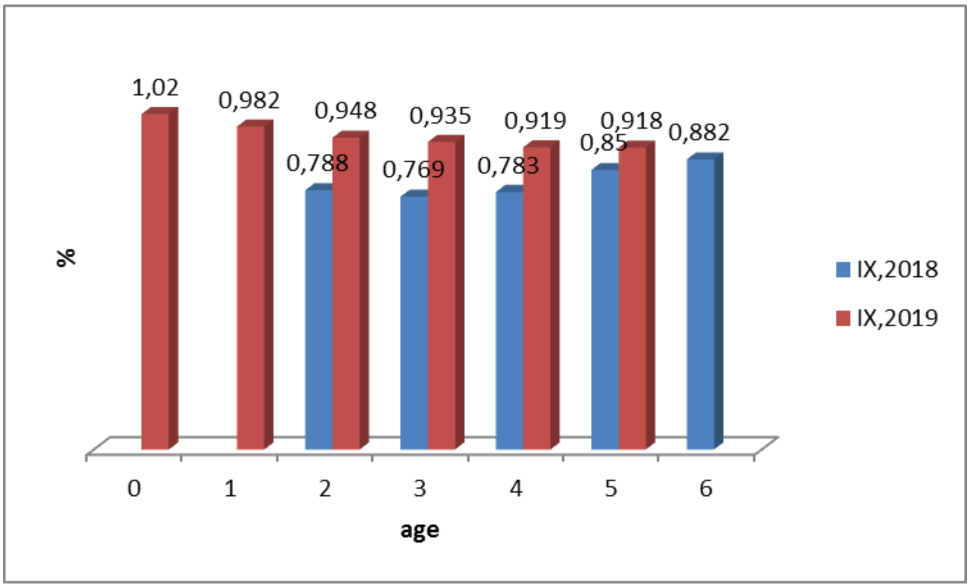

Fig. 3.4.3. Condition factor by age groups in September 2018 and 2019
Note: For September, 2018 no comparative analysis data were available.

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In October, the species reached a good level of K, the condition factor showed a relatively good value in 2018 and 2019 with averages 0.839 and 0.844, respectively.

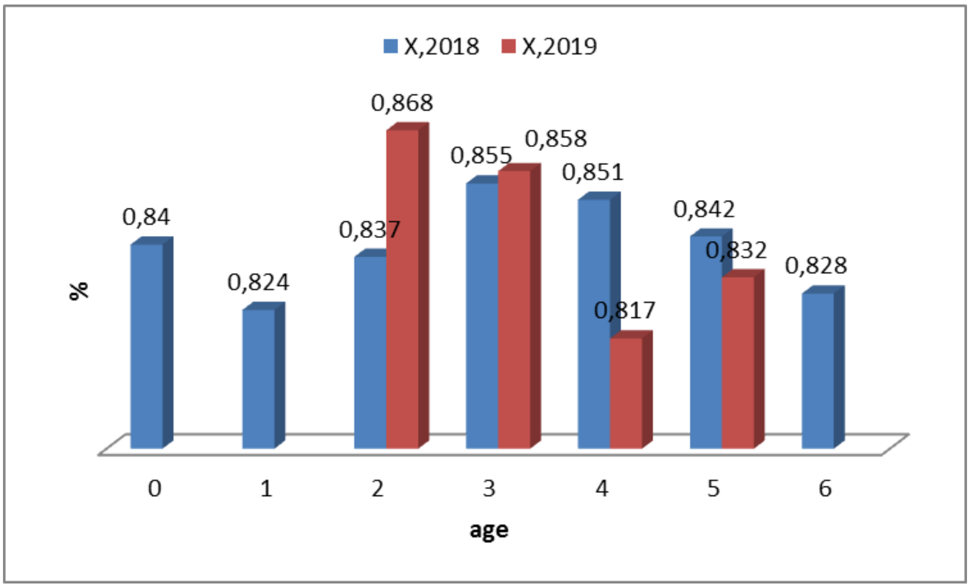
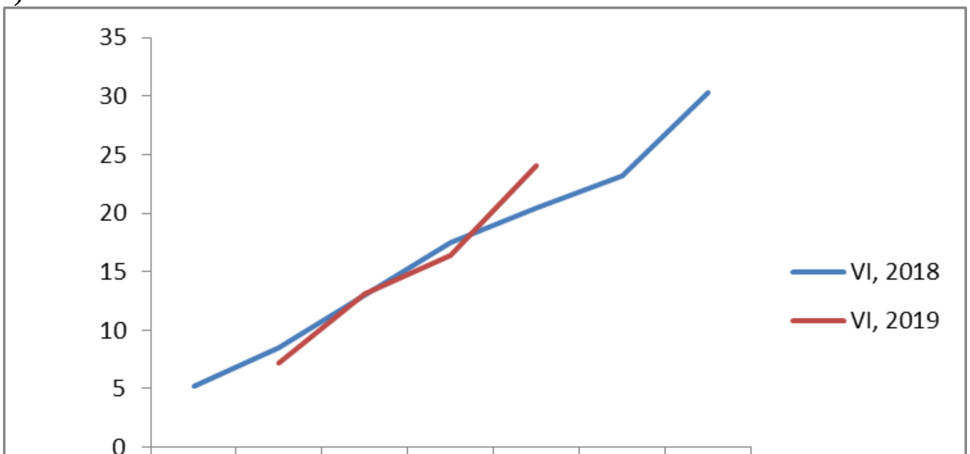


Fig. 3.4.4 Fig. 41. Condition factor by age groups in October, 2018 and 2019
Note: For October, 2017 no comparative analysis data were available.

II.3.5 Weight structure

In June, the weight structure referred to the average multiannual data showed a similar picture (Fig. 3.5.1).



	0	1	2	3	4	5	6
VI, 2018	5,25	8,47	12,95	17,45	20,48	23,15	30,3
VI, 2019		7,15	13,12	16,42	24,02		

Fig. 3.5.1 Variation of average weights by age groups in June, 2018 and 2019
Note: For July, 2017 no comparative analysis data were available.

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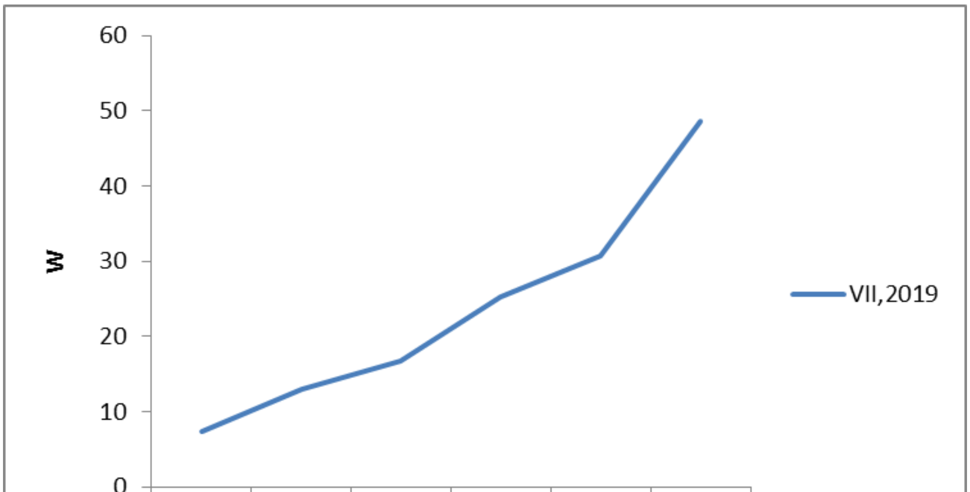
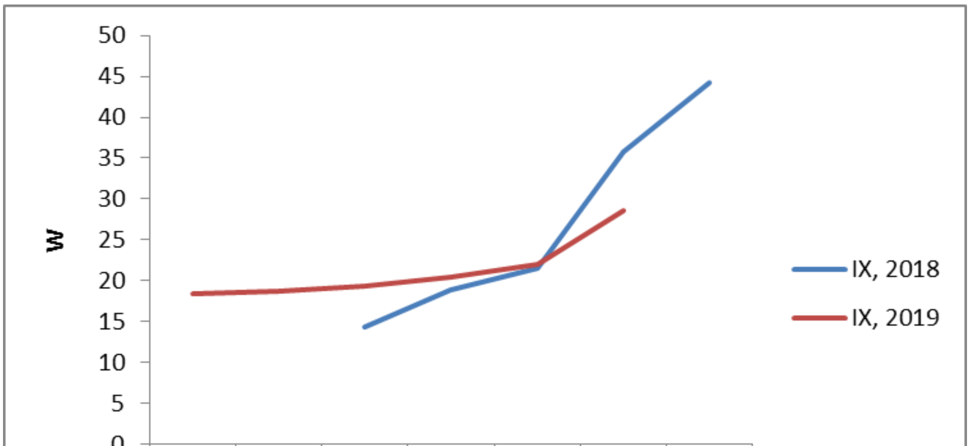


	0	1	2	3	4	5
VII,2019	7,33	12,96	16,66	25,31	30,69	48,6

Fig. 3.5.2 Variation of average weights by age groups in July 2019
Note: For July, 2017 and 2018 no comparative analysis data were available.

After the completion of the breeding process during the autumn migration, horse mackerel continued its increased nurture and accumulation of reserve fats in preparation for the winter period. In September 2018 and 2019, the weight increase of the age of 2+ had a good rate and amounted in the optimum range 14.28-19.35g. In October, the weight increase of age 2+ , lagged behind the norm with a deviation of 7.1 g.



	0	1	2	3	4	5	6
IX, 2018			14,28	18,88	21,54	35,75	44,22
IX, 2019	18,39	18,69	19,35	20,47	22,06	28,55	

Fig. 3.5.3 Variation of average weights by age groups in September 2018 and 2019
Note: For September, 2017 no comparative analysis data were available.

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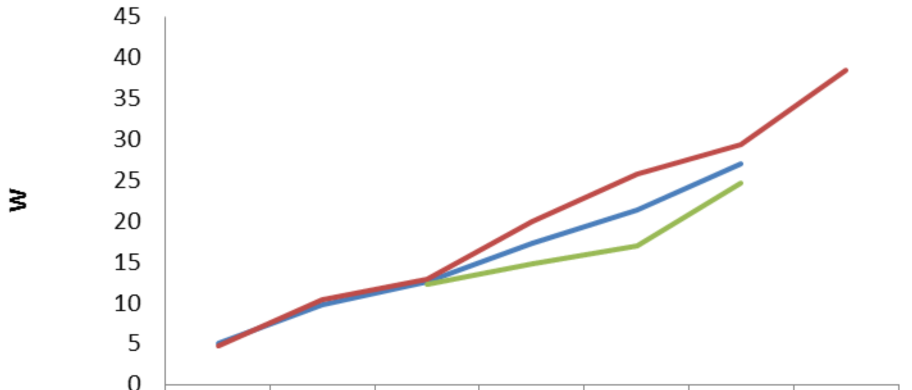
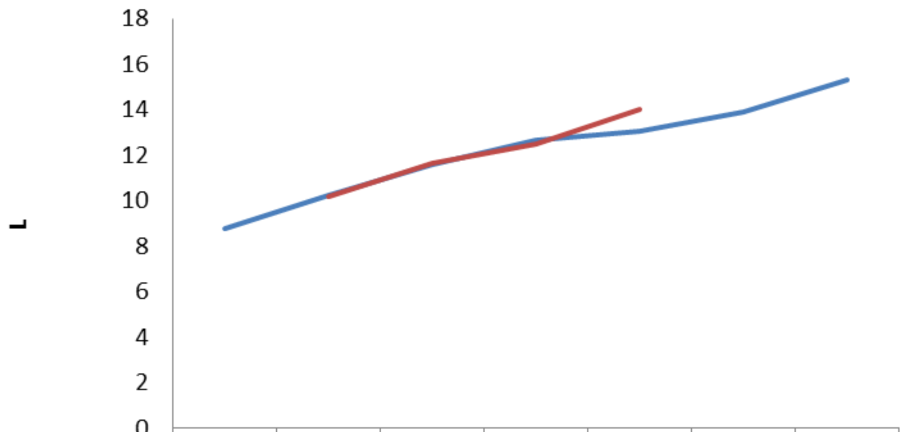


	0	1	2	3	4	5	6
X, 2017	5,11	9,78	12,535	17,35	21,38	27,005	
X, 2018	4,77	10,32	12,82	19,99	25,8	29,34	38,41
X, 2019			12,25	14,71	16,96	24,67	

Fig. 3.5.4 Variation of average weights by age groups in October 2017 and 2019

II.3.6 Size structure

In June of the reporting period, the average linear dimensions of age 1+ showed values within the average multiannual data of 10.17-10.21 cm. This was an indication of a good increase in replenishment.



	0	1	2	3	4	5	6
VI, 2018	8,75	10,21	11,6	12,67	13,07	13,9	15,3
VI, 2019		10,17	11,64	12,48	14		

Fig. 3.6. 1 Variation of average lengths by age groups in June, 2018 and 2019
Note: For June, 2017 no comparative analysis data were available.

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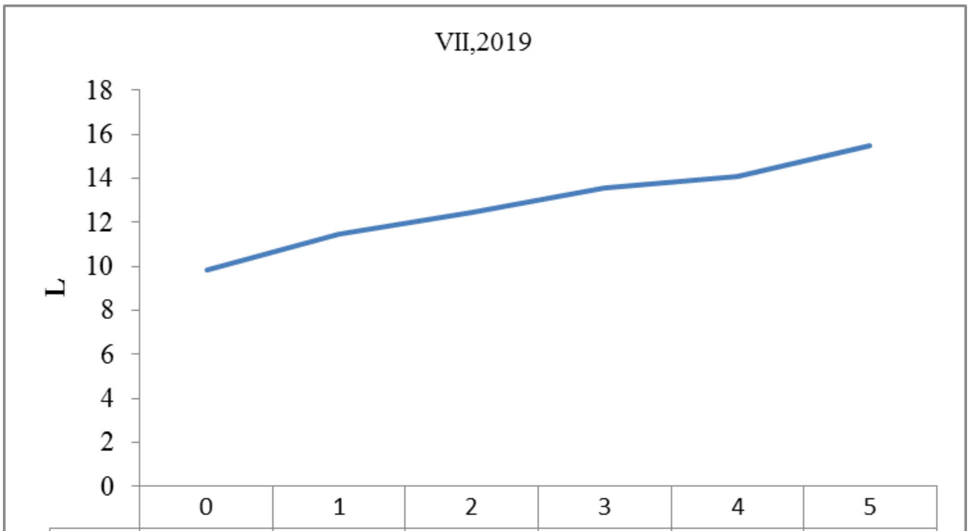
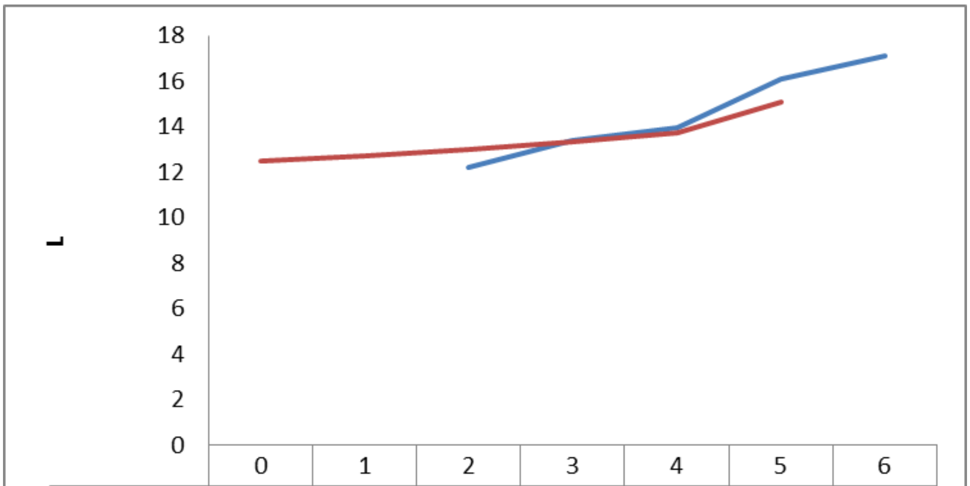


	0	1	2	3	4	5
Series1	9,8333333	11,441176	12,473214	13,573864	14,069231	15,5

Fig. 3.6. 2 Variation of the average lengths by age groups in July 2019
Note: For July, 2017 and 2018 no comparative analysis data were available.

The rise in the autumn months increased in relation to further nurture.



	0	1	2	3	4	5	6
IX, 2018			12,2	13,41	13,93	16,12	17,08
IX, 2019	12,5	12,73	12,98	13,31	13,72	15,05	

Fig. 3.6.3 Variation of average lengths by age groups in September, 2019
Note: For September, 2017 no comparative analysis data were available.

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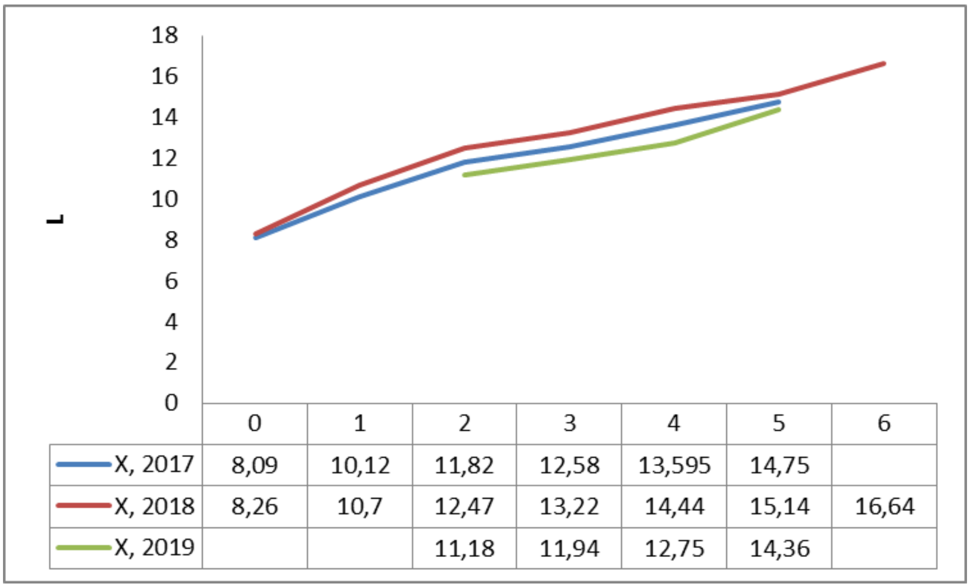

	0	1	2	3	4	5	6
X, 2017	8,09	10,12	11,82	12,58	13,595	14,75	
X, 2018	8,26	10,7	12,47	13,22	14,44	15,14	16,64
X, 2019			11,18	11,94	12,75	14,36	

Fig. 3.6.4 Varying average lengths by age groups in October 2017 and 2019

II.3.7 Length- weight relationship

During the period 2018-2019, the growth of horse mackerel was algometric (n ≠ 3), i.e. not the same in terms of linear and weight growth.

The interrelationship between the size (L) and the weight (W) of the specimens studied is described by the equation:

$$\text{for } 2018: W = 0.065 \cdot L^{3.1169}$$
$$\text{for } 2019: W = 0.078 \cdot L^{3.2412}$$

II.3.8 Sex ratio

Males (♂) prevailed by 64%, followed by female (♀) specimens with 36% in 2018. Females (♀) prevailed by 56%, followed by male (♂) specimens with 44% in 2019 (Fig. 3.8.1).

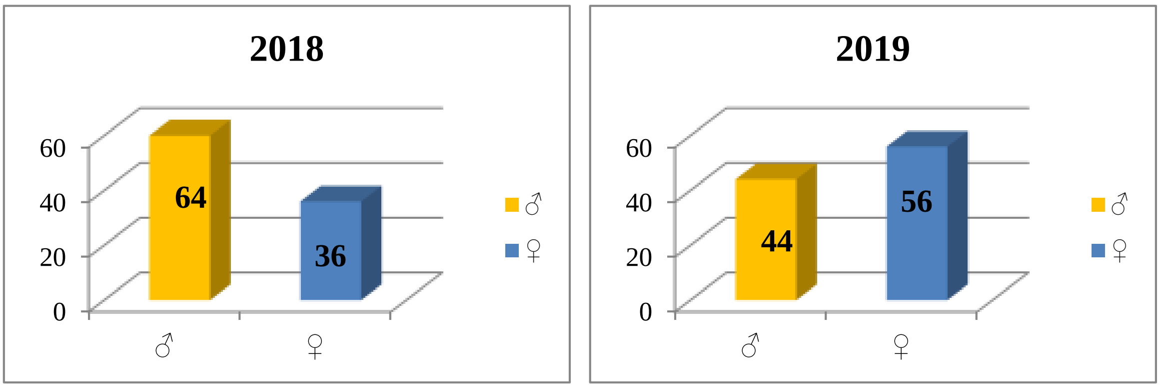

Fig. 3.8.1 Sex ratio of horse mackerel in 2018 and 2019

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II.3.9 Fertility

The dependence between weight and fertility of horse mackerel during the spring-summer season of 2019 showed a relatively strong dependence (R^2 = 0.9) on the gonadosomatic index and the weight of the gland (ovarias).

II.3.10 Sexual maturity

All investigated specimens showed VI-VII degree of maturation and only 10% were in III-IV degree. Horse mackerel is a summer-breeding species. The beginning of the active breed of horse mackerel was registered in June-August. In June, there was a mass of mature sexual products in more than 40% of the female species.

II.3.11 Catch numbers and biomass by age and length

II.3.11.1 Catch numbers and biomass by age and length in 2017

Monthly catches (in tons) 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^{-3}) matrix and biomass (kg) of horse mackerel for selected months

Catch-at-age(10^{-3})			
Age groups	**October**	**November**	**December**
0	0.085	0.080	0.107
1	0.138	0.239	0.095
2	0.201	0.995	0.071
3	0.480	0.863	0.033
4	0.427	0.013	0.004
5	0.042	0.066	
∑	1.373	2.256	0.310
Biomass (kg)			
Age groups	**October**	**November**	**December**
0	761.868	535.379	528.641
1	1444.803	2296.697	1107.651
2	2980.395	12589.129	1293.794
3	9231.934	13974.726	900.177
4	8782.003	262.340	110.023
5	1156.528	1689.397	
∑	24357.530	31347.669	3940.286

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Table 3.11.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of horse mackerel for selected months

Catch-at-length (millions)			
Length group (cm)	**October**	**November**	**December**
7.0			66.847
7.5			76.274
8.0			38.566
8.5		1.760	29.567
9.0		4.399	32.567
9.5	0.464	3.079	25.710
10.0	12.052	11.877	3.428
10.5	6.721	7.918	2.571
11.0	10.198	18.036	
11.5	6.258	15.396	
12.0	13.443	16.716	
12.5	34.302	32.552	
13.0	24.336	48.828	
13.5	15.297	18.475	
14.0	9.734	20.235	
14.5	2.549	5.279	
15.0	1.391	1.760	
15.5	0.695	3.519	
16.0	0.464	8.358	
∑	137.903	218.186	275.531
Biomass (kg)			
Length group (cm)	**October**	**November**	**December**
7.0			467.931
7.5			305.098
8.0			159.084
8.5		8.358	152.763
9.0		24.194	195.400
9.5	3.639	16.320	171.403
10.0	107.799	93.829	27.425
10.5	69.169	71.262	22.711
11.0	125.842	173.141	

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11.5	84.167	190.605	
12.0	212.618	238.851	
12.5	623.759	544.752	
13.0	488.427	862.137	
13.5	337.210	388.575	
14.0	250.172	445.507	
14.5	59.912	115.603	
15.0	41.719	52.787	
15.5	22.528	120.002	
16.0	16.178	312.586	
∑	2443.137	3658.509	1501.814

II.3.11.2 Catch numbers and biomass by age and length in 2018

Table 3.11.2.1 Catch-at-age (10^{-3}) matrix and biomass (kg) of horse mackerel for selected months

Catch-at-age(10^{-3})					
Age groups	**June**	**September**	**October**	**November**	**December**
0	0.013492		0.019155	0.011757	
1	0.01574		0.024628	0.133248	
2	0.058464	0.322836	0.197023	0.219467	0.059789
3	0.150656	0.440537	0.28094	0.344876	0.472333
4	0.266459	1.106386	0.218002	0.254738	0.843024
5	0.12817	0.090798	0.130437	0.031352	0.011958
6	0.044972	0.077346	0.021891		
Biomass (kg)					
Age groups	**June**	**September**	**October**	**November**	**December**
0	70.83093		91.36645	107.2288	
1	133.2705		254.1462	1567.755	
2	757.3383	4608.551	2525.698	3416.665	636.4962
3	2629.095	8317.135	5617.14	6025.603	9175.015
4	5457.677	23826.61	5624.544	5183.143	16740.77
5	2966.837	3245.761	3827.618	700.5693	361.7232
6	1362.451	3420.046	840.7871		
∑	13377.5	43418.1	18781.3	17000.96	26914

Table 3.11.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of horse mackerel for selected months

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Catch-at-length (millions)

Length group (cm)	June	September	October	November	December
7.0			1.183084486		
7.5			2.366168971		
8.0	1.157564243		9.464675885		
8.5	4.630256972		7.098506914		
9.0	8.1029497		3.549253457		
9.5	1.157564243		3.549253457	1.100616166	
10.0	6.945385457	0.80488404	8.281591399	2.201232332	
10.5	11.57564243		18.92935177	3.301848498	2.050916
11.0	10.41807819	4.024420198	17.74626728	12.10677782	6.152749
11.5	16.2058994	5.634188277	24.8447742	14.30801016	7.178208
12.0	64.8235976	18.51233291	67.43581568	15.40862632	17.43279
12.5	130.8047594	74.85421568	125.4069555	47.32649513	19.48371
13.0	147.0106589	119.1228379	205.8567005	45.1252628	38.96741
13.5	91.44757519	54.73211469	146.7024762	59.43327296	71.78208
14.0	83.34462549	50.70769449	105.2945192	23.11293948	53.32383
14.5	50.93282669	49.09792642	145.5193917	28.61602031	19.48371
15.0	42.82987699	46.6832743	147.8855607	16.50924249	1.025458
15.5	19.67859213	20.92698503	57.9711398	11.00616166	1.025458
16.0	6.945385457	18.51233291	33.1263656		
16.5		13.68302867	10.64776037		
17.0		3.219536158	9.464675885		
17.5		3.219536158	4.732337943		
18.0		4.024420198			

Biomass (kg)

Length group (cm)	June	September	October	November	December
7.0			0.041408		
7.5			0.189294		
8.0	0.046303		3.123343		
8.5	0.219937		2.200537		
9.0	0.463026		0.638866		
9.5	0.061351		0.638866	0.066037	
10.0	0.574152	0.096586	1.490686	0.176099	

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10.5	1.052331		28.58332	0.308173	0.174327902
11.0	1.125152	0.321954	25.73209	1.210678	0.662446027
	2.013004	1.054398	69.56537	2.003121	0.892148674
12.0	9.355434	2.495141	552.9737	2.520411	2.440590626
12.5	18.87793	10.94642	2095.55	7.741262	3.408623211
13.0	27.68199	19.89673	6964.132	7.381204	7.219226054
13.5	19.30586	10.30252	3789.325	9.721585	14.10005089
14.0	19.79551	11.26033	2269.097	3.780617	12.01837065
14.5	13.24138	11.87204	4628.972	4.680763	4.624816691
15.0	12.0734	11.28817	5313.528	2.70044	0.29225560
15.5	6.137406	6.414926	877.1033	1.800294	0.328146639
16.0	2.516545	6.406877	308.0752		
16.5		5.336381	36.52182		
17.0		1.400498	30.66555		
17.5		1.577573	8.612855		
18.0		2.068552			

II.3.11.3 Catch numbers and biomass by age and length in 2019

Table 3.11.1 Catch-at-age (10^{-3}) matrix and biomass (kg) of horse mackerel for selected months

Catch-at-Age *10^{-3} (in thousands)						
Age groups	**July**	**August**	**September**	**October**	**November**	**December**
0	0.512690114	3.697709	12.082121	26.5790012	18.6999961	33.8425495
1	1.512435836	10.90824	35.642258	78.4080536	55.1649884	99.8355211
2	3.87081036	27.9177	91.220016	200.671459	141.18497	255.511249
3	6.664971482	48.07021	157.06758	345.527016	243.099949	439.953144
4	5.690860265	41.04456	134.11155	295.026914	207.569956	375.6523
5	0.974111217	7.025646	22.956031	50.5001023	35.5299925	64.3008441
6	0.17944154	1.294198	4.2287425	9.30265043	6.54499862	11.8448923
∑	19.41	139.96	457.31	1006.015	707.794851	1280.9405
Biomass (kg)						
Age groups	**July**	**August**	**September**	**October**	**November**	**December**
0	6.658598731	48.024	156.92	345.1966383	242.86751	439.5325
1	19.22368186	138.648	453.03	996.5986274	701.1697	1268.951

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2	63.5451284	458.311	1497.51	3294.321462	2317.762	4194.598
3	121.3042539	874.891	2858.67	6288.683602	4424.4837	8007.264
4	125.1928225	902.936	2950.31	6490.275688	4566.3164	8263.948
5	30.05749018	216.786	708.34	1558.247461	1096.3249	1984.088
6	6.129684093	44.210	144.45	317.7765216	223.57573	404.619
∑	372.11	2683.81	8769.23	19291.1	13572.5	24563.0

Table 3.11.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of horse mackerel for selected months

Catch-at-length *10^{-3} (in thousands)						
Length groups (cm)	**July**	**August**	**September**	**October**	**November**	**December**
9.5	0.128173	0.924427134	3.020530345	6.644750308	4.674999018	8.460637382
10.0	0.28198	2.033739695	6.645166759	14.61845068	10.28499784	18.61340224
10.5	0.128173	0.924427134	3.020530345	6.644750308	4.674999018	8.460637382
11.0	0.435787	3.143052256	10.26980317	22.59215105	15.89499666	28.7661671
11.5	0.615228	4.437250244	14.49854566	31.89480148	22.43999528	40.61105943
12.0	1.256091	9.059385916	29.60119738	65.11855301	45.81499037	82.91424635
12.5	3.486293	25.14441805	82.15842538	180.7372084	127.1599733	230.1293368
13.0	4.588577	33.09449141	108.1349863	237.882061	167.3649648	302.8908183
13.5	3.229948	23.29556378	76.11736469	167.4477078	117.8099752	213.208062
14.0	2.230202	16.08503214	52.557228	115.6186554	81.34498291	147.2150905
14.5	1.204822	8.689615062	28.39298524	62.46065289	43.94499077	79.52999139
15.0	1.332994	9.614042196	31.41351559	69.1054032	48.61998978	87.99062878
15.5	0.384518	2.773281403	9.061591035	19.93425092	14.02499705	25.38191215
16.0	0.102538	0.739541707	2.416424276	5.315800246	3.739999214	6.768509906
∑	19.41	139.96	457.31	1006.015	707.794851	1280.9405
Biomass (kg)						
Length groups (cm)	**July**	**August**	**September**	**October**	**November**	**December**
9.5	0.852347	6.147440443	20.08652679	44.18758955	31.08874347	56.3
10.0	2.167483	15.63267913	51.07918182	112.3671575	79.05735005	143.1
10.5	1.096018	7.904879139	25.82889059	56.81999819	39.97643604	72.3
11.0	4.457734	32.15080537	105.0515283	231.0988784	162.59257	294.3
11.5	8.575896	61.85249513	202.1006648	444.5935983	312.7995093	566.1

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12.0	19.59325	141.3136581	461.736979	1015.757693	714.6493089	1293.3
12.5	59.10469	426.2846332	1392.868753	3064.119218	2155.800244	3901.5
13.0	64.28774	463.6666772	1515.013154	3332.820059	2344.848155	4243.6
13.5	69.28965	499.7423225	1632.888947	3592.130551	2527.289367	4573.8
14.0	53.71134	387.3858305	1265.768402	2784.515968	1959.081803	3545.5
14.5	33.8097	243.8479063	796.7637178	1752.770327	1233.183969	2231.8
15.0	36.91404	266.2375789	869.9211177	1913.70652	1346.412685	2436.7
15.5	14.5604	105.0149225	343.1322472	754.8436349	531.0798884	961.1
16.0	3.691369	26.62350147	86.99127393	191.3688089	134.6399717	243.7
Σ	372.11	2683.81	8769.23	19291.1	13572.5	24563.0

II.3.12 Coefficient of variation of length

The coefficient of variation (Table 3.12.1) showed a relatively low degree of standard deviation around the average. The variability in the range of 0.07-0.14 could be rated as low. This means that the random sample of horse mackerel in the tested months was conducted according to the variation statistics and correctly reflected the general condition at that time of the year.

Table 3.12.1 Length coefficient of variation in horse mackerel samples

coefficient of variation (CV)	June	July	August	September	October	November	December
1 **sample**	na	na	na	CV = 0.09	CV = 0.07	CV = 0.13	CV = 0.12
2 **sample**				CV = 0.07	CV = 0.12	CV = 0.11	CV = 0.14

III. Conclusions and recommendations

• The age structure was composed of 7 age groups.
• The linear and weight dimensions reached high values. The values of K coefficient showed good physiological status during the spring-summer period of 2018-2019. In the autumn months, a similar picture was recorded when comparing the two periods.
• The dynamics of the gomadosomaticic index during propagation and spawning showed a characteristic rapid maturation of the sexual products, and the correlation between weight and fertility of horse mackerel during the spring-summer season showed a relatively strong dependence on the gonadosomatic index and the weight of the gland.
• The main age groups were three and four-year-olds, which were high-number generations.
• During the period 2018-2019, the growth of horse mackerel was allometric.
• In 2018, males prevailed by 64%, followed by female specimens with 36%. In 2019, females prevailed by 56%, followed by males with 44%.

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

III.1 Objectives

Several species, which are not targeted by the fishery, are also caught as bycatch. The role that these fish species as prey, competitors, predators, and herbivores make them potential key members of communities and key determinants on how other populations fare. One of the species caught as bycatch during several fisheries operations in the Bulgarian Black Sea waters was whiting. The whiting (*Merlangius merlangus euxinus*) is bento-pelagic or demersal fish belonging to the Gadidae family. In the Black Sea, whiting is one of the most abundant demersal fish and appears a key species of the ecosystem of the basin (Bradova and Prodanov, 2003; Popescu, 2010). Besides being an important resource to man, whiting is also an important part of the Black Sea ecosystem. As a large predator, whiting influences other fish and shellfish populations, notably the commercially important stocks of sprat, anchovy, horse mackerel and shrimp (Mazlum and Bilgin, 2014). Multiannual biological monitoring on the landings provides the so called "Fishery dependant" information. The aim of this study was to collect and analyze dynamics in length, weight and age distribution as well as to determine the condition of the whiting. Biological information on a given species collected each month, analyzed and compared to previous periods could be used for estimation of growth parameters. Bycatch and discarding are currently one of the most important topics in fisheries management, both from economic and environmental points of view. The omission of discard data from the stock assessment process may result in underestimation of fishing mortality and can lead to biased assessments, hampering achievement of sustainable resource use. Knowledge of the impacts of bycatch and discarding on the community and ecosystem levels becomes increasingly necessary in the context of the multispecies and ecosystem-based approaches to fisheries management. Collecting bycatch data is critical to effective fisheries management. Determination of growth parameters is an important part of studying the biology of fishes. Incorporation of these parameters into analytic models for fish stock assessment gives valuable insight into the levels of exploitation and directions for management. However, information on such species is also essential to assess the ecosystem condition and therefore manage fisheries properly.

III. 2 Sampling

III. 2.1.1 Geographic area coverage

Data of the present analysis were collected from the Bulgarian Black Sea waters.

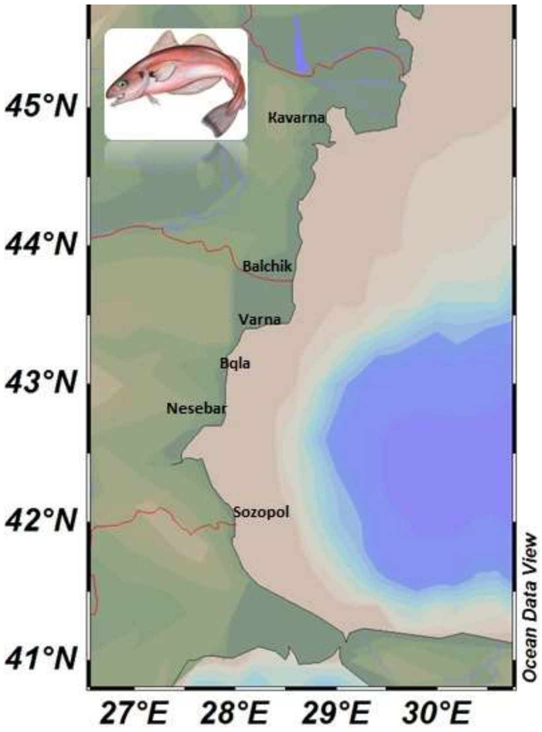


Fig. 2.1.1 Map of the ports for collection of samples of whiting during the period 2017-2019

In 2017, 3 samples were collected, containing 1857 specimens.
In 2018, 4 samples were collected, containing 650 specimens.
In 2019, 8 samples were collected, containing 838 specimens.

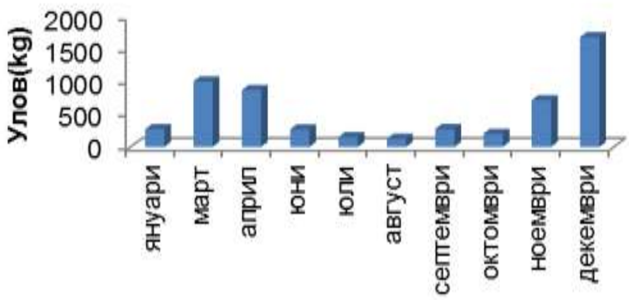
2017		2018		2019	
Date	Vessel	Date	Vessel	Date	Vessel
				10.03.2019	Burevestnik
				21.06.2019	ISHTAR
		17.07.2018	Niko	3.07.2019	ISHTAR
				18.08.2019	Biola
				27.09. 2019	Ciklama
		10.10.2018	Kaliakra	14.10. 2019	Ciklama
		12.10.2018	Irina		
		23.10.2018	Tesi		
1.11.2017	Haithabu			11.11.2019	ISHTAR
4.11.2017	Haithabu				
9.12.2017	Haithabu			5.12.2019	ISHTAR
3 samples with 1857 species		**4 samples with 650 species**		**8 samples with 838 species**	

IV. 2.1.3 Statistical analysis of data

Refer to the methodology used for sprat stock analysis.

III.3 Results

III. 3.1 Landings statistics in the period 2017-2019



Фиг. 3.1.1 Landings statistics for 2017

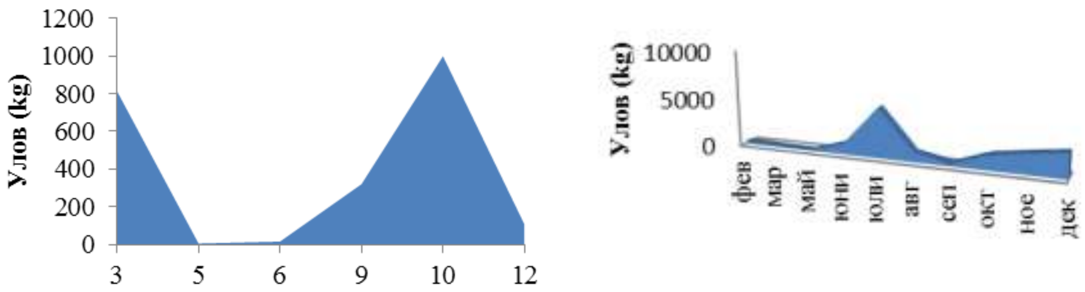


Fig. 3.1.2 Statistics of whiting landings in 2018 (left) and in 2019 (right)

From the collected statistics and graphical interpretations, it is evident that in 2017 the largest quantity and intensity of catches was recorded in December, 2018 - in October and 2019 - in July.

III. 3.2 Size structure in the period 2017-2019

III. 3.2.1 Analysis of the size structure for 2017

In the catches from the Bulgarian Black Sea water area in November 2017, the size composition was represented by individuals with a body length from 7.0 cm to 20.5 cm.

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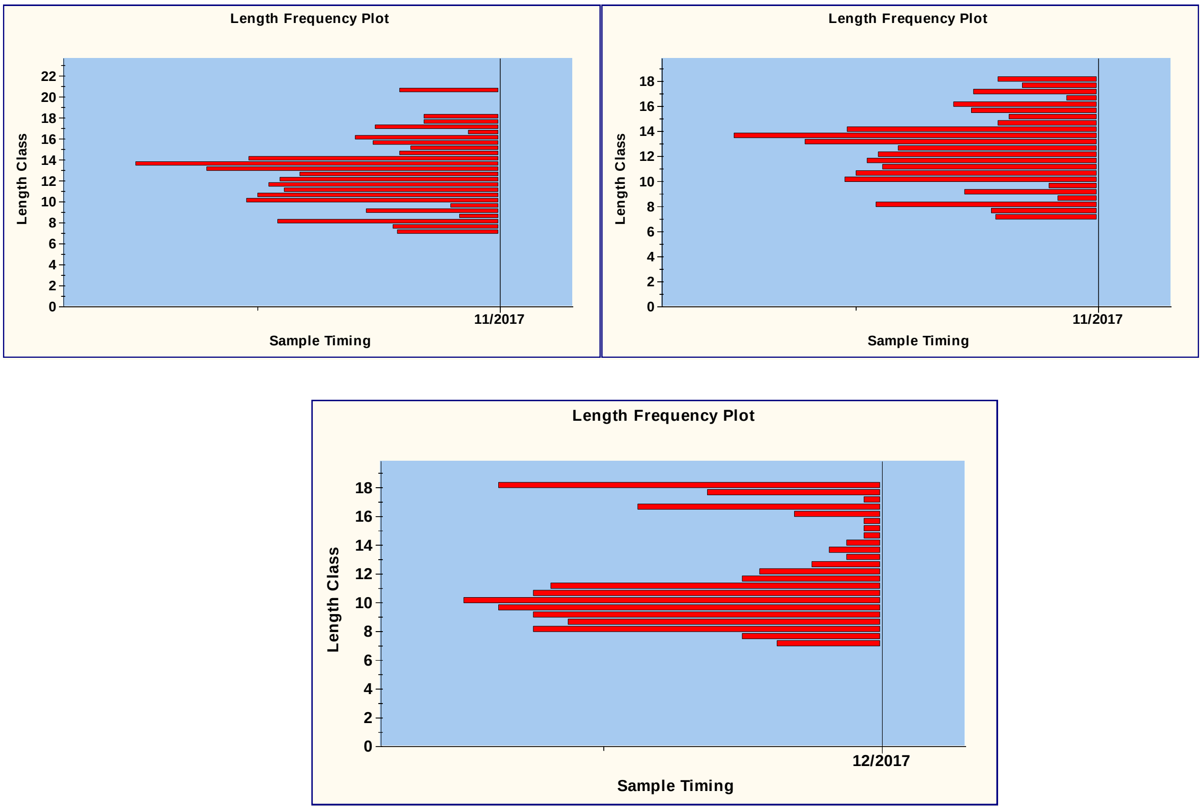

Fig. 3.2.1 Frequency of whiting length from landings in November- December 2017

III. 3.2.2 Analysis of the size structure for 2018

In the catches from the Bulgarian Black Sea water area in October 2018, the size composition was resented by individuals with a body length from 7.5 cm to 17.5 cm.

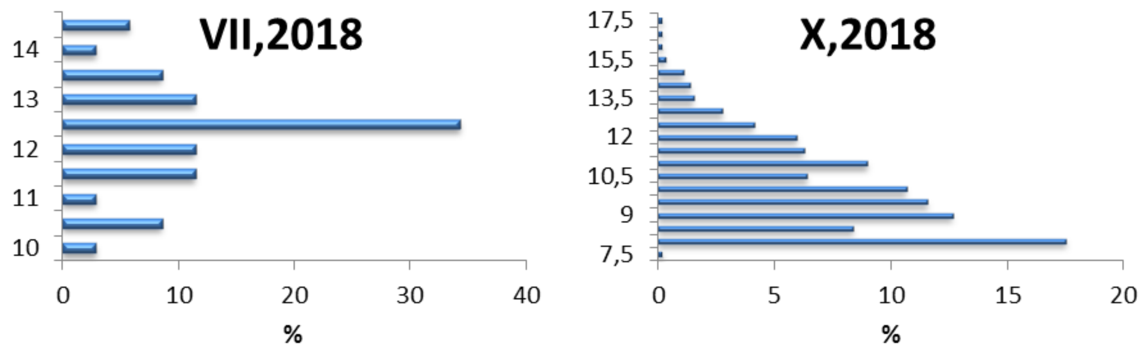

Fig. 3.2.2.1 Frequency of whiting length from landings in 2018

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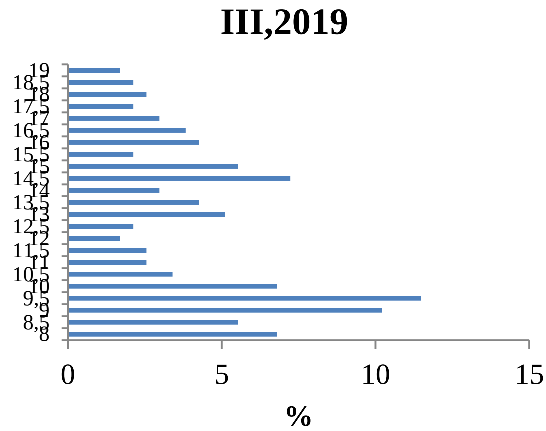
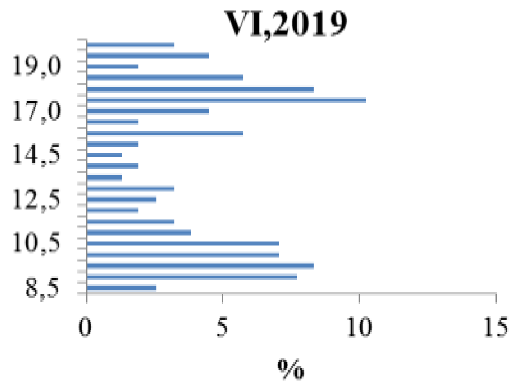
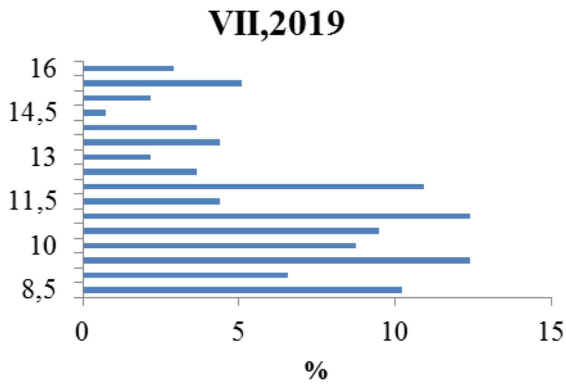
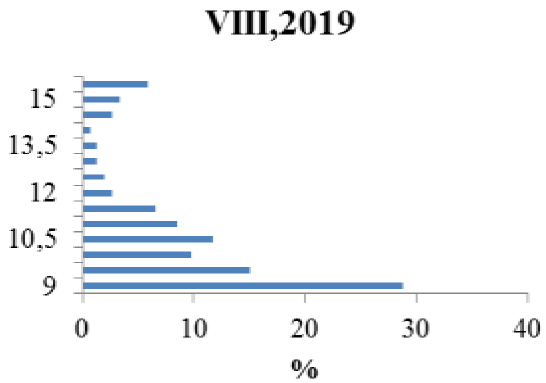
III. 3.2.3 Analysis of the size structure for 2019

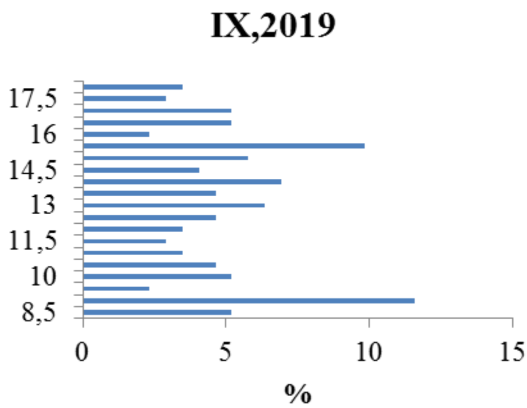
In the catches from the Bulgarian Black Sea water area in 2019, the size composition was represented by individuals with a body length from 8.0 cm to 20.0 cm.

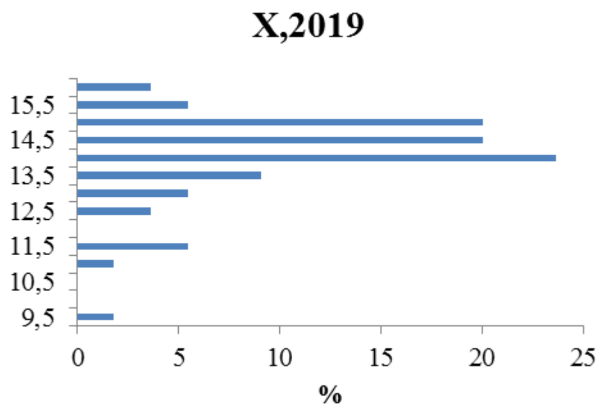












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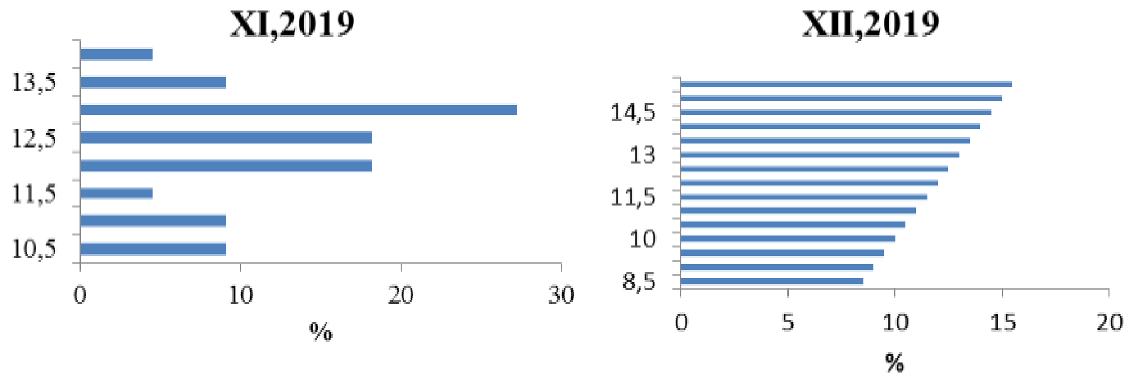
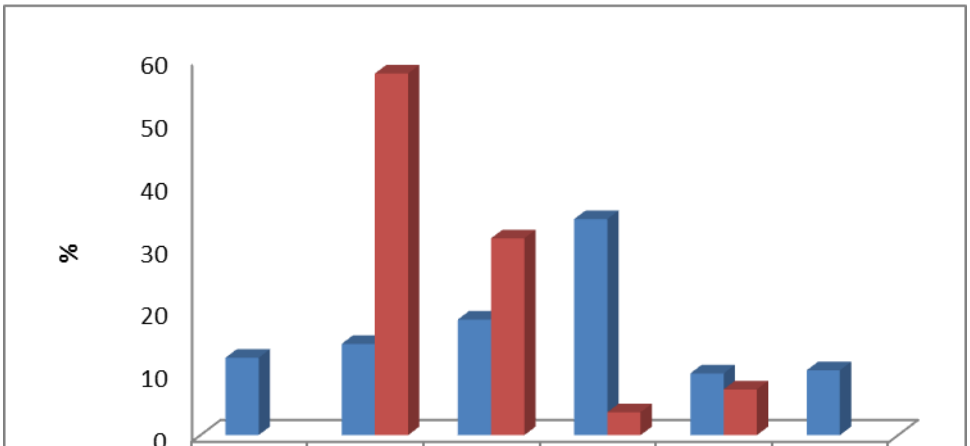


Fig. 3.2.3.1 Frequency of whiting length from landings in 2019

III.3.3 Age structure of whiting

The age structure of whiting during the period 2017-2019 was characterized by 7 age classes. The one-year-olds had the highest participation rate in July 2019, total of 57.66%. Three and four-year-old fish had the lowest percentage of participation. With a relatively high participation rate in July 2018 was the three-year-old fish (34.45%). The winter months (November-December) of the period 2017-2019 were characterized by the absence in the catches of the most senior age group - six-year olds.



	0	1	2	3	4	5
VII 2018	12,34	14,56	18,45	34,45	9,86	10,34
VII 2019		57,66	31,39	3,65	7,3	

Fig. 3.3.1 Variation of the percentage of whiting per age group in July 2018 and 2019
Note: For July 2017, no comparative analysis data were available.

The age structure of whiting in October 2018 and 2019 was represented by a significant participation of the three-year-old fish. In October 2019 - 38.19% and 29-37% in 2018. The senior age classes (six years) were present with a small percentage in the catches - 0.46% in

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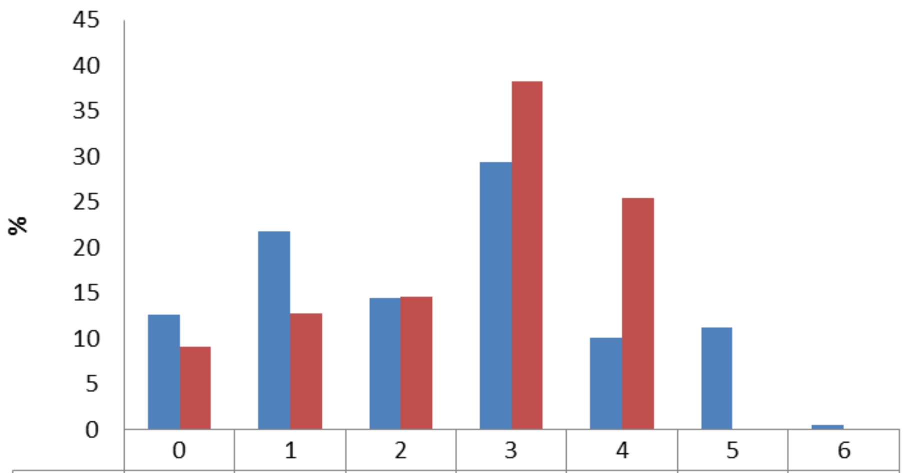
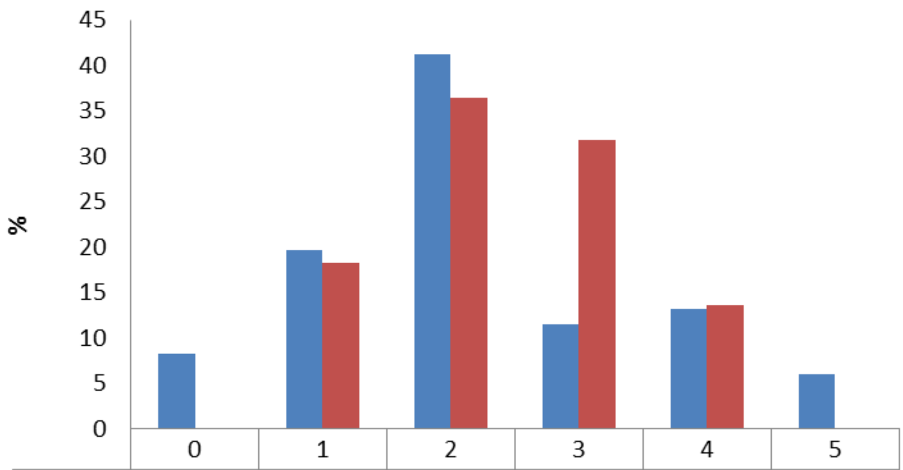
2018 and completely absent in 2019. In November, there was an increased presence of fish aged 2+, which reached 36.36% and 41.27%. In October and November, the new generation of zero-year fish was presented in the catches in the range of 8.31%-9.09%-12.63%. In December of the research period, the filling (0+) was well represented in the catches.



	0	1	2	3	4	5	6
X 2018	12,63	21,76	14,46	29,37	10,05	11,27	0,46
X 2019	9,09	12,72	14,54	38,19	25,45		

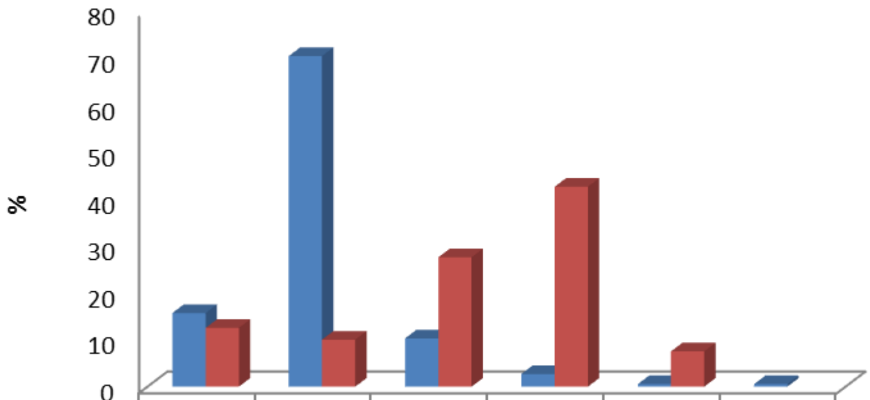
Fig. 3.3.2 Variation of the percentage of whiting per age group in October 2018 and 2019
Note: For October 2017, no comparative analysis data were available.

One and two-year-old fish participated with a high percentage in the catches from November and December of the period 2017-2019.



	0	1	2	3	4	5
XI 2017	8,31	19,68	41,27	11,48	13,22	6,04
XI 2019		18,29	36,36	31,82	13,63	

Fig. 3.3.3. Variation of the percentage of whiting per age groups in November 2017and 2019
Note: For November, 2018 no comparative analysis data were available.



	0	1	2	3	4	5
XII 2017	15,67	70,27	10,27	2,7	0,54	0,541
XII 2019	12,5	10	27,5	42,5	7,5	

Fig. 3.3.4 Variation of the percentage of whiting by age groups in December 2017 and 2019
Note: For December 2018, no comparative analysis data were available.

III.3.4 Condition factor

The average values of the Fulton's condition factor of whiting during the research period ranged widely. The highest averages of K in July belong to 1+ and 2+ age fish. The values of the Fulton's condition facor were the highest in November 2017 and 2019. The lowest Fulton's condition factor was registered for individuals of age 1+ (1.08) in November 2019.

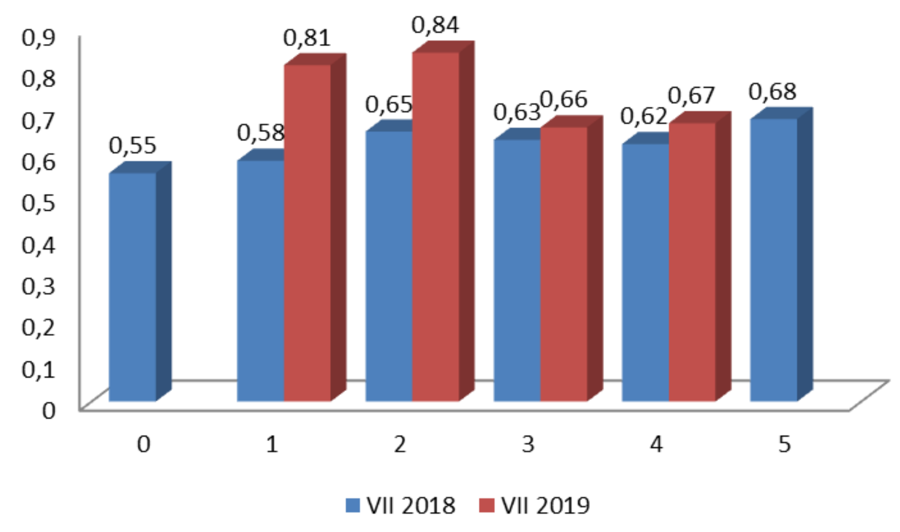


Fig. 3.4.1 Condition factor by age groups in July 2018 and 2019
Note: For July, 2017 there was no comparative analysis data available.

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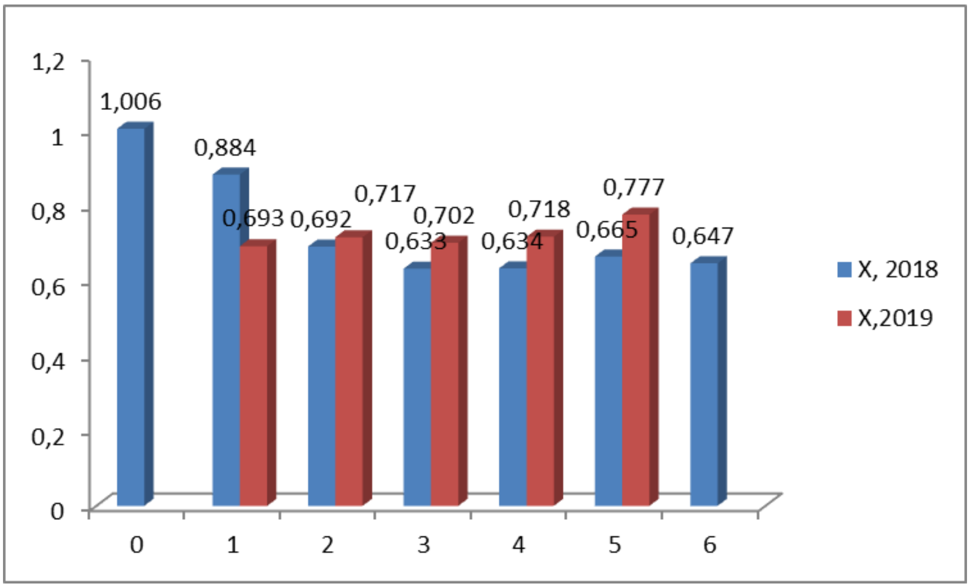

Fig. 3.4.2 Condition factor by age groups in October 2018 and 2019
Note: For October, 2017 no comparative analysis data were available.

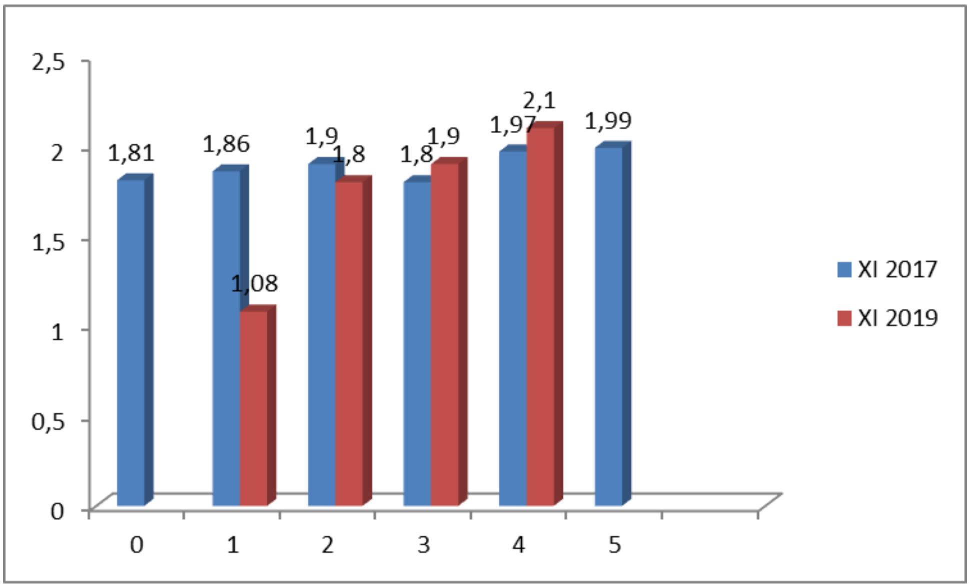

Fig. 3.4.3 Condition factor by age groups in November 2017 and 2019
Note: For November, 2018 no comparative analysis data were available.

III.3.5 Weight structure of whiting

In July, the weight increase relative to the average annual data showed varying values.

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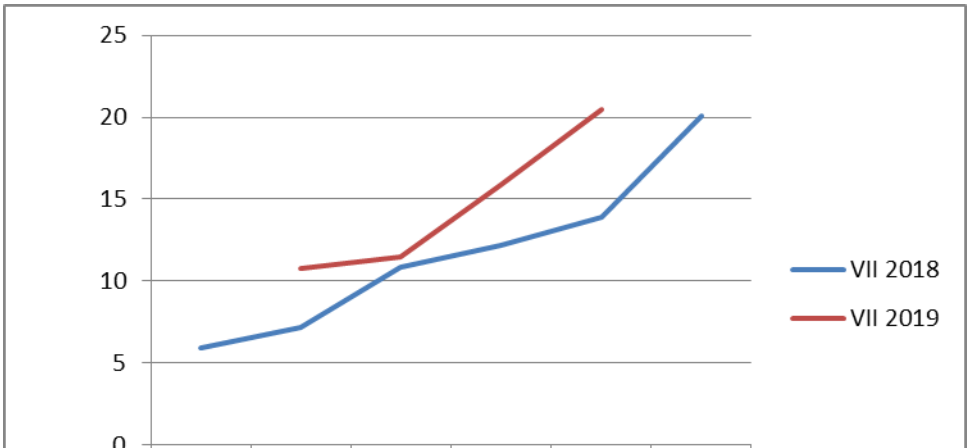
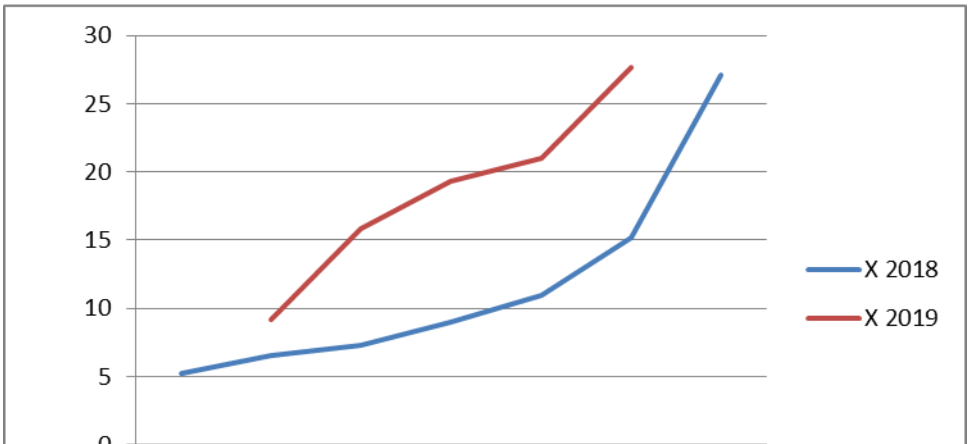


	0	1	2	3	4	5
VII 2018	5,94	7,19	10,87	12,17	13,88	20,05
VII 2019		10,79	11,45	15,84	20,49	

Fig. 3.5.1 Variation of the average weights by age groups in July 2018 and 2019

In October, 2018 at age 1+ the weight increase was below the norm with 2.65g, at 2+ – with 8.58 g, and for age classes 3+, 4+ and 5+ – with 10-12.0 g.
During that period, despite the active nurture of the species, the weight increase was not restored in its previous traditional values.



	0	1	2	3	4	5	6
X 2018	5,22	6,55	7,27	8,97	10,97	15,16	27,13
X 2019		9,2	15,85	19,34	20,98	27,62	

Fig. 3.5.2 Variation of the average weights by age groups in October 2018 and 2019

III. 3.6 Size structure

In July of the reporting period, the average linear dimensions of age 3+ and 4+ showed values within the average multiannual data of 10.4-11.0 cm.

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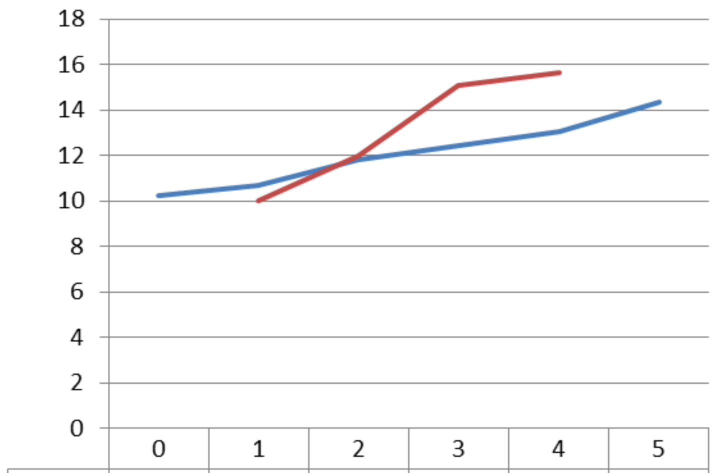
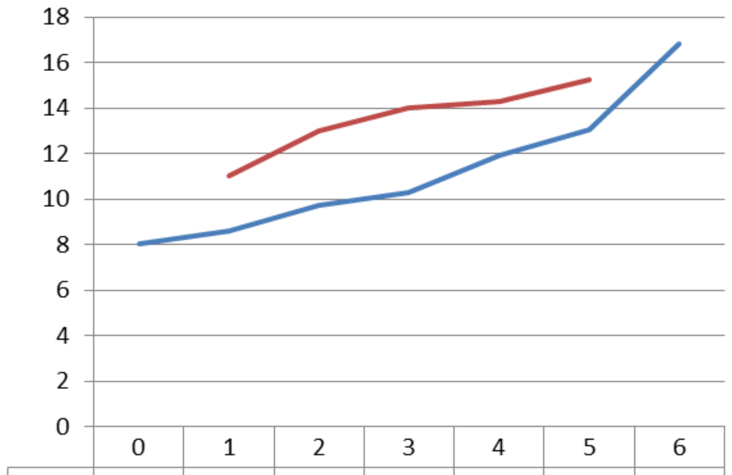


	0	1	2	3	4	5
VII 2018	10,25	10,67	11,83	12,43	13,07	14,33
VII 2019		10,01	11,98	15,1	15,65	

Fig. 3.6.1 Variation of the average lengths by age groups in 2018 and 2019

The rate of linear increase in October 2018 accounted for a reduction in values. In October 2018, the average weights were 2.0-2.5 g lower at ages 1+, 3+; for 4 and 2 year old, the annual lags were 3.7 g.



	0	1	2	3	4	5	6
X 2018	8,03	8,58	9,71	10,3	11,95	13,04	16,83
X 2019		11	13	14	14,28	15,25	

Fig. 3.6.2 Variation of the average lengths by age groups in October 2018 and 2019

III.3.7 Length- weight relationship

It follows from the analysis made that the increase of the whiting was allometric in the period 2017-2019. The interrelation between the size (L) and the weight (W) of the specimens sampled is described by the equation:

$$W = 0.0562*L^{2.1704} \text{ -2018}$$
$$W = 0.0452*L^{2.371} \text{ - 2019}$$

III.3.8 Sex ratio

In 2017-2019, male (♂) fish showed greater participation in the catches than female (♀) specimens.

Fig. 3.8.1 Gender ratio of whiting in the period 2017-2019

III.3.9 Fertility

During the period considered, the whiting showed that the GSI was heavily dependent on the weight of the gonads, which was associated with the high percentage of maturation of females in late spring and summer and the breeding process of the whiting. In total, the dynamics of the GSI was extremely high, which testified to a very rapid process of maturation of the

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gonads, simultaneously with the active nurture, before the inclusion of the species in the breeding process.

III.3.10 Sexual maturity

In 2019, an active ripening of the sex products was observed and in excess of 80% as the degree of maturity was IV-VI.

III.3.11 Catch numbers and biomass by age and length

III.3.11.1 Catch numbers and biomass by age and length for 2017

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

Table 3.11.1 Catch-at-age (10^{-3}) matrix and biomass (kg) of whiting for selected months

Catch-at-age(10^{-3})		
Age groups	**November**	**December**
0	4.157	38.862
1	9.839	174.210
2	20.634	25.462
3	5.742	6.700
4	6.609	1.340
5	3.020	1.340
∑	50.000	247.915
Biomass (kg)		
Age groups	**November**	**December**
0	12557.496	103755.666
1	66811.330	1011659.621
2	228653.478	306007.185
3	137388.927	142182.450
4	176977.857	52129.098
5	96419.511	66065.926
∑	718808.599	1681799.946

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Table 3.11.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of whiting for selected months

Catch-at-length (millions)		
TL,cm	**November**	**December**
7	1.890	3.090
7.5	1.972	4.120
8	4.109	10.300
8.5	0.740	9.270
9	2.465	10.300
9.5	0.904	11.330
10	4.684	12.360
10.5	4.479	10.300
11	3.985	9.785
11.5	4.273	4.120
12	4.068	3.605
12.5	3.698	2.060
13	5.424	1.030
13.5	6.738	
14	4.643	1.545
14.5	1.849	1.030
15	1.643	
15.5	2.342	
16	2.671	
16.5	0.575	
17	2.301	0.515
18	1.397	0.515
20.5	1.849	
∑	68.698	95.274
Biomass (kg)		
TL,cm	**November**	**December**
7	0.0463	0.061
7.5	0.0588	0.102
8	0.0290	0.315
8.5	0.0323	0.320
9	0.1270	0.417
9.5	0.0543	0.619
10	0.3356	0.818
10.5	0.3746	0.652
11	0.3658	0.878

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11.5	0.4554	0.423
12	0.6183	0.431
12.5	0.5399	0.267
13	0.8479	0.160
13.5	1.1927	
14	0.8125	0.323
14.5	0.5048	0.224
15	0.4109	
15.5	0.6394	
16	0.8546	
16.5	0.2065	
17	0.9664	0.200
18	0.6985	0.254
20.5	1.1445	
∑	11.3157	6.463

III.3.11.2 Catch numbers and biomass by age and length in 2018

Table 3.11.2.1 Catch-at-age (10^{-3}) matrix and biomass (kg) of whiting for selected months

Catch-at-age (10^{-3})	
Age groups	**October**
0	0.014521
1	0.025018
2	0.01662
3	0.033765
4	0.011547
5	0.012946
6	0.000525
Biomass (kg)	
Age groups	**October**
0	75.77106
1	163.7887
2	120.8688
3	302.8879
4	126.6477
5	196.2847
6	14.24098
∑	1000.4

Table 3.11.2.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of whiting for selected months

Catch-at-length (millions)		
Length group (cm)	**July**	**October**
7.5		0.452106
8		51.99218
8.5		24.86583
9		37.52479
9.5		34.36005
10	0.995016	31.64741
10.5	2.985049	18.98845
11	0.995016	26.67425
11.5	3.980065	18.53634
12	3.980065	17.63213
12.5	11.94019	12.20686
13	3.980065	8.137907
13.5	2.985049	4.521059
14	0.995016	4.068953
14.5	1.990032	
15		3.164741
15.5		0.904212
16		0.452106
17		0.452106
17.5		0.452106
Biomass (kg)		
Length group (cm)	**July**	**October**
7.5		0.020797
8		2.703593
8.5		1.36762
9		2.176438
9.5		2.061603
10	0.053731	1.993787
10.5	0.19361	1.241483
11	0.085661	2.172821
11.5	0.395011	1.711673
12	0.420136	2.00509
12.5	1.522375	1.515007
13	0.521786	1.146993
13.5	0.452145	0.796159

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14	0.206685	0.768128
14.5	0.391867	
15		0.729247
15.5		0.254988
16		0.121616
17		0.121164
17.5		0.179486

III.3.11.3 Catch numbers and biomass by age and length in 2019

Table 3.11.3.1 Catch-at-age (10^{-3}) matrix and biomass (kg) of whiting for selected months

Catch-at-Age *10^{-3} (in thousands)					
Age groups	**March**	**June**	**July**	**August**	**September**
0	0.087269	2.891894	3.600791	2.01408875	0.739608194
1	0.86022	28.50581	35.49352	19.85316054	7.290423628
2	0.583453	19.33437	24.07386	13.46562193	4.944809069
3	0.149603	4.957532	6.172785	3.452723572	1.267899761
4	0.29422	9.749813	12.13981	6.790356357	2.493536197
5	0.114696	3.800774	4.732469	2.647088072	0.972056484
∑	2.09	69.24	86.21	48.22	17.71
Biomass (kg)					
Age groups	**March**	**June**	**July**	**August**	**September**
0	0.397505725	13.17248	16.40148	9.174106	3.36889
1	7.089897645	234.9438	292.5362	163.629	60.0874
2	7.736626268	256.375	319.2209	178.555	65.56847
3	3.992892955	132.3158	164.7507	92.15269	33.84006
4	9.764860824	323.5863	402.9079	225.365	82.75791
5	5.135361022	170.1747	211.8901	118.5199	43.52256
∑	34.12	1130.57	1407.71	787.40	289.15

Age groups	**October**	**November**	**December**
0	2.920812567	0.005251474	2.863742454
1	28.79086673	0.05176453	28.22831848
2	19.52771831	0.035109855	19.14616384
3	5.007107258	0.009002527	4.909272778
4	9.847310941	0.01770497	9.654903131
5	3.838782231	0.006901937	3.763775797
∑	69.93259804	0.125735294	68.56617647
Age groups	**October**	**November**	**December**
0	13.3042	0.02392	13.04425
1	237.2933	0.426641	232.6568

2	258.9388	0.465559	253.8793
3	133.639	0.240276	131.0278
4	326.8222	0.58761	320.4363
5	171.8765	0.309025	168.5182
∑	1141.874	2.053032	1119.563

Table 3.11.3.2 Catch-at-length (10^{-3}) matrix and biomass (kg) of whiting for selected months.

Catch-at-length *10^{-3} (in thousands)					
Length group (cm)	**March**	**June**	**July**	**August**	**September**
8	0.039894	1.322008517	1.646076	0.920726	0.338107
8.5	0.089762	2.974519163	3.703671	2.071634	0.76074
9	0.319154	10.57606814	13.16861	7.36581	2.704853
9.5	0.191991	6.362165988	7.921741	4.430995	1.627138
10	0.122176	4.048651083	5.041108	2.819724	1.035451
10.5	0.127163	4.213902148	5.246868	2.934815	1.077715
11	0.114696	3.800774486	4.732469	2.647088	0.972056
11.5	0.079788	2.644017034	3.292152	1.841453	0.676213
12	0.079788	2.644017034	3.292152	1.841453	0.676213
12.5	0.057348	1.900387243	2.366234	1.323544	0.486028
13	0.082282	2.726642566	3.395032	1.898998	0.697345
13.5	0.069815	2.313514905	2.880633	1.611271	0.591687
14	0.069815	2.313514905	2.880633	1.611271	0.591687
14.5	0.077295	2.561391502	3.189272	1.783907	0.655082
15	0.084775	2.809268099	3.497912	1.956543	0.718477
15.5	0.117189	3.883400019	4.835349	2.704633	0.993188
16	0.052361	1.735136179	2.160475	1.208453	0.443765
16.5	0.047374	1.569885114	1.954715	1.093362	0.401502
17	0.057348	1.900387243	2.366234	1.323544	0.486028
17.5	0.064828	2.14826384	2.674874	1.49618	0.549423
18	0.062335	2.065638308	2.571994	1.438635	0.528292
18.5	0.034907	1.156757452	1.440317	0.805636	0.295843
19	0.017454	0.578378726	0.720158	0.402818	0.147922
19.5	0.017454	0.578378726	0.720158	0.402818	0.147922
20	0.012467	0.413127662	0.514399	0.287727	0.105658
∑	2.09	69.24	86.21	48.22	17.71
Biomass (kg)					

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Length group (cm)	March	June	July	August	September
8	0.173193	5.739241	7.146117	3.997153	1.467824
8.5	0.411168	13.6252	16.96519	9.489412	3.484676
9	1.617823	53.61116	66.75301	37.33804	13.71117
9.5	1.113063	36.8845	45.92609	25.68858	9.433291
10	0.945523	31.33257	39.01321	21.82189	8.013374
10.5	1.144523	37.92702	47.22417	26.41466	9.699918
11	1.175041	38.93831	48.48337	27.11898	9.95856
11.5	0.916547	30.37238	37.81764	21.15315	7.767803
12	1.090276	36.12939	44.98589	25.16268	9.240172
12.5	0.806026	26.70994	33.25742	18.60241	6.831127
13	1.289288	42.72422	53.19732	29.75572	10.92681
13.5	1.173158	38.87592	48.40568	27.07553	9.942602
14	1.287054	42.65017	53.10513	29.70415	10.90788
14.5	1.56909	51.99625	64.74223	36.21332	13.29816
15	1.968552	65.23355	81.22442	45.43257	16.68362
15.5	2.966355	98.29856	122.3948	68.46103	25.14007
16	1.458259	48.32354	60.16923	33.65542	12.35885
16.5	1.5373	50.94277	63.43051	35.47961	13.02873
17	2.041588	67.65379	84.23794	47.11817	17.30261
17.5	2.486159	82.38592	102.5814	57.37851	21.07038
18	2.786363	92.33403	114.9681	64.30698	23.61463
18.5	1.640651	54.3676	67.69488	37.86487	13.90463
19	0.89782	29.7518	37.04494	20.72095	7.609089
19.5	0.940756	31.17461	38.81653	21.71188	7.972976
20	0.681568	22.58569	28.12218	15.73003	5.77634
∑	**34.12**	**1130.57**	**1407.71**	**787.40**	**289.15**

Catch-at-length $*10^{-3}$ (in thousands)			
Length group (cm)	**October**	**November**	**December**
8	1.335228602	0.002400674	1.309139408
8.5	3.004264355	0.005401516	2.945563667
9	10.68182882	0.019205391	10.47311526
9.5	6.425787648	0.011553243	6.300233399
10	4.089137594	0.007352064	4.009239436
10.5	4.256041169	0.007652148	4.172881862

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11	3.838782231	0.006901937	3.763775797
11.5	2.670457204	0.004801348	2.618278815
12	2.670457204	0.004801348	2.618278815
12.5	1.919391116	0.003450969	1.881887898
13	2.753908992	0.00495139	2.700100028
13.5	2.336650054	0.004201179	2.290993963
14	2.336650054	0.004201179	2.290993963
14.5	2.587005417	0.004651306	2.536457602
15	2.83736078	0.005101432	2.781921241
15.5	3.922234019	0.00705198	3.84559701
16	1.75248754	0.003150884	1.718245472
16.5	1.585583965	0.0028508	1.554603046
17	1.919391116	0.003450969	1.881887898
17.5	2.169746479	0.003901095	2.127351537
18	2.086294691	0.003751053	2.045530324
18.5	1.168325027	0.00210059	1.145496982
19	0.584162513	0.001050295	0.572748491
19.5	0.584162513	0.001050295	0.572748491
20	0.417258938	0.000750211	0.409106065
∑	69.93259804	0.125735294	68.56617647
Length group (cm)	**October**	**November**	**December**
8	5.796634	0.010422	5.683373
8.5	13.76146	0.024742	13.49257
9	54.14727	0.097354	53.08928
9.5	37.25334	0.06698	36.52544
10	31.64589	0.056898	31.02756
10.5	38.30629	0.068873	37.55781
11	39.3277	0.070709	38.55927
11.5	30.6761	0.055154	30.07672
12	36.49069	0.065608	35.77769
12.5	26.97704	0.048503	26.44993
13	43.15146	0.077584	42.30832
13.5	39.26468	0.070596	38.49748
14	43.07667	0.07745	42.23499
14.5	52.51621	0.094422	51.49009
15	65.88588	0.11846	64.59853
15.5	99.28155	0.178503	97.34167
16	48.80678	0.087752	47.85314

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16.5	51.4522	0.092508	50.44687
17	68.33032	0.122854	66.99521
17.5	83.20978	0.149607	81.58393
18	93.25737	0.167672	91.43521
18.5	54.91128	0.098728	53.83836
19	30.04932	0.054027	29.46218
19.5	31.48636	0.056611	30.87114
20	22.81155	0.041014	22.36583
∑	1141.874	2.053032	1119.563

V. Conclusions and recommendations

• The age structure of whiting during the period 2017-2019 was characterized by 7 age classes. The year-olds had the highest participation rate in July 2019 (total of 57.66%). Three and four-year-old individuals had the lowest percentage of participation.
• The average values of the Fulton's condition factor of whiting during the investigation period ranged widely.
• In July 2018-2019, the weight increase relative to the average annual data showed varying values.
• The linear increase rate in October 2018 accounted for a reduction in values.
• It follows from the analysis that the increase in the period 2017-2019 of whiting was allometric.
• In 2017-2019, males (♂) showed greater participation in the catches than females (♀).
• During the period considered, the whiting showed that the GSI was heavily dependent on the weight of the gonads which was associated with the high percentage of maturation of females in late spring and summer and the whiting breeding process.
• An active maturation of sex products was observed, as in over of 80% the degree of maturity was IV-VI.

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IV. Biological monitoring of red mullet (*Mullus Barbatus*)

IV.1 Objectives

Red mullet is one of the most important fish species fished and consumed traditionally in the Black Sea countries. Multiannual biological monitoring on the landings provides the so called "Fishery dependant" information. The aim of this study was to collect and analyze dynamics in length, weight and age distribution as well as to determine the condition of the red mullet species using the so-called condition factor. The condition factor is also a useful index for monitoring of feeding intensity, age and growth rates in fish. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live. Biological information on species collected each month, analyzed and compared to previous periods could be used for estimation of the growth parameters. These indicators are very important for the species. Reliable and informative long-term data are crucial for the assessment of fish stocks, fisheries management and the decision-making process in general.

IV.2 Sampling in the period 2017-2019

IV.2.1 Geographic area of coverage

For the entire period of the research, samples were collected directly from landings at the designated Bulgarian fishing ports (Fig. 2.1.1).

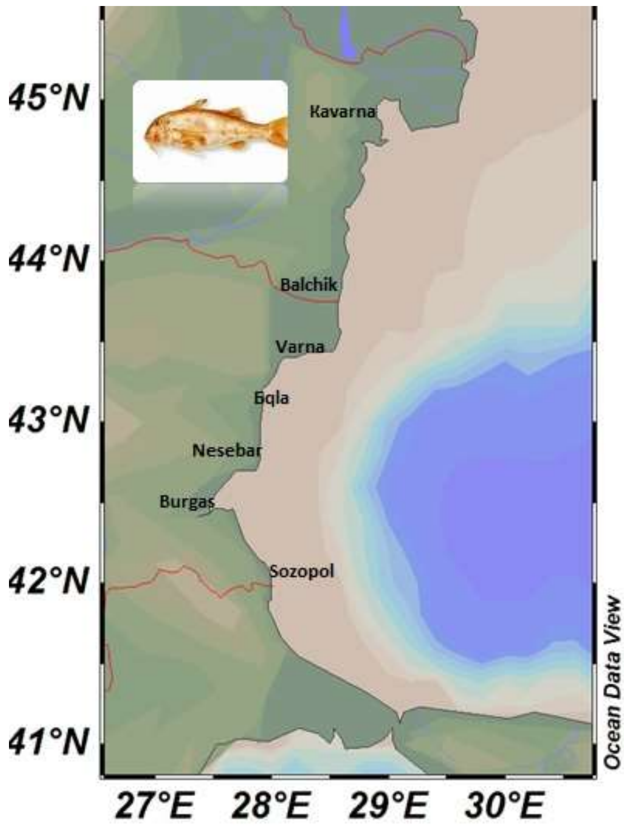

Fig. 2.1.1 Sampling ports along the Bulgarian Black Sea coast (2017-2019)

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IV.2.2 Samples description

In October-November 2017, 3194 specimens were collected and processed for analysis of the population dynamics of red mullet along the Bulgarian Black Sea coast.
In 2018, 500 specimens were collected processed.
In 2019, 16 samples (2027 specimens) were collected and processed.
Information about the size and structure of the catches was also collected and recorded.

2017		2018		2019	
Date	**FV**	**Date**	**FV**	**Date**	**FV**
				1.02. 2019	SVETA ANNA - 1 VN 8265
				4.03. 2019	PERLA VN3480
				12.05. 2019	BIOLA БС 042
				13.06.2019	БЛ 2133
				6.07. 2019	BARBUN VN 7979
		04.09.2018	FVIva	6.07. 2019	KORSAI II VN 7643
		13.09.2018	FV Libra	24.08. 2019	TRIGONA VN8579
16.10.2017	Lavrak. Barbun	14.09.2018	FV Korsai	29.08. 2019	SV. NIKOLAI VN 8190
27.10.2017	Haithabu	10.10.2018	FV M27 G9	6.09. 2019	SVETA ANNA I VN 8265
		13.10.2018	FV Irina	27.09. 2019	PERLA VN3480
		15.10.2018	FV 40 Бс 258	7.10. 2019	ELEKTA VN 8042
		23.10.2018	FV Tesi VN 77-50	29.10. 2019	IVA - 1 VN 8194
7.11.2017	FV KB 6296	7.11.2018	FV 40 Бс 258	4 .11. 2019	FV БС280
				8.11. 2019	Diamant VN 7141
				9 .12.2019	"SVETI NIKOLA I"БС175
		04.12.2018	FV Tais	14.12. 2019	KIRIL 45 БС280
3 samples with 3194 species		**9 samples with 500 species**		**16 samples with 2027 species**	

IV.2.3 Statistical analysis

Refer to the methodology used for sprat stock analysis.

IV.3 Results

IV.3.1 Landings in 2017-2019

The official statistics of red mulled landings in 2017 is presented in Fig. 3.1.1. The highest fishing intensity and the biggest catches were registered in November (172527.2 kg). The lowest fishing intensity and respectively the smallest catches of red mullet were registered in May (152 kg) (Fig. 3.1.1).
The official red mullet landing statistics in 2018 is presented in Fig. 3.1.2 (left). The highest fishing intensity and the biggest catches were registered in September (200490.4 kg). The lowest fishing intensity and respectively the smallest catches of red mullet were registered in April (3 kg) (Fig. 3.1.2 , left).

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The official red mullet landing statistics in 2019 is presented in Fig. 3.1.2 (right). The highest fishing intensity and the biggest catches were registered in November (15794.1 kg). The lowest fishing intensity and respectively the smallest catches of red mullet were registered in August (14194 kg) (Fig. 3.1.2 , right).

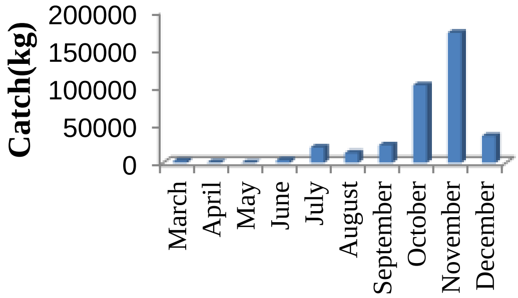

Fig. 3.1.1 Red mullet landings in 2017

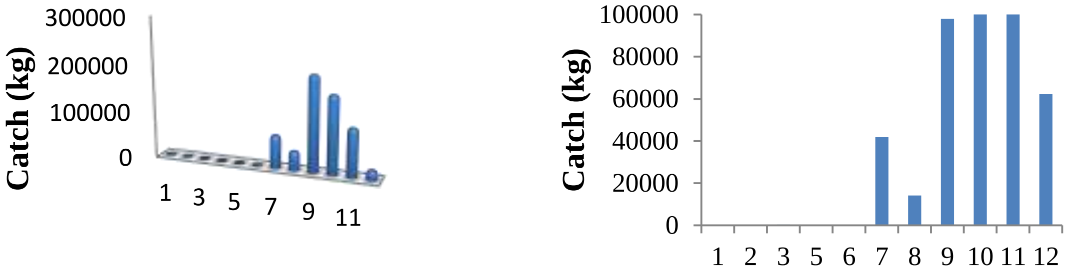

Fig. 3.1.2 Red mullet landings in 2018 (left) and 2019 (right)

IV.3.2 Length structure of red mullet in the period 2017-2019

IV.3.2.1 Length structure analysis for 2017

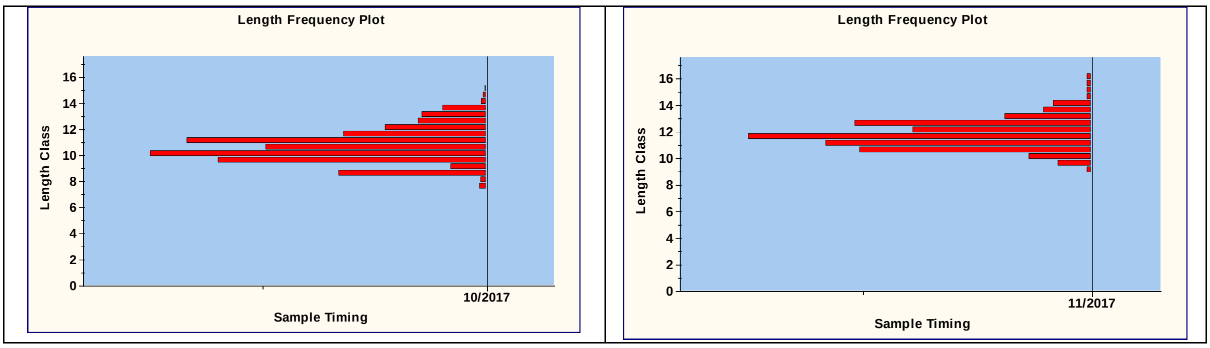

Fig. 3.2.1.1 Length structure of red mullet presented in catches in October-November, 2017

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The length structure of red mullet in the period October-November is presented in Fig. 3.2.1.1. The total length of the specimens presented in the catches varied from 7cm to 16 cm. The most frequent in October catches were length classes 9-12 cm and in November 10-13 cm.

IV.3.2.2 Length structure analysis for 2018

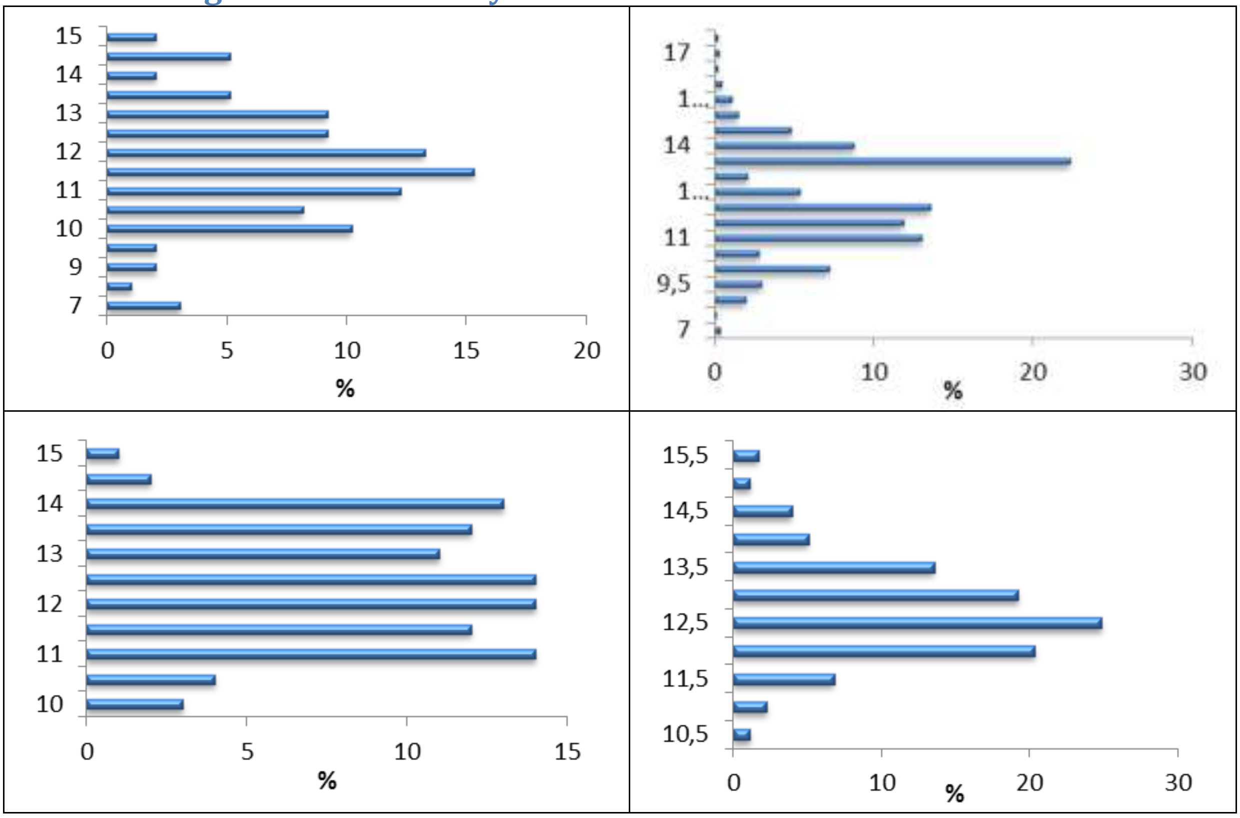

Fig. 3.2.2.1. Length structure of red mullet presented in the catches during the period September-December, 2018

In September, the total length of the specimens presented in the samples varied from 7cm to 15 cm. Most frequently presented in the length structure were length classes 11, 11.5 and 12 cm. Less frequent – length classes 7.5, 9 and 9.5 cm. In October, the total length of the sampled red mullet specimens varied in the range 7 – 17.5 cm. The most frequent length class presented in the length structure of the catches was 13.5 cm. The less frequent were classes 7.5cm and 17.5 cm. In November, the total length of the sampled red mullet specimens varied in the range 10-15 cm. Length classes 11, 12, 12.5 and 14 cm were presented with the biggest percentage share in the length structure. The length class 15 cm was presented with the smallest percentage share. In December, the most frequent length classes were 7, 5, 8 and 10 cm. The less frequent was the length class 11.5 cm.

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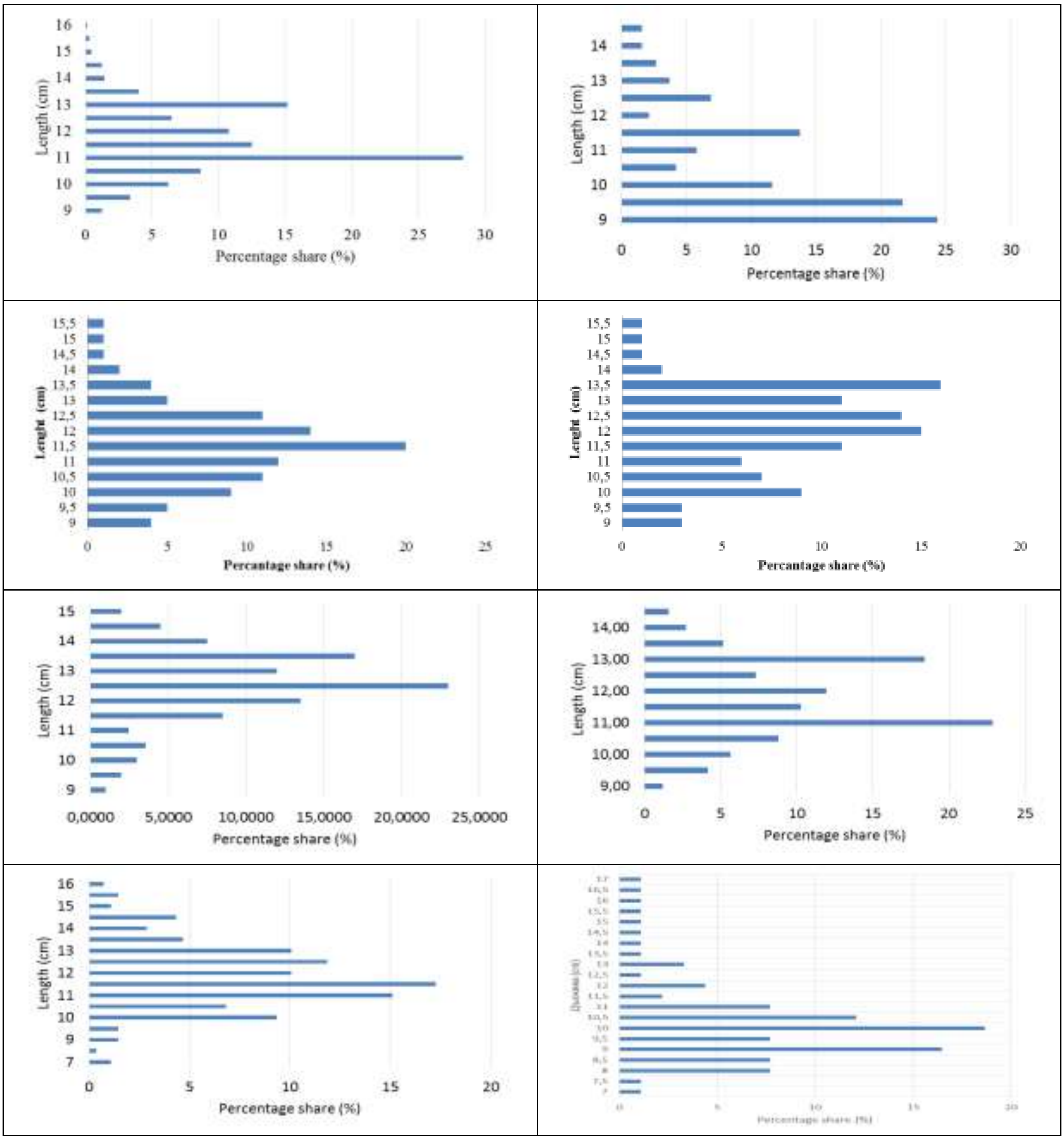
IV.3.2.3 Length structure analysis for 2019



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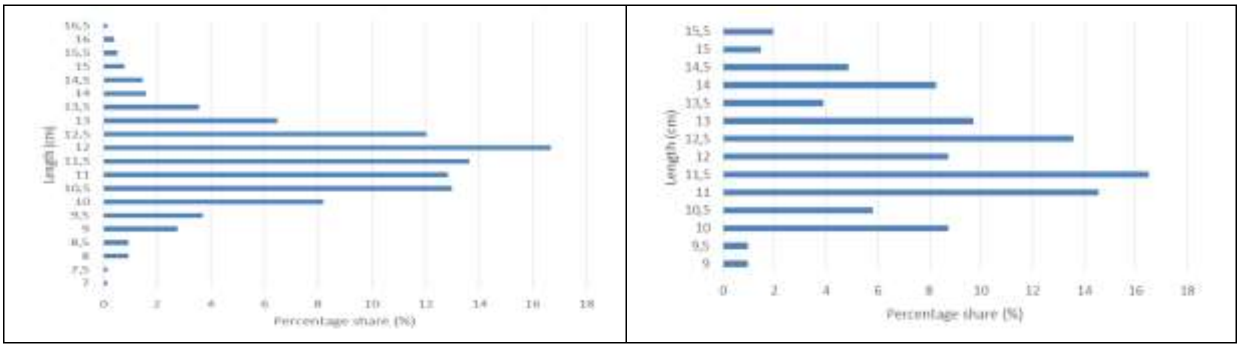

Fig. 3.2.3.1 Length structure of red mullet presented in the catches during the periods February-March and May-December, 2019

In February, the total length of the specimens presented in the samples varied from 9 cm to 16 cm. With the highest percentage share in the length structure were presented length classes 11 cm and 13 cm. With the lowest – length classes 15, 15.5 and 16 cm. In March, the total length of the specimens presented in the samples varied from 9 cm to 15.5 cm. Recorded as the most frequent were length classes 9, 9.5 and 11.5 cm. The less frequent classes in the length-frequency samples were 14 cm and 14.5 cm. In May, length class 11.5 cm was represented with the biggest percentage share and classes 14.5, 15 and 15.5 cm were recorded with the smallest shares in the length structure. In June, with the highest frequency of occurrence in the length-frequency samples were length classes 12, 12.5 and 13.5 cm. The lowest frequencies were recorded for 14.5, 15 and 15.5 cm. In July, the total length of the specimens presented in the samples varied from 9 cm to 15 cm. The most frequent were classes 12.5 cm and 13.5 cm. The less frequent class was 9 cm. In August, the total length of the specimens presented in the samples varied from 9 cm to 14.5 cm. The most frequent length classes were 11cm and 13 cm. The less frequent class was 9 cm. In September and October with the highest percentage shares in the length structure were recorded length classes 9, 10, 11 and 11.5 cm. The lowest percentage shares were recorded for length classes 7 cm and 8 cm. The rest length classes were recorded with very low frequency of occurrence in the length-frequency samples and that was most probably due to the absence of actively reproducing sexually mature specimens. Furthermore, there were clear indications that the active reproduction period had already passed at that time. In the length-frequency samples collected in November the most frequent was length class 12.5 cm. The less frequent were length classes 7, 8 and 16.5 cm, and in December -11cm and 11.5 cm, and 9 cm and 9.5 cm, respectively.

Due to the large number of samples collected in 2019, the population dynamics of the red mullet seasonality and individual growth dynamics could be easily followed by the length structure of the samples throughout the year. For the entire period of the research (2017-2019) most abundant and respectively most frequent in the length structure of the catches were the specimens with total length 9-12 cm. The specimens with total length below 7 cm were less frequent due to the selectivity of the fishing gears and it could be further considered that in the exploitation phase the specific lengths ranged from 7 cm to 16 cm. Specimens over 15cm length were hardly presented in the catches due to the natural specific physiology and biology of the studied species.

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IV.3.3 Red mullet age structure analysis in the period 2017-2019

IV.3.3.1 Age structure analysis for 2017

Three readers determined the age of red mullet otoliths and one of them read all otoliths twice. The test of symmetry (χ^2_{R1vsR2} = 8. *df* = 6. *P* = 0.3451; χ^2_{R1vsR3} = 7.09. *df*=6. P=0.319; χ^2_{R2vsR3} = 8.24. *df*= 9. *P*=0.3417) showed that age disagreement was due to simple random error and not to a systematic difference between readers.

Table 3.3.1.1 Indices of precision for age readings of red mullet from the Bulgarian Black Sea waters within and between readers

Index	Index comparison	
	1-st reader	Between the readers
APE [%]	1.924	4.961
CV [%]	2.164	3.168
D [%]	1.964	5.438

APE = average percentage error, CV = coefficient of variation, D = index of precision

The age structure of the studied specimens contained age groups 0-0+, 1-1+, 2-2+, 3-3+ and 4+. Old specimens (age 5-5+) were not presented in the catches for the entire research period. The biggest share of representation in October samples had the specimens from age group 1-1+ (45.37%). Age groups 3-3+ and 4-4+ were not significantly presented in the catches age structure (Fig. 3.3.1.1). The biggest share of representation in November samples had the age group 2-2+(42.17%) (Fig. 3.3.1.1). The presence of age groups 1-1+ and 3-3+ was recorded with almost equal shares. Specimens from age group 5-5+ were again absent in the catches.

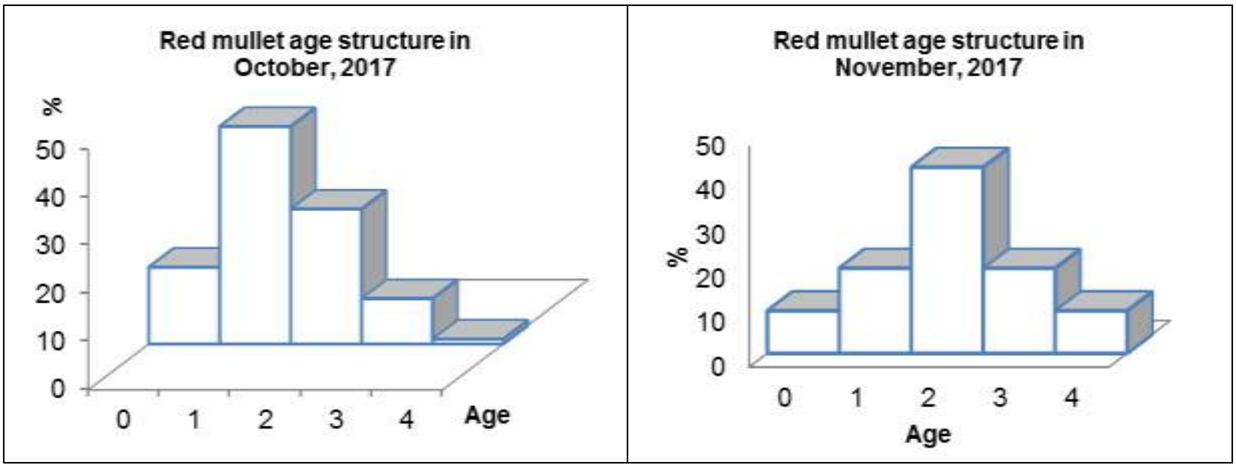

Fig. **3.3.1.1** Age structure of red mullet in October and November, 2017

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IV.3.3.2 Age structure analysis for 2018

The same technology for age reading as the one applied for 2017 was used for age determination of sampled specimens in 2018. The test of symmetry (χ^2_{R1vsR2} = 6. *df* = 7. *P* = 0.5243; χ^2_{R1vsR3} = 8.07. *df*=5. P=0.845; χ^2_{R2vsR3} = 7.48. *df*= 8. *P*=0.2119) showed that age disagreement was due to simple random error and not to a systematic difference between readers.

Таблица 3.3.2.1 Indices of precision for age readings of red mullet from the Bulgarian Black Sea waters within and between readers

Index	Index comparison	
	Reader 1	Between readers
APE [%]	1.924	4.961
CV [%]	2.164	3.168
D [%]	1.964	5.438

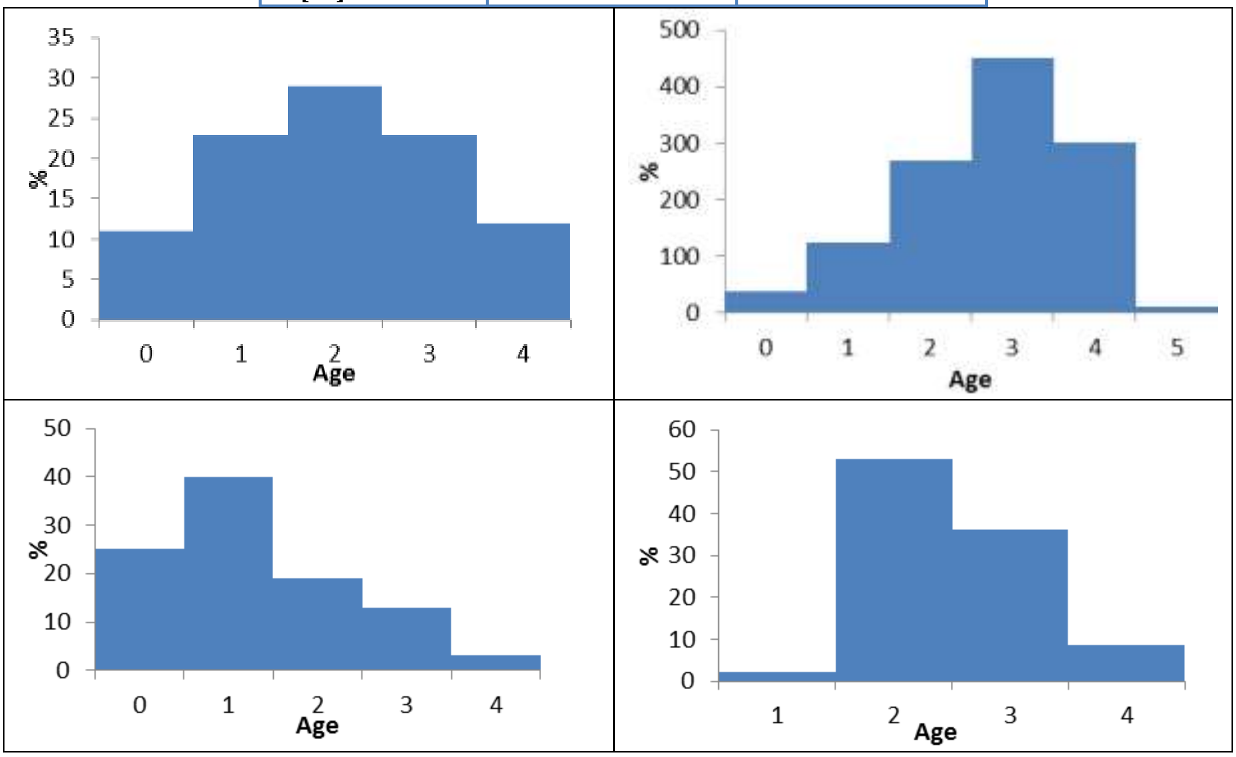

Fig. 3.3.2.1 Age structure of red mullet in the period September – December, 2018

The age structure of the studied specimens in September presented age groups 0-0+, 1-1+, 2-2+, 3-3+ and 4+. Old specimens (age 5-5+) were absent in the catches for the entire research period. The most frequent in the catches were age groups 2-2+ (29%) - in September and December, 3-3+ (38%) in October and 1-1+ in November (Fig. 3.3.2.1).

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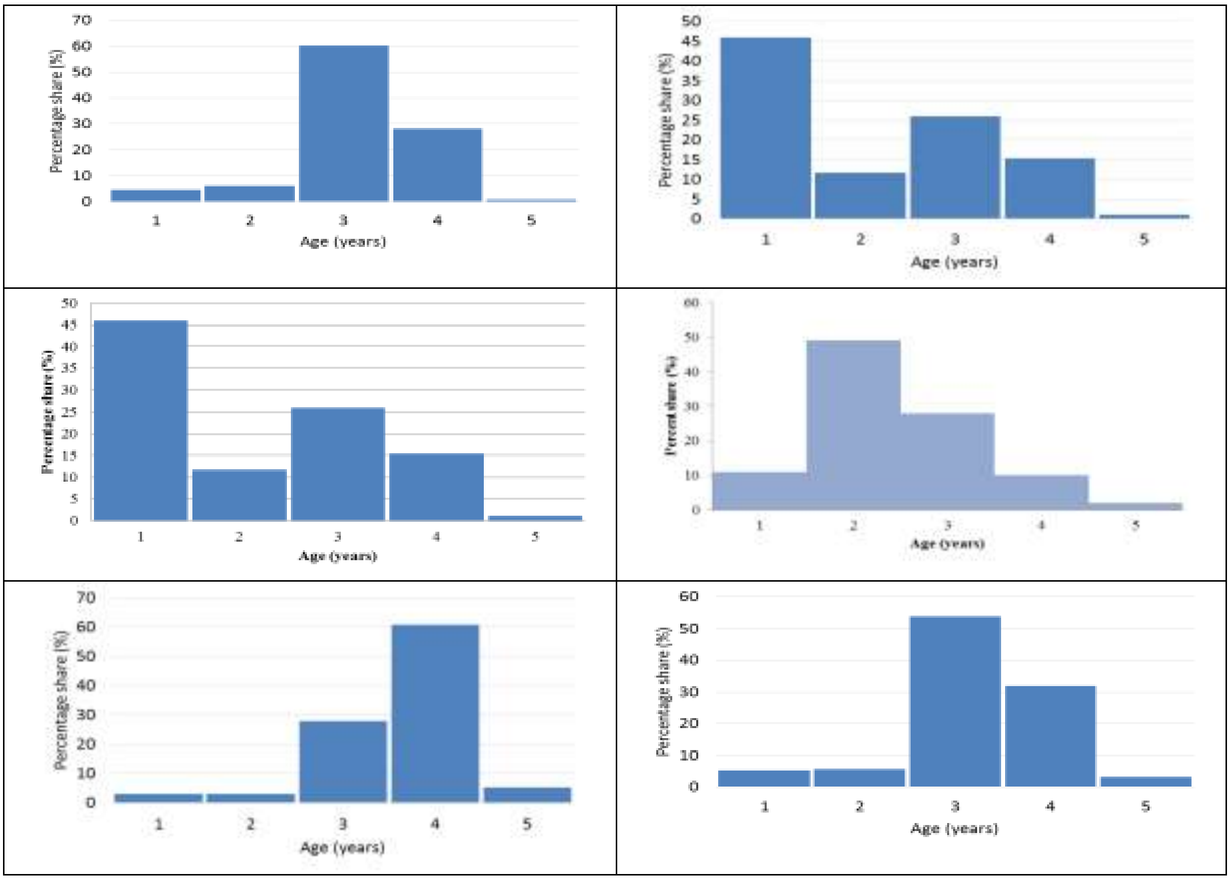
IV.3.3.3 Age structure analysis for 2019

The same technology for age reading as the one applied for 2017 was used for age determination of sampled specimens in 2018. The test of symmetry ($\chi 2$ R1vsR2 = 3. df = 4. P = 0.1452; $\chi 2$ R1vsR3 = 7.12. df=3. P=0.220; $\chi 2$ R2vsR3 = 6.22. df=5. P=0.2201) showed that age disagreement was due to simple random error and not to a systematic difference between readers.

Table 3.3.2.1 Indices of precision for age readings of red mullet from the Bulgarian Black Sea waters within and between readers.

Index	Index comparison	
	Reader 1	Between readers
APE [%]	1.022	4.230
CV [%]	2.323	3.114
D [%]	1.401	5.006



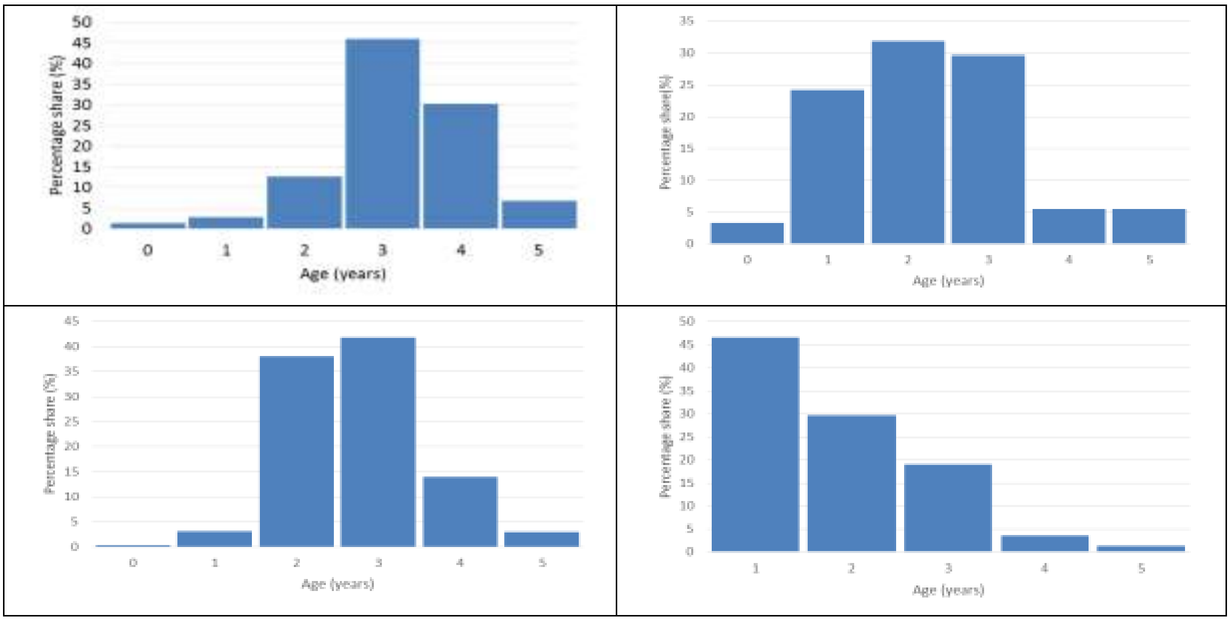


Fig. 3.3.2.1 Age structure of red mullet in the periods February – March and May – December, 2019

3-3+ years old specimens were the most frequent in February (60%), followed by 4-4+ (27%). The younger (1-2+) and the oldest (5+) specimens showed insignificant presence in the catches. March age distribution was predominated (45%) by 1-1+ year old individuals. Second in terms of presence were 3-3+ year old individuals. May age distribution showed prevailance of 2-2+ and 3-3+ age old specimens. In July, 4-4+ year olds reached 60%, followed by 3-3+ olds with 28%. The rest of the age groups were presented with very small share. In August, the distribution of the age groups was similar to the one witnessed in July with the exception of the increase of 3-3+ age group share up to 53% and decrease in 4-4+ age group share to 32%. The age distribution in September was similar to the age distribution in the samples collected in July and August, as 3-3+ and 4-4+ predominated in the catches. In October 2019, 1-3 + year olds predominated. Presence of recruitment (0+yr, 30%) was observed. In November samples, recruitment was absent, 1-1+ age old decreased significantly in the catches and the oldest 5+, 2-3+ yr retained their high percentage, similar to October 2019. The age structure in December 2019 showed significant increase in 1-1+ age group and comparatively lower presence of specimens from age groups 2-2+ and 3-3+.

IV.3.4 Red mullet Fulton's condition factor analysis in the period 2017-2019

IV.3.4.1 Red mullet Fulton's condition factor analysis for 2017

The highest values of Fulton's condition factor for October were calculated for age groups 2-2+ and 4-4+ (Fig. 3.4.1.1). In November, the highest values were calculated for age groups 0-0+ and 1-1+. Such fluctuations were natural for the fish species and were most probably a result of the recruitment process.

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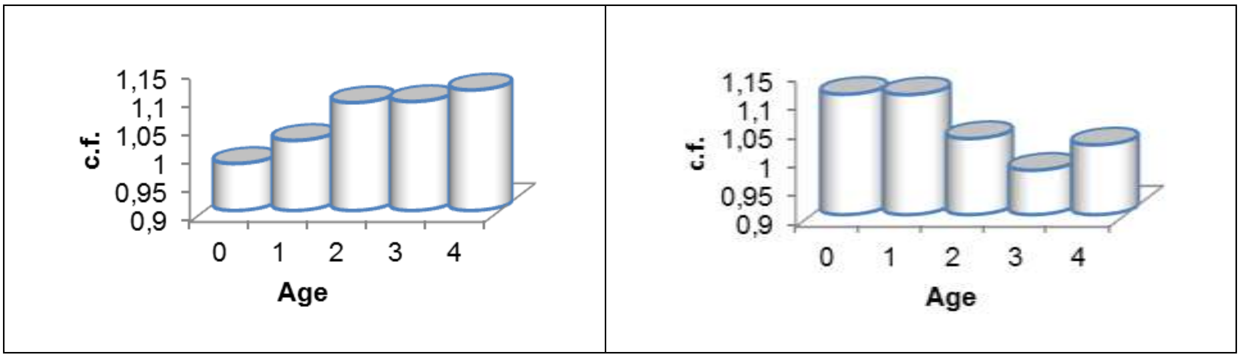


Fig. 3.4.1.1 Red mullet condition factor in the period October-November, 2017

IV.3.4.2 Red mullet Fulton's condition factor analysis for 2018

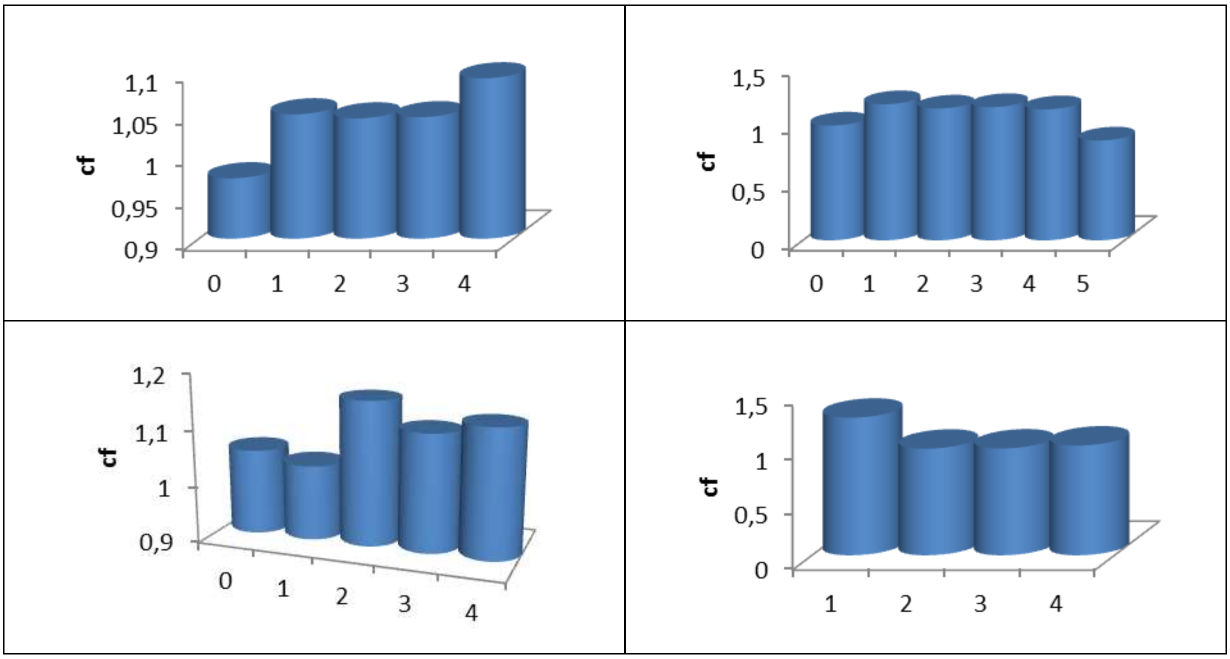


Fig. 3.4.2.1 Red mullet condition factor in the period September-December, 2018

For the period of the research, the natural fluctuations of the Fulton's condition factor which were closely related to the variability and seasonality of the species's growth parameters and its environment were evident.

IV.3.4.3 Red mullet Fulton's condition factor analysis for 2019

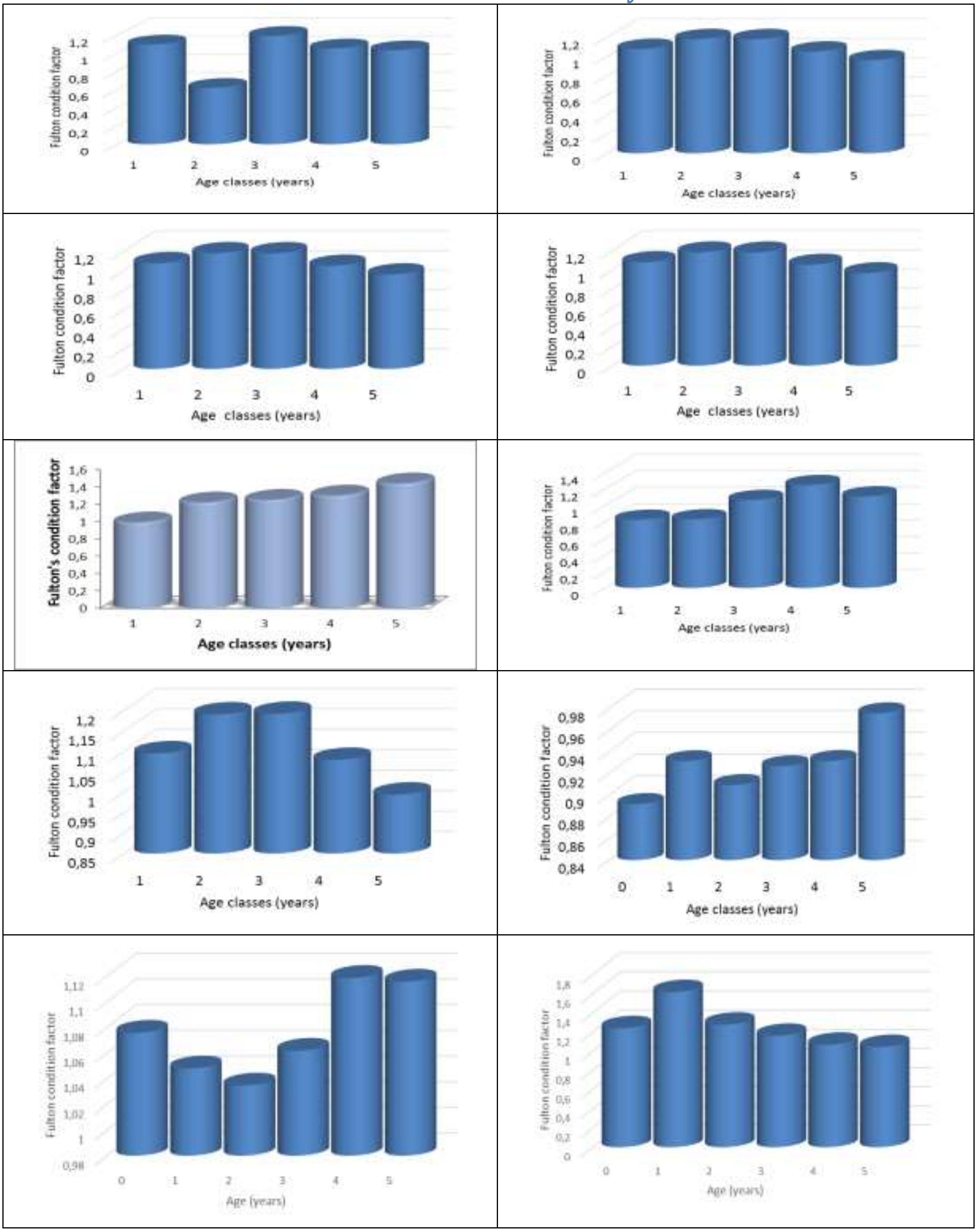


Fig. 3.4.3.1 Red mullet condition factor in the periods February-March and May-December, 2019

In 2019, Fulton's condition factor again varied significantly by age groups and those variations were strongly connected to the natural variability of the individual growth parameters, biology and physiology of the studied species as well as its environment and food availability.

IV.3.5 Weight structure of red mullet in the period 2018-2019

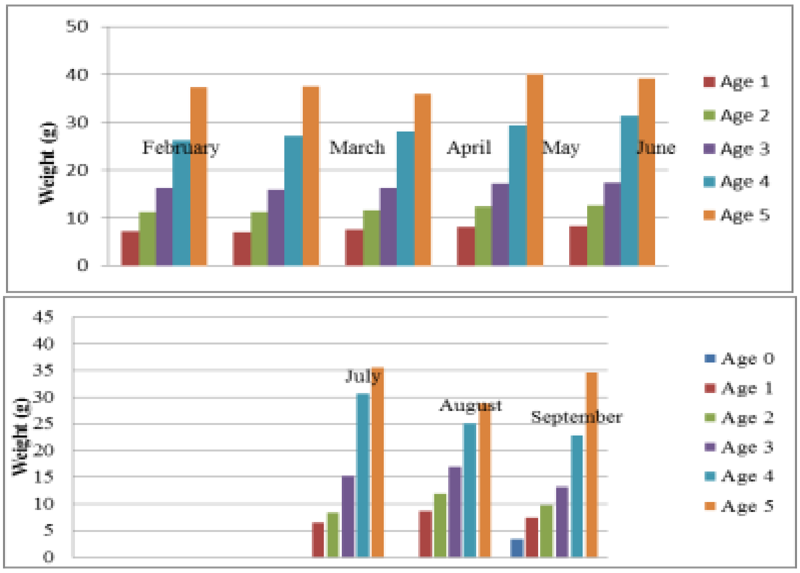
IV.3.5.1 Weight structure in 2018

Table 3.5.1.1 Weight structure of red mullet by age groups in 2018

age	September	October	November	December
		Weight (g)		
0	7.14	7.20	14.22	
1	12.77	13.31	15.99	15.55
2	16.51	16.03	18.68	19.26
3	20.74	23.12	27.49	20.51
4	31.72	30.27	29.76	31.42
5		39.73		

IV.3.5.2 Weight structure of red mullet in 2019

2027 sampled specimens were weighted providing the following outcome (Fig. 3.5.2.1)



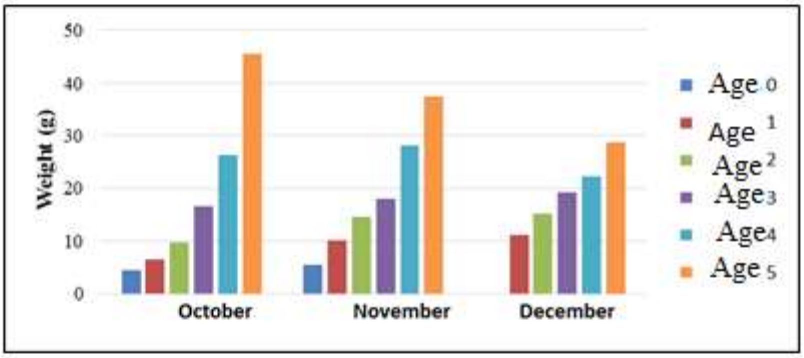


Fig. 3.5.2.1 Weight structure of red mullet by age groups in 2019

The analysis of red mullet weight structure for a large period of time provided insights to the pattern of the natural variability and seasonality of red mullet weight.

IV.3.6 Length structure of red mullet by age groups for the period 2018-2019

Table 3.6.1 Length structure by age groups in 2018

age	September	October	November	December
	Length (cm)			
0	8.73	8.88	11.00	
1	10.65	10.36	13.15	10.75
2	3.86	11.18	13.34	12.51
3	12.54	12.54	13.88	12.77
4	14.25	13.90	14.67	14.60
5		16.64		

Table 3.6.2 Length structure by age groups in 2019

	February	March	May	June	July	August	September
Age	Length (cm)						
0	n/a	n/a	n/a	n/a	n/a	n/a	7.25
1	9.25	9.25	9.25	9.25	9.25	9.25	9.25
2	10	10	10	10	10	10	10.25
3	11.25	11.25	11.25	11.25	11.25	11.25	11.25
4	13.5	13.5	13.5	13.5	13.5	13.25	13.5
5	15.5	14.5	14.75	14.5	14.75	14.25	15.25

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	October	November	December
Age	**Length (cm)**		
0	7.5	7.5	
1	8.5	8.5	10.75
2	9.75	10.5	12.25
3	11.5	11.5	13.5
4	13.25	13.75	14.75
5	16	15.25	15.25

Tables 3.6.1 and 3.6.2 show that in 2019 there was a tendency for a slight decrease in the average lengths by age groups except for ages 5-5+ (which, however, was not reported in the catches for all months during the study period). As weight and length are parameters characterized by a great variability, that observation cannot be considered as a solid base for general conclusions about the stock.

IV.3.7 LWR of red mullet in the period 2018-2019

IV.3.7.1 LWR in 2018

LWR model of red mullet in 2018 is described with high coefficient of determination with the following nonlinear equation: $W = 0.0273*L^{2.5675}$
Red mullet growth was alometric negative (b = 2.5675).

IV.3.7.1 LWR in 2019

LWR model of red mullet in 2019 is described with high coefficient of determination with the following nonlinear equation: $W = 0.0222*L^{2.6907}$
Red mullet growth was alometric negative (b = 2.5675).
Von Bertalanffy growth parameters were calculated as follows: L_{asimpt}=36.672, K=0.0651,t_0 =-3.3509.

IV.3.8 Sex structure of red mulled in the period 2017-2019

IV.3.8.1 Red mullet sex ration in 2017

The female specimens (♀) were presented with 64%, the male specimens (♂) - with (36%).

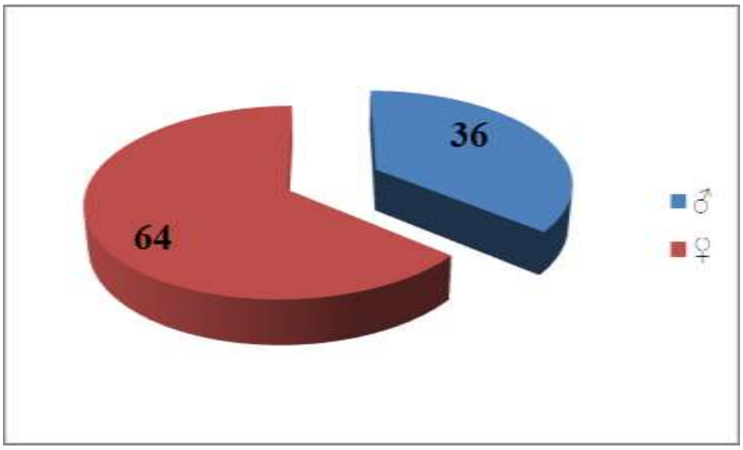

Fig. 3.8.1.1 Red mullet sex structure in 2017

IV.3.8.2 Red mullet sex structure in 2018

The female specimens (♀) were presented with 52%, the male specimens (♂) - with 48% .

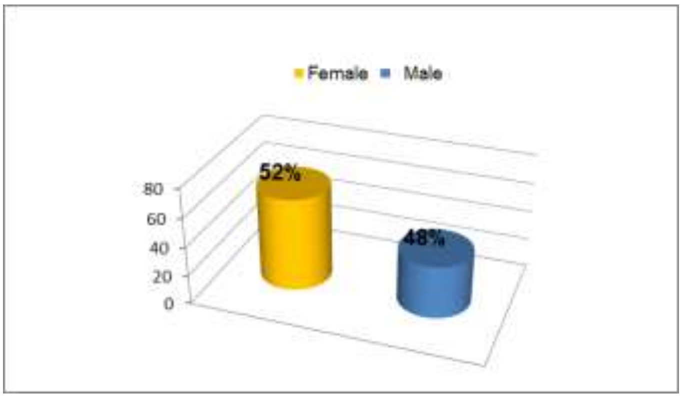

Fig. 3.8.2.1 Red mullet sex structure in 2018

IV.3.8.3 Red mullet sex structure in 2019

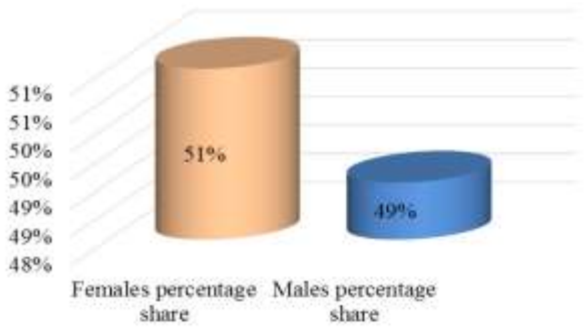

Fig. 3.8.3.1 Red mullet sex structure in 2019

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IV.3.9 Fecundity

100 specimens were studied for batch fecundity of red mullet. The degree of reproduction during the research period indicated a good level of determinicity ($r^2 = 0.5$) which was directly dependent on the active propagation period of the species.

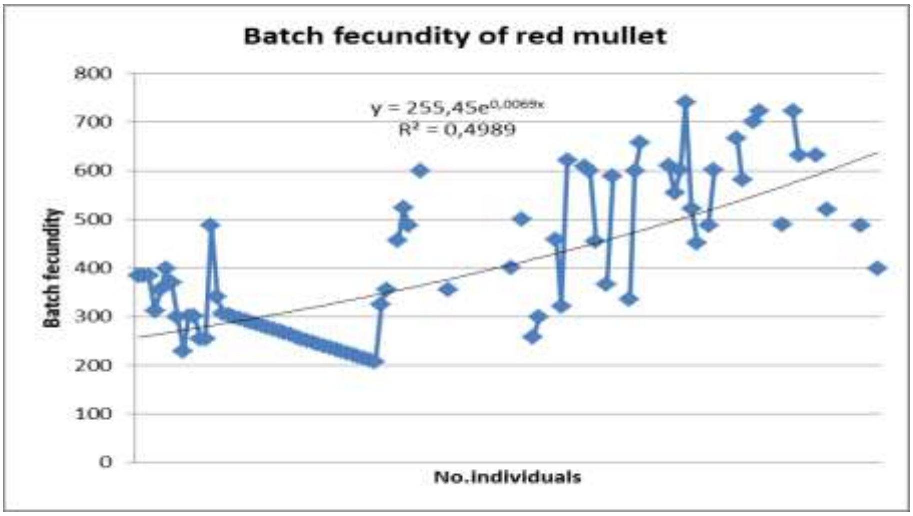

Fig. 3.9.1 Dependence of the fertility on the weight of the measured specimens

The gonadosomatic index for red mullet varied widely with no pronounced correlation between the index and the individual weight of the measured specimens (Fig. 3.9.2).

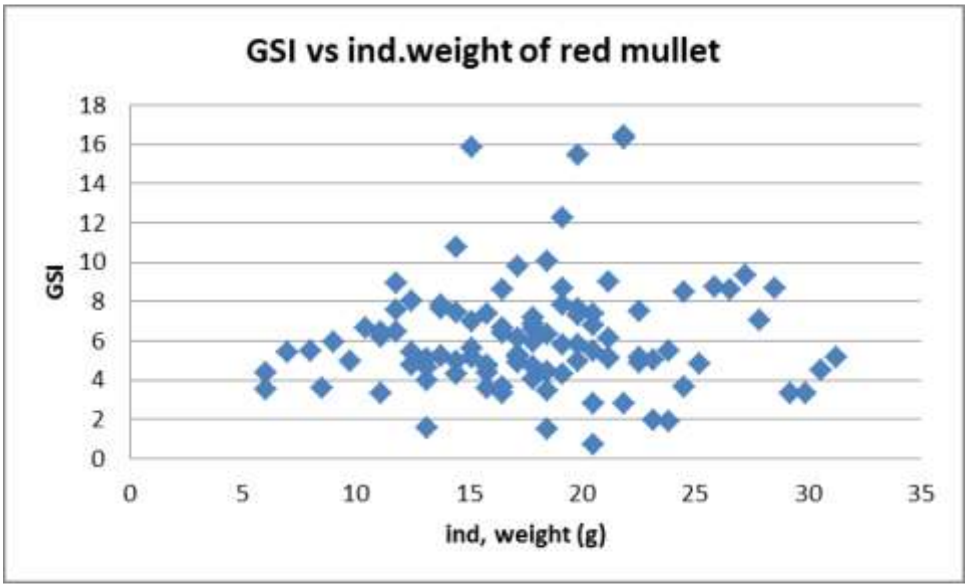

Fig. 3.9.2. Dependence of the gland weight on the GSI

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IV.3.10 Sexual maturity

250 specimens were examined for maturity determination. Red mullet is a summer breeding species. The beginning of the active breeding of the species was registered in March-April. In June were observed mass mature sex products in over 40% of the female spesimens.
The October-December period of 2019 was beyond the active breeding season of the species. Sexually immature individuals (12.5%) were presented with a relatively high percentage. Individuals with glandular maturity 2b-4b (GFCM macroscopic maturity scale for bony fish) predominated.
The active breeding season for the red mullet passed in October-December, 2019. Due to that fact, determination of GSI and fertility could not be performed during the period of research.

IV.3.11 Catch-in-numbers and biomass by age and length

IV.3.11.1 Catch-in-numbers and biomass analysis of red mullet by age and length for 2017

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

Table 3.11.1.1 Catch-at-age (10^{-6}) matrix and biomass (kg) of red mullet for selected months

Catch-at-age (10^{-6})		
Age groups	**October**	**November**
0	1085.969	189.133
1	3078.485	378.266
2	1909.889	827.457
3	642.138	378.266
4	68.463	189.133
5	6784.944	
∑	13569.888	1962.255
Biomass (kg)		
Age groups	**October**	**November**
0	10302361.884	2267305.875
1	41593217.618	5299927.323
2	36044588.569	14074190.54
3	12702249.633	7974817.015
4	2158421.913	5628665.336
5	102800839.616	
∑	102.801	35244906.091

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Monthly catches (in tons) together with mean weights of red mullet were used to derive the monthly catch numbers. The shares (%) by length groups and catch numbers were used to create a catch-at-length matrix for selected months by age groups .

Table 3.11.1.1 Catch-at-length (10^{-6}) matrix and biomass (kg) of red mullet for selected months

Catch-at-length (millions)		
Length group (cm))	**November**	**December**
7.0	0.043	
7.5	0.515	
8.0	0.430	
8.5	10.396	
9.0	2.535	0.421
9.5	18.859	2.946
10.0	23.627	5.470
10.5	15.508	20.199
11.0	21.050	23.144
11.5	10.052	29.877
12.0	7.131	15.570
12.5	4.811	20.619
13.0	4.554	7.574
13.5	3.093	4.208
14.0	0.387	3.366
14.5	0.258	0.421
15.0	0.129	0.421
15.5	0.086	0.421
∑	123.419	134.657
Biomass (kg)		
Length group (cm)	**November**	**December**
7.0	0.001	
7.5	0.021	
8.0	0.018	
8.5	0.581	
9.0	0.188	0.033
9.5	1.421	0.331
10.0	2.429	0.700
10.5	1.847	2.869
11.0	2.861	3.513

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11.5	1.680	5.394
12.0	1.303	3.154
12.5	1.062	4.854
13.0	1.130	1.994
13.5	0.894	1.182
14.0	0.117	1.068
14.5	0.086	0.151
15.0	0.046	0.170
15.5	0.049	0.195
∑	15.734	25.610

IV.3.11.2 Catch-in-numbers and biomass analysis of red mullet by age and length for 2018

Monthly catches (in tons) together with mean weights of red mullet were used to derive the monthly catch numbers. The shares (%) by age groups and catch numbers were used to create a catch-at-age matrix for selected months by age groups (Table 3.11.2.1).

Table 3.11.2.1 Catch-at-age (10^{-6}) matrix and biomass (kg) of red mullet for selected months

Catch-at-age (10^{-6})				
Age groups	**September**	**October**	**November**	**December**
0	1.290806	0.237491	1.40761	
1	2.698959	0.768722	2.252176	0.021824
2	3.403035	1.687439	1.069784	0.512874
3	2.698959	2.812399	0.731957	0.349191
4	1.408152	1.881182	0.168913	0.081842
5		0.068748		
Biomass (kg)				
Age groups	**September**	**October**	**November**	**December**
0	9222.46	1710.941	20020.23	
1	34452.32	10233.16	36002.64	339.4325
2	56176.22	27051.97	19984	9880.062
3	55970.46	65018.74	20122.18	7162.121
4	44668.94	56950.04	5026.916	2571.385
		2731.152		
∑	200490.4	163696	101156	19953

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

Table 3.11.2.1 Catch-at-length (10^{-6}) matrix and biomass (kg) of red mullet for selected months

Catch-at-length (millions)				
Length group (cm)	**September**	**October**	**November**	**December**
7.0	2.96364061	26.8288727		
7.5	0.9878802	6.70721818		
8.0				
8.5				
9.0	1.97576041	154.266018		
9.5	1.97576041	234.752636		
10.0	9.87880203	570.113545	2.84196661	
10.5	7.90304162	221.3382	3.78928881	1.763956599
11.0	11.8545624	1039.61882	13.2625108	3.527913199
11.5	14.818203	945.717764	11.3678664	10.5837396
12.0	12.8424426	1079.86213	13.2625108	31.75121879
12.5	8.89092183	422.554745	13.2625108	38.80704519
13.0	8.89092183	160.973236	10.4205442	29.98726219
13.5	4.93940102	1784.12004	11.3678664	21.16747919
14.0	1.97576041	697.550691	12.3151886	7.937804697
14.5	4.93940102	382.311436	1.8946444	6.173848098
15.0	1.97576041	114.022709	0.9473222	1.763956599
15.5		80.4866182		2.645934899
16.0		33.5360909		
16.5		13.4144364		
17.0		20.1216545		
17.5		13.4144364		
Biomass (kg)				
Length group (cm)	**September**	**October**	**November**	**December**
7.0	0.08061102	0.6854777		
7.5	0.04020672	0.26895945		
8.0				

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8.5				
9.0	0.15687538	11.2228967		
9.5	0.16793963	21.6453014		
10.0	1.06256395	64.4843582	0.26525022	
10.5	0.94599408	32.4128333	0.45471466	0.28592854
11.0	1.6714933	169.929798	1.92306407	0.52552677
11.5	2.30314391	160.074604	1.70517996	1.51700268
12.0	2.2916845	202.396999	2.31146617	5.45062589
12.5	1.86966207	94.273351	2.76618083	7.3116001
13.0	1.98475012	40.1331636	2.78512727	6.47372072
13.5	1.3573474	526.764083	3.08827038	5.03609609
14.0	0.56309172	214.78374	3.76086914	2.14320727
14.5	1.60105745	120.539677	0.65365232	1.90507313
15.0	0.78190718	39.0072023	0.35998244	0.65266394
15.5		26.4271104		0.95253656
16.0		12.0729927		
16.5		5.36577455		
17.0		8.18280618		
17.5		6.10356855		

IV.3.11.3 Catch-in-numbers and biomass analysis of red mullet by age and length for 2019

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

Table 3.11.3.1 Catch-at -age (10^{-6}) matrix and biomass (kg) of red mullet for selected months

Age groups	**Catch-at-Age *10^{-3} (in thousands)**						
	February	**March**	**May**	**June**	**July**	**August**	**September**
0	0.007267	0.056902	0.005932	0.003856	6.212633	2.104962	14.53112
1	0.390259	3.055966	0.318579	0.207076	333.6515	113.0477	780.3984
2	0.303669	2.377917	0.247893	0.161131	259.6219	87.96497	607.2459
3	1.7482	13.68948	1.427102	0.927616	1494.622	506.4072	3495.865
4	0.754027	5.904492	0.615532	0.400096	644.6545	218.4216	1507.823
5	0.046654	0.365332	0.038085	0.024755	39.88711	13.51453	93.29446
	Biomass (kg)						
Age groups	**February**	**March**	**May**	**June**	**July**	**August**	**September**
0	2.04E-05	0.00016	1.67E-05	1.08E-05	0.017457	0.005915	0.040832
1	0.002556	0.020017	0.002087	0.001356	2.185417	0.740462	5.111609

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2	0.002721	0.021306	0.002221	0.001444	2.326212	0.788166	5.440923
3	0.024202	0.189517	0.019757	0.012842	20.6915	7.010686	48.39665
4	0.018097	0.141708	0.014773	0.009602	15.47171	5.242118	36.18775
5	0.001404	0.010993	0.001146	0.000745	1.200203	0.406652	2.80723

Monthly catches (in tons) together with mean weights of red mullet 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 3.11.3.2 Catch-at-length (10^{-6}) matrix and biomass (kg) of red mullet for selected months

Length groups (cm)	**Catch-at-length *10^{-3} (in thousands)**						
	February	**March**	**May**	**June**	**July**	**August**	**September**
7	0.005616416	0.043979979	0.00458483	0.002980139	4.801749418	1.626926807	11.23111337
7.5	0.001254226	0.009821355	0.001023858	0.000665507	1.072298942	0.363315896	2.508067359
9	0.113130363	0.885880003	0.092351316	0.060028356	96.72068812	32.77086465	226.2260936
9.5	0.240107784	1.880190955	0.196006354	0.12740413	205.2799051	69.55285489	480.1420661
10	0.295851218	2.31669617	0.241511198	0.156982279	252.9376969	85.70024873	591.6118692
10.5	0.333002888	2.607616495	0.271839093	0.17669541	284.7004796	96.46210198	665.903837
11	0.69636906	5.452996089	0.568464539	0.36950195	595.3600174	201.7196416	1392.524946
11.5	0.345898043	2.708593447	0.282365749	0.183537737	295.7251785	100.197486	691.6901979
12	0.335099903	2.624037405	0.273550941	0.177808112	286.4933203	97.06955154	670.0972247
12.5	0.29265404	2.291660312	0.238901257	0.155285817	250.2042732	84.77411122	585.2184929
13	0.336753251	2.636984134	0.274900613	0.178685399	287.9068487	97.54848267	673.4034152
13.5	0.143829577	1.126273648	0.1174119	0.076317735	122.9669503	41.66361263	287.6151249
14	0.059691519	0.467421142	0.048727771	0.031673051	51.03320357	17.29104951	119.3647658
14.5	0.037647169	0.294800382	0.030732383	0.019976049	32.18640869	10.90538605	75.28281329
15	0.010355469	0.081089659	0.008453444	0.005494738	8.853397238	2.999704491	20.70776698
15.5	0.002077393	0.016267258	0.001695831	0.00110229	1.77606493	0.601765605	4.15414984
16	0.000738118	0.005779913	0.000602545	0.000391654	0.631052902	0.21381309	1.476009276
Length groups (cm)	**Biomass (kg)**						
	February	**March**	**May**	**June**	**July**	**August**	**September**
7	1.53141E-05	0.000119919	1.25013E-05	8.12585E-06	0.01309277	0.004436087	0.030623502
7.5	5.1047E-06	3.99729E-05	4.1671E-06	2.70862E-06	0.004364257	0.001478696	0.010207834
9	0.000789084	0.006179013	0.00064415	0.000418698	0.6746268	0.228576781	1.577927003
9.5	0.001767042	0.013837024	0.001442484	0.000937614	1.510731097	0.511865303	3.533543869
10	0.002673535	0.020935414	0.002182477	0.00141861	2.285735801	0.774452085	5.346251057
10.5	0.003599624	0.02818726	0.002938469	0.001910005	3.077494886	1.042715579	7.198146121
11	0.009593367	0.075121936	0.00783132	0.005090358	8.201839253	2.778943877	19.18379708

11.5	0.005369785	0.042048707	0.004383498	0.002849274	4.590892543	1.555484365	10.73792698
12	0.005685766	0.044523031	0.004641442	0.003016937	4.861040033	1.647015629	11.36979191
12.5	0.005290203	0.04142553	0.004318533	0.002807047	4.522853782	1.532431499	10.57878684
13	0.007416923	0.058079045	0.006054631	0.00393551	6.341090405	2.148485701	14.83157471
13.5	0.00364404	0.028535064	0.002974727	0.001933572	3.115468283	1.055581711	7.286964486
14	0.00163529	0.012805323	0.001334931	0.000867705	1.398089632	0.473700167	3.27007967
14.5	0.00108531	0.008498641	0.000885967	0.000575879	0.927884616	0.314385492	2.170287619
15	0.000327517	0.002564662	0.000267361	0.000173785	0.280010709	0.094873116	0.654934639
15.5	7.14658E-05	0.000559621	5.83394E-05	3.79206E-05	0.061099594	0.02070174	0.142909678
16	3.06282E-05	0.000239837	2.50026E-05	1.62517E-05	0.02618554	0.008872174	0.061247005

Table 3.11.3.3 Catch-at-length (10^{-3}), catch-at-age (10^{-3}) and biomass (kg) of the red mullet (October-December, 2019)

	catch-at-length in numbers * 10-3			**Biomass (kg)**		
Length (cm)	***October***	***November***	***December***	***October***	***November***	***December***
7	62.00442	58.73555727	31.65023796	0.232393	0.220140875	0.118625095
7.5	53.23348	50.42702096	27.17310072	0.232393	0.220140875	0.118625095
8	232.7179	220.4490533	118.7911603	1.626748	1.540986122	0.830375665
8.5	218.381	206.8679721	111.4728599	1.626748	1.540986122	0.830375665
9	490.7018	464.8320253	250.4793501	4.415459	4.182676616	2.253876806
9.5	483.1639	457.6915829	246.6316519	4.299263	4.072606179	2.194564259
10	1083.864	1026.722633	553.2596807	11.27104	10.67683241	5.75331711
10.5	1171.656	1109.886023	598.0730986	14.05975	13.31852291	7.176818251
11	1129.616	1070.062527	576.6138127	15.5703	14.74943859	7.947881369
11.5	1022.836	968.911989	522.1078414	16.15128	15.29979078	8.244444106
12	957.383	906.9098807	488.69739	17.19705	16.29042471	8.778257034
12.5	636.3233	602.7764409	324.8120675	13.94356	13.20845247	7.117505703
13	363.8599	344.677237	185.7327499	8.366133	7.925071483	4.270503422
13.5	156.1741	147.9406584	79.71929202	4.183067	3.962535741	2.135251711
14	151.6038	143.6112519	77.38634837	3.485889	3.302113118	1.779376426
14.5	88.78684	84.10600874	45.32135753	2.556318	2.42154962	1.304876046
15	34.18789	32.38551154	17.45125431	1.161963	1.100704373	0.593125475
15.5	26.58616	25.18454138	13.57094007	1.045767	0.990633935	0.533812928
16	10.38626	9.838698303	5.301680226	0.464785	0.440281749	0.23725019
16.5	4.921486	4.662026144	2.512179057	0.232393	0.220140875	0.118625095
17	2.355537	2.231353509	1.202386984	0.116196	0.110070437	0.059312548
	catch-at-age in numbers * 10-3			**Biomass (kg)**		
Age (years)	***October***	***November***	***December***	***October***	***November***	***December***
0+	139.3825	132.034226	71.14795305	0.697178	0.660422624	0.355875285

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1	1799.442	1704.575801	918.5275878	16.38368	15.51993165	8.363069202
2	3357.554	3180.543988	1713.867694	43.806	41.49655485	22.36083042
3	2459.383	2329.724398	1255.395113	44.27079	41.9368366	22.59808061
4	531.4159	503.3997282	271.2619396	13.59497	12.87824116	6.939568061
5	93.56456	88.63184724	47.76015052	3.485889	3.302113118	1.779376426

IV.3.12 Red mullet coefficient of variations in length

The dimensionless expressions of CVs showed relatively low magnitude of standard deviation around mean. The variability was within the limits of 0.10 - 0.22 and could be estimated as low. This means that the random sampling of red mullet in the months of interest was conducted according to the variation statistics and correctly reflected the general population at this time of the year.

Table 3.12.1 Length coefficient of variation of red mullet samples

Coefficient of variation (CV)	February	March	May	June	July	August	September	October	November	December
1st sample	na	na	na	na	CV = 0.17	CV = 0.16	CV = 0.15	CV = 0.10	CV = 0.11	CV = 0.13
2nd sample					CV = 0.18	CV = 0.20	CV = 0.20	CV = 0.14	CV = 0.22	CV = 0.20

VI. Conclusions and recommendations

- In the spring season (May-June), the red mullet age structure was characterized by 4-5 age classes. In 2019, one-year-old fish were presented in the age structure in the spring catches (March) with a high participation rate which was associated with its high yield.
- Size and age composition in months and seasons will depend on the seasonal dynamics and the distribution of the stock.
- During the period of study the proportion of male individuals in all age groups was lower than that of females. The breeding rate showed a good degree of determination which was directly dependent on the active breeding season of the species.
- The percentage share of the size group 9-12.5 cm dominated in the catches in October-December, 2019.
- Recruitment 0+ yr was registered in October, in November it decreased and in December - was completely absent in the catches.
- Red mullet condition was remarkably good during the October-December period with a decline under the situation in December, most noticeable for the 14 cm size group, corresponding to the age of 4+ yr.

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- According to the growth model, the growth rate was very low at the expense of the maximum theoretical dimensions.
- The active breeding season for the red mullet passed in October-December, 2019. Due to that fact, determination of GSI and batch fecundity could not be performed during the period of study.
- Recommendations: The presence of recruitment in the coming months should be monitored in order to draw conclusions about the reproductive potential of the species.

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

V.1 Objectives

The European anchovy (*Engraulis encrasicolus*) is a small pelagic coastal marine fish forming large schools. This species is essential for fishing and the economy of the countries bordering the Black Sea. Information on the age of individual fish species significantly enhances the quality of studies on population characteristics such as growth, recruitment, mortality and reproduction. It is often a prerequisite for more detailed studies on life history, strategies and stock assessment. Multiannual biological monitoring on the landings provides the so called “Fishery dependent” information. The aim of this study was to collect and analyze dynamics in length and weight, as well as to determine the condition of anchovy species using the so-called condition factor. The condition factor is also a useful index for monitoring of feeding intensity, age and growth rates in fish. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live.The purpose was to define the age of anchovy as one of the important indicators for the assessment of fishing reserves. Biological information on a given species collected each month, analyzed and compared to previous periods could be used for estimation of growth parameters. These indicators are very important for the species. Reliable and informative long-term data are crucial for the assessment of fish stocks, fisheries management and the decision-making process in general.

V.2 Sampling

V.2.1.1 Geographic area coverage

Data of the present analysis were collected from landing ports on the Bulgarian Black Sea coast.

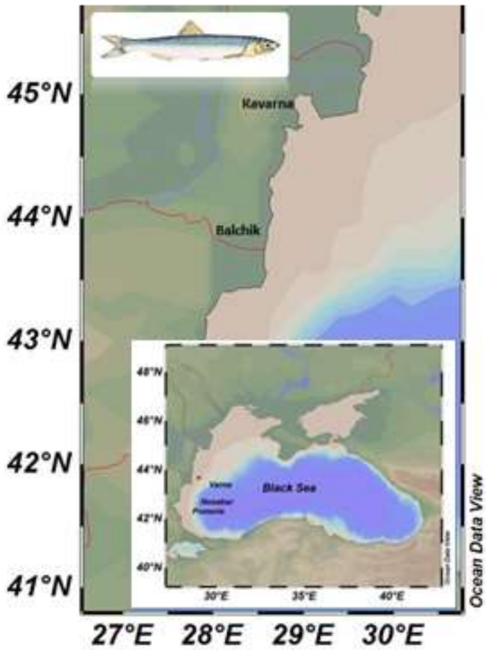

Fig. 2.1.1 Map of ports for sampling of anchovy in the period 2017-2019

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In 2017, 3 samples with 1525 species were collected.
In 2018, 2 samples with 1550 species were collected.
In 2019, 8 samples with 1643 species were collected.

V.2.1.2 Sampling period

2017		2018		2019	
Date	Vessel	Date	Vessel	Date	Vessel
				9.04. 2019	FV 40
		25.06.2018	Trap net Ikantalaka	27.06.2019	FV 40
				19.08. 2019	LEFER BH 03
				22.09. 2019	EGEO 2 BH 8339
		18.10.2018	FV БС 2133	22.10.2019	EGEO 1 BH 8428
2.11.2017	LEFER BH 03			8.11.2019	EGEO 1 8428
7.12.2017	NIKO			7.12.2019	NIKO
				19.12. 2019	FV40
3 samples with 1525 species		**2 samples with 1550 species**		**8 samples with 1643 species**	

V.2.1.3 Statistical analysis of data

Refer to the methodology used for sprat stock analysis.

V.3.1 Catch statistics for the period 2017-2019

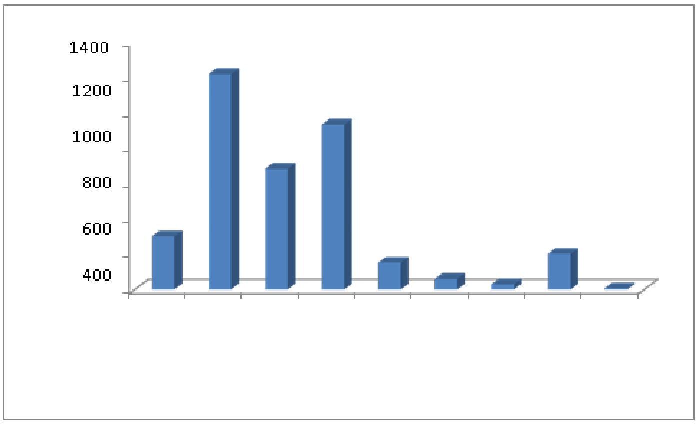

Fig. 3.1.1 Landing statistics for 2017

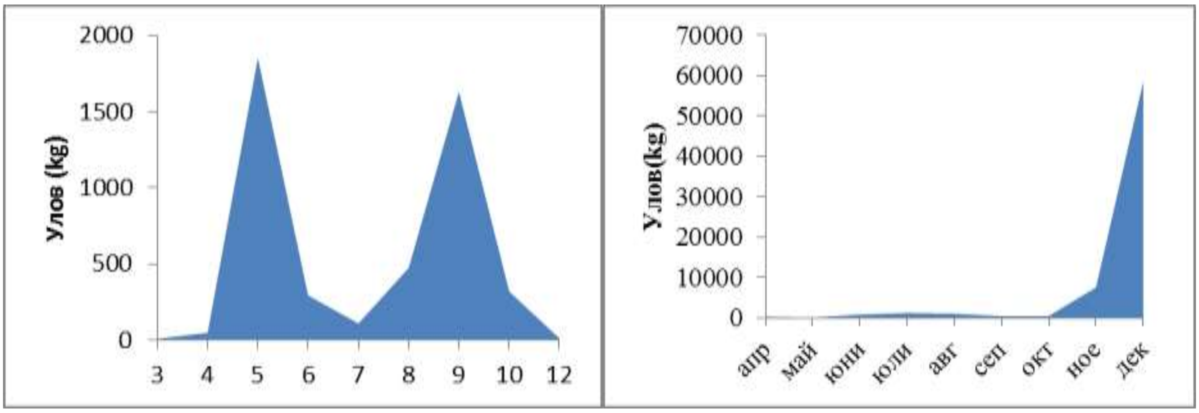

Fig. 3.1.2 Landings statistics for 2018 (left) and 2019 (right)

V.3.2 Size structure in the period 2017-2019

V.3.2.1 Size structure analysis for 2017

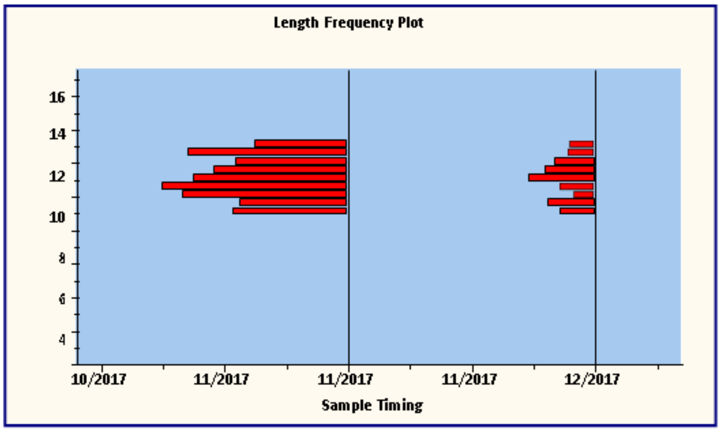

Fig. 3.2.1.1 Frequency of anchovy length from landings in 2017

V.3.2.2 Size structure analysis for 2018

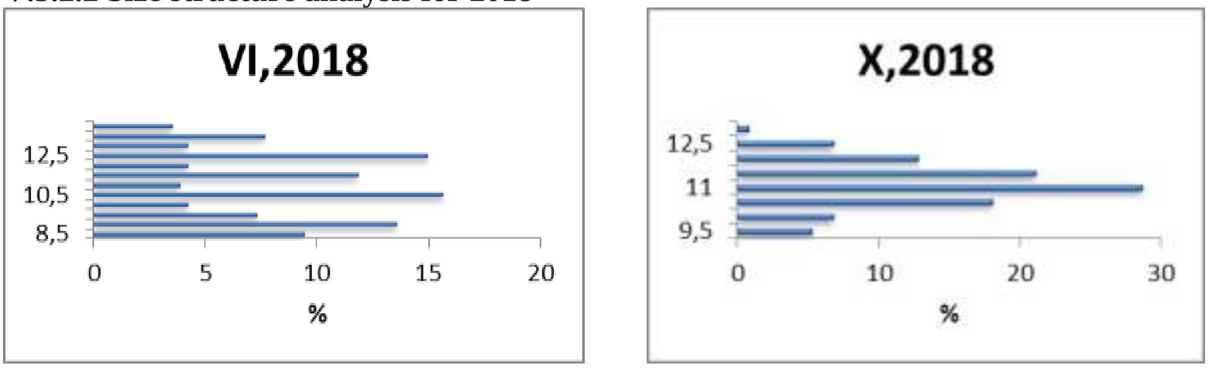

Fig. 3.2.2.1 Frequency of anchovy from landings in 2018

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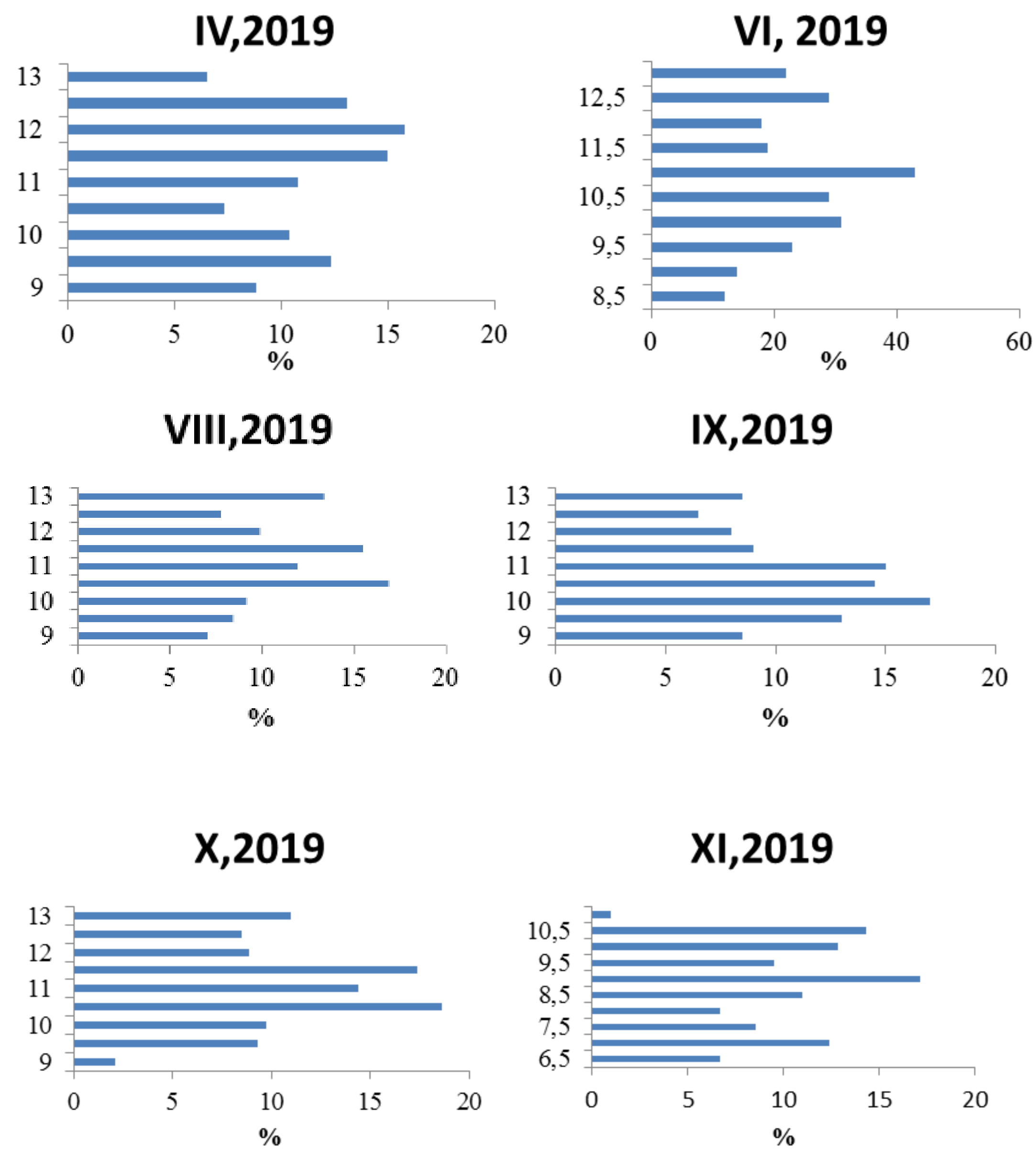
V.3.2.3 Size structure analysis for 2019

In the catches from the Bulgarian Black Sea area in April 2019, the size composition was represented by individuals with a body length from 9.0 cm to 13.0 cm. There was dominance of the individual class 11 cm in June, 10.5 cm - in August and October, 10 cm - in September, 9.0 cm - in November and 9.5 cm - in December. On Fig. 3.2.3.1 is shown that during the different months the variation order was interrupted and it is absent or represented by very weak individuals with definite dimensions. In June, the anchovy with a body length of 8.5 -9 cm had less share. In December, it impressed with the absence of an individual measures between 11.5-12.5 cm. The absence of certain size groups in the catches during the season indicated that they did not reflect the composition of the population proportionately.



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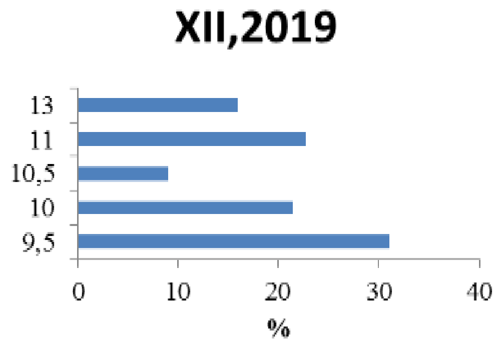
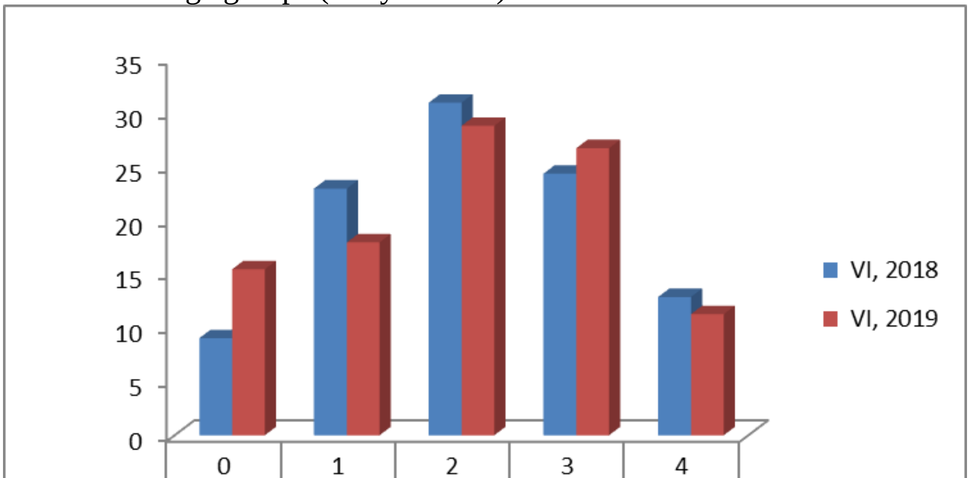


Fig. 3.2.3.1 Frequency of anchovy length from landings in 2019

V.3.3 Age structure of landings

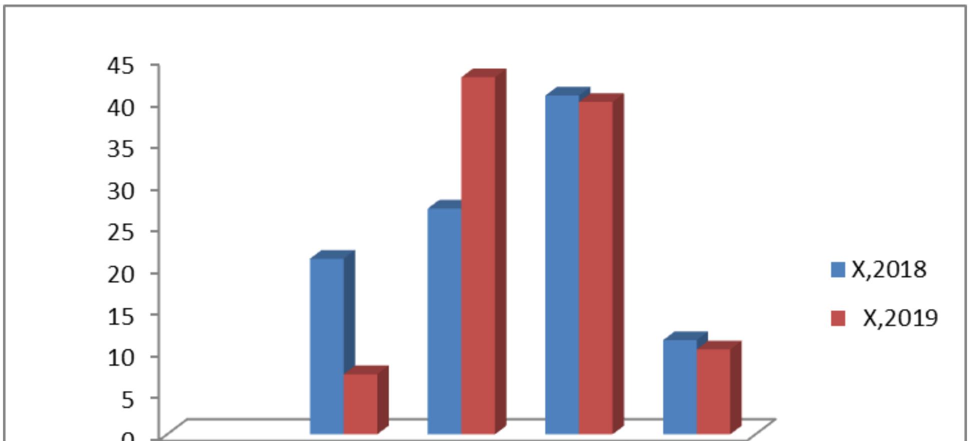
During the accounting period (2017 – 2019), in separate years, deviations were reported in some of the typical biological parameters: number and condition of the new generations, age-linear and weight structure, condition factor and gonadosomatic index. The age structure of the anchovy during the period 2017-2019 was characterised by 5 age classes. During the period 2017 – 2019, the senior age groups (five and six years) were missing. The most indicative, in terms of the biological state of the species, was the age composition in the spring which most closely reflectsed the real qualitative composition in the catches of the species in the Bulgarian Black Sea waters. A larger share had the two-year-olds in June, 2018 (30.9%) and to some extent in 2019 (28.75%). The three-year-olds were well represented during that period with a percentage varying between 24.3% (June, 2018) and 26.67% (June, 2019). Young age groups (annuals) were covered in the catches with a participation varying between 17.92% (June, 2018) and 22.92% (June, 2019). On Fig. 3.3.1 is presented the range of variation of the percentage composition in the different age classes in June. In a multiannual plan this age distribution remained below normal for the species due to the low participation of senior age groups (5-6 years old).



	0	1	2	3	4
VI, 2018	9,02	22,92	30,9	24,3	12,85
VI, 2019	15,42	17,92	28,75	26,67	11,25

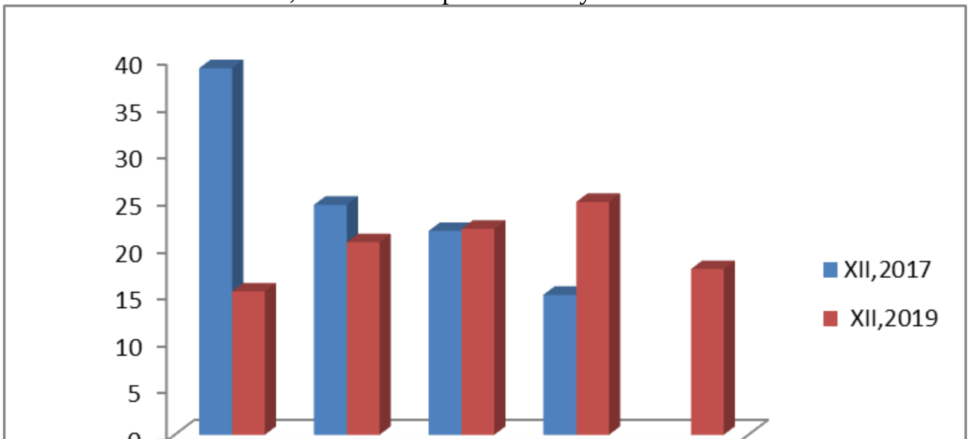
Fig. 3.3.1 Variation of the percentage participation of anchovy by age groups in June 2018-2019
Note: For June, 2017 no comparative analysis data were available.

In the autumn season of the accounting period (2017-2019), three-year-olds dominated with a significant share in the catches, reaching 40.6% (October, 2018) and 39.8% (October, 2019).



	0	1	2	3	4
X,2018		21,05	27,06	40,6	11,28
X,2019		7,2	42,79	39,83	10,17

Fig. 3.3.2 Variation of the percentage participation of anchovy by age groups in October, 2018 and 2019
Note: For June, 2017 no comparative analysis data were available.



	0	1	2	3	4
XII,2017	38,98	24,45	21,68	14,89	
XII,2019	15,24	20,47	21,9	24,76	17,62

Fig. 3.3.3 Variation of the percentage participation of anchovy by age groups in December, 2017 and 2019
Note: For June, 2018 no comparative analysis data were available.

V. 3.4 Condition factor

During the spring migration along our coast in June, the species was with condition factor K = 0.60-0.65 in 2019 and lower values in the same period of 2018 (Fig. 3.4.1).

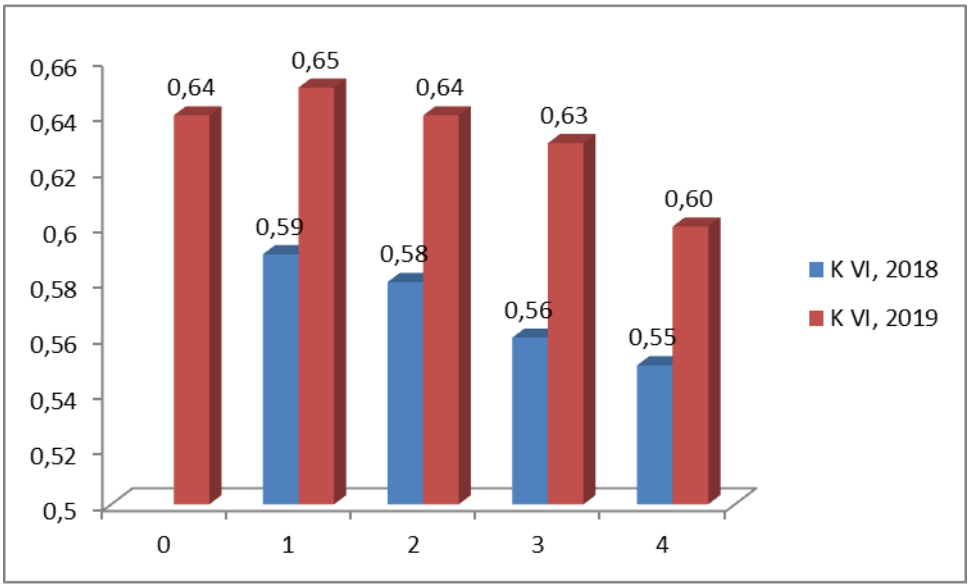


Fig. 3.4.1 Condition factor by age groups in June, 2018 and 2019
Note: For June, 2017 no comparative analysis data were available.

The condition factor in 2019 marked a slight increase compared to 2018. In June 2019, a particularly typical increase was observed in 2+ year-olds. With the onset of the active propagation period and the accumulation of spare fats, Fulton's condition factor showed relatively high values in October 2018 and 2019 (Fig. 3.4.2).

Autumn months were characterized by higher values of K coefficient (October 2018). The autumn coefficients reach lower values ranging from 0.51 to 0.53 in September, 2019. In November 2017, the condition factor was relatively higher for one-year-olds compared to the following years.

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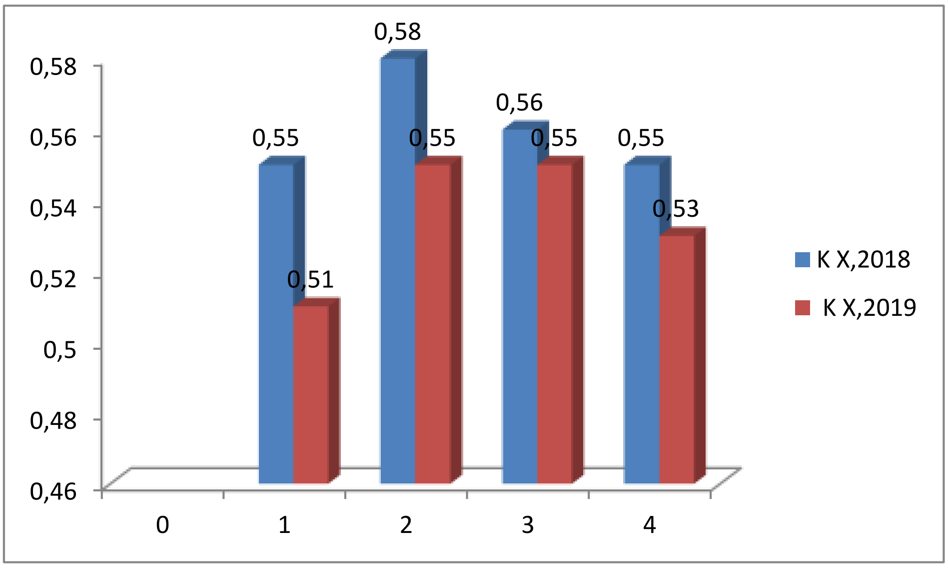

Fig. 3.4.2 Condition factor by age groups in October 2018 and 2019
Note: For October, 2017 no comparative analysis data were available.

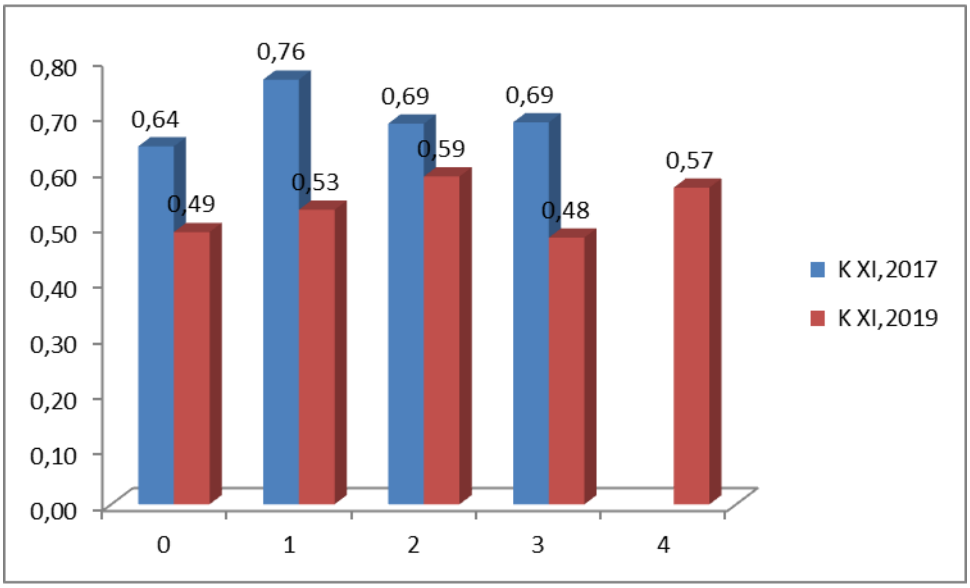

Fig. 3.4.3 Condition factor by age groups in November 2017 and 2019
Note: For November, 2018 no comparative analysis data were available.

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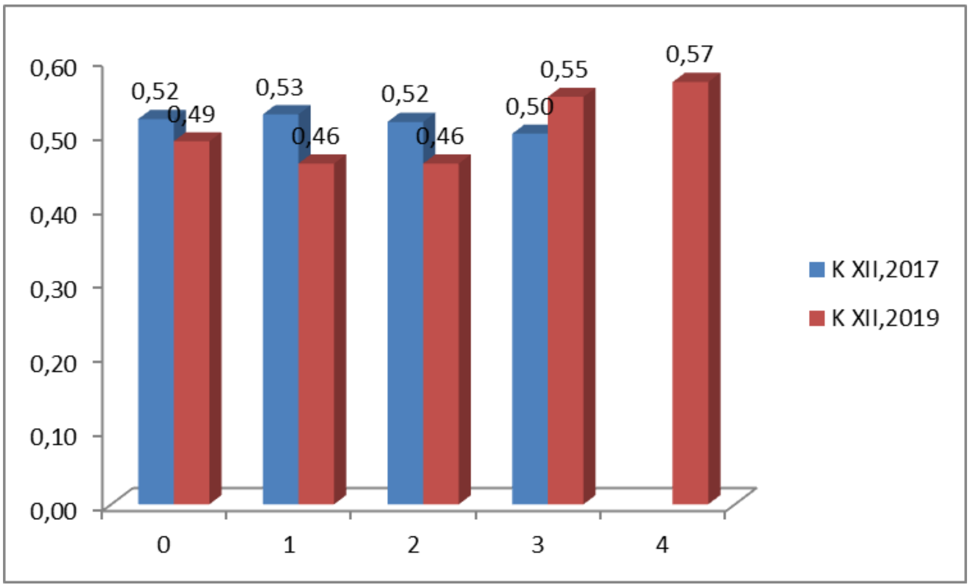

Fig. 3.4.4 Condition factor by age groups in December 2017 and 2019
Note: For, December, 2018 no comparative analysis data were available.

V.3.5 Sex ratio

In 2019, females (♀) dominated by 61%, followed by males (♂) with (39%) (Fig. 3.5.1).

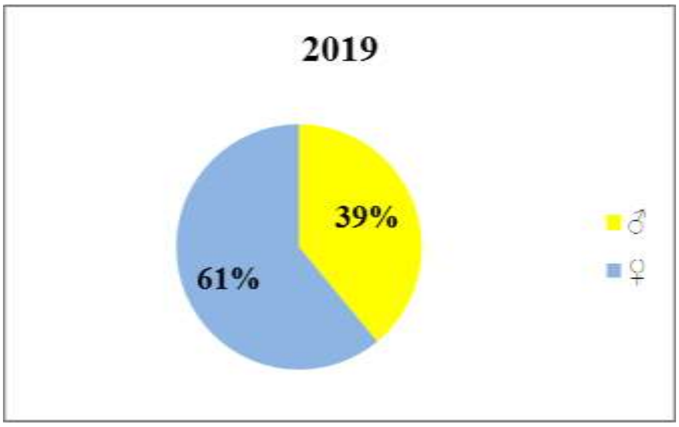

Fig. 3.5.1 Sex ratio of anchovy

V3.6 Weight structure

In June and October, the weight structure referred to the average multiannual data showed a similar picture (Fig. 3.6.1). In connection with the onset of the breeding period in June 2019, the values of the individual weights and the condition factor associated with the accumulation of fats increased.

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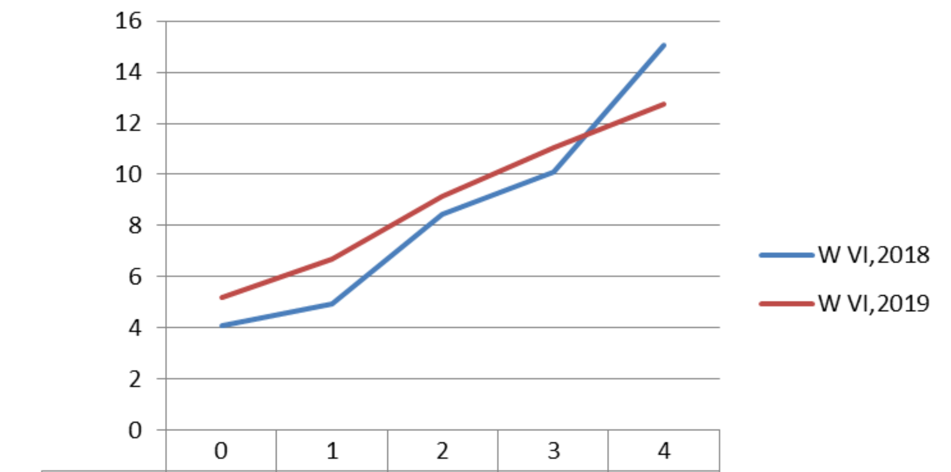
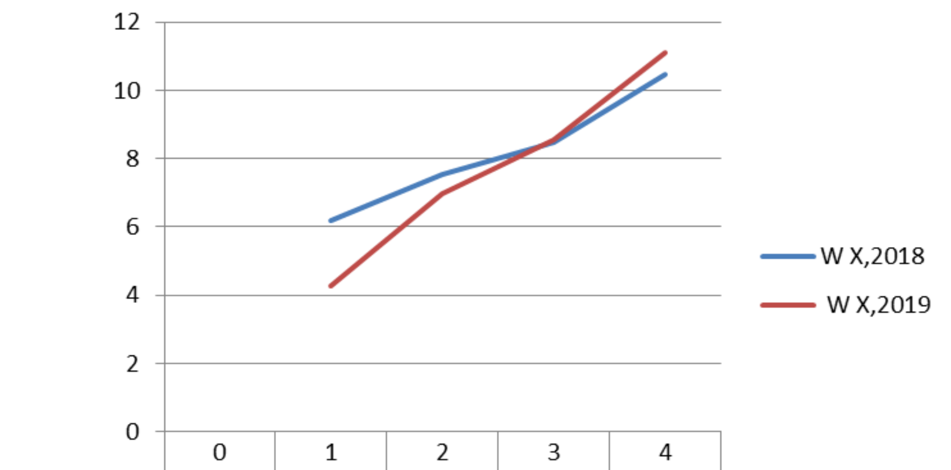


	0	1	2	3	4
W VI,2018	4,1	4,92	8,43	10,08	15,04
W VI,2019	5,2	6,69	9,13	11,07	12,73

Fig. 3.6.1 Variation of the average weights by age groups in June, 2018 and 2019

It is noticeable that during the period 2018-2019, the linear sizes at different ages remained almost constant in October compared to November 2017. In November 2019, the average weights by age group showed a decrease.



	0	1	2	3	4
W X,2018		6,2	7,54	8,49	10,45
W X,2019		4,25	6,99	8,56	11,09

Fig. 3.6.2 Variation of the average weights by age groups in October, 2018 and 2019

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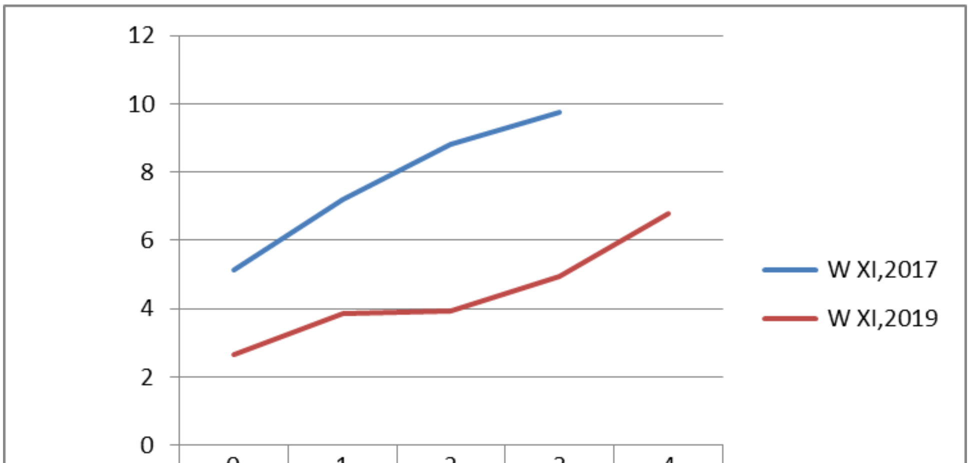
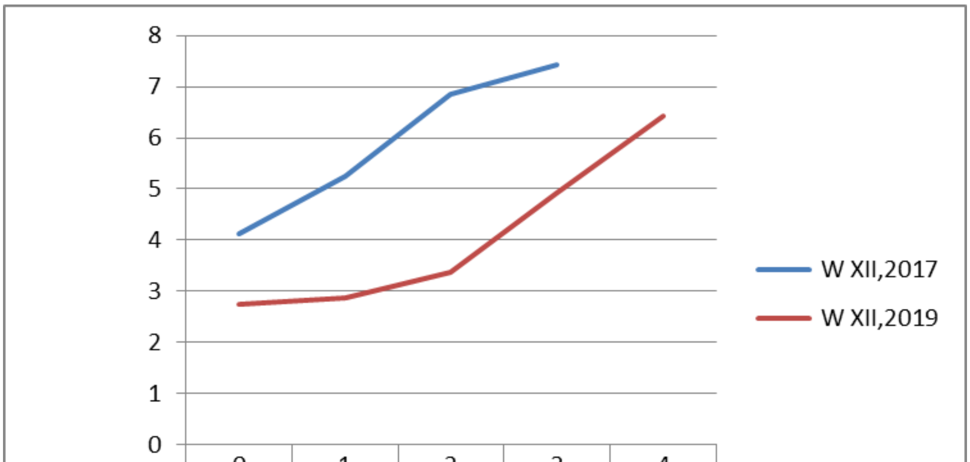


	0	1	2	3	4
W XI,2017	5,1380925	7,19	8,83	9,77	
W XI,2019	2,67	3,87	3,94	4,93	6,78

Fig. 3.6.3 Variation of the average weights by age groups in November, 2017 and 2019



	0	1	2	3	4
W XII,2017	4,12	5,25	6,86	7,43	
W XII,2019	2,75	2,88	3,37	4,92	6,42

Fig. 3.6.4 Variation of the average weights by age groups in December, 2017 and 2019

V.3.7 Size structure

In June of the reporting period, the average linear dimensions of age 1+ showed values within the average multiannual data of 9.24-10.04 cm. That was an indication of a good increase in replenishment.

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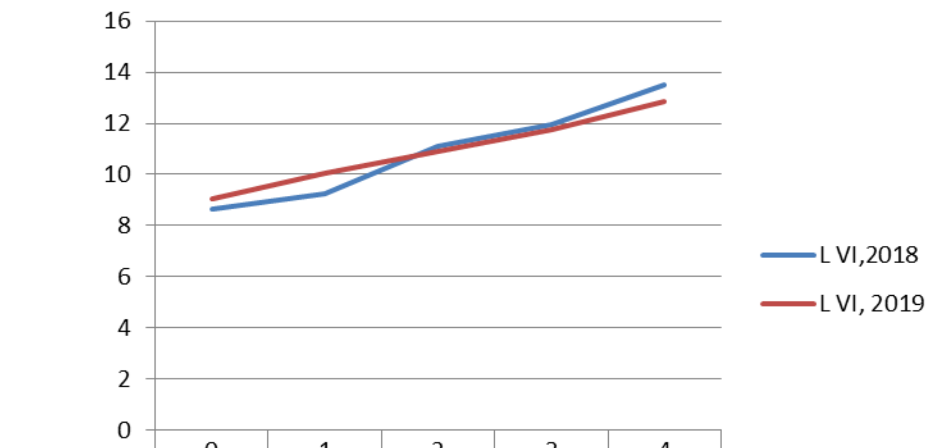
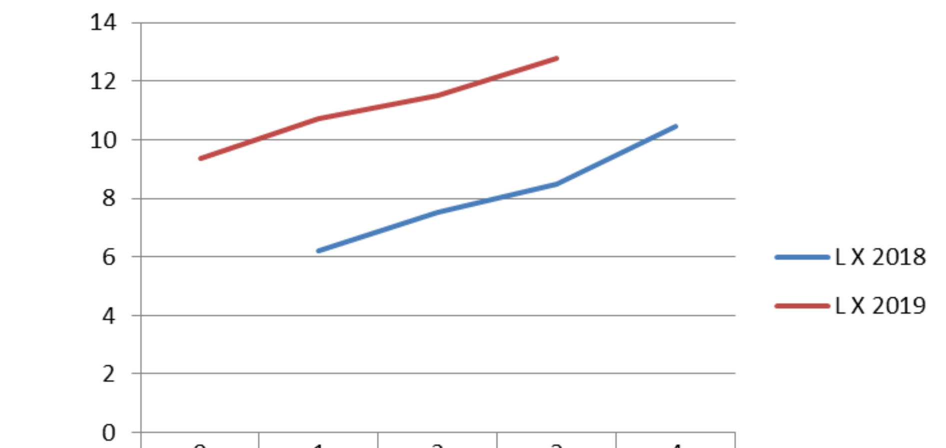


	0	1	2	3	4
L VI,2018	8,67	9,24	11,1	11,94	13,51
L VI, 2019	9,03	10,04	10,92	11,73	12,84

Fig. 3.7.1 Variation of the average lengths by age groups in June, 2018 and 2019

In October of the reporting period, the average linear dimensions of age 1+ showed values within the range of 6.19-10.72 cm, which lowered only in 2018. The increase in two-and three-year-old fish compared to the average level was lower with 3.97- 4.3 cm (Fig. 3.7.2).



	0	1	2	3	4
L X 2018		6,19	7,54	8,49	10,45
L X 2019	9,35	10,72	11,51	12,79	

Fig. 3.7.2 Variation of the average lengths by age groups in October, 2018 and 2019

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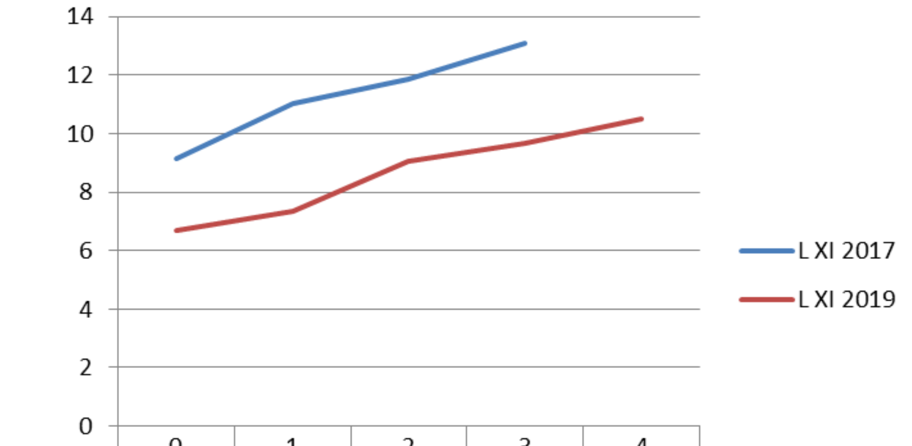
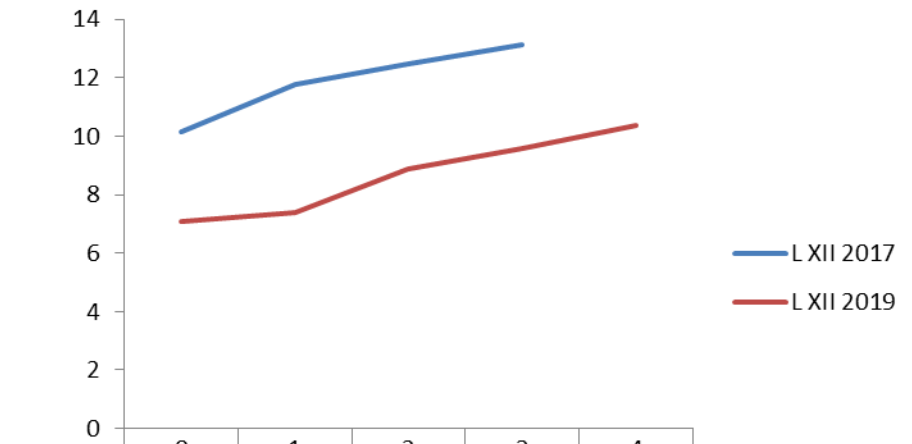


	0	1	2	3	4
L XI 2017	9,12	11,01	11,84	13,09	
L XI 2019	6,69	7,33	9,05	9,67	10,5

Fig. 3.7.3 Variation of the average lengths by age groups in November, 2017 and 2019



	0	1	2	3	4
L XII 2017	10,13	11,75	12,46	13,11	
L XII 2019	7,09	7,41	8,89	9,56	10,39

Fig. 3.7.4 Variation of the average lengths by age groups in December, 2017 and 2019

V.3.8 Length- weight relationship

It followed from the analysis that the increase in anchovy was allometric.

$$W = 0.0167*L^{2.5582} \text{ for 2018}$$
$$W = 0.0129*L^{2.2921} \text{ for 2019}$$

II.3.9 Fertility

The gonadosomatic index was highly dependent on the weight of the gonads which was associated with the high rate of maturation of females in late spring and summer and the breeding process of anchovy.

V.3.10 Sexual maturity

All investigated specimens showed a degree of maturity V-VII as a small percentage of 5% were in the range of II-IV. In June, mass mature sex products in over 40% of the examined female specimens were observed.

V.3.11 Catch numbers and biomass by age and length

V.3.11.1 Catch numbers and biomass by age and length in 2017

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

Table 3.11.1.1 Catch-at-age (10^{-3}) matrix and biomass (kg) for selected months

Age groups	November	December
0	0.004	0.00053
1	0.010	0.00033
2	0.007	0.00029
3	0.005	0.00020
∑	0.026	0.00135
Biomass (kg)		
Age groups	**November**	**December**
0	19.729	2.167
1	71.211	1.732
2	59.977	2.006
3	51.086	1.493
∑	202.004	7.398

Table 3.11.1.2 Catch-at-length (10^{-3}) matrix and biomass (kg) for selected months

Catch-at-length (millions)		
TL.cm	**November**	**December**
9.0	108.087	56.091
9.5	102.244	75.888
10.0	155.800	34.644
10.5	174.302	57.741
11.0	145.089	105.583
11.5	125.614	80.837

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12.0	105.165	64.340
12.5	149.958	44.543
13.0	87.638	41.243
∑	1153.897	560.909
Biomass (kg)		
TL.cm	**November**	**December**
9.0	430.184	228.991
9.5	545.370	387.786
10.0	919.222	228.369
10.5	1180.836	457.537
11.0	1101.486	944.079
11.5	1023.304	793.636
12.0	940.220	655.381
12.5	1599.301	530.823
13.0	1069.180	575.963
∑	8809.103	4802.565

V.3.11.2 Catch numbers and biomass by age and length in 2018

Table 3.11.2.1 Catch-at-age (10^{-3}) matrix and biomass (kg) for selected months

Catch-at-age		
Age groups	**June**	**October**
0	0.003135	
1	0.007958	0.008463
2	0.010732	0.01088
3	0.008441	0.016321
4	0.004462	0.004533
Biomass (kg)		
Age groups	**June**	**October**
0	12.87816	
1	39.1831	52.43894
2	90.47244	82.04578
3	85.13827	138.6383
4	67.12803	47.37698
∑	294.8	320.5

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Table 3.11.2.2 Catch-at-length (10^{-3}) matrix and biomass (kg) for selected months

Catch-at-length (millions)		
Length group (cm)	**June**	**October**
8.5	25.03848	
9.0	36.16669	
9.5	19.47437	6.567834
10.0	11.12821	8.444358
10.5	41.73079	22.51829
11.0	10.20086	35.65396
11.5	31.52993	26.27134
12.0	11.12821	15.95045
12.5	39.87609	8.444358
13.0	11.12821	0.938262
13.5	20.40172	
14.0	9.27351	
Biomass (kg)		
Length group (cm)	**June**	**October**
8.5	0.976501	
9.0	1.627501	
9.5	0.973719	0.319478
10	0.754245	0.530118
10.5	2.944775	1.556671
11	0.80772	2.751829
11.5	2.673738	2.242728
12	1.014559	1.527303
12.5	4.784242	0.894914
13	1.580206	0.001267
13.5	3.060258	
14.0	1.474488	

V.3.11.3 Catch numbers and biomass by age and length in 2019

Table 3.11.3.1 Catch-at-age (10^{-3}) matrix and biomass (kg) for selected months

Catch-at-Age *10^{-3} (in thousands)							
Age groups	**April**	**June**	**August**	**September**	**October**	**November**	**December**
0	3.849928	2.950136	0.590027	0.560526	1.475068	2.212155	818.0846
1	5.356421	4.104537	0.820907	0.779862	2.052269	3.077781	1138.205
2	10.62915	8.144941	1.628988	1.547539	4.072471	6.107473	2258.625
3	8.034632	6.156806	1.231361	1.169793	3.078403	4.616672	1707.307
4	3.766234	2.886003	0.577201	0.548341	1.443001	2.164065	800.3001
∑	**31.64**	**24.24**	**4.85**	**4.61**	**12.12**	**18.18**	**6722.521**
Биомаса (кг)							

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Age groups	April	June	August	September	October	November	December
0	20.34988	15.59378	3.118756	2.962818	7.79689	11.69297	4324.217
1	32.85364	25.1752	5.03504	4.783288	12.5876	18.87759	6981.183
2	85.83827	65.77645	13.15529	12.49753	32.88823	49.32238	18240.07
3	77.19408	59.15255	11.83051	11.23899	29.57628	44.35546	16403.24
4	44.81684	34.34241	6.868481	6.525057	17.1712	25.7516	9523.286
∑	**261.05**	**200.04**	**40.01**	**38.01**	**100.02**	**150**	**55472**

Table 3.11.3.2 Catch-at-length (10^{-3}) matrix and biomass (kg) for selected months

Catch-at-length (millions)							
Length group (cm)	**April**	**June**	**August**	**September**	**October**	**November**	**December**
8.5	0.502164502	0.384800385	0.07696	0.073112	0.192400192	0.288600289	106.7066835
9.0	1.966810967	1.50713484	0.301427	0.286356	0.75356742	1.13035113	417.9345103
9.5	3.640692641	2.78980279	0.557961	0.530063	1.394901395	2.092352092	773.6234552
10.0	3.933621934	3.014269681	0.602854	0.572711	1.50713484	2.260702261	835.8690205
10.5	3.891774892	2.982202982	0.596441	0.566619	1.491101491	2.236652237	826.9767969
11.0	4.937950938	3.783870451	0.756774	0.718935	1.891935225	2.837902838	1049.282387
11.5	3.431457431	2.629469296	0.525894	0.499599	1.314734648	1.972101972	729.162337
12.0	3.138528139	2.405002405	0.481	0.45695	1.202501203	1.803751804	666.9167717
12.5	3.640692641	2.78980279	0.557961	0.530063	1.394901395	2.092352092	773.6234552
13.0	2.552669553	1.956068623	0.391214	0.371653	0.978034311	1.467051467	542.425641
∑	**31.64**	**24.24**	**4.85**	**4.61**	**12.12**	**18.18**	**6722.521**
	Biomass (kg)						
Length group (cm)	**April**	**June**	**August**	**September**	**October**	**November**	**December**
8.5	1.988571	1.52381	0.304762	0.289524	0.761904762	1.142857	422.5585
9.0	8.358947	6.405323	1.281065	1.217011	3.202661536	4.803992	1776.222
9.5	20.09662	15.39971	3.079942	2.925945	7.6998557	11.54978	4270.401
10	24.89983	19.08033	3.816065	3.625262	9.54016354	14.31025	5291.051
10.5	28.38531	21.75119	4.350239	4.132727	10.87559724	16.3134	6031.693
11	40.17244	30.78348	6.156695	5.84886	15.39173767	23.08761	8536.381
11.5	31.74648	24.3268	4.865361	4.622093	12.16340244	18.2451	6745.92
12	31.28359	23.9721	4.79442	4.554699	11.98605099	17.97908	6647.56
12.5	40.95324	31.38179	6.276359	5.962541	15.69089707	23.53635	8702.297
13	33.16769	25.41585	5.08317	4.829012	12.70792582	19.06189	7047.917
∑	**261.05**	**200.04**	**40.01**	**38.01**	**100.02**	**150**	**55472**

V.3.12 Coefficient of variation of length

The coefficients of variation showed a relatively low degree of standard deviation around the average. The variability was in the range of 0.09-0.22 and can be rated as low. This means that the random sampling of anchovy in the studied months was conducted according to the variation statistics and correctly reflected the general condition at that time of the year.

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Table 3.12.1 Length coefficient of variation of anchovy

coefficient of variation (CV)	November	December
1 **sample**	CV = 0.09	CV =0.22
2 **samples**	CV =0.14	CV =0.18
3 **samples**	CV =0.10	

VII. Conclusions

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

- The age composition was built of 5 age classes which was indicative for its normalization but still reduced by symbolic participation of the senior age classes as of 5-year-old fish.
- A larger share had the two-year-olds in June 2018 (30.9%) and to some extent in 2019 (28.75%). The three-year-olds were well represented during that period with a percentage varying between 24.3% (June, 2018) and 26.67% (June, 2019). Young age groups (annuals) were covered in the catches with a participation varying between 17.92% (June, 2018) and 22.92% (June, 2019).
- In June and October, the weight structure referred to the average multiannual data showed a similar picture.
- It follows from the analysis that the increase in anchovy during the investigation period was allometric.
- The values of Fulton's condition factor indicated a good physiological state of the species.
- The dynamics of the GSI during propagation and spawning showed a characteristic rapid maturation of the sexual products.

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

VI.1 Objectives

Studies on the population dynamics of the Black sea picked dogfish are rare. The present research investigated the population structure of the picked dogfish by analyzing samples collected as bycatch in commercial catches of targeted species.

VI.2 Sampling in the period 2018-2019

IV.2.1 Geographical area of coverage

The sampled specimens were weighted and measured onboard of the fishing vessels.

VI.2.2 Sampling description

In 2018, 57 specimens (25 male and 32 female) were collected and processed for length, weight and sex structure analyses.
In 2019, 148 specimens were collected and processed for length, weight, sex structure and population dynamics analyses.

Date	Sampling ports	Species	Fishing vessel
09/02/2019	Balchik	picked dogfish	VN 8112
23/05/2019	Carevo	picked dogfish	GG-2 ЦР 212
24/06/2019	Balchik	picked dogfish	Beni VN 2998
10/ 08/ 2019	Carevo	picked dogfish	Evropa ЦР 576
05/09/2019	Balchik	picked dogfish	VN 8112
26/09/2019	Balchik	picked dogfish	VN 8112
17/10 /2019	Kavarna	picked dogfish	Viking VN 8406
11/11/2019	Kavarna	picked dogfish	Galiver KB5562
11/11/2019	Kavarna	picked dogfish	Viking VN 8406
18/11/2019	Дurankulak	picked dogfish	ШБ 6056
9/12/2019	Kavarna	picked dogfish	Гondola VN4321
17/12/2019	Carevo	picked dogfish	VARDA ЦР720

IV.2.3 Statistical analysis

Refer to the methodology used for sprat stock analysis.

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IV.3 Results

IV.3.1 Landings statistics 2018-2019

Official statistics of picked dogfish catches landed on ports in 2018 is presented on Fig. 3.1.1. The average catch was estimated to 840.18 kg. The smallest catch in weight (142 kg) was reported in November and the biggest one was reported in January (2937 кg).
Official statistics for picked dogfish catches in 2019 is presented on Fig.3.1.2. The biggest catches in weight were declared in October (2774 kg).

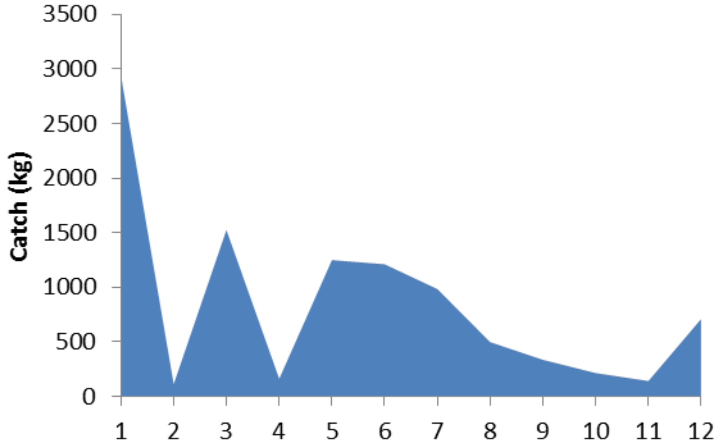

Fig.. 3.1.1 Official picked dogfish landing statistics in 2018

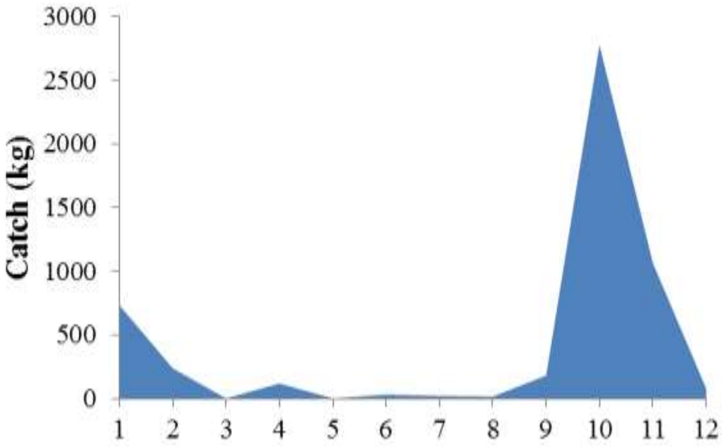

Fig.. 3.1.2 Official picked dogfish landing statistics in 2019

VI.3.2 Sex, length and weight structure of picked dogfish in the period 2018 – 2019

IV.3.2.1 Sex, length and weight structure of picked dogfish in 2018

The samples collected were processed and analyzed and the outcome showed that the female specimens were represented with 56% and the male ones - with 44%. The mean total length of the studied specimens was calculated as 116.75 ±0.135 cm. Male specimens' length varied

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in the range of 109-123 cm, and the the female - in the range of 114-125 cm (Fig. 3.2.1.1, Fig. 3.2.1.2). The mean weight registered for the female specimens was 6.1 kg. The mean and maximum weight for the male specimens were 6.0 kg and 7.3 kg, respectively (Fig. 3.2.1.3, Fig. 3.2.1.4).

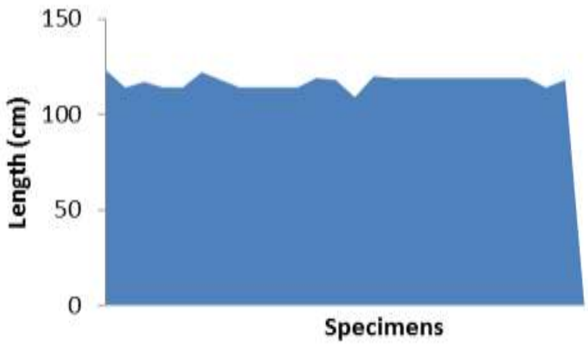

Fig. 3.2.1.1 Picked dogfish length structure (♂) presented in catches in 2018

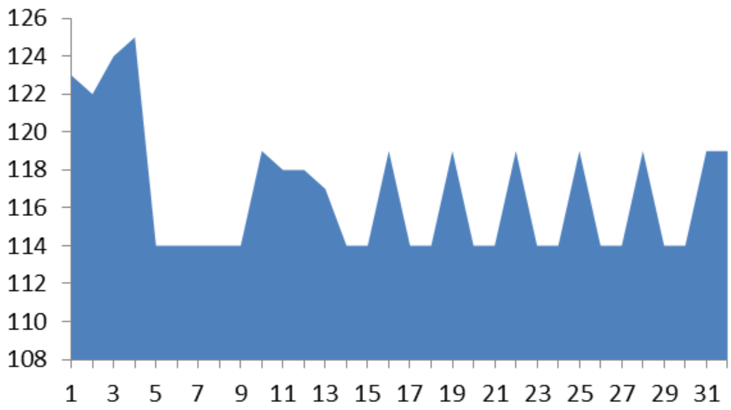

Fig. 3.2.1.2 Picked dogfish length structure (♀) presented in catches in 2018

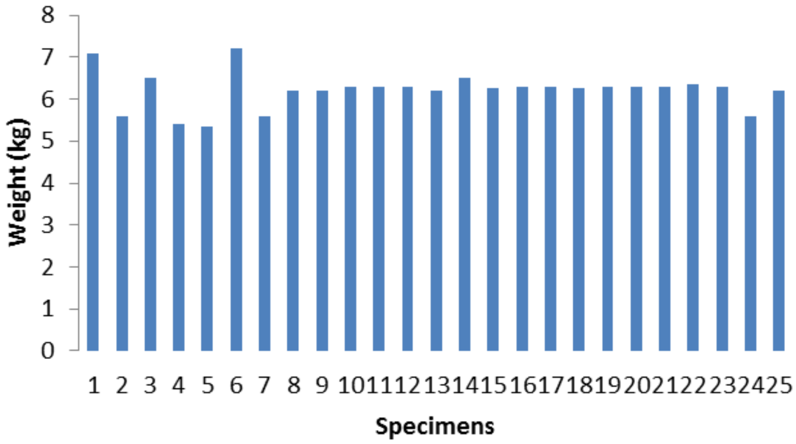

Fig. 3.2.1.3 Picked dogfish weight structure (♂) presented in catches in 2018

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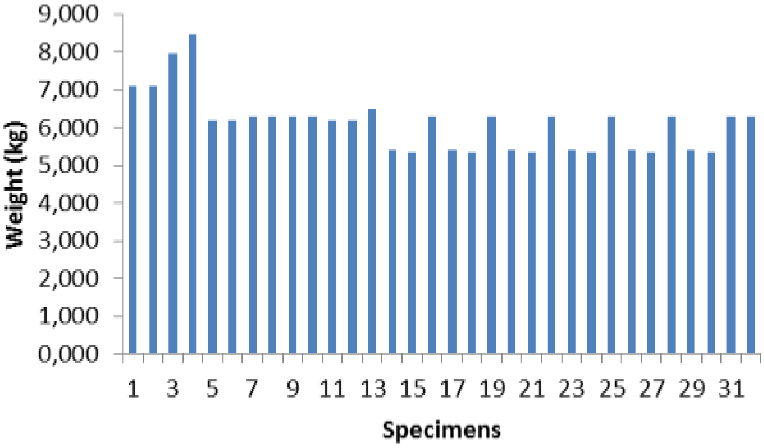

Fig. 3.2.1.4 Picked dogfish weight structure (♀) presented in catches in 2018

IV.3.2.2 Sex, length and weight structure of picked dogfish in 2019

Fig. 3.2.2.1 shows the results of weight and length structure analyses for the samples collected in 2019. The mean weight calculated for the female specimens (represented with 3.64% in the catches' structure) was 7.1кg corresponding to mean length of 102 cm. The male specimens' (93.6%) mean length was calculated to be 111.76 cm with corresponding mean weight of 6.183 кg.

$$W_{♀} = 7.1\ kg,\ L_{cp.♀} = 102\ cm,\ W_{cp.♂} = 6.183\ kg,\ L_{cp.♂} = 111.7556\ cm$$

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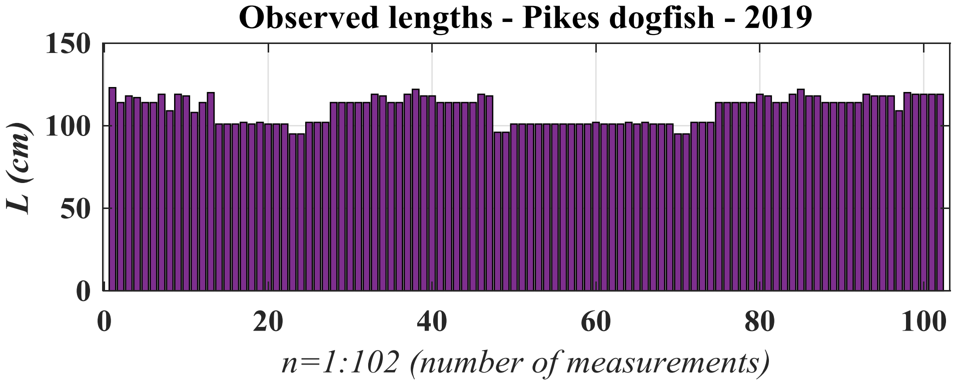

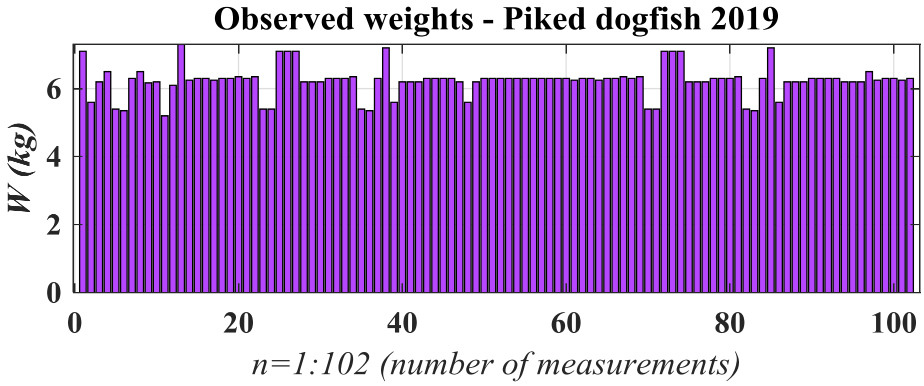

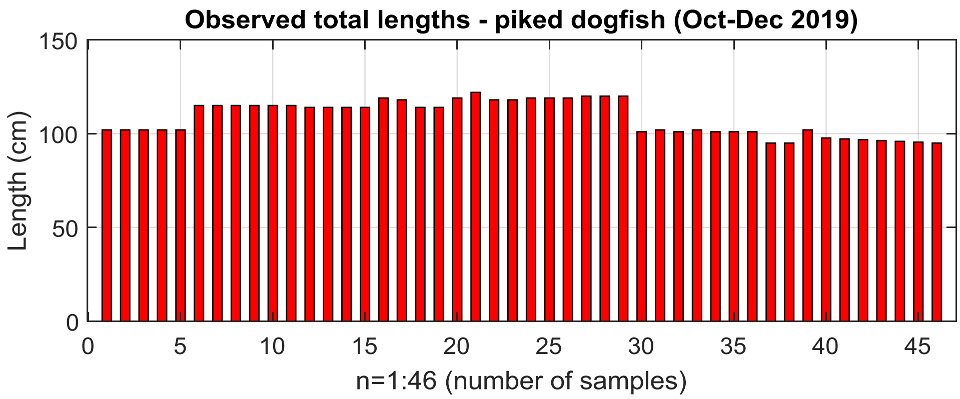

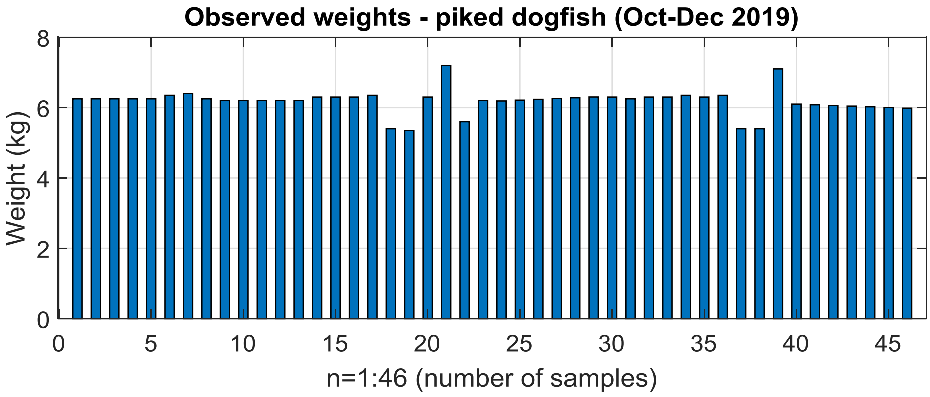

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Fig. 3.2.2.1 Picked dogfish (presented in catches) length and weight structure

The total length of the picked dogfish in the period October-December 2019 varied from 95 cm to 122 cm, and the weight varied in the range of 5.350-7.200 kg.

$$W_{mean\_female} = 6.277083kg.\ L_{mean\ female} = 118.375\ cm.$$

$$Wmean\ male = 6.14503\ kg.\ L_{mean\ male} = 105.0111\ cm$$

The mean weight of females equalled to 6.277 kg, and the mean TL was 118 cm. Males exhibited lower mean weight of 6.14 kg corresponding to TL of 105 cm.
Sex was determined on 50 specimens (January-June 2019). The sample was composed of 96. 36 % males and 3. 64 % females.

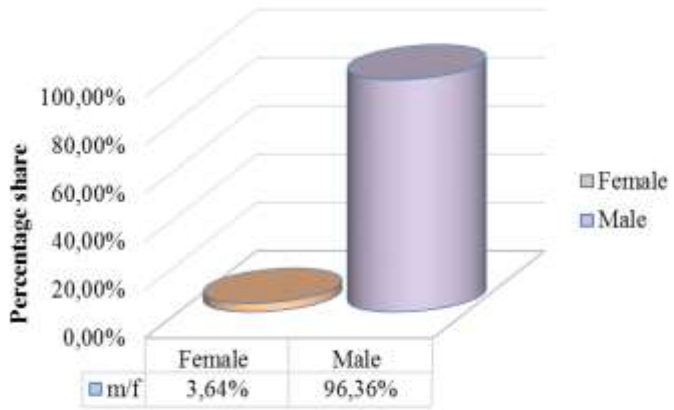

Fig. 3.2.2.2 Picked dogfish sex ratio in the samples collected (January-June)

Sex was determined on 46 specimens (October-December 2019). Males predominated in the samples by 74%, and females hold lower share of 26%.

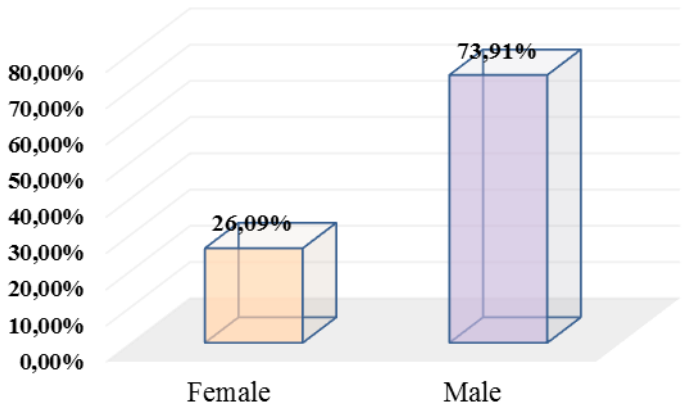

Fig. 3.2.2.3 Picked dogfish sex ratio in the samples collected October-December, 2019

Length-weight relationship of picked dogfish is best described by the following non-linear general model : f(x) = a*exp(-b*x)+c. where: a = 0.8147, b = 0.9058, c = 6.281 (CL6.241. 6.322)

$$W = 0.8147 * e^{(-0.9058*L)} + 6.281$$

Project proposal № BG14MFOP001-3.003-0001 "Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2017-2019", funded by the Maritime Affairs and Fisheries Program, co-financed by the European Union through the European Maritime and Fisheries Fund

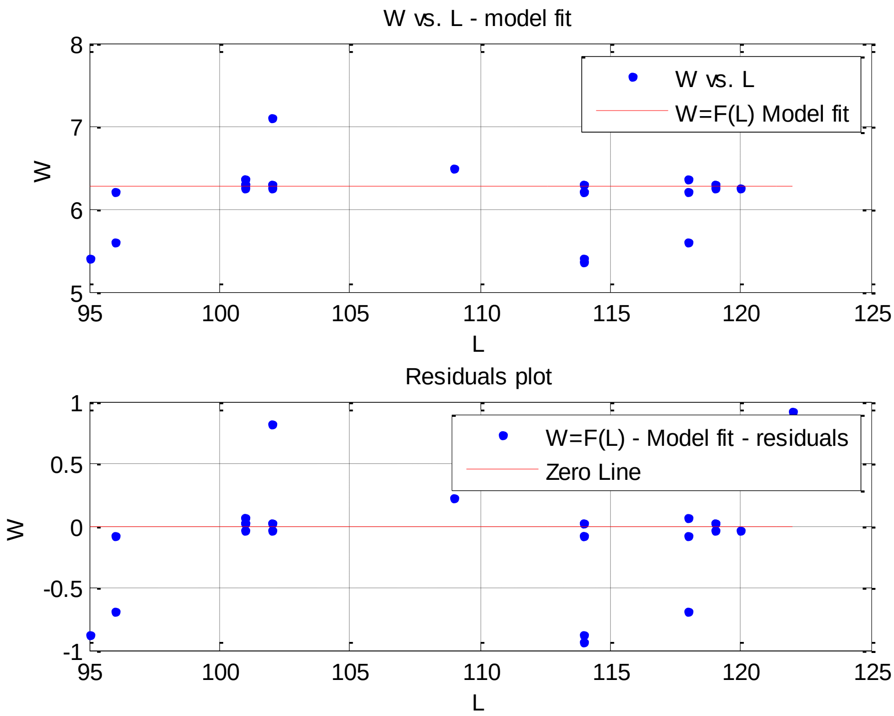

Fig. 3.2.2.4 LWR model of picked dogfish (January-June)

LWR analysis for the period October-December is best described with the following polynomial model:

Linear model Poly4:

*f(x) = p1*x^4 + p2*x^3 + p3*x^2 + p4*x + p5*

where x is normalized by mean 108.5 and std 9.261

Coefficients (with 95% confidence bounds):

p1 = 0.1055 (-0.0938. 0.3049)
p2 = 0.1529 (0.06213. 0.2437)
p3 = -0.2791 (-0.7377. 0.1796)
p4 = -0.1461 (-0.2696. -0.02253)
p5 = 6.362 (6.155. 6.569)

Goodness of fit:

SSE: 1.038. R-square: 0.8016
Adjusted R-square: 0.7822. RMSE: 0.1591

The coefficient of determination for the approximating model of LWR is R^2 = 0.7822.

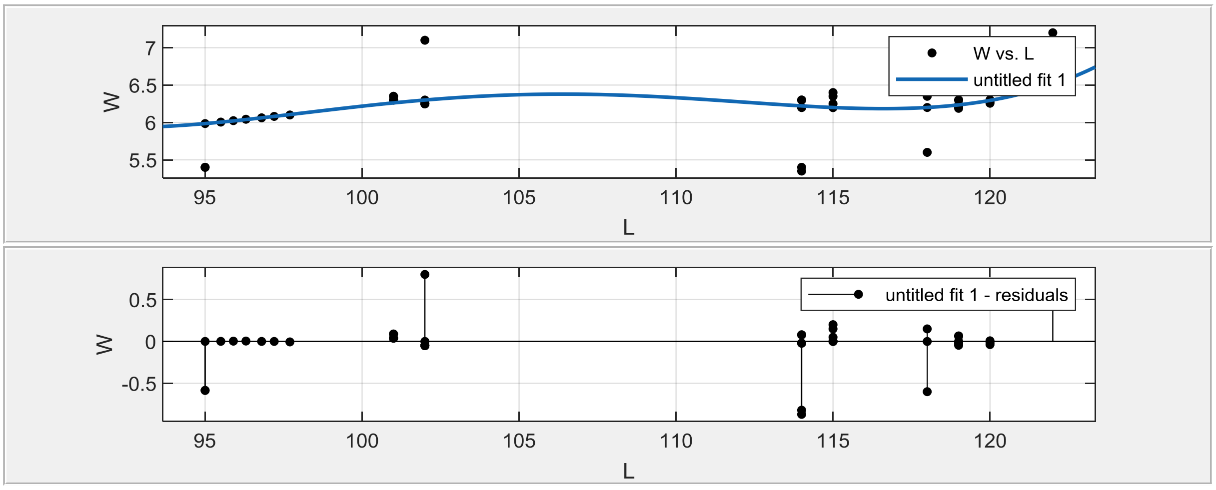

Fig. 3.2.2.5 LWR model of picked dogfish (October-December)

IV.3.2.3 Fecundity

30 samples were used for maturity analysis (January-June). In that period, the female specimens were sexually mature with apparent presence of embryos. Additional 46 samples were used for maturity analysis (July-December). In that period, actively ripening gonads were observed in all male individuals. The females were found with developed gonads, occupying a large part of the abdominal cavity with a high degree of maturity.

V. Conclusions and recommendations

Studies on this species are rare and regular monitoring studies are essential to understand the dynamics of exploited spiny dogfish stocks under the pressure of environmental changes in the Black Sea ecosystem.

- Male individuals predominated in the observed period (73.91% : 26.09%).
- Females had higher individual sizes and weights than males.

Recommendation:

A study of the proportion between non-sexually mature and sexually mature individuals of both sexes should be monitored for the remainder of the active breeding season.